Public Power Corporation S.A.
New Generation Activities Procurement Department

Market Consultation Invitation – Request for Information (RFI)
NGAPD-3005

Critical Powering Equipment for the Data Center at the Agios Dimitrios Power Plant, Kozani – Greece.

1 Introduction

PPC (Public Power Corporation) is conducting a Market Consultation Invitation / Request for Information (RFI) process in order to formulate the requirements of a forthcoming procurement procedure for the PPC Data Center at the Agios Dimitrios Power Plant, Kozani, Greece.

This project involves developing a Data Center (DC) Campus in Agios Dimitrios Power Plant in Kozani, Northern Greece. The Data Center will be built in phases within the area of a former Lignite yard of the existing power station. As a first phase the Data Center Campus consists of multiple data center buildings of IT load for a site of total 300MW load that can be expanded up to GW scale. Design and Facility follow Uptime Institute Tier III intent.

2 Project Overview

Primary power for the campus will be provided via a redundant (2N) utility substation. The first phase will include two utility 340MVA (400/33/33kV) transformers to provide power for Data Center building(s). The utility (PPC) will provide Medium Voltage (MV) 33kV power to the Data Center(s). The MV power feeds to the facility will be run below ground, diverse paths/separation between MV rings with concrete encasement. MV switchgears will be GIS type and housed in dedicated equipment areas on the site near each data center building.

2.1 400kV Gas Insulated Substation (GIS) equipment

During the first phase, the DC will be supplied by two existing **400kV bays** from the nearby **Agios Dimitrios TSO 400kV substation** via two new underground cable circuits. These two underground circuits will terminate at two corresponding circuit bays within a new **400kV Gas Insulated Substation (GIS)** featuring a double-busbar configuration.

The GIS will be developed on a dedicated plot of land adjacent to DC.

GIS will include seven (7) bays, one (1) coupling bay and 4 disconnectors which will be used for Data Center purposes as follows:

- Two (2) line bays for the connection with the TSO substation
- Two (2) transformer bays for the connection of the first phase Transformers (340/170/170 MVA - 400/33/33kV)
- One (1) busbars coupling bay

To accommodate future growth, the GIS will also include the following equipment:

- Two (2) 400kV overhead lines from an adjacent Pumped Hydro Storage (PHS) facility.
- One (1) 400kV overhead line from a nearby Battery Energy Storage System (BESS).
- Four (4) 400kV busbar extension disconnectors for the future expansion of the busbars.

2.2 Power Transformers

Two new three-winding transformers will be initially installed for DC powering, each with a capacity of 340/170/170 MVA (400/33/33kV) with a minimum short-circuit impedance (uk) of 15%.

Each transformer will operate at 50% capacity to ensure 2N redundancy, allowing either unit to support the total DC load seamlessly in case of a failure.

These transformers will be fed from the 400kV GIS via two dedicated transformer bays.

As the DC scales up—potentially reaching 1000 MW in the final phase—additional similar transformer sets will be added.

2.3 Medium Voltage (MV) 33kV GIS Switchboards

Each transformer will feed two **33kV GIS Switchboards with busbars** (minimum rating **3150A**) via overhead 33kV busducts.

- **Incomer Switchgears (4):** Each busduct arrival at the busbar will be managed through a 33kV incoming circuit breaker panel.
- **Outbound Feeders (48):** Each busbar will host **12 outgoing 33kV/630A feeders**. These feeders will supply an equal number of RMUs which will form the **Low Voltage (LV) rings** of the IT loads.
- **Auxiliary Power Feeders (2):** One additional 33kV feeder per transformer is planned to power an auxiliary 33/0.4kV transformer to serve **operational needs**.

Technical Specifications

- **Short-Circuit Level:** The 33kV MV GIS system will have a minimum short-circuit rating of **25kA**.
- **Cable Routing:** Cable departures from the 33kV panels will be routed through the floor.

- **Technology:** For the 33kV MV switchgear, both **Vacuum** and **SF_6** technologies are acceptable, with **Vacuum** being the preferred solution.

3 Purpose

The main purpose of this RFI is for PPC to identify potential Technology Providers (Participants) **that have the capability and capacity to provide critical Powering equipment under the following scope:**

- engineering services, manufacturing and procurement of critical power equipment such as **400kV Gas Insulated Substation (GIS) equipment, Power Transformers and Medium Voltage (MV) 33kV GIS Switchboards,** including Spare Parts, Transportation and Unloading, Assembly and Cold Commissioning Supervision.

Based on PPC's currently envisaged procurement and implementation approach, the integration of the above equipment is expected to be performed by an independent Contractor under a separate Contract with the scope described below.

The Contractor shall perform the engineering, procurement and installation of all the remaining necessary equipment/services, other than the ones provided by the Technology Provider, including all civil works, in order for the Power equipment (under the present RFI) to be in operation and integrated into the overall Data Center Design. Data Center Design is an ongoing process and will be provided by a Specialized Independent Consultant.

This approach is provided for information purposes only and may be further defined, modified or supplemented by PPC in any future procurement procedure.

This Market Consultation Invitation / RFI refers to all potential Technology Providers complying with the categories below:

- General Requirements
  - ü It is not mandatory for Participants to provide information and offer solutions for all equipment categories. Participants are invited to provide information in accordance with the General Requirements applicable to the relevant equipment offered and the Heads of Terms (HoTs) and Technical Specifications attached to this RFI.

- Specific Requirements
  - ü Participants providing information for **GIS equipment** shall be manufacturers of 400 kV GIS equipment and shall have procured

at least **one** 400kV GIS bay, being installed in Greek 400kV Transmission System (IPTO) during the last ten (10) years and has been in continuous and trouble-free operation for at least two (2) years. A reference list of installed 400 kV GIS bays in IPTO (Greek TSO) shall be supplied with the RFI.

- ü Participants providing information for **Power Transformers** shall be manufacturers of 3-windings 400kV/MV Power Transformers and shall have procured at least **one** 3-windings 400kV/MV Transformer of ≥200MVA during the last ten (10) years, which has been installed in a 400kV Transmission System and has been in continuous and trouble-free operation for at least two (2) years. A reference list of installed Power Transformers shall be supplied with the RFI.
- ü Participants providing information for **33kV GIS Switchboards** shall be manufacturers of 33 kV GIS Switchboards and shall have procured at least **100 33kV GIS** switchgears during the last ten (10) years, which have been installed and have been in continuous and trouble-free operation for at least two (2) years. A reference list of installed **33kV GIS** Switchgears shall be supplied with the RFI.

In addition to the above, PPC is particularly interested in receiving market information regarding indicative lead times, availability and potential constraints for the following long-lead items and related services falling within the requested scope, in order to assess feasible and optimized delivery timeframes:

- 400 kV GIS equipment
- Power Transformers
- 33kV GIS Switchboards
- Transportation to Site and Unloading - DPU Incoterms 2020, with customs clearance to be performed by PPC.
- Mandatory Assembly and Cold Commissioning Supervision, and other Services by Participants
- Provision of critical spare parts

Any information disclosed to PPC by any Participant under this RFI shall be treated as confidential, subject to the terms of the NDA, and shall not be made available to any other participant or third party, except only as strictly required for the purposes of project development, basic design, market assessment and PPC's internal consideration of potential next steps for the Project.

Market Consultation scope:

- Market research and evaluation of potential Technology Providers for the RFI scope required by PPC
- Preliminary market mapping of the technical, professional and financial profile of potential Technology Providers, to support PPC's

internal assessment, planning and further consideration of potential next steps for the Project.

For the avoidance of doubt, this RFI is conducted solely for market consultation and information-gathering purposes. The Heads of Terms (HoTs) and Technical Specifications attached to this RFI are provided on an indicative and non-binding basis, for the purpose of assisting Participants in completing the questionnaire, including the provision of budgetary information. They do not constitute final or binding requirements of PPC and may be further defined, modified or supplemented at PPC's discretion.

4 Participation Process

Participants in this RFI process will be required to complete and submit a relevant questionnaire, as well as to sign the enclosed NDA. In case of multiple proposals by a Technology Provider (proposals for different types of equipment), separate questionnaires must be submitted for each proposal. **All submitted documents must be signed by an authorized person of the participating company.**

The submission of the questionnaire(s) and the distribution of the RFI documents shall be carried out using the "cosmoONE" platform of the PPC Electronic Contracts System at the online address www.cosmo-one.gr or www.marketsite.gr. Registration does not incur any costs for those interested.

Necessary condition for participation of any interested party is registration in the System. Upon successful registration, interested parties shall be provided with System Access Codes, so as to download the questionnaire(s) and NDA (in editable format).

Responses (completed questionnaire(s) and signed NDA) shall be submitted by the interested parties electronically, with a start date of submission on the 12th of May 2026 and a closing date and time of submission on the 22nd of May 2026 at 16:00 (Greek time).

After the above deadline, submission of responses shall not be possible, unless PPC, at its own discretion, decides to extend the period of the potential Technology Providers' responses submission so as to ensure the proper execution of the process.

The questionnaire(s) to potential Technology Providers mainly contain(s) questions regarding:

- Technical data of the product offered.

- Their technical and professional capacity and experience in the execution of similar contracts of equivalent scope to the scope described herein.
- Their basic financial data.
- Their quality assurance system.
- Their reference list for successfully commercially delivered projects up to April 2026.
- Budgetary information for the Equipment under consideration.

5 Non-Binding Nature of the RFI

It is noted that this invitation to participate in this RFI does not constitute an announcement of a call for tenders, request for quotation, invitation to submit binding offers, prequalification procedure or contract award procedure and does not imply the undertaking of any legal commitment or obligation on the part of either the Participants or PPC.

6. No reimbursement / costs

Participation in this RFI process shall be at the sole cost and expense of each Participant. PPC shall not bear or reimburse any costs, expenses or losses incurred by any Participant in connection with the preparation or submission of its response or participation in this RFI process.

7. Contact Details

Participants should indicate contact details of persons responsible for providing information / clarifications for this Market Consultation / RFI

Name: .....
Phone Number: .....
Email: .....

Information regarding the participation process can be obtained from:

Name: Lydia Tsiaousi
Email: l.tsiaousi@ppcgroup.com

Name: Despoina Veneri
Email: d.veneri@ppcgroup.com

HEADS OF TERMS – RFI NGAPD-3005

Critical Powering Equipment for the Data Center at the Agios Dimitrios Power Plant, Kozani – Greece

SUMMARY OF HoTs

1. Purpose of Document

   This document defines indicative Heads of Terms for the above mentioned RFI
2. Project Overview

   Location: ex-SES Agios Dimitrios, Kozani

   Voltage Levels: 400kV / 33kV
3. Scope of Supply

   400kV GIS, Power Transformers, 33kV Boards, Spare Parts

   Services

   Assembly and Cold Commissioning Supervision
4. Milestone-based Time Plan

   As per defined milestone schedule.
5. Delivery of Goods & Logistics

   Supplier responsible for packing, transport and unloading (DPU Incoterms 2020).
6. Commercial Principles

   Lump Sum pricing, milestone-based payments
7. Securities & Guarantees

   APG, Performance Bond, minimum 24 months warranty.
8. Risk Allocation – High-Level Principles

   Supplier risk allocation, Force Majeure principles, overall liability cap, LDs / performance guarantees to be defined at any subsequent procurement stage.
9. Standards & Compliance

   IEC, EN, Grid Code compliance.
10. Confidentiality

    All information is strictly confidential, subject to the provisions of the respective NDA
11. Required Feedback from Participants

    Company profile and references, scope capability, budgetary information, manufacturing lead times, key risks / constraints
12. Legal Disclaimer

    Non-binding, no obligation to award.
13. Governing Law

    Possible future contracts to be governed by Greek Law

DETAILED HEADS OF TERMS

Market Consultation Invitation – Request for Information (RFI) NGAPD-3005

Critical Powering Equipment for the Data Center at the Agios Dimitrios Power Plant, Kozani – Greece

1. Purpose of this Document

These Heads of Terms (HoTs) define the **high-level commercial, contractual, scheduling and logistical framework** which may be considered by PPC in the context of any possible future procurement process relating to the above mentioned RFI.

The present HoTs are **indicative and non-binding** and aim to enable potential participants to:

- assess feasibility and risks,
- comment on market capabilities,
- provide meaningful input for PPC's further consideration of potential next steps, including the possible preparation of a Request for Quotation (RFQ) and tender documentation.

2. Project Overview

- Project: New Extra High Voltage Substation
- Location: **SES Agios Dimitrios, Kozani – Greece**
- Voltage Levels: **400 kV / 33 kV**
- End User: Transmission Network Operator (PPC/IPTO – indicative)
- Contracting Strategy: To be determined (separate supply packages or EP packages)

3. Scope of Supply (Indicative)

The RFI covers, indicatively, the following equipment categories and services:

- 400 kV GIS equipment (including GIL interfaces)
- Power Transformers
- 33 kV Switchgear Boards
- Associated auxiliaries and accessories
- Packing, Transport and Unloading
- Assembly and Cold commissioning supervision

4. Milestone-Based Time Plan

4.1 400 kV GIS Equipment

- Letter of Intent (LoI): Day 1
- Submission of bay drawings for manufacturing start: Day 20
- Approval of above-mentioned drawings: Day 30
- Finalization of GIL routing by PPC: Day 120
- Submission of GIL drawings: Day 135
- Approval of GIL drawings: Day 140
- Completion of manufacturing & FAT: *To be defined by manufacturer*
- Delivery at Site: **Day 365**
- Assembly of equipment: Within **4 months** after delivery

4.2 Power Transformers

- Letter of Intent (LoI): Day 1
- Submission of drawings for manufacturing start: Day 20
- Approval of drawings: Day 35
- Completion of manufacturing & FAT: *To be defined by manufacturer*
- Delivery at Site: **Day 335**
- Assembly of equipment: Within **4 months** after delivery

4.3 33 kV Boards

- Letter of Intent (LoI): Day 1
- Submission of drawings for manufacturing start: Day 40
- Approval of drawings: Day 50
- Completion of manufacturing & FAT: *To be defined by manufacturer*
- Delivery at Site: **Day 395**
- Assembly of equipment: Within **3 months** after delivery

Participants are invited to comment on the feasibility of the above milestone dates and propose optimizations.

5. Delivery of Goods & Logistics

- All equipment shall be **properly packed**, suitable for **outdoor temporary storage**.
- Unloading shall take place at the designated **open storage area**, accessible by trucks and mobile cranes.
- **Transportation to Site and unloading is fully within the Supplier's scope, as per DPU Incoterms 2020.** Import customs clearance shall be performed by PPC, while any applicable import duties, VAT, taxes and customs charges shall be borne by PPC. The foregoing shall constitute PPC's sole responsibility in this respect.
- For transformer main bodies:
    - unloading shall take place **directly at the final foundation position**,
    - all required lifting, jacking, skidding or special equipment is included in Supplier scope.

6. Commercial Principles (Indicative)

6.1 Pricing

- Preferred pricing structure: **Lump Sum / Fixed Price**
- Prices to include:
    - design,
    - manufacturing,
    - FAT,
    - packing,
    - transport to site,
    - unloading,
    - Assembly and Cold commissioning supervision
- Options and deviations to be clearly identified.

Participants may provide comments on whether, and under what conditions, internationally accepted price indexation mechanisms would be relevant for the type of equipment and delivery schedule under consideration.

6.2 Payment Terms (Indicative – Market Feedback Requested)

Typical milestone-based payment structure, which may indicatively include:

- Advance payment (10%) against Advance Payment Guarantee
- Design approval milestone
- Raw Material Procurement, or other significant Purchase Order
- FAT completion Milestone
- Delivery at Site
- Assembly / Cold Commissioning milestone
- Provisional Acceptance Milestone

7. Securities & Guarantees (Indicative)

- Advance Payment Guarantee
- Performance Bond (10–15% of Contract Price)
- Warranty Period:
    - Minimum **24 months from Provisional Acceptance** or **36 months from delivery**, whichever occurs first
    - Warranty Bond (5-10% of Contract Price)

8. Risk Allocation – High-Level Principles

- Supplier would bear the risks related to:
    - design and manufacturing errors,
    - delays attributable to Supplier,
    - logistics and transportation up to unloading.
- Force Majeure to follow international practice (FIDIC-oriented principles).
- Overall Liability Cap 100% of Contract price and exclusion of indirect damages
- Delay Liquidated Damages and performance guarantees to be defined at the stage of any subsequent procurement procedure, if launched.

9. Standards & Compliance

- IEC / EN standards
- Applicable Grid Code & TSO requirements
- Health, Safety & Environmental regulations (EU & National)
- Anti-corruption, sanctions, ESG compliance

10. Confidentiality

All information provided within the frame of this RFI and these HoTs shall be treated as **strictly confidential**, subject to the terms of the NDA to be executed between the Participant and PPC, as appended in this RFI.

11. Required Feedback from Participants

Participants are invited to submit:

1. Company profile & references (EHV substations)
2. Scope capability (what can be offered)
3. Bugdetary information for the equipment under consideration
4. Indicative manufacturing lead times

5. Key risks and constraints
6. Comments on the above HoTs
7. Recommendations to optimize schedule and execution

12. Legal Disclaimer

This RFI and the present HoTs are indicative and non-binding, do not constitute an offer, request for quotation, invitation to submit binding offers, prequalification procedure or contract award procedure, do not oblige PPC to proceed with any tender, procurement process or award, and may be amended, supplemented or cancelled by PPC without liability.

13. Governing Law

To be further defined at RFQ / procurement procedure stage, if applicable. Any possible future contract would be expected to be governed by Greek law, unless otherwise specified in the relevant procurement documents.

TENDER DOCUMENT

Procurement of
Gas-Insulated Switchgear (GIS) 400 kV

Greece

1. INTRODUCTION

This Tender Document defines the requirements for the procurement, supply, installation, testing, and commissioning of 400 kV Gas-Insulated Switchgear (GIS) equipment for high-voltage transmission infrastructure.

The objective is to ensure a reliable, efficient, and environmentally compliant GIS installation aligned with European and Greek regulatory frameworks.

The extent of the scope of supply, the **"Scope of Supply"**, associated to the request for quotation to construct the new ''Agios Dimitrios Datacenter'' under a turnkey project, will be defined.

Terminology used in all documents is listed below:

OWNER:	PPC or representative designated by this company.
CONTRACTOR:	Natural or legal person who carries out engineering, supply and construction works, both civil and electrical works (including electromechanical assembly) in OWNER.
MANUFACTURER:	Natural or legal person in charge of manufacturing required materials.
SUPPLIER:	Natural or legal person who delivers equipment good or material and associated services to OWNER.
BIDDER:	Natural or legal person to whom OWNER sends a Request for Quotation.

Suppliers are invited to submit a comprehensive tender proposal that outlines their technical approach, project team qualifications, and financial terms.

All relevant details regarding documentation submission process and deadlines, are included in the attached tender documentation.

2. PROJECT DEFINITION & SCOPE OF WORK

The OWNER is willing to build a new Extra High Voltage Substation (hereinafter the "EHVS") in Kozani, Northern Greece. The Substation will be located in the facilities of PPC's Agios Dimitrios Power Plant to connect the new Data Center project.

The new EHVS shall include a 400kV Gas Insulated Switchgear (hereinafter the "GIS") located inside a new Control Building.

The Supplier's Scope of Work regarding the 400kV GIS is intended to be composed by the following main works and installations:

- Detailed engineering and design
- Manufacturing and factory testing of GIS equipment
- Transportation and delivery to site
- Supervision of erection
- Supervision of Site testing and commissioning
- Training of Employer personnel
- Warranty

The Scope of Supply of the GIS has to be considered as a complete "package", therefore any component / device requested in this document and all components / devices anyway requested shall aim to achieve:

- The correct functional and operating conditions and design as required;
- The performances / features requested by the present Technical Specification;
- The respect of the Standards issued by Authorities, National Grid Operator (IPTO), applicable laws and safety regulations.

The Supplier shall consider the requirements of this Tender Document as minimum design criteria

It is clarified that any drawings attached to the present Tender document are to be considered as "indicative" and adherence to their content shall be mandatory. However, the Contractor shall be considered responsible for the

design of the works and as such, it shall be his responsibility to verify and integrate the design provided by the Owner.

The GIS switchgear shall be designed to withstand the seismic requirements of IEE 61166 with qualification level of AF5 (0,5g Horizontally). For vertical severity the direction factor (D) shall be 0,5 (as per IEC60068-3-3). Furthermore, the requirements of the Inquiry shall be satisfied.

The qualification level shall be proved either by test certificates of a bay identical to the ones required by this hereby technical description or by combined test and mathematical analysis for the O.H.L bay of this hereby technical description. The test certificates or the mathematical analysis must be submitted along with the technical offer. If neither is submitted, the eventual supplier shall carry out the test without any cost for IPTO.

All the bushings for connections of GIS with 420 kV overhead lines (SF_6-to-air bushings), 420 kV cables (SF_6-to-cable bushings) shall generally be in accordance with IEC 60137, IEC 62271-305, IEC-62271- 306 and IEC 61462 where applicable.

All air bushing whether they are intended for O.H.L or cable shall either be from silicon rubber.

Creepage distance shall be 10500 mm (minimum).

2.1 Maintenance, repair and extension

Routine maintenance of external parts of the switchgear including instrument transformers shall not be necessary at intervals of less than 5 years.

The maintenance of the circuit breaker shall not be less than 15 rated short circuit current interruptions, or 2000 rated current interruptions or 20 years operation whichever is earlier. Maintenance activities shall comprise only simple inspections and no exchange of parts or complex adjustments.

Checking the contact condition of the interrupter unit of the circuit breaker shall be possible without disturbing any other gas compartment and without interrupting any hydraulic piping. It shall be possible to safely replace the interrupter contacts of the circuit breaker even while the remaining switchgear is "live". The circuit breaker enclosure shall have provisions for easy withdrawal of the contact assembly. This procedure shall not involve the removal or dislocation for neighbouring bay enclosure parts. The removed interrupter assembly shall be easily and safely accessible for inspections and possible repairs.

Maintenance, repair and extension (MRE) activities, in each bay, must comply with the requirements outlined in the following tables.

FOR BAYS CONNECTED TO BUSBARS					
No	Equipment	BB1 Shutdown	BB2 Shutdown	Bay Shutdown	MRE Code
1	Circuit Breaker	0	0	1	MRE 01
2	BB1 Disconnector	1	0	1	MRE 11
3	BB2 Disconnector	0	1	1	MRE 11
4	BB1	1	0	1	MRE 11
5	BB2	0	1	1	MRE 11
6	Bay CT 1	0	0	1	MRE 01
7	Bay CT 2	0	0	1	MRE 01
8	Bay VT	0	0	1	MRE 01
9	Line Disconnector	0	0	1	MRE 01
10	Cable housing	0	0	1	MRE 01
11	BB1 VT	1	0	0	MRE 10
12	BB2 VT	0	1	0	MRE 10
13	BB1 Earthing Switch	1	0	0	MRE 10
14	BB2 Earthing Switch	0	1	0	MRE 10
15	Future extension	0	1	0	MRE 10
16	Future extension	1	0	0	MRE 10

FOR BAY CONNECTED TO LINE BAYS				
No	Equipment	Main bay	Bay Shutdown	MRE CODE
1	Circuit breaker	0	1	MRE 01
2	Disconnector	0	1	MRE 01
3	Bay CT 1	0	1	MRE 01
4	Bay CT 2	0	1	MRE 01
5	Bay VT	0	1	MRE 01
6	Line Disconnector	0	1	MRE 01
7	Cable housing	0	1	MRE 01
8	Bay VT	0	1	MRE 01
9	Bay Earthing Switch	0	1	MRE 01

The above mentioned MRE requirements will ensure the following:

a. Both busbars shall remain in continuous operation during maintenance or repair activities on a bay with the exception of maintenance or repair of a busbar disconnector, where operation will be limited to a single busbar. In all cases the uninterrupted service for the adjacent bays to maintenance or repair activities shall be ensured (see Table 1).

b. Uninterrupted operation of the main bay during maintenance or repair activities on bays connected to line bays, including Shunt Reactors, Capacitors, or Cable line bays (see Table 2). Uninterrupted operation of selected critical bays (as they are defined at the Inquiry) during maintenance or repair of the busbar disconnector compartment of the adjacent bays (Table 1).

c. For any future extension, provisions shall be made for a disconnector with an earthing switch and a buffer chamber at the end of the busbars on the extension side. This arrangement shall guarantee the uninterrupted operation of the bay adjacent to the extension and enable the safe performance of High Voltage Tests.

d. No work is allowed next to gas compartments at a rated pressure either energized or de-energized.

3. EQUIPMENT SCOPE

3.1 GENERAL

The following sections list the main components, works and services to be included in the Supplier's Scope of Supply for a 400kV GIS Switchgear.

Even if the sections define the Scope of Supply required by the Owner in detail or in principle, all the components, works, services or other items not expressly declared in this document, but necessary for the safe and reliable operation of the 400kV GIS Switchgear in regular and irregular conditions, or in any case necessary for external interconnections (grid, services, etc.), or demanded by IPTO justified by their specifications, practice etc. shall be considered as included, without any extra cost for the Owner.

3.2 TECHNICAL REQUIREMENTS

The GIS shall be designed, manufactured and tested in accordance with the best international engineering practices under strict quality control and shall comply with the following requirements:

a) It shall meet the requirements of the latest available version of **IPTO's** Specifications, including the provisions of **ΤΠ ΔΝΕΜ/ΤΜΥΣ & ΚΥΤ-3/αναθ.5** and TD-85 of Technical Volume II

b) It shall meet the following International Electromechanical Commission (IEC) publications:

   i. IEC 62271-203 Gas-insulated metal-enclosed switchgear for rated voltage above 52kV
   ii. IEC 62271-207 Seismic qualification for gas-insulated switchgear assemblies for rated voltages above 52 kV
   iii. IEC 60376 Specification of technical grade sulfur hexafluoride (SF6) for use in electrical equipment
   iv. IEC 62271- 100 Alternating-current circuit-breakers
   v. IEC 62271-1 Common specifications for high voltage Switchgear and controlgear
   vi. IEC 62271-102 Alternating current disconnectors and earthing switches
   vii. IEC 60044-1 Current transformers
   viii. IEC 60044-2 Inductive voltage transformers
   ix. IEC 60137 Insulated bushings for alternating voltages above 1000 V

x. IEC 62271-209 Cable connections for gas-insulated switchgear
xi. IEC 60480 Guidelines for the checking and treatment of sulphur hexafluoride (SF6) from electrical equipment and specification for its re-use
xii. IEC 61639 Direct connection between power transformers and gas-insulated metal-enclosed switchgear for rated voltages of 72.5 kV and above

c) The Supplier of the offered GIS equipment shall have a proven sales record of at least ten (10) GIS bays of the same design type and at the same voltage level as the offered equipment.

d) At least one GIS installation (comprising a minimum of four (4) bays, of the same design type, voltage level, and manufacturing origin as the offered GIS equipment) shall have been installed within the last ten (10) years in Electric Power Systems (EPS) and shall have demonstrated certified satisfactory operation for a minimum period of two (2) years.

e) It is noted that a deviation in the manufacturing plant of the above-mentioned installation, compared to the plant where the offered equipment for the project will be manufactured, may be accepted, provided that the plants belong to the same corporate group and apply common certified procedures for Material Management, Quality Assurance, and Quality Control.

3.3 Characteristics & Configuration Overview

3.3.1 Equipment Electrical Rated Characteristics

420 kV Gas Insulated Switchgear equipment shall have the following rating characteristics:

1. System Ratings

Rated Voltage (Ur)	420 kV
Operating Voltage	380–400 kV
Rated Frequency	50 Hz
System Earthing	Solidly earthed

2. Power-Frequency Withstand Voltage (50 Hz, 1 min)

Phase-to-earth & between phases	620 kV (rms)
Across open switching device / isolating distance	800 kV (rms)
3. Lightning Impulse Withstand Voltage (1.2/50 µs)	
Phase-to-earth & between phases	1425 kV (peak)
Across open switching device / isolating distance	1425 (+240) kV (peak)
4. Switching Impulse Withstand Voltage	
Phase-to-earth & across open switching device	1050 kV (peak)
Between phases	1575 kV (peak)
Across isolating distance	900 (+345) kV (peak)
5. Partial Discharge Requirement	
Cast resin at 1.2 × Ur/√3	< 5 pC
6. Current Ratings	
Busbars Rated Current	3150 A
Feeders Rated Current	3150 A
Bus coupler Rated Current	3150 A
7. Short-Circuit Ratings	
Rated short-time rated current	40 kA
Rated Peak withstand current	100 kA (peak)
Rated duration of short circuit	3 sec
8. Gas System	
Gas loss per compartment	< 0.5% per year
9. Auxiliary Supply	
DC Supply	220 V
AC Supply	230/400 V, 50 Hz

3.3.2 COMPONENTS

The main components of the GIS Switchgear 400kV per bay comprise of:

a. Circuit Brakers

b. Busbars

c. Disconnectors

d. Busbar Disconnectors

e. Earthing Switches

f. High Speed Earthing Switches

g. Current Transformers

h. Voltage Transformers

i. Interlocking facilities

j. Padlocks

k. Auxiliary control Equipment and Monitoring Sensos

l. SF6 –to-cable terminations

m. Local Control Cubicles (LCC)

3.3.3 GIS CONFIGURATION

The 400 kV GIS installation for Agios Dimitrios Data center Project shall comprise the following bay configuration:

- Two (2) line bays. Each Line Bay shall include:
    - Two (2) sections of 400 kV busbars
    - Two (2) three-pole 400 kV disconnectors with motor-operated mechanism
    - One (1) three-pole 400 kV circuit breaker
    - Two (2) motor-operated 400 kV earthing switches on either side of the 400 kV circuit breaker
    - Two (2) sets (triplets) of current transformers on either side of the 400 kV circuit breaker and between the two motor-operated earthing switches
    - One (1) motor-operated three-pole 400 kV disconnector at the bay outlet

- One (1) motor-operated 400 kV high-speed earthing switch at the bay outlet, equipped with an interlocking mechanism
- Three (3) inductive voltage transformers with three secondary windings
- One (1) Local Control Cubicle (LCC) located in the GIS equipment room.
- Three (3) SF_6 Gas-insulated transmission conductors (GIL), as well as the supporting structures for the said conductors
- Three (3) SF6 to Cable Terminations

- Five (5) transformer bays. Each Transformer Bay shall include:

  - Two (2) sections of 400 kV busbars
  - Two (2) three-pole 400 kV busbar disconnectors with motor-operated mechanisms
  - One (1) three-pole 400 kV circuit breaker
  - Two (2) motor-operated 400 kV earthing switches on either side of the 400 kV circuit breaker
  - Two (2) sets (triplets) of current transformers located on either side of the 400 kV circuit breaker and between the two motor-operated earthing switches
  - One (1) motor-operated three-pole 400 kV disconnector at the bay outlet
  - One (1) motor-operated 400 kV high-speed earthing switch at the bay outlet, equipped with an interlocking mechanism
  - Three (3) inductive voltage transformers with four secondary windings
  - One (1) Local Control Cubicle (LCC) located in the GIS room
  - Three (3) SF_6 Gas-insulated transmission conductors (GIL), as well as the supporting structures for the said conductors
  - Three (3) SF_6-to-air bushings for connection to 400 kV overhead conductors (if an overhead connection to the Unit is selected - consideration for Future phase connection of 160MVA Trafos), or
  - Three (3) SF_6-to-cable terminations (if a cable connection to the Unit is selected – consideration for current phase connection of 340MVA Trafos and for future phase connection of 280MVA Trafo)

- One (1) bus coupler bay. It shall include:

  - Two (2) sections of 400 kV busbars
  - Two (2) three-pole 400 kV busbar disconnectors with motor-operated mechanism
  - One (1) three-pole 400 kV circuit breaker installed between the disconnectors

- Two (2) motor-operated 400 kV earthing switches, located on either side of the 400 kV circuit breaker
- Two (2) sets (triplets) of current transformers located on either side of the 400 kV circuit breaker and between the two motor-operated earthing switches
- One (1) Local Control Cubicle (LCC) located in the GIS equipment room.

- Bus voltage transformers (VTs) bay. The Bay shall include per busbar:

  - 400 kV busbar section
  - One (1) three-pole 400 kV disconnector with motor-operated mechanism
  - Two (2) high-speed 400 kV earthing switches (one per busbar section), located on either side of the bus section disconnector (BS disconnector), equipped with an interlocking mechanism
  - Two (2) sets (triplets) of inductive voltage transformers (one set per busbar section), located on either side of the bus section disconnector

The GIS shall be designed on a double bus configuration, ensuring operational flexibility and reliability in accordance with transmission system requirements.

It shall consist of separate modular compartments ensuring maintenance can be performed without shutdown of adjacent sections. These compartments will be separated by gas barrier insulators.

Each GIS Bay shall be fully equipped with circuit breakers, disconnectors, and earthing switches as required for safe operation and maintenance. Safety earthing switches as well as high speed earthing switches will be supplied.

Adequately sized current and voltage instrument transformers will be used for protection relaying and measuring purposes. Regarding the Ratios and Characteristics of instrument transformers, such as the numbers of cores, rating, ratios, accuracy class, burdens etc, they should be additionally in accordance with the project specific requirements.

Especially regarding the Transformer Bays, as per IPTO's 3_ΤΠ ΔΝΕΜ_ΤΜΥΣ_ΚΥΤ_3_5 the rated primary current of the current transformers depends on the rated power of the 400 kV/MV power transformer to be installed in the project. In any case, the primary current shall be defined in the Connection Works Agreement. The following standardization is provided for indicative purposes:

Power transformer rating: 200 MVA → CT rated primary current: 300 A
Power transformer rating: 400 MVA → CT rated primary current: 600 A

For Agios Dimitrios Project please refer to attached IPTO Specifications and GIS Equipment Tender SLD.

In addition, the GIS shall include compartments with disconnectors and Fast Earthing Switches at both ends of the busbars to allow for future extension of the installation. These provisions shall enable the connection of additional bays without major modification to the existing GIS arrangement.

All necessary space, interfaces, and mechanical provisions shall be included in the initial design to accommodate such future expansions, including busbar extensions, control system scalability, and protection scheme adaptability.

Partial Discharge Monitoring system (PDM) shall be supplied for UHF online monitoring of Partial Discharge (PD) in GIS/GIL. Additionally monitoring of the density or pressure of the SF_6 insulating gas and the temperature of the insulating gas will be provided. The contractor shall be responsible for the design, supply, delivery, installation, site testing and commissioning of the complete PDM system.

Cables (Underground) will be connected to the GIL terminals of two-Line bays and two 340MVA Transformer bays while overhead conductors will be connected to the GIL Terminals of the 160MVA Transformer Bays.

The GIL for the 160MVA Transformers is not part of this Tender.

Each Bay shall be locally monitored and controlled through its LCC cabinet located in the building. Circuit braker and disconnector operation will be possible according to the applicable interlocking scheme.

The GIS Bays will be installed in the control building's TSO (IPTO) area by the use of properly sized supporting metal structures. The GIS switchgear shall be designed for installation in a seismic zone and shall be capable of withstanding earthquake-induced stresses. Seismic forces, including both horizontal and vertical accelerations acting simultaneously, shall be considered in the structural design. Seismic qualification shall comply with IEC 62271-207.

Seismic qualification shall be provided through a dynamic model analysis study.

The GIS equipment and all associated components shall be mechanically robust and adequately interconnected to withstand normal operational loads as well as additional stresses arising under seismic conditions without loss of functionality or structural integrity.

The GIS bays shall be connected to Gas-Insulated Transmission Lines (GIL) for the export of circuits outside the GIS building.

The GIL system shall extend from the GIS enclosures and pass through the external walls of the GIS building via appropriately designed wall bushings or sealing ends, ensuring mechanical integrity, gas tightness, and compliance with insulation coordination requirements. For their support, appropriate metal structures will be foreseen.

It is within the obligation of the supplier to provide the female and male part for the cable to SF6 terminations of the Bays. These parts must be provided by an already IPTO approved (type tested system of termination and cable) provider such as PFISTERER and TYCO. The female part shall be pre-installed at the factory and will be electrically tested during GIS routine and FAT testing.

At the external interface points, located outside the GIS building, the GIL terminations shall provide connection points for Overhead line conductors (via suitable air-insulated terminations – Future Provision for 160MVA Transformer Bays), and High-voltage cable systems (via cable sealing ends).

All outdoor terminations shall be designed for the specified environmental conditions and shall ensure safe electrical clearances, accessibility for maintenance, and compatibility with the overall substation layout.

The Contractor's scope shall include the design, supply, installation, and testing of the complete GIL system, including wall interfaces and outdoor terminations, up to the defined connection points with overhead lines and/or cable systems. The Contractor is obligated to provide all necessary equipment to be installed in the IPP part of the building.

All air-to- SF6 bushings shall be with silicone rubber insulation.

3.4 TESTS

The offered GIS equipment shall comply with the type test requirements specified in IPTO Specification TD-85 and in accordance to IEC-62271-203. The Contractor shall submit type test reports covering the required standard type tests as well as any additional tests specified in the contract.

Specifically, for the metallic support structures of the GIS and the converter valves, the following coefficients shall be used:

i. Importance factor, γ_1= 1.3
ii. Behavior factor, q= 1.5
iii. Damping factor, η= 1.08 (ζ=4 , bolted connections)
iv. Foundation factor Θ=1
v. Spectral amplification factor, β_0 = 2.5

Regarding the foundations and anchors of the above E/M equipment, the Contractor shall carry out an independent static study in accordance with the applicable Eurocode regulations, the requirements of paragraph 2.2.7.3 of Technical Specifications ΔΝΕΜ/ΤΜΥΣ ΚΥΤ-2, as well as any additional requirement specified in the Project Technical Documents.

These data shall:

i. Be classified by type of action, with clear separation between:
   - Permanent loads (self-weight of equipment, weight of gas/oil, auxiliary loads)
   - Seismic actions, as per the provisions of IEC 62271-207 and the relevant SS and TD Technical Specifications of Volume IIA.
ii. Be presented per direction of application (X, Y, Z) for both forces (Fx, Fy, Fz) and moments (Mx, My, Mz)
iii. Be provided without the application of safety factors, to allow the proper application of safety factors as required by the Eurocodes and the aforementioned Techincal Specification ΔΝΕΜ/ΤΜΥΣ ΚΥΤ-2 paragraph 2.2.7.3.

The Contractor shall incorporate the above data into the structural study in the form of input tables and shall fully document their origin by providing references to official manufacturer documents.

Type test reports for GIS assemblies, including circuit breakers, disconnectors, earthing switches, current transformers, and voltage transformers in accordance with the relevant IEC standards, shall be provided. In addition, type test reports for SF_6/Air and oil-impregnated bushings as per IEC 60137 shall also be submitted.

For routine tests new SF6 in accordance with IEC60376, or used SF6 in accordance with IEC60480, can be used. The routine tests shall be performed on all components of a substation. Depending on the nature of tests, some tests may be performed on components, transport units or on the complete installation. The routine tests ensure that the product is in accordance with the equipment on which the type test haw been carried out.

After installation, and before put into service, the GIS shall be tested in order to check the correct operation and the dielectric integrity of the equipment according IEC 62271-203 par. 10.2.

These tests and verifications comprise of the following:

- Dielectric tests on the main circuits after the final and complete installation of the whole GIS system, according IEC 62271-203 par. 10.2.101, PROCEDURE B.30. Simultaneously, partial discharge measurements will be carried out. Values of test voltages and partial discharge measurements should be in accordance with Table 6 and 7 of the above Standard,

- Dielectric tests on auxiliary circuits and control circuits, measurement of the resistance of the main circuit,

- Check for good performance and operation for all the CBs, Disconnectors, Earthing switches etc, with measurement of the operation time.

- Check of SF6 purity and quality.

- Check for SF6 leakage. The method and the measuring instruments used should be suitable for detection of a percentage of leakage at least equal to the guaranteed value per year (as it is determined at the "Special Terms" of the Contract).

All insulators of the 400 kV and MV equipment to be installed in the outdoor area shall be made of silicon rubber, with a creepage distance of 31 mm/kV, instead of porcelain, which may be referred to in certain specifications. The silicon rubber material shall be hydrophobic, resistant to pollution and UV solar radiation, and shall comply with the requirements of IEC 61462: "Composite hollow insulators – Pressurized and unpressurized insulators for use in electrical equipment with rated voltage greater than 1,000 V".

In particular, in addition to the design and type tests, it is emphasized that the silicon rubber material shall have successfully passed the following tests in accordance with IEC 62217:

- "Steep-front impulse voltage test"
- "Hardness test"
- "Accelerated weathering test"

- "Tracking and erosion test – 5000 h – multiple stresses, Annex B & IEC/TR 62730"
- "Evaluation of resistance to tracking and erosion according to IEC 60587"
- "Fingerprinting of silicone rubber according to CIGRE Technical Brochure 595"

It is further emphasized that the last two tests ("resistance to tracking and erosion" and "fingerprinting") shall accompany the insulators to be used in the Project as routine acceptance tests (3 samples).

3.5 SPARE PARTS

The required spare parts will follow the provisions of IPTO Specification TD-85 and the Connection Works Agreement. Indicatively the following are described:

Primary Spare Parts	Unit	Qty
1-pole line bay	pcs	1
1-pole transformer bay	pcs	1
1-pole coupling bay	pcs	1
One current (single phase) transformer of each type	pcs	2
One voltage (single pole) transformer of each type	Pcs	2
SF6 –to-air bushings	Pcs	2
SF6 –to-Cable bushings (male & female)	pcs	4
Secondary Spare Parts		
Sets of breaker contacts, closing and tripping coils and contactors	sets	4
Closing and tripping coils	sets	4
Sets of valves, gas filters, gas seals	sets	2
Disconnectors & earthing switches of each type	pcs	1
Disconnectors & earthing switches contacts set and operating mechanism of each type	pc	1
Gas monitor for switchgear	pc	3

Heaters and thermostats	pc	4
SF6-Sealings	pc	2
Bursting disks	pc	3
Operating mechanisms of disconnectors/ earthing switches/ fast earthing switches (of each type)	sets	1
Auxiliary contacts, contactors, relays and MCBs (of each type)	sets	2
Operating mechanism of the circuit breaker	pc	1

ΑΝΕΞΑΡΤΗΤΟΣ
ΔΙΑΧΕΙΡΙΣΤΗΣ ΜΕΤΑΦΟΡΑΣ
ΗΛΕΚΤΡΙΚΗΣ ΕΝΕΡΓΕΙΑΣ

ΤΠ ΔΝΕΜ/ΤΜΥΣ & ΚΥΤ-3/αναθ.5

ΗΛΕΚΤΡΟΜΗΧΑΝΟΛΟΓΙΚΟΣ ΕΞΟΠΛΙΣΜΟΣ ΙΣΧΥΟΣ ΚΑΙ ΒΟΗΘΗΤΙΚΟΣ ΕΞΟΠΛΙΣΜΟΣ ΣΕ ΕΡΓΑ 150 kV ή 400 kV ΣΥΝΔΕΣΗΣ ΜΕ ΤΟ ΕΣΜΗΕ

ΝΟΕΜΒΡΙΟΣ 2022

ΠΕΡΙΕΧΟΜΕΝΑ

4. ΕΞΟΠΛΙΣΜΟΣ 170 kV ΜΕ ΜΟΝΩΣΗ ΑΕΡΑ (AIS) – ΕΠΙΜΕΡΟΥΣ ΣΤΟΙΧΕΙΑ ΕΞΟΠΛΙΣΜΟΥ

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- 5.4 Πύλη GIS 420 kV σύνδεσης Μ/Σ 400 kV/ΜΤ προς εξυπηρέτηση Χρήστη
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- 6.5 Πύλη AIS 420 kV σύνδεσης Μ/Σ 400 kV/ΜΤ προς εξυπηρέτηση Χρήστη
- 6.6 Πύλη AIS 420 kV σύνδεσης αυτεπαγωγής στους Ζυγούς
- 6.7 Πύλη AIS 420 kV σύνδεσης με ΑΜ/Σ 400/150/30 kV

1. ΓΕΝΙΚΑ

Στην παρούσα τεχνική περιγραφή γίνεται συνοπτική παρουσίαση των βασικών στοιχείων εξοπλισμού ισχύος και λοιπού βοηθητικού και υποστηρικτικού εξοπλισμού που ενδέχεται να εγκατασταθεί σε ένα έργο 150 kV ή 400 kV σύνδεσης με το ΕΣΜΗΕ.

Το πλήθος και το είδος του εξοπλισμού ισχύος και των βοηθητικών εγκαταστάσεων που προβλέπονται για κάθε συγκεκριμένο έργο θα καθορίζεται στο τεχνικό τεύχος που περιγράφει το Αντικείμενο του έργου ή στην Σύμβαση Σύνδεσης Χρήστη (ΣΣΧ).

Όλος ο εξοπλισμός που θα εγκατασταθεί στο έργο, πρέπει να ικανοποιεί τους όρους της παρούσας και των τεχνικών προδιαγραφών που επισυνάπτονται στον Τόμο ΙΙΑ, καθώς επίσης και τους συναφείς Ευρωπαϊκούς Κανονισμούς IEC και τα εφαρμοζόμενα πρότυπα EN. Επίσης, στην παρούσα τεχνική περιγραφή, καταγράφονται ενδεικτικά και όχι περιοριστικά οι ελάχιστες απαιτούμενες δοκιμές επί τόπου του έργου, ανά στοιχείο εξοπλισμού ή ανά ηλεκτρομηχανολογικό σύστημα, καθώς και οι υποχρεώσεις του Αναδόχου για προμήθεια και παράδοση ανταλλακτικών, εργαλείων, αναλωσίμων, βοηθητικού εξοπλισμού και χημικών για το έργο.

Όλα τα στοιχεία Η/Μ εξοπλισμού που πρόκειται να εγκατασταθούν στο έργο, για να γίνουν τεχνικά αποδεκτά, θα πρέπει να ικανοποιούν τις απαιτήσεις της αντίστοιχης προδιαγραφής καθώς και τις απαιτήσεις δοκιμότητας και συστάσεων που προβλέπονται ανά υλικό στην εκάστοτε Διακήρυξη ή Σύμβαση ή ΣΣΧ.

Επίσης, σε περίπτωση ανέγερσης του έργου σε περιοχή με θαλάσσια ρύπανση (σύμφωνα με τα οριζόμενα στην εκάστοτε Σύμβαση), θα ισχύουν τα παρακάτω, επιπλέον των σχετικών προδιαγραφών :

- το σύστημα βαφής όλων των εκτεθειμένων μεταλλικών επιφανειών του εξοπλισμού (ΑΜ/Σ, Μ/Σ ισχύος, Μ/Σ εσωτερικής υπηρεσίας, αυτεπαγωγές κλπ) θα είναι κατάλληλο για να παρέχει προστασία έναντι της υψηλής ατμοσφαιρικής διαβρωτικότητας της περιοχής (θα ληφθεί κατηγορία CX «extreme, offshore areas-salt spray») και υψηλής αντοχής (κατηγορία «Η»), σύμφωνα με τα πρότυπα ISO 12944-1, -2, -5 (2018).
- αντίστοιχα, σε περίπτωση γαλβανισμένων εν θερμώ χαλύβδινων επιφανειών, θα εφαρμόζονται τα πρότυπα ISO 14713-1, -2 για ατμοσφαιρική διαβρωτικότητα C5 (πολύ υψηλή) και κλάση αντοχής γαλβανίσματος Η (υψηλή).
- όλα τα μεταλλικά ερμάρια υπαίθριας εγκατάστασης (πχ τοπικοί πίνακες εξοπλισμού ισχύος, πυροσβεστικές φωλιές κλπ), αλλά και τα λοιπά μεταλλικά υλικά εντός του κτηρίου (πίνακες, μεταλλικές θύρες, μεντεσέδες, εξωτερικοί μεταλλικοί αεραγωγοί, εξωτερικά αρμοκάλυπτρα, κλπ) θα είναι από ανοξείδωτο χάλυβα κατηγορίας SAE 316L.
- οι κοχλιωτές συνδέσεις (κοχλίες, παξιμάδια, ροδέλες κλπ) που θα χρησιμοποιηθούν στον υπαίθριο χώρο θα είναι ανοξείδωτες ποιότητας Α4.

- όλα τα γυμνά τμήματα των αγκυρίων Η/Μ εξοπλισμού μεταξύ της μεταλλικής βάσης του εξοπλισμού και της βάσης σκυροδέματος θα είναι εγκιβωτισμένα προς αποφυγή διάβρωσης.
- σε περίπτωση χρησιμοποίησης αγωγών αλουμινίου στον υπαίθριο χώρο, αυτοί θα είναι σειράς 5000 (5052, 5083, 5059) ή 6000 (6082, 6005A, 6063).
- όλοι οι μονωτήρες του εξοπλισμού 170 kV, 400 kV και ΜΤ που θα εγκατασταθούν στον υπαίθριο χώρο θα είναι από πυριτιούχο ελαστομερές («silicon rubber»), με μήκος ερπυσμού 31 mm/kV, αντί για πορσελάνη που ενδεχομένως αναφέρουν κάποιες προδιαγραφές. Το πυριτιούχο ελαστομερές θα είναι υδροφοβικό, μη προσβαλλόμενο από μόλυνση και ηλιακή ακτινοβολία UV και θα ικανοποιεί τις απαιτήσεις του κανονισμού IEC-61462 : «Συνθετικοί μονωτήρες-κοίλοι μονωτήρες για χρήση σε υπαίθριο και εσωτερικού χώρου ηλεκτρολογικό εξοπλισμό». Συγκεκριμένα εκτός των δοκιμών σχεδιασμού και τύπου επισημαίνεται ότι το πυριτιούχο ελαστομερές θα πρέπει να έχει υποστεί επιτυχώς τις ακόλουθες δοκιμές σύμφωνα με IEC 62217:
  - *«Steep-front impulse voltage test»*
  - *«Hardness test»*
  - *«Accelerated weathering test»*
  - *«Tracking and erosion test- 5000h-multiple stresses Annex B & IEC/TR 62730»*
  - *«Evaluation of resistance to tracking and erosion according to IEC 60587»*
  - *«Fingerprinting of silicone rubber according to CIGRE Technical Brochure 595»*

  Επισημαίνεται ότι οι δύο τελευταίες δοκιμές («*resistance to tracking and erosion*» & «*fingerprinting*») θα πρέπει να συνοδεύουν τους μονωτήρες που θα χρησιμοποιηθούν στο έργο ως δοκιμές παραλαβής (3 δείγματα).

  Για όσα στοιχεία εξοπλισμού υπάρχει τεκμηριωμένη αδυναμία προμήθειας τους με μονωτήρες πυριτιούχου ελαστομερούς, μπορεί κατ' εξαίρεση να γίνει αποδεκτή η εγκατάσταση μονωτήρων πορσελάνης με βαφή σιλικόνης, η οποία θα ακολουθεί την σχετική προδιαγραφή («RTV silicone coating») του τεχνικού τόμου ΙΙΑ.

2. ΕΞΟΠΛΙΣΜΟΣ 170 kV ΜΕ ΜΟΝΩΣΗ ΑΕΡΙΟΥ SF6 (GIS)

Εφόσον προβλέπεται στο έργο, η προμήθεια και εγκατάσταση εξοπλισμού ισχύος 170 kV εγκιβωτισμένου σε μεταλλικά περιβλήματα με μόνωση αερίου SF_6 (170 kV GIS Switchgear), αυτός θα ικανοποιεί τις απαιτήσεις της προδιαγραφής TD-29 του Τόμου ΙΙΑ. Για τον εξοπλισμό GIS που θα εγκαθίσταται θα προβλέπονται δυνατότητα πρόσβασης σε όλα τα σημεία του και κατάλληλες αποστάσεις για τους ελέγχους και τις συντηρήσεις.

Οι συνηθέστεροι τύποι πυλών GIS 170 kV που απαρτίζουν έναν Υ/Σ ή ΚΥΤ 150 kV, περιγράφονται κατωτέρω.

Σημειώνεται ότι οι απαιτήσεις επιφόρτισης («Burden») σε (VA) για τα δευτερεύοντα τυλίγματα των Μ/Σ έντασης και τάσης που αναγράφονται στις παρακάτω περιπτώσεις

5. ΕΞΟΠΛΙΣΜΟΣ 400 kV ΜΕ ΜΟΝΩΣΗ ΑΕΡΙΟΥ SF6 (GIS)

Εφόσον προβλέπεται στο έργο η προμήθεια και εγκατάσταση εξοπλισμού ισχύος 400 kV εγκιβωτισμένου σε μεταλλικά περιβλήματα με μόνωση αερίου SF_6 (400 kV GIS Switchgear), αυτός θα ικανοποιεί τις απαιτήσεις της προδιαγραφής TD-85 του Τόμου ΙΙΑ.
Οι συνηθέστεροι τύποι πυλών GIS 400 kV που απαρτίζουν ένα ΚΥΤ 400 kV, περιγράφονται κατωτέρω.

5.1 Πύλη GIS 400 kV σύνδεσης με εναέρια Γραμμής Μεταφοράς 400 kV

Α. Τμήμα Εξοπλισμού GIS

Περιλαμβάνει :

- Δύο τμήματα ζυγών 400kV
- Δύο τριπολικούς αποζεύκτες 400kV ζυγών με ηλεκτροκίνητο μηχανισμό
- Ενα τριπολικό διακόπτη 400kV
- Δύο ηλεκτροκίνητους γειωτές 400kV εκατέρωθεν του τριπολικού διακόπτη 400kV
- Δύο σετ (τριάδες) Μ/Σ Εντάσεως εκατέρωθεν του τριπολικού διακόπτη 400kV και μεταξύ των δύο ηλεκτροκίνητων γειωτών.

Οι Μ/Σ εντάσεως 400kV προς το μέρος των ζυγών θα είναι διπλής σχέσεως, δύο δευτερευόντων τυλιγμάτων : 800-1600/1-1Α. Η κλάση ακριβείας και η ονομαστική ισχύς εξόδου των δευτερευόντων τυλιγμάτων θα είναι :

1. Τύλιγμα προστασίας (1S1-1S2)
   - Ονομαστική ισχύς εξόδου : 25 VA
   - Κλάση ακριβείας :5P
   - Συντελεστής ορίου ακριβείας : 20

Το τύλιγμα αυτό θα τροφοδοτεί τον Η/Ν της 1ης προστασίας αποστάσεως ή τον Η/Ν 1ης προστασίας Δ/Φ ΓΜ με ενσωματωμένη προστασία αποστάσεως (σε περιπτώσεις ΓΜ 400kV με μήκος μικρότερο των 20km).

2. Τύλιγμα προστασίας (2S1-2S2)
   - Ονομαστική ισχύς εξόδου : 25 VA
   - Κλάση ακριβείας :5P
   - Συντελεστής ορίου ακριβείας : 20

Το τύλιγμα αυτό θα τροφοδοτεί τον Η/Ν της 2ης προστασίας αποστάσεως ή τον Η/Ν 2ης προστασίας Δ/Φ ΓΜ με ενσωματωμένη προστασία αποστάσεως (σε περιπτώσεις ΓΜ 400kV με μήκος μικρότερο των 20km).

Οι Μ/Σ εντάσεως 400kV προς το μέρος της Γ.Μ. 400kV θα είναι διπλής σχέσεως δύο δευτερευόντων τυλιγμάτων 800-1600/1-1Α. Η κλάση ακριβείας και η ονομαστική ισχύς εξόδου των δευτερευόντων τυλιγμάτων θα είναι :

1. Τύλιγμα μετρήσεων (1S1-1S2)
   - Ονομαστική ισχύς εξόδου : 25 VA

- Κλάση ακριβείας :0,5
- Συντελεστής ασφαλείας οργάνου : Fs ≤ 5

2. Τύλιγμα προστασίας (2S1-2S2)
   - Ονομαστική ισχύς εξόδου : 25 VA
   - Κλάση ακριβείας :5P
   - Συντελεστής ορίου ακριβείας : 20

Το τύλιγμα αυτό θα τροφοδοτεί τον Η/Ν Δ/Φ προστασίας ζυγών.

- Έναν ηλεκτροκίνητο τριπολικό αποζεύκτη 400kV στην έξοδο της πύλης
- Έναν ηλεκτροκίνητο ταχυγειωτή 400kV στην έξοδο της πύλης με μηχανισμό μανδάλωσης
- Τρεις Μ/Σ Τάσεως επαγωγικού τύπου με τρία δευτερεύοντα τυλίγματα 400000:√3/ 100:√3-100:√3-100:√3 με τα παρακάτω τεχνικά χαρακτηριστικά :

1. Τύλιγμα μετρήσεων (1a-1n)
   - Ονομαστική ισχύς εξόδου : 25 VA
   - Κλάση ακριβείας : 0,5
   - Ποσοστιαίο σφάλμα τάσης : ±0.5
   - Φασική μετατόπιση : ±20min
2. Τύλιγμα μετρήσεων (2a-2n)
   - Ονομαστική ισχύς εξόδου : 25 VA
   - Κλάση ακριβείας : 0,5
   - Ποσοστιαίο σφάλμα τάσης : ±0.5
   - Φασική μετατόπιση : ±20min
3. Τύλιγμα προστασίας (3a-3n)
   - Ονομαστική ισχύς εξόδου : 10 VA
   - Κλάση ακριβείας : 3P
   - Ποσοστιαίο σφάλμα τάσης : ±3
   - Φασική μετατόπιση : ±120min

- Τοπικό πίνακα ελέγχου (Local Control Cubicle) στην αίθουσα εξοπλισμού GIS.

Για την έξοδο της πύλης από το κτήριο στον υπαίθριο χώρο μπορεί να επιλεγούν (ανάλογα με τα προβλεπόμενα στα σχέδια της Διακήρυξης/Σύμβασης) είτε μονωτήρες διέλευσης SF6 και αγωγοί GIL είτε τρία ακροκιβώτια SF6 – καλωδίου (cable sockets, τεχνολογίας plugin) σύνδεσης με καλωδιακή γραμμή 400 kV, καθώς και τα αντίστοιχα μονοπολικά καλώδια 400 kV.

Β. Τμήμα υπαίθριου εξοπλισμού

Διαμορφώνεται ανάλογα με τον σχεδιασμό που θα επιλεγεί για την έξοδο της πύλης από το κτήριο και ενδέχεται να περιλαμβάνει :

- Αγωγούς με μόνωση αερίου SF6 (GIL), καθώς και τα ικριώματα στήριξης των υπόψη αγωγών ή/και μονοπολικά καλώδια 400kV με τα αντίστοιχα υπαίθρια ακροκιβώτια

καλωδίων 400kV.

- Τρία αλεξικέραυνα 400kV.
- Κυματοπαγίδα και Πυκνωτής Ζεύξης (εφόσον απαιτούνται).
- Τα απαιτούμενα ικριώματα στήριξης του υπαίθριου εξοπλισμού.
- Τα απαιτούμενα ικριώματα πρόσδεσης της Γ.Μ. 400 kV.
- Εναέριους αγωγούς, σφιγκτήρες κλπ.

5.2 Πύλη GIS 400 kV σύνδεσης με καλωδιακή Γραμμή Μεταφοράς 400 kV

Α. Τμήμα Εξοπλισμού GIS

Η πύλη περιλαμβάνει :

- Δύο τμήματα ζυγών 400kV
- Δύο τριπολικούς αποζεύκτες 400kV ζυγών με ηλεκτροκίνητο μηχανισμό
- ένα τριπολικό διακόπτη 400kV, που θα είναι κατάλληλος για μονοπολική λειτουργία μέσω Η/Ν ελεγχόμενης ζεύξης/απόζευξης (POW – Point On Wave)
- Δύο ηλεκτροκίνητους γειωτές 400kV εκατέρωθεν του τριπολικού διακόπτη 400kV
- Δύο σετ (τριάδες) Μ/Σ Εντάσεως εκατέρωθεν του τριπολικού διακόπτη 400kV και μεταξύ των δύο ηλεκτροκίνητων γειωτών.
- Οι Μ/Σ εντάσεως 400kV προς το μέρος των ζυγών θα είναι μονής σχέσεως, δύο δευτερευόντων τυλιγμάτων : 1000/1-1A
- Η κλάση ακριβείας και η ονομαστική ισχύς εξόδου των δευτερευόντων τυλιγμάτων θα είναι :

1. Τύλιγμα προστασίας (1S1-1S2)
   - Ονομαστική ισχύς εξόδου : 25 VA
   - Κλάση ακριβείας :5P
   - Συντελεστής ορίου ακριβείας : 20

   Το τύλιγμα αυτό θα τροφοδοτεί τον Η/Ν 1ης Δ/Φ προστασίας καλωδίου (με εφεδρική («backup») προστασία αποστάσεως).
2. Τύλιγμα προστασίας (2S1-2S2)
   - Ονομαστική ισχύς εξόδου : 25 VA
   - Κλάση ακριβείας :5P
   - Συντελεστής ορίου ακριβείας : 20

   Το τύλιγμα αυτό θα τροφοδοτεί τον Η/Ν της 2ης Δ/Φ προστασίας καλωδίου (με εφεδρική («backup») προστασία αποστάσεως).

   Οι Μ/Σ εντάσεως 400kV προς το μέρος της Γ.Μ. 400kV θα είναι μονής σχέσεως δύο δευτερευόντων τυλιγμάτων:1000/1-1A

   Η κλάση ακριβείας και η ονομαστική ισχύς εξόδου των δευτερευόντων τυλιγμάτων θα είναι :

1. Τύλιγμα μετρήσεων (1S1-1S2)

- Ονομαστική ισχύς εξόδου : 25 VA
- Κλάση ακριβείας :0,5
- Συντελεστής ασφαλείας οργάνου : Fs ≤ 5

Το τύλιγμα θα τροφοδορεί και τον Η/Ν ελεγχόμενης Ζεύξης – Απόζευξης (Point On Wave).

2. Τύλιγμα προστασίας (2S1-2S2)
   - Ονομαστική ισχύς εξόδου : 25 VA
   - Κλάση ακριβείας :5P
   - Συντελεστής ορίου ακριβείας : 20

Το τύλιγμα αυτό θα τροφοδοτεί τον Η/Ν Δ/Φ προστασίας ζυγών.

- Έναν ηλεκτροκίνητο τριπολικό αποζεύκτη 400kV στην έξοδο της πύλης
- Έναν ηλεκτροκίνητο ταχυγειωτή 400kV στην έξοδο της πύλης με μηχανισμό μανδάλωσης
- Τρεις Μ/Σ Τάσεως επαγωγικού τύπου με τρία δευτερεύοντα τυλίγματα 400000:√3/ 100:√3-100:√3-100:√3 με τα παρακάτω τεχνικά χαρακτηριστικά :
  1. Τύλιγμα μετρήσεων (1a-1n)
     - Ονομαστική ισχύς εξόδου : 25 VA
     - Κλάση ακριβείας : 0,5
     - Ποσοστιαίο σφάλμα τάσης : ±0.5
     - Φασική μετατόπιση : ±20min
  2. Τύλιγμα μετρήσεων (2a-2n)
     - Ονομαστική ισχύς εξόδου : 25 VA
     - Κλάση ακριβείας : 0,5
     - Ποσοστιαίο σφάλμα τάσης : ±0.5
     - Φασική μετατόπιση : ±20min
  3. Τύλιγμα προστασίας (3a-3n)
     - Ονομαστική ισχύς εξόδου : 10 VA
     - Κλάση ακριβείας : 3P
     - Ποσοστιαίο σφάλμα τάσης : ±3
     - Φασική μετατόπιση : ±120min
- Αλεξικέραυνα GIS
- Έναν τοπικό πίνακα ελέγχου (Local Control Cubicle) στην αίθουσα εξοπλισμού GIS.

Β. Τμήμα υπαίθριου εξοπλισμού

Περιλαμβάνει :

- Τρεις αγωγούς με μόνωση αερίου SF6 (GIL)
- Τα ικριώματα στήριξης των ως άνω αγωγών μόνωσης αερίου SF6 (GIL)
- Τρία ακροκιβώτια SF6 – καλωδίου (cable sockets, τεχνολογίας plugin) σύνδεσης με την καλωδιακή γραμμή 400kV.

5.3 Πύλη GIS 400 kV σύνδεσης με αυτεπαγωγή αντισταθμίσεως, προσαρτημένη σε πύλη καλωδιακής ΓΜ 400 kV

Α. Τμήμα Εξοπλισμού GIS

Περιλαμβάνει :

- Τρεις αγωγούς με μόνωση αερίου SF_6 γεφύρωσης με την πύλη GIS 400 kV καλωδιακής γραμμής.
- ένα τριπολικό αποζεύκτη 400kV με ηλεκτροκίνητο μηχανισμό.
- ένα τριπολικό διακόπτη 400kV , που θα είναι κατάλληλος για μονοπολική λειτουργία μέσω Η/Ν ελεγχόμενης ζεύξης/απόζευξης (POW – Point On Wave).
- ένα τριπολικό ηλεκτροκίνητο γειωτή 400kV μεταξύ αποζεύκτη και διακόπτη.
- Ένα σετ (τριάδα) Μ/Σ Εντάσεως ανάμεσα στον γειωτή και στον τριπολικό διακόπτη 400kV.

  Οι Μ/Σ εντάσεως 400kV θα είναι μονής σχέσεως, δύο δευτερευόντων τυλιγμάτων : 100/1-1 Α (εκτός αν ο λόγος ορίζεται αλλιώς για το υπόψη έργο).

  Η κλάση ακριβείας και η ονομαστική ισχύς εξόδου των δευτερευόντων τυλιγμάτων θα είναι :

  1. Τύλιγμα προστασίας (1S1-1S2)
     - Ονομαστική ισχύς εξόδου : 30 VA
     - Κλάση ακριβείας :5P
     - Συντελεστής ορίου ακριβείας : 20

  Το τύλιγμα αυτό θα τροφοδοτεί τον Η/Ν REF.

  2. Τύλιγμα μετρήσεων (2S1-2S2)
     - Ονομαστική ισχύς εξόδου : 30 VA
     - Κλάση ακριβείας :0,5
     - Συντελεστής ασφαλείας οργάνου : Fs ≤ 5

     Το τύλιγμα θα τροφοδορεί και τον Η/Ν ελεγχόμενης Ζεύξης – Απόζευξης (Point On Wave).
- Τοπικό πίνακα ελέγχου (Local Control Cubicle) στην αίθουσα εξοπλισμού GIS.

Β. Τμήμα υπαίθριου εξοπλισμού προσαρτημένης πύλης αυτεπαγωγής αντισταθμίσεως

Περιλαμβάνει :

- Τρεις αγωγούς με μόνωση αερίου SF_6 (GIL) για σύνδεση με τον υπαίθριο εξοπλισμό της πύλης αυτεπαγωγής.
- Τρεις μονωτήρες διέλευσης σύνδεσης SF6 με τους εναέριους αγωγούς 400kV της πύλης αυτεπαγωγής.
- Τρία αλεξικέραυνα 400kV.
- Κατάλληλα μεταλλικά ικριώματα στήριξης του ανωτέρω εξοπλισμού.

5.4 Πύλη 400 kV ΑΜ/Σ 400/150/30 kV

Α. Τμήμα Εξοπλισμού GIS

Περιλαμβάνει :

- Δύο τμήματα ζυγών 400kV
- Δύο τριπολικούς αποζεύκτες 400kV ζυγών με ηλεκτροκίνητο μηχανισμό
- Έναν τριπολικό διακόπτη 400kV
- Δύο ηλεκτροκίνητους γειωτές 400kV εκατέρωθεν του τριπολικού διακόπτη 400kV
- Τρεις Μ/Σ εντάσεως 400kV μεταξύ διακόπτη και γειωτή αποζευκτών 400kV μονής σχέσεως και ενός δευτερεύοντος τυλίγματος 400/1Α. Η κλάση ακριβείας και η ονομαστική ισχύς εξόδου του δευτερεύοντος τυλίγματος θα είναι :
  1. Τύλιγμα προστασίας (1S1-1S2)
     - Ονομαστική ισχύς εξόδου : 30 VA
     - Κλάση ακριβείας :5P
     - Συντελεστής ορίου ακριβείας : 20

  Το τύλιγμα αυτό θα τροφοδοτεί τον Η/Ν Δ/Φ προστασίας του ΑΜ/Σ

  Οι τροφοδοσίες όλων των υπολοίπων Η/Ν προστασίας καθώς και των μετρήσεων θα εξασφαλίζονται από τους Μ/Σ εντάσεως στους μονωτήρες διέλευσης «bushings» 400kV του ΑΜ/Σ και από τους Μ/Σ τάσεως των ζυγών 400kV.
- Τοπικό πίνακα ελέγχου (Local Control Cubicle) στην αίθουσα εξοπλισμού GIS.

Β. Τμήμα υπαίθριου εξοπλισμού

Περιλαμβάνει:

- Τρεις αγωγούς με μόνωση αερίου SF6 (GIL)
- Τα ικριώματα στήριξης των ως άνω αγωγών μόνωσης αερίου SF6 (GIL)
- Τρια ακροκιβώτια SF6 – αέρα σύνδεσης με εναέριους αγωγούς 400kV προς αλεξικέραυνα 400kV και bushings 400kV του ΑΜ/Σ **ή**

  Τρία ακροκιβώτια SF6 – καλωδίου, τρία ακροκιβώτια καλωδίου – αέρα και τρία κατάλληλα μονοπολικά καλώδια XLPE 400kV προς εναέριους ζυγούς του ΑΜ/Σ.
- Έναν ΑΜ/Σ σχέσεως 400/150/30 kV και ισχύος 280/280/60 MVA.
- Τρία αλεξικέραυνα 400 kV.
- Τα απαιτούμενα ικριώματα στήριξης του πιο πάνω υπαίθριου εξοπλισμού.
- Αγωγούς, σφιγκτήρες κλπ

5.5 Πύλη Διασύνδεσης Ζυγών GIS 400 kV

Περιλαμβάνει:

- Δύο τμήματα ζυγών 400kV
- Δύο τριπολικούς αποζεύκτες 400kV ζυγών με ηλεκτροκίνητο μηχανισμό
- Έναν τριπολικό διακόπτη 400kV μεταξύ των αποζευκτών

- Δύο ηλεκτροκίνητους γειωτές 400kV εκατέρωθεν του τριπολικού διακόπτη 400kV
- Δύο σετ (τριάδες) Μ/Σ Εντάσεως εκατέρωθεν του τριπολικού διακόπτη 400kV και μεταξύ των δύο ηλεκτροκίνητων γειωτών.

  Οι Μ/Σ εντάσεως 400kV του ενός σετ θα είναι διπλής σχέσεως, δύο δευτερευόντων τυλιγμάτων: 1200-2400/1-1A. Η κλάση ακριβείας και η ονομαστική ισχύς εξόδου των δευτερευόντων τυλιγμάτων θα είναι :

  1. Τύλιγμα μετρήσεων (1S1-1S2)
     - Ονομαστική ισχύς εξόδου : 25 VA
     - Κλάση ακριβείας :0,5
     - Συντελεστής ασφαλείας οργάνου : Fs ≤ 5
  2. Τύλιγμα προστασίας (2S1-2S2)
     - Ονομαστική ισχύς εξόδου : 25 VA
     - Κλάση ακριβείας :5P
     - Συντελεστής ορίου ακριβείας : 20

  Το τύλιγμα αυτό θα τροφοδοτεί τον Η/Ν Δ/Φ προστασίας ζυγών.

  Οι Μ/Σ εντάσεως 400kV του δευτέρου σετ θα είναι διπλής σχέσεως ενός δευτερεύοντος τυλίγματος 1200-2400/1A. Η κλάση ακριβείας και η ονομαστική ισχύς εξόδου των δευτερευόντων τυλιγμάτων θα είναι :

  1. Τύλιγμα προστασίας (1S1-1S2)
     - Ονομαστική ισχύς εξόδου : 25 VA
     - Κλάση ακριβείας :5P
     - Συντελεστής ορίου ακριβείας : 20

  Το τύλιγμα αυτό θα τροφοδοτεί τον Η/Ν Δ/Φ προστασίας ζυγών.
- Τοπικό πίνακα ελέγχου (Local Control Cubicle) στην αίθουσα εξοπλισμού GIS.

5.6 Πύλη Τομής, Ταχυγειωτών και Μ/Σ Τάσεως Ζυγού

Η Πύλη **<u>ανά ζυγό</u>** περιλαμβάνει:

- Τμήμα Ζυγού 400kV
- Ένα τριπολικό αποζεύκτη 400kV με ηλεκτροκίνητο μηχανισμό
- Δύο ταχυγειωτές 400 kV (<u>έναν ανά τμήμα ζυγού) εκατέρωθεν του Α/Ζ της τομής ζυγών</u> με μηχανισμό μανδάλωσης
- Δύο σετ (τριάδες) Μ/Σ τάσεως επαγωγικού τύπου (<u>ένα σετ ανά τμήμα ζυγού) εκατέρωθεν του Α/Ζ της τομής ζυγών</u> δύο δευτερευόντων τυλιγμάτων 400000:√3/ 100:√3-100:√3 με τα παρακάτω τεχνικά χαρακτηριστικά:

  1. Τύλιγμα μετρήσεων (1a-1n)
     - Ονομαστική ισχύς εξόδου : 25 VA
     - Κλάση ακριβείας : 0,5
     - Ποσοστιαίο σφάλμα τάσης : ±0,5

- Φασική μετατόπιση : ±20min

2. Τύλιγμα μετρήσεων (2a-2n)
   - Ονομαστική ισχύς εξόδου : 25 VA
   - Κλάση ακριβείας : 0,5
   - Ποσοστιαίο σφάλμα τάσης : ±0,5
   - Φασική μετατόπιση : ±20min

- Τοπικό πίνακα ελέγχου (Local Control Cubicle) στην αίθουσα εξοπλισμού GIS.

Σε περίπτωση Τομής Ζυγών **με Α/Δ**, η Πύλη (**ανά ζυγό**) θα περιλαμβάνει:

- Τμήμα Ζυγού 400kV
- Δύο τριπολικούς αποζεύκτες 400kV με ηλεκτροκίνητο μηχανισμό
- Έναν τριπολικό διακόπτη 400kV μεταξύ των αποζευκτών
- Δύο ηλεκτροκίνητους γειωτές 400kV εκατέρωθεν του τριπολικού διακόπτη 400kV
- Δύο σετ (τριάδες) Μ/Σ Εντάσεως εκατέρωθεν του τριπολικού διακόπτη 400kV και μεταξύ των δύο ηλεκτροκίνητων γειωτών.

  Οι Μ/Σ εντάσεως 400kV του ενός σετ θα είναι διπλής σχέσεως, δύο δευτερευόντων τυλιγμάτων: 1200-2400/1-1A. Η κλάση ακριβείας και η ονομαστική ισχύς εξόδου των δευτερευόντων τυλιγμάτων θα είναι :

  1. Τύλιγμα μετρήσεων (1S1-1S2)
     - Ονομαστική ισχύς εξόδου : 25 VA
     - Κλάση ακριβείας :0,5
     - Συντελεστής ασφαλείας οργάνου : Fs ≤ 5
  2. Τύλιγμα προστασίας (2S1-2S2)
     - Ονομαστική ισχύς εξόδου : 25 VA
     - Κλάση ακριβείας :5P
     - Συντελεστής ορίου ακριβείας : 20

  Το τύλιγμα αυτό θα τροφοδοτεί τον Η/Ν Δ/Φ προστασίας ζυγών.

  Οι Μ/Σ εντάσεως 400kV του δευτέρου σετ θα είναι διπλής σχέσεως δύο δευτερευόντων τυλιγμάτων 1200-2400/1-1A. Η κλάση ακριβείας και η ονομαστική ισχύς εξόδου των δευτερευόντων τυλιγμάτων θα είναι :

  1. Τύλιγμα προστασίας (1S1-1S2)
     - Ονομαστική ισχύς εξόδου : 25 VA
     - Κλάση ακριβείας :5P
     - Συντελεστής ορίου ακριβείας : 20

  Το τύλιγμα αυτό θα τροφοδοτεί τον Η/Ν Υ/Ε.

  2. Τύλιγμα προστασίας (2S1-2S2)
     - Ονομαστική ισχύς εξόδου : 25 VA
     - Κλάση ακριβείας :5P

- Συντελεστής ορίου ακριβείας : 20

Το τύλιγμα αυτό θα τροφοδοτεί τον Η/Ν Δ/Φ προστασίας ζυγών.

- Δύο ταχυγειωτές 400 kV (<u>έναν ανά τμήμα ζυγού) εκατέρωθεν της τομής ζυγών</u> με μηχανισμό μανδάλωσης
- Δύο σετ (τριάδες) Μ/Σ τάσεως επαγωγικού τύπου (<u>ένα σετ ανά τμήμα ζυγού) εκατέρωθεν της τομής ζυγών</u> δύο δευτερευόντων τυλιγμάτων 400000:√3/ 100:√3-100:√3 με τα παρακάτω τεχνικά χαρακτηριστικά:

1. Τύλιγμα μετρήσεων (1a-1n)
   - Ονομαστική ισχύς εξόδου : 25 VA
   - Κλάση ακριβείας : 0,5
   - Ποσοστιαίο σφάλμα τάσης : ±0,5
   - Φασική μετατόπιση : ±20min
2. Τύλιγμα μετρήσεων (2a-2n)
   - Ονομαστική ισχύς εξόδου : 25 VA
   - Κλάση ακριβείας : 0,5
   - Ποσοστιαίο σφάλμα τάσης : ±0,5
   - Φασική μετατόπιση : ±20min

- Τοπικό πίνακα ελέγχου (Local Control Cubicle) στην αίθουσα εξοπλισμού GIS.

5.7 Πύλη σύνδεσης με Μ/Σ Χρήστη 400kV/ΜΤ

<u>Α. Τμήμα Εξοπλισμού GIS</u>

Περιλαμβάνει :

- Δύο τμήματα ζυγών 400KV
- Δύο τριπολικούς αποζεύκτες 400KV ζυγών με ηλεκτροκίνητο μηχανισμό
- Ενα τριπολικό διακόπτη 400KV
- Δύο ηλεκτροκίνητους γειωτές 400KV εκατέρωθεν του τριπολικού διακόπτη 400KV
- Δύο σετ (τριάδες) Μ/Σ Εντάσεως εκατέρωθεν του τριπολικού διακόπτη 400KV και μεταξύ των δύο ηλεκτροκίνητων γειωτών.

Οι Μ/Σ εντάσεως 400KV προς το μέρος των ζυγών θα είναι μονής σχέσεως, τριών δευτερευόντων τυλιγμάτων : xxx/1-1-1A. Η κλάση ακριβείας και η ονομαστική ισχύς εξόδου των δευτερευόντων τυλιγμάτων θα είναι:

1. Τύλιγμα προστασίας (1S1-1S2)
   - Ονομαστική ισχύς εξόδου : 25VA
   - Κλάση ακριβείας :5P
   - Συντελεστής ορίου ακριβείας : 20

   Το τύλιγμα αυτό θα τροφοδοτεί προστασίες της Μονάδας Παραγωγής (π.χ. τον Η/Ν προστασίας REF - πλευρά Παραγωγού).

2. Τύλιγμα προστασίας (2S1-2S2)
   - Ονομαστική ισχύς εξόδου : 25VA
   - Κλάση ακριβείας :5P
   - Συντελεστής ορίου ακριβείας : 20

   Το τύλιγμα αυτό θα τροφοδοτεί τον Η/Ν προστασίας Υ/Ε φάσεων και γης με κατεύθυνση.

3. Τύλιγμα μετρήσεων (3S1-3S2)
   - Ονομαστική ισχύς εξόδου : 25VA
   - Κλάση ακριβείας :0,2S
   - Συντελεστής ασφαλείας οργάνου : Fs ≤ 5

   Το τύλιγμα αυτό θα χρησιμοποιείται για τις μετρήσεις της πύλης στην πλευρά του Παραγωγού.

Οι Μ/Σ εντάσεως 400KV προς το μέρος της Γ.Μ. 400KV θα είναι μονής σχέσεως, τριών δευτερευόντων τυλιγμάτων xxx/1-1-1A. Η κλάση ακριβείας και η ονομαστική ισχύς εξόδου των δευτερευόντων τυλιγμάτων θα είναι :

1. Τύλιγμα μετρήσεων (1S1-1S2)
   - Ονομαστική ισχύς εξόδου : 25VA
   - Κλάση ακριβείας :0,2S
   - Συντελεστής ασφαλείας οργάνου : Fs ≤ 5

   Το τύλιγμα αυτό θα χρησιμοποιείται αποκλειστικά για την κύρια εκκαθάριση της μέτρησης ενέργειας.

2. Τύλιγμα μετρήσεων (2S1-2S2)
   - Ονομαστική ισχύς εξόδου : 25VA
   - Κλάση ακριβείας :0,2S
   - Συντελεστής ασφαλείας οργάνου : Fs ≤ 5

   Το τύλιγμα αυτό θα χρησιμοποιείται για την επαλήθευση της εκκαθάρισης της μέτρησης ενέργειας και για τις μετρήσεις της πύλης στην πλευρά του ΑΔΜΗΕ

3. Τύλιγμα προστασίας (3S1-3S2)
   - Ονομαστική ισχύς εξόδου : 25VA
   - Κλάση ακριβείας :5P
   - Συντελεστής ορίου ακριβείας : 20

   Το τύλιγμα αυτό θα τροφοδοτεί τον Η/Ν Δ/Φ προστασίας ζυγών.

   (Σημειώνεται ότι το ονομαστικό ρεύμα πρωτεύοντος των Μ/Σ έντασης εξαρτάται από την ονομαστική ισχύ του Μ/Σ 400 kV/ΜΤ που θα εγκατασταθεί στο έργο. Σε κάθεψω< περίπτωση το ρεύμα πρωτεύοντος θα καθορίζεται στην Σύμβαση. Ενδεικτικά σημειώνεται η παρακάτω τυποποίηση :
   Ισχύς Μ/Σ: 200 MVA, Ονομαστικό ρεύμα πρωτεύοντος για τον Μ/Σ έντασης: 300 Α,
   Ισχύς Μ/Σ: 400 MVA, Ονομαστικό ρεύμα πρωτεύοντος για τον Μ/Σ έντασης: 600 Α,
   Ισχύς Μ/Σ: 800 MVA, Ονομαστικό ρεύμα πρωτεύοντος για τον Μ/Σ έντασης: 1200 Α)

- Έναν ηλεκτροκίνητο τριπολικό αποζεύκτη 400KV στην έξοδο της πύλης
- Έναν ηλεκτροκίνητο ταχυγειωτή 400KV στην έξοδο της πύλης με μηχανισμό μανδάλωσης
- Τρεις Μ/Σ Τάσεως επαγωγικού τύπου με τέσσερα δευτερεύοντα τυλίγματα 400000:√3/100:√3-100:√3-100:√3-100:√3 με τα παρακάτω τεχνικά χαρακτηριστικά :

1. Τύλιγμα μετρήσεων (1a-1n)
   - Ονομαστική ισχύς εξόδου : 25 VA
   - Κλάση ακριβείας : 0,2
   - Ποσοστιαίο σφάλμα τάσης : ±0.2

- Φασική μετατόπιση : ±10min

Το τύλιγμα αυτό θα χρησιμοποιείται αποκλειστικά για την κύρια εκκαθάριση της μέτρησης ενέργειας.

2. Τύλιγμα μετρήσεων (2a-2n)
   - Ονομαστική ισχύς εξόδου : 25VA
   - Κλάση ακριβείας : 0,2
   - Ποσοστιαίο σφάλμα τάσης : ±0.2
   - Φασική μετατόπιση : ±10min

   Το τύλιγμα αυτό θα χρησιμοποιείται για την επαλήθευση της εκκαθάρισης της μέτρησης ενέργειας και για τις μετρήσεις της πύλης στην πλευρά του ΑΔΜΗΕ

3. Τύλιγμα μετρήσεων (3a-3n)
   - Ονομαστική ισχύς εξόδου : 25VA
   - Κλάση ακριβείας : 0,2
   - Ποσοστιαίο σφάλμα τάσης : ±0.2
   - Φασική μετατόπιση : ±10min

   Το τύλιγμα αυτό θα χρησιμοποιείται για τις μετρήσεις στην πλευρά του Παραγωγού.

4. Τύλιγμα προστασίας (4a-4n)
   - Ονομαστική ισχύς εξόδου : 10 VA
   - Κλάση ακριβείας : 3P
   - Ποσοστιαίο σφάλμα τάσης : ±3
   - Φασική μετατόπιση : ±120min

   Το τύλιγμα αυτό θα τροφοδοτεί τον Η/Ν προστασίας Υ/Ε φάσεων και γης με κατεύθυνση.

- Τοπικό Πίνακα Ελέγχου (Local Control Cubicle) στην αίθουσα GIS.
- Τρεις αγωγούς με μόνωση αερίου SF6 (GIL) (εφόσον απαιτούνται)
- Τρία ακροκιβώτια SF6 – αέρα σύνδεσης με εναέριους αγωγούς 400kV (εφόσον επιλεγεί εναέρια σύνδεση με την Μονάδα) ή
- Τρία ακροκιβώτια SF6 – καλωδίου (εφόσον επιλεγεί καλωδιακή σύνδεση με την Μονάδα)

Β. Τμήμα υπαίθριου εξοπλισμού

- Τρια αλεξικέραυνα 400kV (εφόσον απαιτούνται)
- Καλώδια 400kV και ακροκιβώτια καλωδίου-αέρα (εφόσον επιλεγεί καλωδιακή σύνδεση με την Μονάδα)
- Τα απαιτούμενα ικριώματα στήριξης του πιο πάνω υπαίθριου εξοπλισμού.
- Τα απαιτούμενα ικριώματα πρόσδεσης της Γραμμής 400 kV σύνδεσης με Μονάδα (εφόσον επιλεγεί εναέρια σύνδεση με την Μονάδα).
- Αγωγούς, σφιγκτήρες κλπ

5.8 Πύλη σύνδεσης με Α/Ε αντιστάθμισης

Α. Τμήμα Εξοπλισμού GIS

Περιλαμβάνει :

- Δύο τμήματα ζυγών 400KV

- Δύο τριπολικούς αποζεύκτες 400KV ζυγών με ηλεκτροκίνητο μηχανισμό
- Ενα τριπολικό διακόπτη 400KV, που θα είναι κατάλληλος για μονοπολική λειτουργία μέσω Η/Ν ελεγχόμενης ζεύξης/απόζευξης (POW – Point On Wave)
- Δύο ηλεκτροκίνητους γειωτές 400KV εκατέρωθεν του τριπολικού διακόπτη 400KV
- Τρεις Μ/Σ Εντάσεως μεταξύ του τριπολικού διακόπτη 400KV και του γειωτή προς την πλευρά των ζυγών.

Οι Μ/Σ εντάσεως 400KV θα είναι μονής σχέσεως, τριών δευτερευόντων τυλιγμάτων : 400/1-1-1A (ονομαστική ένταση πρωτεόντος για Α/Ε από 65 έως 100MVar). Η κλάση ακριβείας και η ονομαστική ισχύς εξόδου των δευτερευόντων τυλιγμάτων θα είναι:

1. Τύλιγμα προστασίας (1S1-1S2)
   - Ονομαστική ισχύς εξόδου : 25VA
   - Κλάση ακριβείας :5P
   - Συντελεστής ορίου ακριβείας : 20

   Το τύλιγμα αυτό θα τροφοδοτεί τη Διαφορική προστασία Ζυγών..

2. Τύλιγμα προστασίας (2S1-2S2)
   - Ονομαστική ισχύς εξόδου : 25VA
   - Κλάση ακριβείας :5P
   - Συντελεστής ορίου ακριβείας : 20

   Το τύλιγμα αυτό θα τροφοδοτεί τον Η/Ν Υ/Ε Φάσεων και Γης με κατευθυνση της Πύλης.

3. Τύλιγμα μετρήσεων (3S1-3S2)
   - Ονομαστική ισχύς εξόδου : 25VA
   - Κλάση ακριβείας :0,5
   - Συντελεστής ασφαλείας οργάνου : Fs ≤ 5

   Το τύλιγμα αυτό θα χρησιμοποιείται για τις μετρήσεις της πύλης.

   Τα τυλίσματα στα bushings της Α/Ε θα χρησιμοποιούνται για την προστασία REF και για την τροφοδοσία του Η/Ν ελεγχόμενης Ζεύξης – Απόζευξης (Point On Wave).

- Έναν ηλεκτροκίνητο τριπολικό αποζεύκτη 400KV στην έξοδο της πύλης
- Έναν ηλεκτροκίνητο ταχυγειωτή 400KV στην έξοδο της πύλης με μηχανισμό μανδάλωσης
- Τρεις Μ/Σ Τάσεως επαγωγικού τύπου με δύο δευτερεύοντα τυλίγματα 400000:√3/100:√3-100:√3 με τα παρακάτω τεχνικά χαρακτηριστικά :

1. Τύλιγμα μετρήσεων (1a-1n)
   - Ονομαστική ισχύς εξόδου : 25 VA
   - Κλάση ακριβείας : 0,5
   - Ποσοστιαίο σφάλμα τάσης : ±0.2
   - Φασική μετατόπιση : ±10mintις μετρήσεις της Πύλης.

2. Τύλιγμα προστασίας (2a-2n)
   - Ονομαστική ισχύς εξόδου : 10 VA
   - Κλάση ακριβείας : 3P
   - Ποσοστιαίο σφάλμα τάσης : ±3
   - Φασική μετατόπιση : ±120min

   Το τύλιγμα αυτό θα τροφοδοτεί τον Η/Ν προστασίας Υ/Ε φάσεων και γης με κατεύθυνση.

- Τοπικό Πίνακα Ελέγχου (Local Control Cubicle) στην αίθουσα GIS.

- Τρεις αγωγούς με μόνωση αερίου SF6 (GIL) (εφόσον απαιτούνται).
- Τρία ακροκιβώτια SF6 – αέρα σύνδεσης με εναέριους αγωγούς 400kV (εφόσον επιλεγεί εναέρια σύνδεση με την Α/Ε 400kV) ή
- Τρία ακροκιβώτια SF6 – καλωδίου (εφόσον επιλεγεί καλωδιακή σύνδεση με την Α/Ε 400kV).

Β. Τμήμα υπαίθριου εξοπλισμού

- Τρια αλεξικέραυνα 400kV.
- Καλώδια 400kV και ακροκιβώτια καλωδίου-αέρα (εφόσον επιλεγεί καλωδιακή σύνδεση με την Α/Ε 400kV)
- Τα απαιτούμενα ικριώματα στήριξης του πιο πάνω υπαίθριου εξοπλισμού.
- Αγωγούς, σφιγκτήρες κλπ

November 2022

TECHNICAL DESCRIPTION TD-85/6

420 kV SF_6 GAS INSULATED METAL-ENCLOSED SWITCHGEAR (GIS)

1. Scope of Supply

This technical description concerns the technical characteristics, design features and testing of 420 kV SF_6 Gas Insulated Switchgear (GIS) for installation indoors at IPTO 400/150/30 kV EHV substations control buildings. The installation of the switchgear shall be carried out in accordance with the IEC62271-203.

If the GIS is installed outdoors, then the additional requirements of Annex “A” will be applied.

2. Keywords

Gas Insulated Switchgear (GIS), sulphur hexafluoride (SF_6), Overhead Line (O.H.L.), bay, Cable feeder bay, Autotransformer (AT/F) bay, Bus Coupler bay.

3. Operating Conditions

The switchgear of this Technical Description is suitable for installation indoors with the following conditions:

- Ambient temperature indoors :-5 °C ÷ 40 °C

- Altitude : ≤ 1000 m
- Seismicity :As specified by the Purchaser (see para. 6)
- Relative humidity range :≤ 95%
- Induced electromagnetic disturbances in secondary systems :1,6 kV
- Corrosivity category of atmosphere, according to ISO 9223 : C3

4. Equipment Electrical Rated Data

All 420 kV Gas Insulated Switchgear equipment shall have the following rating characteristics:

Equipment Electrical Rated characteristics	
Rated voltage	420 kV
Operating voltage	380-400 kV
Rated frequency	50 Hz
Rated power frequency withstand voltage (1 min-50 Hz) - Phase to earth and between phases - Across open switching device and/or isolating distance	 620 kV rms 800 kV rms
Rated lightning impulse (1,2/50 μs) Withstand voltage - Phase to earth and between phases - Across open switching device and/or isolating distance	 1425 kV peak 1425(+240) kV peak
Rated switching impulse withstand voltage - Phase-to-earth and across open switching device: - Between phases : - Across isolating distance:	 1050 kV,peak 1575 kV, peak 900(+345) kV, peak
Permissible partial discharge intensity for cast resin at 1.2 x U_R kV/ $\sqrt{3}$	<5 pC
Rated normal current for busbars	3150 A, unless otherwise defined in the Inquiry

Rated normal current for feeders	3150 A, unless otherwise defined in the Inquiry
Rated normal current for bus coupler	3150 A, unless otherwise defined in the Inquiry
Rated short-time current,	40 kA
Rated peak withstand current	100 kA peak
Rated duration of the short circuit	3 sec
Loss of gas (per year and compartment)	<0.5%
Auxiliary sources of supply D.C. A.C.	 220 V 230/400, 50 Hz
Method of earthing of the 400 kV system	Solidly earthed

5. Standards

IEC62271-203 :Gas insulated metal-enclosed switchgear for rated voltages above 52KV

IEC62271-1 :Common specifications for high-voltage switchgear and Control gear standards.

IEC60376 :Specification and acceptance of new sulphur hexafluoride.

IEC60480 :Guide to the checking of sulphur hexafluoride (SF_6) taken from electrical Equipment.

IEC62271-100 :High voltage alternating-current circuit-breakers.

IEC62271-101 :Synthetic testing of high-voltage alternating current circuit-breakers.

IEC62271-200 :High voltage alternating current disconnectors and earthing switches.

IEC61869-2 :Current transformers.

IEC61869-3 :Voltage transformers.

IEC60137 :Insulated bushings for alternating voltages above 1000V.

IEC61462 : Composite hollow insulators for voltages greater than 1000V.

IEC60099-4 :Non-linear resistor type arresters for AC systems

IEC62271-209 :Cable connections for gas-insulated metal-enclosed switchgear

for rated voltages above 52KV.

IEC62271-211 :Direct connection between power transformers and gas-insulated metal-enclosed switchgear for rated voltages above 52KV.

ISO 9223 : Corrosivity of atmosphere – classification, determination, estimation

6. General Requirements for Gas Insulated Switchgear

The design of the metalclad switchgear shall comply with IEC Publications 62271-203, 62271-100 and 60694.

Any components or assemblies that may require replacement during the normal life of the switchgear shall be of a common design for all circuits to permit these to be interchangeable and to reduce spare holdings. This requirement is particularly important for circuit breaker, disconnector and earth switch operating mechanisms.

The double busbar switchgear shall be designed such that it is possible to remove, repair or add any circuit bay whilst maintaining one busbar in service at all times.

The GIS switchgear shall be accompanied by supporting structures. Bidders should submit drawings of the suitable supporting structures subject to Purchaser's approval.

The switchgear and its supports shall have adequate external anticorrosive protection, suitable for the atmospheric corrosivity stated in par.3. The Manufacturer shall submit for approval to the Purchaser the protection system of each metallic part, as well as test reports or calculation proofing the adequacy of the anticorrosive protection.

The GIS switchgear shall be designed to withstand the seismic requirements of IEE 61166 with qualification level of AF5 (0,5g Horizontally). For vertical severity the direction factor (D) shall be 0,5 (as per IEC60068-3-3). Furthermore the requirements of the Inquiry shall be satisfied.

The qualification level shall be proved either by test certificates of a bay identical to the ones required by this hereby technical description or by combined test and mathematical analysis for the O.H.L bay of this hereby technical description.
The test certificates or the mathematical analysis must be submitted along with the technical offer. If neither is submitted, the eventual supplier shall carry out the test without any cost for IPTO.

6.1. Bushings

All the bushings for connections of GIS with 420 kV overhead lines (SF_6-to-air bushings), 420 kV cables (SF_6-to-cable bushings) shall generally be in accordance with IEC 60137, IEC 62271-305 IEC-62271-306 and IEC 61462 where applicable.
All air bushing whether they are intended for O.H.L or cable shall either be of porcelain of grey color or from silicon rubber.
Creepage distance shall be 10500 mm.

6.2. Enclosures and Conductor Expansion

Busbar and conductor connections and enclosures shall be designed to absorb the effects of thermal expansion and contraction and the agreed permissible movement of the foundations without impairing the guaranteed performance of the equipment.

Expansion joints of flexible connections shall be provided in the enclosures at suitable locations to directly absorb any differential movements and to ensure the installation will not be subjected to stresses leading to premature failures. In addition adjustable mountings shall be provided to accommodate reasonable tolerances with associated civil works and other plant to which the switchgear may be connected. Tolerances that can be accommodated shall be stated in the Technical Data Sheets.

Equipment foundation, floor and structure fixing to suit the switchgear design concept utilized by the manufacturer whereby movement can be absorbed within the switchgear expansion joints or is transmitted through the enclosure and sliding supports to flexible connections, shall be provided.

A flexible conductor and enclosure connection shall be provided at the coupling point and shall be capable of withstanding these conditions for the life of the equipment.

6.3. Gas Compartments

The switchgear shall be divided into separate gas compartments by the use of gas tight barriers.

Gas section volumes shall be as large as possible to minimise the effects of any internal overpressure and 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 energised.

Each gas compartment shall be provided with facilities for routine checking of gas moisture content and purity. Gas compartments shall be fitted with permanent connection points and valves for filling, emptying and gas treatment equipment without moving the switchgear.

All such valves shall have facilities for attaching two lead seals, one of which will be attached by the Owner and the other by the Contractor. This is to ensure that the gas system may only be opened in the presence of both parties. The seals will be fixed initially upon commissioning of the switchgear.

Busbar enclosures shall be segregated into gas tight compartments of such volumes so as to ensure the amount of time necessary for discharging the SF_6 and its subsequent vacuum treatment and refilling does not exceed the time stated in the Technical Data Sheets.

Where compartments are interconnected through external gas pipes, these pipes shall be provided with vacuum couplings to prevent the escape of gas during testing or maintenance.

Each gas compartment shall include the following.

- A pressure relief device to guard against excessive overpressure.
- An absorber to take up residual moisture.
- A density switch functioning as a temperature compensated - pressure monitor with a two level alarm.

6.4. Gas Filters

Each gas compartment shall be fitted with gas filters, driers or desiccants for the absorption of moisture and the gaseous products of switching. It shall be possible to replace the active materials of the filter without extensive dismantling and preferably without taking disconnectors or circuit-breakers out of service.

6.5. Gas Barrier and Supporting Insulators

All internal support insulators and gas barriers shall be of a high quality material designed to minimise internal and surface electrical stresses. The materials shall be free of voids and partial discharges at the maximum working voltages.

Gas barriers shall be gas tight and of sufficient strength to withstand short circuit forces and the maximum pressure differential that can occur under internal fault conditions.

6.6. 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. Details of the materials used and methods of sealing shall be stated in the Technical Data Sheets.

6.7. SF_6 Gas Requirements

All SF_6 gas supplied for use in the switchgear shall comply with the detailed requirements of IEC 62271-303 and IEC 60376 which are the minimum standards acceptable.

The gas system of the switchgear shall utilise low pressures to minimise leakages and eliminate any possibility of liquefaction at the lowest ambient temperatures. The equipment shall be designed such that no heating elements will be required for satisfactory operation within the range of ambient temperatures and pressures encountered under service conditions.

The minimum dew point temperatures in unheated SF6 gas filled equipment shall not exceed -20^{o}C at the working pressure.

6.8. Gas Monitoring

An SF6 gas sensor shall be installed on each independent gas tight compartment providing analog or digital continuous temperature compensated indication for gas density and temperature. The measuring temperature range shall be -40÷+70^0 C and the measuring range shall be 0÷900 kPa absolute at 20^0 C and 0÷60 kg SF_6/m^3 or otherwise adjusted to the specific design requirements of the GIS equipment. Typical accuracy of the density sensor shall be ±1% FS at 20^0 C. The sensor output shall be integrated to the DCS and the Gas Monitoring System of the substation.

Additionally a dew point and temperature sensor shall be installed for on-line monitoring of SF6 dew point. Measurement range of the dew point sensor shall be appropriate for the GIS system installed, with a typical accuracy of ±3^o C. The analogue or digital output of the sensor shall be also integrated to the DCS and GMS systems of the substation.

It is permitted to use sensors that combine both density and dew point measurement with individual characteristics compatible with the ones described above.

Alternatively to a dew point sensor, a calculated value of dew point based on gas pressure and temperature could be accepted as long as the accuracy of a sensor is guaranteed. The initial setup and verification of the calculation algorithm is the responsibility of GIS manufacturer and will be verified during SAT.

The DCS and Gas Monitoring System shall be able to visualize the aforementioned signals and shall be configurable in order to allow the setting of alarm thresholds based on absolute limits and rate-of-change patterns.

6.9. Enclosures

The enclosures for the SF_6 gas insulated switchgear shall be either of aluminium alloy, panted only in the outside or from welded steel painted inside and outside, and shall be designed to minimise losses and heating due to circulating currents.

Dimensioning of enclosure wall thickness and type of material shall be such as to safely withstand over-pressures caused by internal faults corresponding to maximum fault levels for a minimum time of 500 milliseconds then the arcing shall be contained for the longer time necessary for protection operation.

Bursting discs or equivalent shall be provided where necessary to protect the main enclosure from uncontrolled discharge of arced gases due to burn through of the enclosure or mechanical failure.

Bursting discs shall be directed away from personnel operating zones by suitable vents also designed to prevent accidental damage to discs.

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 include facility for easy access to the circuit breaker, disconnector and earth switch contacts for inspection and repair and removal.

Each enclosure shall be provided with lifting points to facilitate maintenance or repair work.

The enclosures shall be connected to earth (effectively earthed). All metal parts which do not belong to a main or an auxiliary circuit shall be earthed.

6.10. 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.

Indicators shall be of a reliable mechanical design and be positively driven in both directions by the final drive stage of the contact operating mechanism. Each indicator shall be clearly visible to operating staff at operating control points and access routes provided under this contract.

Additionally inspection windows capable of withstanding internal faults and external damages shall be foreseen for visual checking of the contact positions of all three phases of each particular item.

6.11. Pressure relief devices

Pressure relief devices shall be arranged so as to minimize the danger to an operator during the time that work is performed in the gas-insulated substation if gases or vapours are escaping under pressure.

6.12. Interconnecting components

The various components of the GIS shall be assembled together by means of standardized bolted flanges.

Telescopic coupling elements (in busbars for example) shall be used to connect adjacent switchgear sections. Expansion elements with metal bellows shall be used where necessary to compensate for thermal expansion or contraction cycles.

6.13. Labelling and equipment information to limit SF_6 greenhouse gas emissions

Based on regulation (EU) No 517/2014 of the European Parliament and of the Council on fluorinated greenhouse gases, the manufacturer must provide the following information, as required in the contract terms:

1. a reference that the equipment contains SF_6 greenhouse gas or that its functioning relies upon SF_6 greenhouse gas
2. the accepted industry designation
3. the quantity expressed in weight (kg) and in CO_2 equivalent (kt CO_2 – eq), contained in each GIS equipment unit, and the global warming potential (GWP) of SF_6 greenhouse gas

7. Bay equipment

7. 1 Circuit Breakers

7.1.1. General

1. Circuit breakers shall be of the puffer type or auto puffer type or self compression type (self blust) with operating mechanism of either spring type or hydraulic or type.
   Unless otherwise specified herein, all material, equipment, fabrication and testing of the subject circuit breakers shall conform to the latest revision of IEC 62271-100 standard.

2. Each circuit breaker shall be capable of making and breaking short circuit faults in accordance with the quantities, factors and service operation, requirements specified and in addition to fulfil all the requirements specified hereafter in this specification under par. 7.1.3. "*Specific Requirements for Circuit Breakers*".

3. All equipment entering into the breakers shall be new, of first grade quality, as to material, workmanship and design. Material and apparatus furnished under this Specification shall be subject to inspection by Purchaser. Purchaser's Inspectors shall have access, during working hours, to all parts of shops where material is manufactured and shall be provided by Seller with reasonable inspection facilities. Purchaser's representative may at any time inspect any or all test data. Release of material shall not relieve Seller from

responsibility for furnishing material to conform to all requirements of Purchaser's order nor invalidate any claim which Purchaser may make because of defective or unsatisfactory material.

4. The circuit breaker shall not be strained when making or breaking the rated short circuit currents. Under these conditions there shall be no leakage of SF6.

5. Auxiliary arcing contacts shall be provided to protect the main contact during the operation of the circuit breakers. All contacts shall be readily and quickly replaceable.

6. All seals shall be sufficiently tight to hold pressures incident to temperature changes resulting from normal operation and changes in ambient temperatures without leakage or breathing of moisture.

7. The circuit-breakers operating mechanism shall be of the spring operated or hydraulic type.
   The circuit breakers and operation mechanism shall be suitable for high speed three-pole and single-pole auto-reclosing (one shot).

   Operating mechanism shall be of the mechanically and electrically trip-free type.

   Electrical tripping devices shall operate between limits of 30 per cent below and 10 per cent above normal operating voltage with the coils at a temperature of 45 ^{o}C.

   The circuit-breaker operating mechanism shall be so designed that the circuit-breaker is free open immediately when the trip coil is energized.

   The circuit-breaker shall consist of 3 separate single-phase units with three (3) operating mechanisms, they shall be so coupled that accurate alignment of the units is not necessary and so that any unit can readily be replaced by a spare unit. It shall be possible to make independent adjustments on each unit.

   Means shall be provided for the manual operation of all circuit breakers for maintenance purpose.

8. An approved design of handling equipment shall be provided for each type of circuit-breaker.

9. In addition to the accessories specified here above, each circuit breaker shall be equipped with a central control cabinet which shall contain the following:
   -
   - Space heater element or elements automatically controlled by thermostat, inside the weatherproof housing of the operating mechanism.
   - Operation counter.
   - Wiring diagram mounted inside the main door of the mechanism housing.
   - Position indicator to show clearly from the vicinity of the mechanism the open and closed positions of the circuit-breaker.
   - Copper grounding pads.
   - Name plate of non-corrosive material giving Manufacturer's name, address and apparatus type, year of manufacture, serial number and main characteristics of the breakers operating mechanism.
   - Manual-emergency operation of the circuit breaker in case of DC auxiliary supply voltage loss or charging motor failure. The manual operation shall be realised by a hand crank and it shall be possible to lock the operating mechanism box after the manual operation.

   - Local-Remote-Off control switch located at the Local Control Cubicle, with as many stages as needed for the control circuits of the breaker. The “local” position and in conjunction with two (2) push-buttons or a control switch, will be used to control the CB from the LCC for maintenance purpose only. When the CB is under local control, the CB bay will be out of service. The “remote” position shall be used to control the CB from a remote place and for tripping purposes. Furthermore, the “Local-Remote-Off” switch shall be equipped with an additional number of stages to those used for the control circuits in order to interrupt both positive (+) and negative (-) 220 V DC buses of the control circuits.
   - Two push-buttons for local closing and opening of breaker.
   - Auxiliary contacts readily changeable to normally open or normally closed as follows:

     10 free N.O. contacts (at least)
     10 free N.C. contacts (at least)

11. Each pole of the circuit breaker shall be equipped with an operating mechanism cabinet; which among other things, it shall contain:
   - an SF6 density monitor

7.1.2.Operating Duty and Performance

(i) The requirements of IEC62271-100 in respect of service, operation and the making and breaking of fault currents shall apply to the specified circuit breakers.

(iii) Rated of Rise of Restriking Voltage: Attention is drawn to the requirements of Schedule of Tests wherein the minimum inherent rates of rise of restriking voltage of test plant arrangements are stated. Where not specifically stated in the test certificates submitted with the Tender, the Tenderer shall certify that the R.R.R.V. to which the circuit breaker was subjected during the short circuit tests was not less than the inherent values of the test plant stated in the Schedule of Tests for the first phase to clear factor of 1.3. Any device incorporated in a circuit breaker to limit or control the rate of restriking voltage across the circuit breaker contacts shall likewise be to the Engineer's approval and full descriptions of any such device shall be given.

(iv) Reclosure Duty: Circuit breakers controlling transmission lines shall be suitable for high speed auto reclosure. Circuit breakers must be capable of coping with the interrupting duties produced by out of synchronism conditions associated with auto reclosure.

(v) Interrupting Duty: Circuit breakers must be capable of coping with the interrupting duties produced by the switching of transformer magnetizing currents, line charging currents, cable charging currents, capacitor banks, short-line faults and out-of-phase switching duties.

(vi) Fault Clearance Time: The overall fault clearance time including relay operating time shall not exceed 100 ms.

7.1.3. Specific Requirements for Circuit Breakers

1. The circuit breakers shall have one or two interrupting chamber per phase. All units shall be suitable for high speed three-pole and single-pole auto-reclosing (one shot).

2. Rated voltage (according to IEC) : 420 kV

3. Lightning impulse withstand voltage,(1,2/50 μs)

- between phase and ground and between phases: 1425 kV crest
- across breaker’s open contacts : 1425 (+240)

4. Rated frequency : 50 Hz

5. Switching impulse withstand voltage
   -phase to earth and across open contacts : 1050 kV, peak
   -between phases : 1575 kV, peak

6. Power frequency withstand
   Voltage, 50 Hz, for 1 minute, phase to earth
   and between phases : 620 kV rms
   -across breaker's open contacts : 800 kV rms

7. Rated normal current : as defined in § 4

8. Rated short-circuit breaking current (at 420 kV)

   -r.m.s. value of A.C. component : 40 kA rms.
   -percentage of D.C. component : in accordance with IEC62271-100

9. Rated transient recovery characteristics for terminal faults corresponding to 100% rated short-circuit breaking current:
   -First-pole-to-clear factor (phase factor) : 1.3
   -Rated transient recovery voltage : 624 kV peak
   -Rate of rise of recovery voltage : 2 kV/μs

10. Rated transient recovery voltage for out-of-phase
   -First-pole-to-clear factor (phase factor) : 2
   -Rated transient recovery voltage : 857 kV peak
   -Rate of rise of recovery voltage : 1.54 kV/μs

11. <u>Rated transient recovery characteristics for short-line faults</u>
   -First pole to clear factor : 1
   -Rated transient recovery voltage : 480 kV peak
   -Rate of rise of recovery voltage : 2 kV/μs

12. Rated short-circuit making current : 100 kA peak

13. Rated short circuit duration : 3 sec

14. Rated operation cycle : O-0.3sec-CO-3min-CO

15. <u>Interruption of shunt reactor currents</u>

The breaker will have shunt reactor load switching capability, according to IEC 62271-110.

16. Interruption of unloaded lines
    The breaker shall be able to interrupt overhead line charging currents of 400 A, with class C2 (very low restrike possibility) according to IEC 62271-100.

17. Interruption of unloaded underground cables
    The breaker shall be able to interrupt capacitive cable charging currents of 400A with class C2 (very low restrike possibility) according to IEC 62271-100.

18. Mechanical endurance class: M1 (2000 operations)

19. Interrupting time
    The maximum interval between energization of the tripping coil and interruption of the main circuit in all poles of the breaker must not be greater than 50 ms, at 100% of the rated breaking capacity, and 70 ms at 10%, 30%, 60% of the rated breaking capacity.

20. Operating time diversion
    The operating time diversion between breaker poles and between breaks of each pole, on closing or tripping shall not exceed 5msec (shorter times will be preferred).

21. Number of tripping coils : two (2)

22. Number of closing coils : One (1)

23. Supply voltage of tripping and closing coils : 220 V dc

24. Tolerances of the supply voltage of the tripping coils :-30%,+10%

25. Tolerances of the supply voltage of the closing coil :-15%,+10%

26. Rated short-time withstand current :40 kA, rms

27. Rated peak withstand current :100 kA, peak

7.1.4. General Arrangement and pressure withstand

Evidence shall be provided that enclosures subject to pressures in excess of normal atmospheric pressures can have withstand these pressures, without leakage, permanent distortion or any temporary distortion such as might cause malfunction of the circuit- breaker.

Means shall be provided to allow access for the inspection and maintenance of fixed and moving contacts and other enclosed components.

7.1.5. CB's operating mechanism additional requirements

Circuit-breaker mechanisms shall be "trip free" as defined in IEC Publication 60050 (441).
Each part of the operating mechanisms shall be of substantial construction, utilising such materials as stainless steel, brass or gunmetal where necessary to prevent sticking due to rust or corrosion. The overall designs shall be such as to reduce mechanical shock due to fault current stresses, vibration or other causes.

An approved mechanically operated indication shall be provided on each circuit-breaker operating mechanism to show whether the circuit-breaker is open or closed.

Since the circuit breaker is comprised of three independent units it shall be possible to make independent adjustments to each unit and or to the three units so that make and break the circuits simultaneously, if it is so required. In the event of any phase failing to complete a closing operation, provision shall be made for automatic tripping of all three phases of the circuit- breaker(pole discrepancy).

Anti-pumping relays shall be provided to prevent reclosing if the closing coil remains energised and the circuit-breaker fails to latch in the closed position or is tripped during closing.
Approved means for manual operation of the circuit breaker shall be provided.

7.2. Busbars

Double busbars shall be extendible according to the requirements of the Inquiry. The three phases of each busbar shall be placed in common or in separate

compartments filled with SF_6. Each busbar shall be earthed through maintenance earthing switch. The bus bar current rating shall be 3150 A.

7.3. Disconnectors

Disconnectors shall comply with the requirements of IEC62271-101 and IEC62271-203.

Disconnecting switches shall be designed for live operations and will not be required to switch current other than bus charging currents.

1. The lightning impulse withstand voltage shall be:
- Phase to earth and between phases : 1425 kV peak
- Across the isolating distance : 1425 (+240)

2. The switching impulse withstand voltage
- Phase to earth :1050 kV peak
- Between phases :1575 kV peak
- Across isolating distance :900(+345) kV, peak

3. The power frequency withstand voltage shall be
- phase to earth and between phases : 620 kV rms
- Across the isolating distance : 800 kV rms

4. The rated current shall be : as defined in Inquiry
5. The rated short-time withstand current shall be : 40 kA
6. The rated peak withstand current shall be : 100 kA peak
7. The rated duration of short circuit shall be : 3 sec
8. The mechanical endurance class shall be :M1 (2000 operations)
9.The mechanism shall include provision for manual operation in case of an emergency.

The manual emergency operation shall be carried out via rotary motion and metallic reduction gear with a hand-handle which shall be removable. The electric control circuit shall be placed automatically out of service when the hand-handle is inserted for the manual emergency operation. The parts of the handle which come in contact with the human hands shall be covered with insulating material. The insertion of the removable hand-handle to the housing shall be possible through an opening in the outer surface of the housing of the operating mechanism. This opening shall be capable of being secured with a padlock. The removable handle shall be kept inside the housing of the operating mechanism.

10. Local-Remote-Off control switch located at the Local Control Cubicle, with as many stages as needed for the control circuits of the disconnectors and earthing switches of the bay. The “local” position and in conjunction with two (2) push-

buttons or a control switch, will be used to control the disconnector, from the LCC for maintenance purpose only. The “remote” position shall be used to control the disconnector from a remote place.

Locking in both open and close positions shall be provided for the manual hand crank, with mechanical couplings to ensure all three phases open and close simultaneously. Means for emergency manual operation shall be provided.
Disconnectors of a metalclad and approved type design shall be arranged to permit safe maintenance of any section of the equipment when the remainder is alive.
The position of the disconnector contacts is to be indicated by a reliable indicating device.
The lightning and power frequency withstand voltages shall apply at the minimum operating density of the insulating medium.
The disconnectors shall be equipped with auxiliary contacts as follows:

- 7 voltage free N.O. contacts (at least)
- 7 voltage free N.C. contacts (at least)

7.4.Busbar Disconnectors

For on load changeover of busbars in duplicate busbar stations the disconnectors shall be interlocked so that it is not possible to parallel or disconnect two sections of busbars by means of the busbar disconnectors unless a paralleled bus-coupler circuit is already closed.

The busbar disconnectors shall have the ability to open and close the busbar charging current as well as a small capacitive current and a small inductive current. The very fast transient overvoltage (VFTO) generated when the disconnecting switch opens and closes the busbar charging current shall not damage the equipment, and the resulting transient voltage rise on the enclosure shall not endanger personal safety.

In all other circumstances busbar disconnectors shall be interlocked so that their respective circuit-breakers can only be connected to one set of busbars at a time.

The value of the rated bus-transfer current for disconnectors shall be 60 % of the rated normal current, but limited to 4000A.

The busbar disconnectors shall be equipped with auxiliary contacts as follows:

- 7 voltage free N.O. contacts (at least)
- 7 voltage free N.C. contacts (at least)

7.5. Earthing Switches of low speed (maintenance earthing switches)

Earthing switches without making capacity, integral with disconnectors or separately mounted shall function in such a manner as to provide an earthed zone, permitting access for maintenance to circuit breakers, busbars, and all parts of the main circuits. Earthing switches shall be electrically operated. They will be used in conjunction with the circuit breaker, one at each side of the breaker.

The earthing switch, when in the closed position, shall be capable of carrying the rated short time current (40 kA) for three seconds without the contacts to be burned or to be melted.

Facilities integral with the earthing switch for primary current injection or low voltage checks shall be insulated from earth and incorporate a detachable earth strap.

The position of the earthing switch is to be indicated by a reliable indicating device.

The maintenance earthing switches shall be equipped with auxiliary contacts as follows:

- 7 voltage free N.O. contacts (at least)
- 7 voltage free N.C. contacts (at least)

7.6. High Speed Earthing Switches

High speed earthing switches shall be capable of sustaining for three seconds the rated short circuit current (40 kA) of the switchgear. They shall be used in conjunction with bus coupler (tie) disconnectors and the disconnectors of the line or cable feeder. They shall also be used in conjunction with the O.H Line disconnector. Power operated mechanisms shall be self locking in both open and closed position.
High speed earthing switches shall be capable of interrupting induced currents as may be necessary when used for grounding one out of two or more parallel circuits.

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.

The position of the earthing switch is to be indicated by a reliable indicating device.

The high speed earthing switches shall be electrically operated.

The high Speed earthing switches shall be equipped with auxiliary contacts as follows:

- 7 voltage free N.O. contacts (at least)
- 7 voltage free N.C. contacts (at least)

7.7. Earthing Switch Operating Mechanisms.

High speed and normal speed earthing switch operating mechanisms 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.

All power driven earth switches shall include provision for manual operation. The manual operation shall be carried out via rotary motion and metallic reduction gear with a hand-handle which shall be removable. The electric control circuit shall be placed automatically out of service when the hand-handle is inserted for the manual operation. The parts of the handle which come in contact with the human hands shall be covered with insulating material. The insertion of the removable hand-handle to the housing shall be possible through an opening in the outer surface of the housing of the operating mechanism. This opening shall be capable of being secured with a padlock. The removable handle shall be kept inside the housing of the operating mechanism.

Through the Local-Remote-Off control switch located at the LCC, the earthing switch shall be able to be operated either locally or remotely. The “local” position and in conjunction with two (2) push-buttons or a control switch, will be used to control the earthing switch, from the LCC for maintenance purpose only. The “remote” position shall be used to control the earthing switch from a remote place.

7.8. Current Transformers

Current transformers shall be included in the SF_6 switchgear for the various circuits and shall comply with IEC61869-2.

The number of current transformers, the number of secondary windings of each current transformer and the corresponding technical characteristics of its windings (e.g. ratio, burden, accuracy class, etc) will be defined in the Inquiry.

In case separate terminal boxes are used for current transformer secondary wiring, the identifying labels shall be fitted to the terminal boxes in a conspicuous position but not on removable covers.

Current transformers shall have a short time thermal primary current rating not less than that of the associated switchgear (40 kA). The dynamic current rating shall be 2,5X the rated short time thermal current. Secondary windings of each current transformer shall be earthed at one point only through a link and wired through the terminal blocks.

Magnetisation and core loss curves shall be provided for each type and rating of current transformer.

The power frequency voltage withstand of the secondary windings shall be 3 kV rms.

All secondary winding connections shall be brought out and connected by means of separately insulated leads to a terminal board mounted in an accessible position.

Current transformers for indication or metering shall have their secondary winding earthed at the switchgear.

Secondary windings which are not loaded must be short circuited before the transformer is energized.

The rated continuous thermal current of the current transformers shall be 1,2X rated current.

The terminal designation of the primary and secondary windings shall be in accordance with IEC61869-2.

7.9. Voltage Transformers

Voltage transformers (VTs) shall comply with IEC61869-3 and shall be included in the SF_6 switchgear. The number of voltage transformers, the number of secondary windings of each voltage transformer and the corresponding technical characteristics of its windings (e.g. ratio, burden, accuracy class, etc) will be defined in the Inquiry.

Voltage transformer secondary windings shall be earthed at the switchgear through a link, which can be removed for insulation testing.

The rated voltage factors of the VTs shall be: 1,2 continuous
1,5 for 30 sec

The power frequency withstand voltage of secondary windings shall be 3 kV rms.

A label shall be provided at the secondary terminal boards (boxes) clearly indicating the connection required for each winding and/or ratio.

All secondary terminals shall be suitable to be wired with 4 mm² size conductors furthermore, all secondary phase leads shall be protected by appropriate explosion type fuses and the neutral leads by links.

The VT compartment shall be able to be disconnected/isolated for maintenance reasons.

7.10. Surge arresters

If GIS surge arresters are requested to be installed in the GIS, these arresters shall have to following characteristics.
The surge arresters shall be in accordance with IEC 60094-4, second edition:

a. Continuous Operating voltage, Uc :267 ≤ Uc ≤ 289 kV rms
b. Rated voltage as defined in IEC60094-4,Ur :360 kV rms
c. Nominal discharge current (8/20 μs) :20 kA, peak
d. High current impulse withstand :100 kA, peak
e. Short circuit withstand capability :40 kA rms
f. Classification
   -Class :Station
   - Duty : High
   -Thermal energy rating W_{th} :≥10 kJ/kV(Ur)
   - Repetitive charge transfer rating Q_{rs} : ≥2.4 C
g. Residual voltages
   at 2 kA switching current impulse (>30/60 μs)
   (Switching Impulse Protection Level, SIPL) :≤772 kV,peak
   -
h. Residual voltages
   at 20 kA lighting current impulse (8/20 μs)
   (Lightning Impulse protection Level, LIPL) : ≤1020 kV, peak

The surge arresters shall be equipped with monitoring device, which will register each current surge with time tag, count the current surges and measure the resistive leakage current of the arrester. It will be suitably configured to register also switching current surges. The time tagged switching current events will be transmitted to the Substation Automation System. All necessary devices to realize this will be provided by the Contractor.It is preferable that the surge arresters compartment shall be able to be disconnected/isolated for maintenance reasons.

7.11. Interlocking Facilities

Disconnecting devices, earthing switches, circuit breakers etc, shall be provided with an interlocking system, which ensures safe operation of the equipment under all service conditions.

Where mechanical interlocks are employed, they shall be effective at the point where handpower is applied so that stresses cannot be transferred to parts remote from that point.

Auxiliary control switches used in the electrical interlocking schemes shall be arranged to ensure that the associated switching device is either in the fully open or fully closed position (as appropriate) before the interlocking circuit is completed.

Circuit breakers shall be interlocked so that, except under maintenance conditions, it is not possible to close a circuit breaker unless its associated disconnector or disconnnectors is/are closed.

Disconnecting switches shall be so interlocked that they cannot be operated unless the associated circuit-breaker is open except where on load transfer of feeder circuits from one busbar to another where in this case the bus-tie disconnectors can be closed providing the bus-tie breaker is closed and the disconnector of the other bus-bar is also closed.

Earthing switches shall be interlocked such that they cannot be operated unless their associated disconnecting switches are open.

7.12. Padlocks

Padlocks shall be provided on each item of substation equipment as detailed below and shall be additional to any mechanical interlocking devices specified in Chapter 7.1.12.

The following padlocks shall be provided:

(A) On the circuit breaker’s and disconnector’s manual hand crank
(B) On operating mechanism cubicle access doors.
(C) On air or gas system isolating valves in open or closed positions.

Locks shall be designed, constructed and located on the equipment so that they will remain serviceable in the climatic conditions specified without operation or maintenance.

7.13. Operating mechanisms Cubicles and other electrical accessories

Circuit breakers, disconnectors and earthing switches operating mechanisms, which contain auxiliary control switches and associated relays, control cable terminal blocks, and other ancillary equipment shall be accommodated in sheet steel vermin proof cubicles. The cubicles shall free-standing with front access, and shall be equipped with anti condensation heaters controlled by thermostat and interior lighting.

Cubicles shall be of rigid construction. Access to all compartments shall be provided by either removable panels or doors. All fastening shall be integral with the panel or door and provision shall be available for locking. Doors and panels shall be fitted with weatherproof sealing material suitable for the climatic conditions specified. Cubicles shall be well ventilated through vermin-proof louvres. Enclosure classification shall be a minimum of IP42 as per IEC 60529.

The arrangement of equipment within cubicles shall be such that access for maintenance or removal of any item shall be possible with the minimum disturbance of the associated apparatus.

Other electrical accessories installed on the GIS (e.g. SF6 density switches, etc) shall also have classification at least IP42 as per IEC 60529.

7.14. Control and Indications

The GIS switchgear shall be capable of being controlled from the following positions:

- From operating mechanisms cubicles located nearby the equipment such as CB, D/S and E/S and with indications and mimic diagrams.
- From the HMI center located in the substation control room - control of circuit breakers, disconnectrors and earthing switches where power operated, with position indication in each instance.
- Remote IPTO’s transmission dispatching center - control of circuit breakers and disconnectors and position of earthing switches.
- Remote IPTO’s distribution dispatching center, (if applicable)-Control of 150/20 kV transformers and 20 kV equipment.

7.15. Auxiliary Switches and Contactors

Circuit breakers, disconnectors and earthing devices and circuit selector disconnectors shall be provided with suitably rated auxiliary switches and contactors, where necessary, to relay circuit information for the purpose of control and circuit supervision at the substation control room and protection, indication, metering as required. In addition, two normally open and two normally closed auxiliary switches of the same type and rating as those specified above shall be provided as spare items on each equipment.

7.16 SF_6 –to-cable bushings

The SF_6 –to-cable bushings shall be suitable for vertical or horizontal or under angle connection to single-phase 400 kV cables. Bushings shall generally be in accordance with IEC 60137 where applicable. The connection of the terminations with the bays shall be designed in such way so that if a malfunction of a 400 kV cable/ termination occurs, it won't create any other problems to the neighboring terminations (sealing-ends) or cables. All the necessary equipment for the connection of the 400 kV cables to the GIS bay must be part of the supply. The remaining technical data of the cables will be given in the inquiry.

SF_6–to-cable bushings of type “plug-in” should be in accordance with IEC 62271-209.

7.17. SF_6 -to-air bushings

Outdoor bushings for connections to external conductors shall be provided where needed. Bushings shall be in accordance with IEC 60137 where applicable.

Creepage distances for the insulators of outdoor bushings fitted to the SF_6 switchgear and for insulators for other external equipment shall be at least 10500 mm.

Outdoor bushings must be capable of withstanding cantilever pull due to the external connection. Factors of safety of 2.5 minimum shall be applied.

7.18. Types of GIS bays

Each Substation of the Inquiry shall be made up by a different combination of GIS bays. Types of GIS bays commonly used in Substations are :

- Overhead Transmission line feeder bay

- Cable/reactor feeder bay

- Transformer feeder bay

- 400/150/30 kV Autotransformer feeder bay

- Power Plant Unit feeder bay

- Bus Coupler bay

- Bus Section bay

The types and numbers of the components included in each bay, as well as the structure of each bay shall be given in the Inquiry or Contract.

8. Tests

8.1. Type tests

The following type tests shall be carried out on a complete single-pole or three pole functional unit of a switchgear bay (including at least a Circuit Breaker, Disconnectors and Earthing Switches and High Speed Earthing Switches) :

a) Tests to verify the insulation level of the equipment and dielectric tests on auxiliary circuits.

b) Tests to prove the radio interference voltage (RIV) lever (if applicable)

c) Tests to prove the temperature rise of any part of the equipment and measurement of the resistance of the main circuit

d) Tests to prove the ability of the main and earthing circuits to carry the rated peak and the rated short-time withstand current

e) Tests to verify the making and breaking capacity of the included switching devices

f) Tests to prove the satisfactory operation of the included switching devices

g) Tests to prove the strength of enclosures

h) Verification of the degree of the enclosure

i) Gas tightness tests

j) Electromagnetic compatibility tests (EMC) (If applicable)

k) Additional tests on auxiliary and control circuits

l) Tests on partitions

m) Testes to prove the satisfactory operation at limit temperatures

n) Tests to prove performance under thermal cycling and gas tightness on insulators

o) Corrosion test on earthing connections (if applicable)

Concerning the VTs of an OHL switchgear bay, the following type tests shall be carried out in accordance with IEC 61869-3 standard:

1. Temperature rise test
2. Short – circuit withstand capability test
3. Radio interference voltage measurement
4. Determination of errors.

Concerning the CTs of an OHL switchgear bay, the following type tests shall be carried out in accordance with IEC 61869-2 standard:

1. Short – time current tests
2. Temperature rise test
3. Determination of errors

Type test certificates for all type tests of this hereby technical description for a complete bay can be accepted instead of actual testing. For this reason, test certificates can be submitted along with the technical offer. If the submitted type tests certificates are found not to be satisfactory, or test certificates are not submitted then the eventual supplier shall carry out these tests without any cost for IPTO S.A.

Special Tests

The following dielectric tests will be performed on a typical GIS bay (CB,DS,ES,HSES), which will be part of the delivery, on the presence of IPTO's inspector, only if the corresponding type test certificates are not accepted by IPTO or are older than fifteen (15) years from the tender date. For test certificates up to 15 years old, the manufacturer should establish that changes made either on construction or installation, during this period, do not influence the result of the corresponding test.

- Lightning impulse test (dry) with both polarities, according to IEC 60060-1. The tests will be performed on a full bay of typical composition, for open and close position.

- Dielectric tests across open switching devices, following the preferred method. The tests will be performed on a full bay of typical composition, for open and close position.

The following tests will be performed on a sample of each partition or internal support insulator, only if the corresponding type test certificates are older than eight (8) years from the tender date or not existing. For test certificates up to 8 years old, the manufacturer should establish that changes made either on construction or installation, during this period, do not influence the result of the corresponding test.

- Thermal cycle test, according to cl.6.106.2 of IEC 62271-203:2011

- Tightness test (only for partitions)

a.2 Routine tests

For routine tests new SF_6 in accordance with IEC60376, or used SF_6 in accordance with IEC60480, can be used.

The routine tests shall be performed on all components of a substation. Depending on the nature of tests, some tests may be performed on components, transport units or on the complete installation. The routine tests ensure that the product is in accordance with the equipment on which the type test haw been carried out.

The following routine tests shall be carried out:

a) Dielectric test on the main circuit

b) Tests on auxiliary and control circuits

c) Measurement of the resistance of the main circuit

d) Tightness test

e) Design and visual checks

f) Pressure tests of enclosures

g) Mechanical operation tests

h) Tests on auxiliary circuits, equipment and interlocks in the control mechanism

i) Pressure test on partitions

The tightness test on the complete GIS bay, including all available gas compartments (e.g, VTs, surge arresters, etc), shall be performed according to the cumulative method, following IEC 60068-2-17, Qm test, method 1. For the other components or transport units, the test will be performed according to the probe method, following IEC 60068-2-17, Qm test, method 2. The tightness coordination chart (TC chart), including leakage rate and time between replenishments, will be prepared by the manufacturer and submitted to IPTO's inspector.

On the VTs of an OHL switchgear bay, the following routine tests shall be carried out in accordance with IEC 61869-3 standard:

1. Verification of terminal markings
2. Power – frequency withstand tests on primary winding
3. Partial discharge measurement
4. Power – frequency withstand test on secondary winding
5. Power – frequency withstand tests between sections of secondary winding.
6. Determination of errors.

On the CTs of an OHL switchgear bay, the following routine tests shall be carried out in accordance with IEC 61869-2 standard:

1. Verification of terminal markings
2. Power-frequency withstand test on primary winding
3. Partial discharge measurement
4. Power-frequency withstand test on secondary windings
5. Power- frequency withstand tests between sections of primary and secondary windings
6. Inter-turn overvoltage test
7. Determination of errors (This test shall be performed after the previous six tests)

a.3 Tests at site

After installation, and before put into service, the GIS shall be tested in order to check the correct operation and the dielectric integrity of the equipment according IEC 62271-203 par. 10.2.

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These tests and verifications comprise:

- dielectric tests on the main circuits after the final and complete installation of the whole GIS system, according IEC 62271-203 par. 10.2.101, PROCEDURE B.

Simultaneously, partial discharge measurements will be carried out. Values of test voltages and partial discharge measurements should be in accordance with Table 6 and 7 of the above Standard,

- dielectric tests on auxiliary circuits and control circuits,
- measurement of the resistance of the main circuit,
- Check for good performance and operation for all the CBs, Disconnectors, Earthing switches etc, with measurement of the response time.
- Check for SF6 leakage. The method and the measuring instruments used should be suitable for detection of a percentage of leakage at least equal to the guaranteed value per year (as it is determined at the “Special Terms” of the Contract).

To ensure minimum disturbance, and to reduce the risk of moisture and dust entering enclosures and thus preventing correct operation of the switchgear , no obligatory periodic inspections or pressure tests concerning the enclosures are specified or recommended when the gas-insulated substation is in service. Reference shall be made in any case, to the manufacturer’s instruction book.

9. Nameplates and Markings

The GIS and all its operating devices shall bear legible and easily accessible nameplates which shall contain at least the following data (according to IEC 62271-203):

- Name of manufacturer
- Year of manufacture
- Type and serial number
- Rated voltage (kV)
- Rated lightning impulse withstand voltage (kV)
- Rated switching impulse withstand voltage (kV)
- Rated power frequency withstand voltage (kV)
- Rated frequency (Hz)
- Rated current of equipment (A)
- Rated current of busbars (A)
- Rated short-time withstand current (kA)
- Rated peak current (kA)
- Rated duration of short-circuit (s)
- Rated short-circuit breaking current of circuit breaker (A)
- Rated duty cycle of circuit breaker
- SF_6 pressure at 20^o C (bar) for all modules
- Weight of required SF_6 for the bay

- Weight of bay including SF_6
- Standards according to which the bay has been manufactured

After placement of the order, the respective texts shall be submitted for approval.

At the front of the bay a removable plate shall be placed whereon the Seller will engrave the name of the bay (e.g. overhead line, etc.).

Plates shall be also placed near the handles showing the positions ON-OFF as well as their respective direction of movement.

10. Inspection, Maintenance, Repair, Extension and Accessibility Requirements

The contractor will guarantee the following:

1. For routine inspections, all elements shall be accessible without removal of supporting structures. The removal of individual enclosure parts or complete switchgear bays shall be possible without disturbing the neighbouring bays.

2. Routine maintenance of external parts of the switchgear including instrument transformers shall not be necessary at intervals of less than 5 years.

3. The maintenance intervals of the circuit breaker shall not be less than 15 rated short circuit current interruptions, or 2000 rated current interruptions or 20 years operation whichever is earlier. Maintenance activities shall comprise only simple inspections and no exchange of parts or complex adjustments.

4. Checking the contact condition of the interrupter unit of the circuit breaker shall be possible without disturbing any other gas compartment and without interrupting any hydraulic piping. It shall be possible to safely replace the interrupter contacts of the circuit breaker even while the remaining switchgear is "live". The circuit breaker enclosure shall have provisions for easy withdrawal of the contact assembly. This procedure shall not involve the removal or dislocation for neighbouring bay enclosure parts. The removed interrupter assembly shall be easily and safely accessible for inspections and possible repairs.

5. Each bay shall be equipped with two buffer chambers between the busbar disconnector compartment and the circuit breaker compartment in order to ensure the uninterrupted operation of the two busbars in case of maintenance or repair of the bay. The adjacent bays shall continue to operate uninterrupted.

6. In case of bays attached to Line bays (such as Shunt Reactors or Cable line bays), a buffer chamber shall be foreseen between the disconnector and the circuit breaker of the attached bay, to ensure the uninterrupted operation of the main bay, during maintenance or repair.

7. Two busbar buffer chambers with transversal insertion shall be foreseen at both sides of selected bays (as they are defined at the Inquiry) in order to ensure the uninterrupted operation of the bay, during maintenance or repair of the busbar disconnector compartment of the adjacent bays.

8. In case of future extension, a disconnector with earthing switch compartment and a buffer chamber shall be foreseen at the end of the busbars (at the extension side) in order to ensure the adjacent to the extension bay shall operate uninterrupted and the secure execution of the High Voltage Test.

9. No work is allowed next to gas compartments at rated pressure either energized or de-energized.

11. Packing and Transport

11.1. General Packing

The equipment shall be delivered as completely assembled as possible. The packing shall include at least the following:

a. Wooden frames protecting all the edges from blows and impacts during transport and shipping. Each side shall be also protected by χ-planks.
b. Plastic wrapping shall protect the equipment from moisture, dust etc.
c. The flat surfaces shall be protected from mechanical stresses by means of corrugated cardboard lining or plastic lining with air inclusions or sheets of volume expanded polystyrene placed inside the plastic wrapping.

The delivery shall be complete. All the components, devices, end-boxes, wirings etc. as well as every removable element must be fitted on the respective bay or packed with it, taking care that no damage or injury would arise during transport.

11.2. Shock Recorders for Transport

One shock recorder will be provided and installed on each major switchgear assembly or part (such as Circuit Breaker, Current Transformer, Voltage Transformer etc.) by the manufacturer, in order to record all horizontal and vertical impacts suffered during transport from factory to site.
The shock recorders will be of digital type and they will include GPS and time tagging of the recordings. They will be SMT HYBRID – MONILOG ENDAL or SHOCKWATCH – SHOCK LOG 298 or MESSKO – CARGOLOG or of an equivalent type, subject to IPTO's approval.

The alarm limit of shock recorders will be set below 5g acceleration,

The recorder is to be operative from the time of packing to unpacking on site, in order to provide an uninterrupted record of all registered data. The recorder is to be suitably sealed so that only IPTO's authorized personnel shall collect the registered data upon arrival at site. An appropriate manual shall be supplied to the Purchaser.

12. Documents

12.1. Documents to be submitted by the bidder

The Supplier shall, together with his offer, submit in three copies all documents with information necessary for the evaluation of the bids, such as certificates, drawings, technical leaflets etc. The information shall indispensably comprise the following:

1. Drawings of the switchgear complete with the components (circuit breakers, isolators, earthing switches. current transformers etc), outline dimensions, weights and other data which may be needed for the installation of the switchgear under the given service conditions.

2. Technical leaflets for all types of bays, modules and accessories (circuit breakers etc.).

3. Preliminary outline drawings of the offered GIS

4. Single-line diagram of the offered GIS

5. A gas compartment diagram where the different gas compartments are clearly defined

6. Complete description of all interlocks employed

7. Complete description of all high speed earthing switches used and their location in the GIS.

8. A table comprising all technical data of the individual devices of the bays offered. Such particulars shall be supported by corresponding information prospectuses of the manufacturer of these devises or by relevant test certificates.

9. Detailed information on the constructional characteristics of the switchgear.

10. Finally the Manufacturer shall furnish detailed information of any deviation of the material offered from the requirements of this technical description, if not mentioned in the above paragraphs.

11. Bidders are required to answer all items of Annex C. Failure to comply will result in ejection of the offer.

Furnishing the above information is mandatory for the Manufacturer. It is recommended that the data requested shall be given clearly, a mere affirmative or negative reply will not be sufficient. Bids not comprising all the foregoing data will be rejected.
In case of no mentioning of any differences, the material will be considered to comply with the Technical Description.

12.2. Documents submitted by the contractor

1. After placement of the order, the Seller shall submit for approval four (4) sets of detailed outline, schematic and wiring drawings.
2. The Seller shall submit, at least one month before the inspection notice, four (4) sets of detailed instructions for installation, operation and maintenance of the equipment.
3. Any delay in submitting the above drawings and instructions owing to the Seller will be regarded as a delay in execution of the contract.

13. <u>Spare Parts</u>

a. The spare parts included in the “Table of Essential Spare Parts (L-1)” of the Inquiry shall be delivered together with the bays. The cost of these spare parts shall included in the economic offer.

b. If the Seller considers some additional spare parts should be offered, he should include them in the separate list of “Table of Recommended Spare Parts (L-2)” of the Inquiry. The Purchaser shall determine during the contract signature which of these spare parts, if any, and in what amount will be included in the order.

14. <u>Warranty</u>

The contractor must provide a warranty of the three (3) years beginning from the date of delivery of the GIS for any damages by faulty design or by unreliable components or by combination of the two.

Table of Essential Spare Parts

Essential Spare Parts	Unit	Qty
Circuit breaker	pcs	1
One current (single phase) transformer of each type	pcs	1
One voltage (single pole) transformer of each type	pcs	1
Sets of breaker contacts, closing and tripping coils and contactors	sets	1
Sets of valves, gas filters, gas seals	sets	2
Disconnectors & earthing switches of each type	pcs	1
Disconnectors & earthing switches contacts set and operating mechanism of each type	pc	1
Gas monitor for switchgear	pc	1
SF_6-Sealings	pc	2
SF_6 –to-air bushings	pc	1
SF_6 –to-Cable bushings	pc	1
Bursting disks	pc	2

Operating mechanism of the circuit breaker	pc	1

ANNEX A
REQUIREMENTS FOR OUTDOOR INSTALLATION

If the GIS will be installed outdoors, the following changes will be applied to the present specification:

- In par. 3, the ambient temperature range will be changed from -5 °C ÷ 40 °C to -25 °C ÷ 40 °C.
- In par.3, the corrosivity category of the atmosphere will be changed from C3 to C4.
- In par.7.1.1.10 an additional requirement for weatherproof housing of the operating mechanism fixed on the base frame of the breaker.
- In par.7.13, the weatherproofing of all operating mechanisms and cubicles installed outdoors will be changed from IP42 to IP54. Especially for Local Control Cubicles, an inspection window for the mimic diagram shall be foreseen. In par.8.1, the following tests will be added to the special tests, performed on a typical GIS bay of the delivery, only if the corresponding type test certificates are older than eight (8) years from the tender date or not existing:
    - IP degree verification (IP 54) according to IEC 60529 for all control and signaling boxes and for all accessories (instruments, sensors, etc.). Additionally weatherproofing test on a full bay of typical composition, according to IEC 62271-1, Annex C.
    - IK degree verification (IK 10) according to IEC 62262 for all control and signaling boxes.
    - Tightness test and mechanical tests according to IEC 62271-203, par. 6.8 and 6.102 for limit temperatures -5° C and +50° C.
    - Solar radiation test according to IEC 60068-2-5, procedure B, for the partitions and all accessories (instruments, sensors, etc.), which are exposed to solar radiation.

ANNEX B

ONLINE PARTIAL DISCHARGE MONITORING SYSTEM IN GIS/GIL

1. General

Partial Discharge Monitoring system (PDM) shall be supplied for UHF online monitoring of Partial Discharge (PD) in GIS/GIL. The contractor shall be responsible for the design, supply, delivery, installation, site testing and commissioning of the complete PDM system.

On the GIS/GIL, a partial discharge monitoring system (PDM, the System) shall continuously collect partial discharge data using UHF technique from the monitored couplers (sensors). The partial discharge data shall be stored locally and transferred automatically to a remote location at intervals. The users must be able to access the data through web and client-server interfaces.

The System shall be able to indicate to the operator at a remote location (e.g. headquarters, maintenance/operation centre etc. through SMS, e-mail or mobile app) when the transferred data indicates partial discharge behaviour which requires his attention. On receiving such an indication, the operator shall be able to retrieve and display partial discharge data from the coupler concerned to enable him to decide on action to be taken.

The remote access to PDM system must be provided via separate web access, based on TCP/IP, through the server located at IPTO's data centre.

The partial discharge data shall be displayed in a way that allows the operator to recognise the type of defect present and indicate an increase in severity (trend analysis). It shall be necessary to be able to recognise signals from partial discharges, switching operations and external sources of interference. Automatic classification of PD through Expert System shall be provided. Access to partial discharge data and System administration functions shall be protected by password.

2. Specification for Internal Couplers

The GIS must be fitted with internal UHF PD couplers. PD couplers must be fitted in a way that GIS meets sensitivity according to **CIGRE Guide no 654 "UHF partial discharge detection system for GIS: Application Guide for Sensitivity verification"** at every place in the GIS/GIL (5pC or better). Specification of PD couplers supplied and installed in GIS equipment by contractor shall be as below:

- The coupler shall be passive, maintenance free antenna type. The optimum number of couplers will be decided based on the electrical single line diagram and the physical layout of GIS in order to meet CIGRE sensitivity verification (minimum detection level of 5 pC anywhere in GIS) It is the obligation of GIS

manufacturer in cooperation with PD monitoring system vendor to ensure that PD sensors layout achieves in practice through the verification procedure and steps described in CIGRE Guide no 654 the required sensitivity. The sensitivity will be verified on site during SAT. In specification/tender phase the proposed PD sensor layout will be submitted for reference reasons only. The sensor position selection will be justified based on rules and /or previous experience from SATs and laboratory testing.

- The coupler shall be sensitive between 200 to 2000 MHz frequency
- Internal PD coupler shall meet the following sensitivity levels (tested using a GTEM horn)
- The internal dimensions of UHF PD sensors must be of the same order as the wavelengths pf the measured frequencies
- Working temperature range: -25° C to +120° C
- Maximum working humidity: 100%
- IP rating: IP54
- UHF Connection shall be of N Type with an impedance of 50 or 75 Ω (Ohm)
- The PD calibrator (PD pulse injection equipment) shall be provided along with the system
- Contractor shall have supply record of supplying barrier couplers for at least three (3) GIS projects with minimum total fifteen (15) bays configuration

3. Specification for Partial Discharge Monitoring System (PDM)

The online PD monitoring must be equipped with following key features:

- Meet sensitivity according to **CIGRE TF15/33.03.05 and CIGRE Guide No.654** at every place in the GIS/GIL (5 pC or better) will be verified as part of site sensitivity tests.
- Continuous real-time measurement and PD analysis; not multiplexed data collection.
- The system shall have individual channel control.
- Node data connection must support both Copper Ethernet and Multi-Mode Fibre Optic.
- Node communication must be by Ethernet, scalable, industrial standard between data nodes central server. The system shall have capability to support 500 UHF sensors or more.
- Each UHF node will support a minimum of 6 continuously active input UHF Channels and 1 UHF noise channel.
- Support Simple Network Time Protocol (SNTP).
- Fixed broadband monitoring (bandwidth >=1 GHz)

- Historical PRPD over 5, 10 or 15 minutes recording period (software selectable).
- Minimum noise detection and suppression facilities:
  - Smart Gating with external type noise antenna.
  - Artificial Intelligence Software detection package. Artificial Intelligence and Neural Network based pattern recognition algorithms should be conditioned over an extensive real PD pattern database.
- UHF Signal classification (5 pattern types or more) for GIS/GIL by an Expert System and the analysis result shall be clearly indicated to the operator. The PDM System shall combine Artificial Neural Networks (ANNS), Genetic Algorithms (GAs) and Fuzzy logic.
- The PDM System shall be able to discriminate between partial discharge sources, external interference and transients, resulting from switching operations of the high-voltage equipment.
- PD Alarm setting module for configuration of all PD alarms within substations.
- Ability to call and display, within Application software, 2-Dimensional GIS Schematics showing spatial relationship between couplers in the GIS/GIL.
- Ability to select standard and high resolution sampling, 8 or 10 bits and 64 or 256 samples per 50 Hz power cycle.
- The System shall be capable of synchronizing, capturing and displaying PD data for a power test frequency in the range 40 Hz÷150 Hz (or wider range). The System shall be capable of operation during HV testing of the GIS/GIL.
- The PDM System shall be designed to operate from substation auxiliary supplies. Failure of auxiliary supply to the System shall be sensed and alarmed by the System.
- The System application software shall incorporate function for the complete
- recording of PD activity during GIS/GIL HV tests. The function shall allow complete review of PD activity during or after the test.
- PD source localization using the time-of-flight (TOF) techniques is desirable.
- The System shall have a PC at a headquarters location with remote application software which can automatically support remote accessing for up to 250 substations.
- The PDM Supplier shall have a proven history of operation at a minimum of five (5) independent substations, each for a minimum of three (3) years. In the tender proposal the tenderer shall provide following information history and be prepared to support those claims with reference from the respective:
  - Complete List of same PDM system type installations indicating for each installation:
    - Year of installation
    - Country and End-user
    - GIS/GIL Voltage level
  - End-user Reference letters (at least two).

- The System shall be sensitive to partial discharge signals throughout the frequency range 300 MHz – 1200 MHz. However, it is recognised that in some cases the use of filters may be necessary to reduce the sensitivity of the System at certain frequencies to signals arising from telecommunications and other external sources. The system shall provide flexibility to select following frequency ranges without adding separate hardware filter (indicative frequency ranges):
  - 300 MHz to 800 MHz
  - 300 MHz to 1200 MHz
  - 440 MHz to 800 MHz
- The System shall have a signal sensitivity of up to -80 dBm.
- History data shall be recorded every 1.5, 5, 10 or 15 minutes (indicative time software selectable). History plots shall be capable of being displayed over a period of 1 year.
- The HMI system shall be equipped with Relational Database Management System (RDBMS) which is:
  - Microsoft ODBC (Open Database Connectivity) specification compliant.
  - ANSI 92 SQL (Structured Query Language) compliant.
- Both the substation and Headquarters shall allow the data from no less than six coupling devices to be displayed simultaneously, such that data from different couplers at different times may be displayed.
- Data shall be displayed in the following formats (indicative):
  - 3 dimensional oblique, snapshot and real time
  - 2 dimensional point on wave; both amplitude and discharge rate
  - PRPD online and historical
  - STT (short term trends)
  - 24-hour summary
- PDM system shall have dynamic range up to 70 dBm for at least 10 frequencies between 300 MHz to 1200 MHz to enable display of PD signals with varying amplitude. The trending shall support showing amplitude with varying ranges of PD signals (-15 dBm to -75 dBm or better).
- The Headquarters shall include a data synchronization function that shall allow any missing data to be downloaded from any substation for a period of up to one year.
- System shall record switching transient generated by CBs (Circuit Breakers) and disconnectors. (Optional analysis of switching patterns).
- The PDM system shall have capability to expand into complete GIS condition monitoring systems. It shall support integration with SF6 leakage monitoring system and Breaker Condition Monitoring system. It shall support industry standard protocols, IEC61850for data integration with the monitoring systems. In case IEC 61850 is not implemented throughout the substation control network, Modbus and DNP3.0 protocols are also accepted. The additional

condition monitoring system is not part of the scope of the current technical description.

- The System shall be type tested by independent accredited test house to following IEC standards for EMC & Environmental for use within EHV substations.

Standard	Description
ES BN 55022 (CISPR22)	Conducted emissions
IEC 60068-2-1	Low temperature
IEC 60068-2-2	Dry heat
IEC 60068-2-6	Vibration
IEC 60068-2-27	Shock
IEC 60068-2-56	Damp heat
IEC 60255-5	Dielectric withstand
IEC 61000-4-2	Electrostatic discharge
IEC 61000-4-3	Radiated immunity
IEC 61000-4-4	Fast transient
IEC 61000-4-5	Surge
IEC 61000-4-6	Conducted immunity
IEC 61000-4-8	Power frequency magnetic field
IEC 61000-4-9	Pulsed magnetic field
IEC 61000-4-10	Damped oscillatory magnetic field
IEC 61000-4-12	Damped oscillatory wave

ANNEX C

420 kV SF_6 GAS INSULATED METAL-ENCLOSED SWITCHGEAR (GIS)

INFORMATION BY SELLER

1. Applied standards :……
2. Manufacturer :……
3. Type :……....
4. Rated voltage :……
5. Operating voltage :……..
6. Rated frequency :……

7. Rated power frequency withstand voltage (1 min-50 Hz)
   - Phase to earth and between phases :……
   - Across open switching device and/or isolating distance :……

8. Rated lightning impulse (1,2/50 μs) withstand voltage
   - Phase to earth and between phases :……
   - Across open switching device and/or isolating distance :……

9. Rated switching impulse withstand voltage
   - Phase-to-earth and across open switching device :……
   - Between phases :……
   - Across isolating distance :……

10. Permissible partial discharge intensity for cast resin at 1.2 x U_R kV/$\sqrt{3}$:……..

11. Rated normal current
   - O.H line bays :……
   - cable feeder bays :……
   - busbars :……
   - bus coupler :……....

12. Rated short-time withstand current for main and earthing circuits :……..

13. Rated peak withstand current for main and earthing circuits :…….

14. Rated duration of short circuit :……..

15. Anticipated loss of gas (per year and compartment) :……

16. Auxiliary sources of supply
    - D.C. :……
    - A.C. :……..

17. Circuit breaker:

a. Rated normal current :……

b. Rated short-circuit breaking current
- rms value of A.C. component :……
- percentage of D.C. component :…….

c. Rated transient recovery characteristics for terminal faults corresponding to 100% rated short-circuit breaking current
-First-pole-to-clear factor (phase factor) :……
-Rated transient recovery voltage :……
- Rate of rise of recovery voltage :……

d. Rated transient recovery voltage for out-of-phase
-First-pole-to-clear factor (phase factor) :……
-Rated transient recovery voltage :……
- Rate of rise of recovery voltage :……

e. Rated transient recovery characteristics <u>for short-line faults</u>
-First-pole-to-clear factor (phase factor) :……
-Rated transient recovery voltage :……
- Rate of rise of recovery voltage :……

f. Rated short-circuit making current :……

g. Rated short-circuit duration :…….

h. Rated operation cycle :……

i. Has the C.B. shunt reactor load switching capability according to IEC 62271-110? :……

j. Is the C.B. able to interrupt overhead line

charging currents of 400 A, with class C2 acc. to IEC 62271-100? :…….

k. Is the C.B. able to interrupt capacitive cable charging currents up to 400 A with class C2 acc.to IEC62271-100? :……..

l. Mechanical endurance class :…….

m. Maximum interrupting time
- at 100% of the rated breaking capacity :……..
- at 10%, 30%, 60% of the rated breaking capacity :……...

n. Operating time diversion between breaker poles and between breaks of each pole :……..
o. Number of tripping and closing coils :…….
p. Supply voltage for tripping and closing coils :…….
q. Tolerances of the supply voltage of the tripping coils :…….
r. Tolerances of the supply voltage of the closing coil :…….
s. Number of free N.O. contacts :…….
t. Number of free N.C. contacts :…….
u. Rated short-time withstand current :…….
v. Rated peak withstand current :…….
w. Can the breaker be operated without the use of the DC auxiliary supply voltage? :……
x. How many interrupting chambers per phase has the C.B.? :……

18. Disconnectors :

a. Rated current :…….....
b. Rated short-time withstand current :……
c. Rated duration of short circuit :…….
d. Mechanical endurance class :……..
e. Is a manual emergency operation provided? :……..

f. Number of free N.O. contacts :……..

g. Number of free N.C. contacts :……

19. Earthing switches:

a. Rated short circuit current :……...

b. Rated short circuit duration :……

c. Number of free N.O. contacts :……....

d. Number of free N.C. contacts :…….

20. Current transformers :

a. Ratio :……...

b. Class (per winding type) :……..

c. Rated burden (per winding type) :……..

d. Short time thermal current rating :……..

e. Dynamic current rating :……..

f. Rated continuous thermal current :……..

g. Power frequency withstand voltage of secondary windings :……

21. Voltage transformers :

a. Ratio :……...

b. Class (per winding type) :……..

c. Rated burden (per winding type) :……..

d. Rated voltage factor

- continuous :…….
- for 30 s :……..

e. Power frequency withstand voltage of secondary windings :……

22. Surge arresters :

a. Continuous operating voltage Uc :……

b. Rated voltage Ur :…….

c. Nominal discharge current (8/20 μs) :…….....

d. High current impulse withstand :…….

e. Short circuit withstand capability :…….

f. Class :…….....

g. Duty :……...

h. Designation :……...

i. Thermal energy rating Wth :……

j. Repetitive charge transfer rating Qrs :……

k. Residual voltage at 2 kA switching current impulse (>30/60 μs) (SIPL) :……

l. Residual voltage at 20 kA lighting current impulse (8/20 μs) (LIPL) :…….

23. Total weight of the offered GIS :……...

24. Total weight of the SF6 in the offered GIS:……..

25. Weight of each bay of the GIS :…….

……

……..

26. Are any high speed earthing switches used in the offered GIS? :…….

……..

27. If the answer to question No.26 is yes, then indicate location of these high speed E/S within the GIS :…….

……

…….

…….

28. Design pressure of the enclosures

a. Circuit breaker :……
b. Other compartments :……

29. Operating pressure of the pressure relief devices

a. Circuit breaker :……
b. Other compartments :……..

30. Type test pressure of the enclosures

a. Circuit breaker :……..
b. Other compartments :……..

31. Routine test pressure of the enclosures

a. Circuit breaker :……
b. Other compartments :……

32. Alarm pressure

a. Circuit breaker :……
b. Other compartments :……

33. Minimum functional pressure

a. Circuit breaker :……
b. Other compartments :……..

34. Is each gas compartment equipped with:

- Pressure relief device? :……..
- Absorber of moisture? :……..
- Density switch? :……..

35. Type of material of the enclosures :……..

……..

……..

36. Type of material of the air bushings :……..

……

……..

37. Creepage distance of the insulators

of outdoor bushings :……..

38. Length of O.H.L. bay, cable bay, autotransformer bay, bus coupler bay reactor bay and bus section bay :……..

……

……

……

39. Width of O.H.L. bay, cable bay, autotransformer bay, bus coupler bay reactor bay and bus section bay :……..

……

……

……

40. For each bay indicate clearly where are high speed earthing switches needed :……..

……

……

……

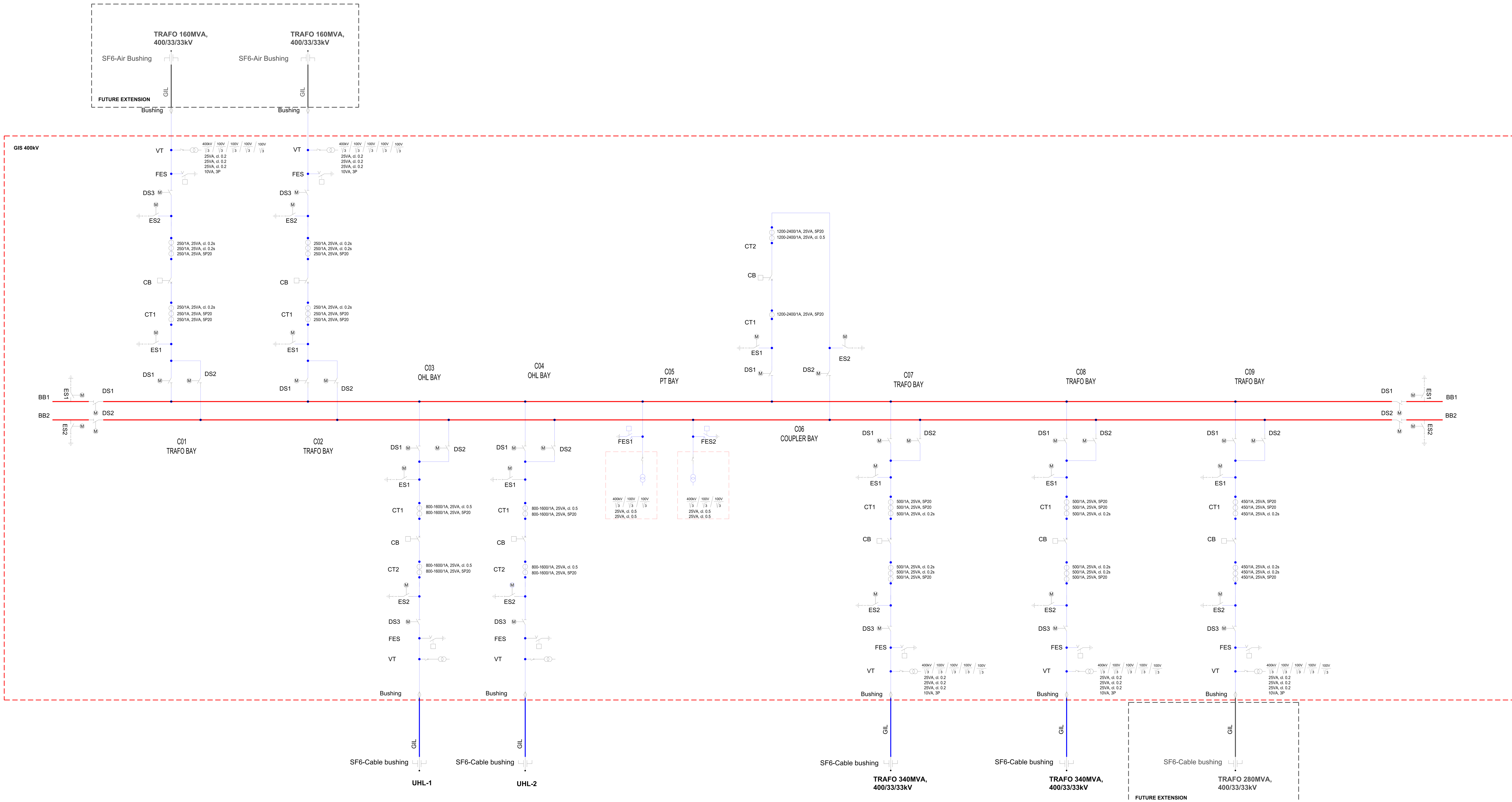
……

41. Is the GIS design according to §10? :…….
   a. Manufacturer :…….
   b. Is it according to Annex A of TD-85? :…….

42. Is an online Partial Discharge Monitoring (PDM) system offered? :…….
   a. Manufacturer /Type :…….
   b. Does it comply with all the design requirements set forth Annex B of TD-85? :…….

c. Sensor layout provided? :……

d. Is a relevant technical leaflet provided,
confirming the required functionalities set forth in Annex B of TD-29?
:……..



420 kV Equipment Legend

Equipment	Legend	Symbol
Circuit breaker	CB	
Disconnector (Motorised)	DS1, DS2, DS3	
Earthing switch (Motorised)	ES1, ES2	M
SF6-cable/air bushing		
High speed earthing switch	FES	
Current transformer	CT1, CT2	
Voltage transformer	VT	
BSG - Bushing		

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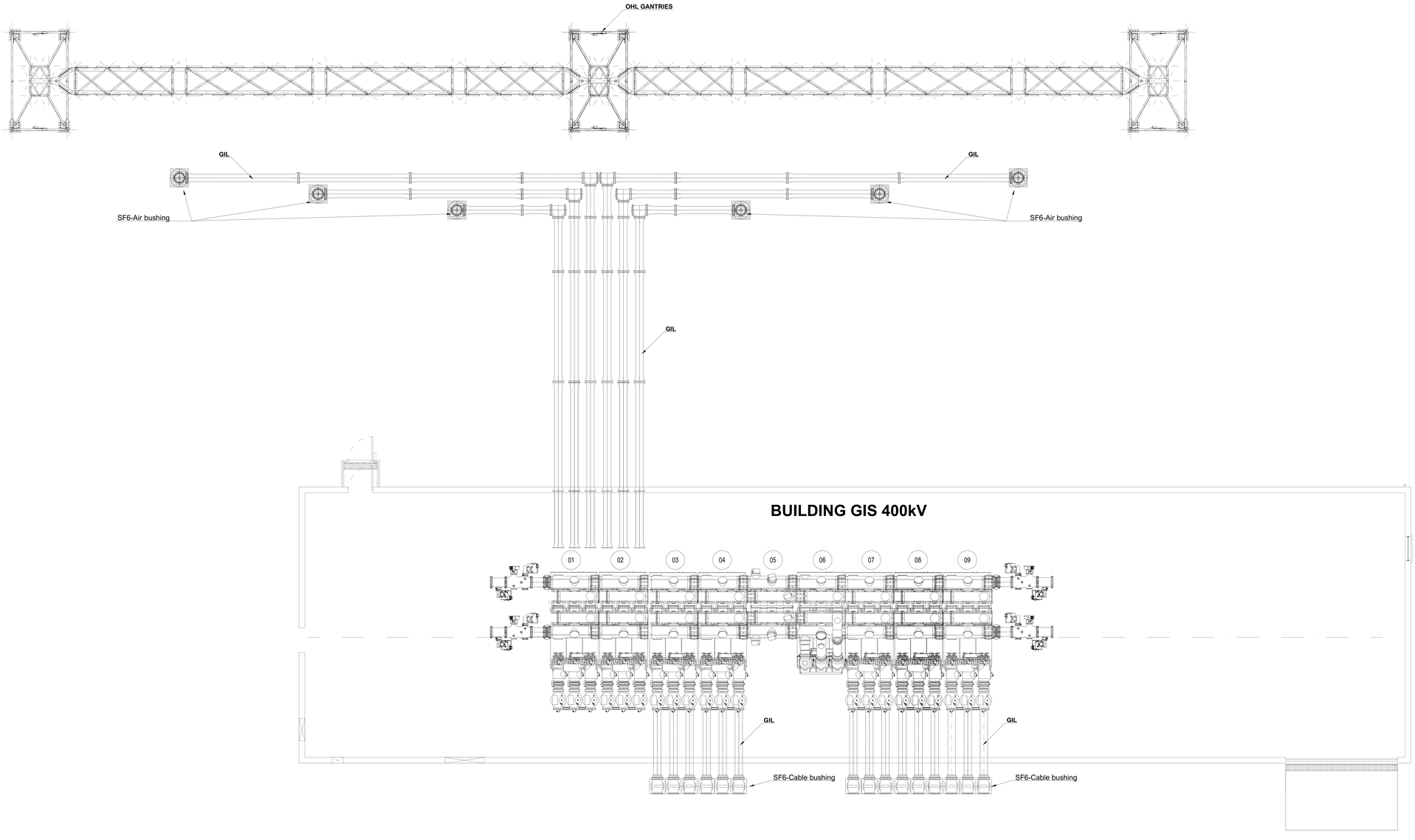
SINGLE LINE DIAGRAM

AGDC-SLD NTS 1/1 00 APR 2026

400 kV BAY SEQUENCE	
	TENDER PROPOSAL
01	OHL BAY FOR FUTURE 160MVA TRAFO
02	OHL BAY FOR FUTURE 160MVA TRAFO
03	UHL BAY FOR TRANSMISSION LINE
04	UHL BAY FOR TRANSMISSION LINE
05	PT BAY
06	COUPLER BAY
07	UHL BAY FOR 340MVA TRAFO
08	UHL BAY FOR 340MVA TRAFO



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GIS LAYOUT

AGDC-GIS ARRANGEMENT 1:50 1/1 00 APR 2026

TECHNICAL SPECIFICATION

340/170/170 MVA, 400/33/33 kV

THREE-PHASE OIL-IMMERSED TRANSFORMER

Contents Table

1. SCOPE

The scope of the present specification is to describe technical requirements regarding the design, construction and testing of a three - phase, 400/33/33kV transformer rated at 340/170/170 MVA. The transformer will be equipped with an on-load tap changer (OLTC).

1.1 Standards

The transformer will be manufactured and tested according to (a) the latest edition of **IEC 60076** Standard, (b) **EU Regulation 548-2014 & 1783-2019 (Tier-2).**

The transformer and equipment related to them as tap-chargers, bushings, outdoor cubicles for tap changer motor control, auxiliary circuits, raw material, tank, windings, etc. shall be designed, fabricated and tested according to the relevant IEC standards.

IEC 60076	Power Transformers **(all** parts)
IEC 60214	On-load tap changers
IEC 60137	Insulated bushings for alternating voltages above 1000 **V**
IEC 61869-2	Current transformers
IEC 60296	Fluids for Electrotechnical Applications - Unused mineral insulating oils for transformers and switchgear
IEC 60034	Rotating electrical machines (e.g. for cooling fans motors)
VDE 0101	Erection for power installations > 1000 V
IEC 60364	Low-voltage electrical installations
IEC 60270	High-voltage test techniques - Partial discharge measurements
IEC 60947	Low voltage switchgear and control gear
IEC 60616	Terminal and tapping marking for power transformers
IEC 61181	Mineral oil-filled electrical equipment - Application of dissolved gas analysis (DGA) to factory tests on electrical equipment
IEC 61558	Safety of power transformers, power supplies, reactors and similar products

1.2 Use

The transformer will be installed for the transformation of the power production units' injected power from 33KV level to 400KV network voltage level.

1.3 Electrical System Characteristics

400KV NETWORK		
1	Nominal Voltage	**400KV**
2	Maximum Operating Voltage	**420KV**
3	Minimum permissible operating voltage	**380KV**
4	Number of phases	3
5	Short Circuit level	**40KA**
6	Short Circuit duration	0.5s
7	Basic Insulation level	1550KV (peak)
8	Power frequency withstand voltage (1min)	680KV (r.m.s.)
9	Switching impulse withstand voltage (1min)	1175KV (r.m.s.)
10	Nominal frequency	50Hz
11	Variations of nominal frequency (normal conditions)	49,85 Hz - 50,15 Hz
12	Available auxiliary D.C. supply voltage	220V D.C
13	Available auxiliary A.C. supply voltage	3-ph, 4-conductors, **230/400V**
14	Method of earthing (grounding)	Effectively earthed
15	Ratio Zo/Z+ range	1-3

33KV NETWORK		
1	Nominal System Voltage	33KV
2	Maximum Operating Voltage	36KV
3	Number of phases	3
4	Short Circuit level	20KA
5	Short Circuit duration	1s
6	Basic Insulation level	250KV (peak)
7	Power frequency withstand voltage (1min)	95KV (r.m.s.)
8	Nominal frequency	50Hz
9	Method of earthing (grounding)	Earthed neutral (via resistance of 19Ohm)
10	Available auxiliary D.C. supply voltage	220V
11	Available auxiliary A.C. supply voltage	3-ph, 230/400V

1.4 Operating Ambient Conditions

Installation	: Outdoors
Limits of ambient temperature	: -25°C to + 40°C
Monthly average ambient temperature (hottest month)	: 30°C
Yearly average ambient temperature	: 20°C
Altitude	: Up to 1000 m above sea level
Other climatic conditions	: Snow, ice and fog

1.5 Required Design Characteristics of the Transformer

1.5.1 Type

Three-phase oil immersed transformer suitable for outdoor installation.

1.5.2 Voltage ratings and number of phase windings and Vector Group

- Primary 400 kV, 3 phases
- Secondaries 2 x 33 kV, 3 phases
- Tertiary winding 11 kV
- Vector Group YNyn0-yn0+d

1.5.3 Nominal apparent power (capacity) ratings

Nominal simultaneous continuous capacity, for 65 C average winding temperature rise, measured by resistance and up to 40 C ambient:

- Primary, 260 MVA ONAN - Natural cooling (natural oil and air circulating) 340 MVA ONAF - Forced cooling (air circulating via fans, natural oil circulating)

-Secondary 1, 130 MVA ONAN – Natural cooling (natural oil and air circulating) 170 MVA ONAF – Forced cooling (air circulating via fans, oil circulating natural)

-Secondary 2, 130 MVA ONAN – Natural cooling (natural oil and air circulating) 170 MVA ONAF – Forced cooling (air circulating via fans, oil circulating natural)

In terms of the above capacities, the current of each transformer winding shall be as follows:

-Primary, 491 A at 400KV, 340 MVA

-Secondary 1 and 2, 2975 A at 33KV, 170 MVA

-Tertiary 1785 A 9 (subject to manufacturer calculations)

General:

The transformer shall be equipped with N+1 detachable heat exchangers (coolers) of the same maximum and minimum pressure withstand with the main tank, in independent groups connected to the tank by isolating valves so that each group may be removed without taking the transformer out of service.

The heat exchangers shall be made out of steel or aluminium, forming an integral part of the tank.

The transformer shall be capable to deliver their rated output, at design ambient conditions, with N coolers in operation while the additional one shall serve as a stand-by cooler, ready to replace any one of the operating coolers.

Forced air-cooling shall be provided for the transformer by means of fan units attached to the radiators.

The heat exchangers (coolers) shall be assembled, framed and braced in such a manner as to provide mechanical protection to themselves and to prevent vibrations.

Heat exchangers shall be pressure tested to ensure liquid tightness. Heat exchangers headers, if provided, shall be sloped so that they can be completely drained and vented. AII portions of equipment shall be accessible for inspection, cleaning and painting.

At least the following accessories shall be provided:

- One (1) inlet and outlet valve for each heat exchanger or group of heat exchangers for connection with the transformer tank or header, respectively.
- One (1) drain valve at the lowest point of each heat exchangers or group of heat exchangers and one (1) filling plug at the highest point of the upper heat exchangers header.
- Thermometer pockets as required for heat run test as per applicable standards. These pockets will be additional to the ones provided for the use of installed instruments, such a soil temperature relays etc.
- One (1) thermometer pocket fitted with a captive screwed cap on the inlet and outlet of each cooler.
- Air release plugs.
- Lifting eyes for heat exchangers removal.

- Connections for coupling a fault detection device to the oil circuit.

Identification symbols (expressed by a four-letter code) according to IEC 60076-2:

First letter: Internal cooling medium:

- O: mineral oil or synthetic insulating liquid with fire point 300 °C;
- K: insulating liquid with fire point > 300 °C;
- L: insulating liquid with no measurable fire point.

Second letter: Circulation mechanism for internal cooling medium:

- N: natural thermosiphon flow through cooling equipment and in windings;
- F: forced circulation through cooling equipment, thermosiphon flow in windings;
- D: forced circulation through cooling equipment, directed from the cooling equipment into at least the main windings.

Third letter: External cooling medium:

- A: air;
- W: water.

Fourth letter: Circulation mechanism for external cooling medium:

- N: natural convection;
- F: forced circulation (fans, pumps).

1.5.4 Type of core

The type of transformer's core will be core-form consisting of five limbs.

The core will be manufactured from silicon steel laminations.

Core laminations shall be made from cold rolled, grain orientated, high permeability silicon steel free from burrs. The core joints shall be interleaved. Each lamination shall be insulated with a material that will not deteriorate due to pressure and due to the action of hot oil.

The core and its clamping plates shall form a rigid unit structure which shall maintain its form and position under the severe stresses encountered during shipment, installation and short-circuits. Care shall be taken to secure evenly distributed mechanical pressure over the whole laminations to prevent settling of the core and to eliminate noise and vibrations when the transformer is in operation.

The core and its mechanical parts shall be designed to withstand forces produced during transportation, short circuits and earthquakes.

1.5.5 Insulation Levels

H.V line terminals 420 kV S1/LI/LIC/AC	1175/1425/1570/680 kV
H.V Bushings 420 kV S1/LI/AC	n/a
H.V. Neutral Winding 145 kV LI/AC	650/275 kV

H.V. Neutral Bushing 145 kV LI/AC	650/305 kV
L.v. line terminals 52KV LI/LIC/AC	250/275/95 kV
L.v. Bushings 52KV LI/AC	250/105 kV

1.5.6 Short circuit withstand capability

Transformer shall be capable of withstanding under service conditions for 2 (two) seconds, on any tap-setting, three-phase or one-phase short circuit at the terminals of any winding without being damaged due to excessive forces or thermal effects. The thermal and dynamic ability of the transformers to withstand short circuit shall be demonstrated by calculation or the performance of a special test, in accordance with IEC 60076-5.

1.5.7 Winding insulation category and connections

a. The primary windings shall be star-connected, with neutral brought out through fully insulated bushing grounded directly at the grounding grid of the substation. The primary and common windings shall be of non-uniform insulation category.

b. The secondary windings will be star connected. The secondary winding will be of uniform insulation category. The neutral node will be grounded via 19Ohm grounding resistance.

1.5.8 Temperature rise limits

The average value of the windings temperature rise will be 65°C (class A) at rated MVA according to IEEE Std C57.12.00, using the combination of connections and taps that give the highest average winding temperature rise, for ambient temperature up to 40°C (IEC 60076-2).

The average temperature of each winding after loading with a symmetrical short- circuit current I of a value and duration as specified in par. 1.3, respectively, shall not exceed the maximum value of 105°C (thermal class A) at any tapping position according to IEC 60076-5.

The maximum (hottest spot) winding temperature rise above ambient temperature shall not exceed 78°C (IEC 60076-2 & IEEE Std C57.12.00) at rated kVA for the particular combination of connections and taps that give the highest maximum (hottest spot) winding temperature rise.

The maximum (hottest spot) winding temperature rise above ambient temperature shall be included in the test report, with the other temperature rise data. A note shall indicate which of the preceding methods was used to determine the value.

The temperature rise at top oil level will be limited up to 60°C for an ambient temperature up to 40°C tested according to IEC corresponding type test.

The transformer thermal model constants, following IEC 60076-7, will be calculated and provided after the final design.

1.5.9 Over-Voltage Capability

Transformer must have an over-voltage capability of 10% at no load and 5% at rated MVA without exceeding the limiting temperature rise according to par.1.5.8 at load power factor of 80% or higher according to IEEE Std 519 and IEEE Std (57.12.00.

1.5.10 Limits of insulations resistance at 20°C

The minimum insulation resistance for transformers at 20°C shall be:

- IR value at HV side: 850MΩ at 20°C
- IR value at LV side: 600MΩ at 20°C

1.5.11 Impedance

Not less than 15% at principal tap of OLTC at rated power 340 MVA.
The short-circuit impedance value in percentage (%) is corrected to 75°C.

1.5.12 Limits of losses/Efficiency

The transformer shall be in compliance with Tier-2 according to EU regulation 548/2014 (ECO design), latest edition, implementing directive 2009/125/EC of European Parliament.

The Contractor must clearly indicate in his technical and economic offer the Peak Efficiency Index (PEI), according to EN 50629, which shall be not less than 99.797% (T2 limit). PEI is considered as guaranteed value for the Project and for its calculation only the following losses shall be taken into account:

o. No-load loss at rated voltage and principal tapping.

b. Load loss at rated current on HV - MV sides, no current on MV side, at principal tapping and corrected to 75°C conductor temperature.

c. Cooling loss during no-load transformer operation.

The formula to be used for the Peak Efficiency Index calculation is:

$$PEI = 1 - \frac{2\left(Po+Pco+Pck(kPEI)\right)}{Sr\sqrt{\frac{Po+Pco+Pck(kPEI)}{Pk}}} = 1 - \frac{2}{Sr}\sqrt{\left(Po+Pco+Pck(kPEI)\right)Pk}\ (\%)$$

Where:

- Po is the no-load loss measured at rated voltage, rated frequency and on rated tap
- Pc0 is the electrical power required by the cooling system for no-load operation derived from the type test measurements of the power taken by the fan and liquid pump motors (for ONAN and ONAN/ONAF cooling systems Pc0 is always zero).
- Pk is the measured load loss at rated current and rated frequency on the rated tap corrected to reference temperature according to IEC 60076-1.
- Pck(kJ is the additional electrical power required (in addition of Pc0) by the cooling system for operation at load factor k, derived from the type test

measurement of the power taken by the fan and pumps motors.

- Sr is the rated power of the transformer as defined in IEC60076-1 on which Pk is based.
- k is the load factor
- k_{PEI} is the load factor at which Peak Efficiency Index occurs
- P_{ckPEI} is the additional electrical power required (in addition of Pc0) by the cooling system for operation at k_{PEI} times the rated load. Pck is o function of the load. P_{ckPEI} is derived from the type test measurements of the power taken by the fan and liquid pump motors (for ONAN cooling systems Pck is always zero).

Transformer losses shall be clearly indicated with the tolerances stated in IEC 60076 and EU regulation 548/2014 (ECO design), whichever is stricter.

The manufacturer will be required to declare additionally the cooling load of fans.

1.5.13 Limits of magnetizing current values

Exciting current shall be as low as possible consistent with economical design.

Percent no-load exciting current shall not exceed 0.3% under sine wave excitation at rated voltage and frequency and shall not increase to more than 2½ times this value at rated frequency and 110 percent rated voltage.

1.5.14 Noise Level

The noise level shall be measured in accordance with IEC 60076-10.

The maximum noise pressure level under nominal conditions and cooling system in operation in 2 m distance from radiating surface shall be 81dB.

1.5.15 Harmonics

The Guidelines IEEE 519-2014 at Point of Common Coupling (PCC) Level are as under:

Individual Harmonic Order (Odd Harmonics) in percent of I_L						
I_{sc}/I_L	<11	11 h<17	17 h<23	23 h<35	35 h	THD
<50	2.0	1.0	0.75	0.3	0.15	2.5
50	3.0	1.5	1.15	0.45	0.22	3.75

Where I_{sc}= maximum short-circuit current at PCC

I_L= maximum demand load current (fundamental frequency component) at PCC

2. ON - LOAD TAP CHANGER (OLTC) AND AUTOMATIC VOLTAGE REGULATOR

The transformer shall be equipped with an On-load tap changer (O.L.T.C.) of resistance type with transfer switches, selector switches and reversing switches for voltage regulation with a tapping arrangement +/- 8x1.25%.

The manufacturer of the tap changer shall be MR Germany or ABB Europe

On Load Tap Changer (OLTC) Steps

n	tap	400kV (HV) (kV)	MV (kV)
8	1.1000	440.0000	20 or 30 or 33
7	1.0875	435.0000	
6	1.0750	430.0000	
5	1.0625	425.0000	
4	1.0500	420.0000	
3	1.0375	415.0000	
2	1.0250	410.0000	
1	1.0125	405.0000	
0	1.0000	400.0000	
-1	0.9875	395.0000	
-2	0.9750	390.0000	
-3	0.9625	385.0000	
-4	0.9500	380.0000	
-5	0.9375	375.0000	
-6	0.9250	370.0000	
-7	0.9125	365.0000	
-8	0.9000	360.0000	

The O.L.T.C. shall be 3-phase and be installed on the High Voltage Y-connected winding of the transformer at the neutral star point end.

The power of the transformer shall remain constant at all tap positions and the OLTC shall be capable of successful tap-changes for the maximum current to which the transformer can be loaded.

The control of the OLTC will be realized either automatically or with manual operation. The OLTC can be controlled also locally at the transformer, through local buttons.

The transfer switches shall be placed in a separate oil tank.

The O.L.T.C. shall be motor operated controlled by an automatic voltage regulator (AVR) supplied by the seller. The voltage regulator shall have current and voltage level input from 33kV through dedicated bushing CT located in the X2 MV bushing of Power Transformer, and it will be digital. It will be supplied as a loose component. The AVR shall have o power input of 220V DC.

Available voltage and current for the analogue inputs: substation voltage transformer with secondary nominal voltage 100V or 110V, current transformer with secondary nominal

current 1A or 2A.

The line-drop compensator shall have two elements X and R for reactance and resistance compensating. The voltage regulator will also include undervoltage, overvoltage and overcurrent function, which will block the operation of the OLTC.

To avoid excessively frequent operation of the O.L.T.C. a time delay device is necessary to be provided with possibilities of adjustment from 10 to 100 sec.

The voltage regulator will follow by selection, either the inverse time delay or the fixed time delay principle. The time delay will be bypassed in case of large voltage deviation from setpoint.

The voltage regulator will include a digital display for indication of the tap position and the measured voltage.

The voltage regulator will be set operated and programed locally or by special computer software. The software and the relevant communication cable shall be delivered by the supplier.

A step-by-step device must be incorporated in the control circuit to ensure one tap-change only, even when the control switches are held continuously in the 'ON' position.

The O.L.T.C. shall be equipped with auxiliary contacts for remote position indication as well as with an operation counter. Provision shall be made for a switchboard change over switch with at least (3) three positions i.e. (a) OFF, (b) automatic load ratio control,
(c) remote-local manual load-ratio control.

The motor drive mechanism of the O.L.T.C. shall be fed by three (3) phase voltage 230/400V, 50Hz and protected against over/under voltage and loss of one phase voltage If a sudden interruption of the current feeding the motor occurs, the switch must not stay between two positions.

AII relays, switches, fuses, motor etc., of the O.L.T.C. shall be mounted in a weather- proof control cabinet mounted on transformer near the OLTC. The control voltage of the OLTC will be 230V AC. The signaling will be realized by voltage-free contacts or through BCD code signaling. A heat resistance shall be provided in the cabinet supplied by 230V AC and controlled by a thermostat.

AII special tools and jigs needed for tap-changer maintenance, dismantling and manual operation (levers, handles, etc.) must be supplied by the Contractor.

2.1 Parts of the on - Ioad tap - changer

The on - load tap changer generally shall consist of a diverter switch, transition resistors, a tap selector and a reversing change - over selector.
The whole being operated by a driving mechanism (motor drive).

2.2 Type of the on - Ioad tap - changer

Vacuum/oil (diverter switch and the transition resistors in vacuum and the tap selector and the reversing change - over selector in oil).

2.3 Number of tapping positions and the corresponding voltage level of each tapping position

Total number of tapping positions: 17 taps at 400kV side including one principal tap and +8/-8 tapping positions above / below of the principal tap.

ON-LOAD TAP CHANGER WITH SEVENTEEN (17) POSITIONS (OLTC)	
400kV	
1.	440.0000
2.	435.0000
3.	430.0000
4.	425.0000
5.	420.0000
6.	415.0000
7.	410.0000
8.	405.0000 in steps of 5000V (1,25 %)
9.	400.0000 Principal tap
10.	395.0000 in steps of 5000V (1,25 %)
11.	390.0000
12.	385.0000
13	380.0000
14.	375.0000
15.	370.0000
16.	365.0000
17.	360.0000

2.4 Applicable Standards

IEC 60214-1 and IEC 60214-2.

2.5 Required operating temperatures of on - load tap - changer

Tap - chanqer	Temperature	
Environment	Minimum	Maximum
In-tank tap changer	-25°C	105°C

The tap - changer will not restrict operation of the transformer under long-time emergency overloading, as described in par. 1.5.9, during which the top-oil temperature can rise up to 115 °C.

2.6 Location of the tap changer components and method of installation

2.6.1 For oil/vacuum type OLTCs

a. The diverter switch and the transition resistors shall be placed in their own hermetically sealed oil comportment. The diverter switching contacts must be of vacuum type.

b. The tap selector and the reversing change - over selector shall be placed in the transformer oil.

c. Both compartments which are mentioned above shall be placed inside the tank of the transformer.

Access to the OLTC and its individual components shall be possible without disturbing connections or other parts of the transformer.

Suitable manholes shall be available on the transformer tank so that the OLTC or any of its components can be removed, on site, in case of failure.

It is of paramount importance that the removal of the OLTC or any of its components does not cause any problems to any of the transformer parts.

2.6.2 Conservator of the OLTC

a. The diverter switch and the transition resistors shall have their own conservator (oil expansion tank).

b. The OLTC conservator shall be equipped with an oil level indicator.

NOTE: It's also accepted one conservator with two (2) spaces, one for the transformer tank and one for OLTC.

2.7 Type of oil of the OLTC

The oil used in the diverter switch and transition resistors compartment shall be exactly the same as the one used in the transformer tank type of mineral oil suitable for transformers, free from any PCBs or PCTs and in accordance with IEC – 60296 Standard.

2.8 Accessories of the diverter switch and transition resistors oil compartment

The compartment shall be equipped with a drain and filling tap.

2.9 Rating and other characteristics of the OLTC

Single or three phase	Three phase
Position of tapping in winding	Neutral – end - HV
Tapping arrangement	Reversing
Maximum rated through current	≥ 400 A
Rated frequency	50Hz
Rated voltage	145KV r.m.s
Rated power – frequency withstand voltage at 50Hz, 1min	275KV r.m.s
Rated lightning impulse withstand voltage (1.2/50μs)	650KV peak
Number of electrical positions	18
Rated phase to earth step voltage (wye connection)	≥2886V

2.10 Operations under load

The OLTC shall be able to perform 500.000 operations (tap changes) without maintenance (apart of the motor drive), under step voltage of 2886V and through current equal to the rated HV transformer winding current at the principal tap (No.0).

2.11 Required protective devices for the OLTC

2.11.1 Oil-flow controlled relay

This oil –flow relay shall be installed in the pipe between the tap changer head and oil conservator and shall respond to a predetermined oil flow (due to low energy phenomena) and enable the transformer to be tripped. The relay shall be designed and tested following EN 50216- 1 and EN 50216-2 standards.

The test certificates shall be presented to Owner's and/or IPTO inspectors.
This oil-flow relay shall be **MR or EMB** type and with the following contact characteristics:

- Two (2) N.O contacts suitable for 220V DC. One for tripping purposes and one for alarm.

2.11.2 Pressure relief device

This pressure relief device will respond in the event of the pressure in the diverter switch compartment exceeding a predetermined value (explosive energy phenomena) and enable the transformer to be tripped. The device will include a metallic cover with a drain, in order to convey the oil safely to the ground. The device shall be designed and tested following EN 50216-1 and EN 50216-5 standards. The test certificates shall be presented to Owner's and/or IPTO inspectors.
The Pressure relief device shall be made by **Qualitrol** or MR make and with the following contact characteristics:

- Tvvo (2) N.O contacts suitable for 220V DC. One for tripping purposes and one for alarm.

2.12 Motor Drive Unit (Driving Mechanism)

a. Control: Local/Remote.
For this reason, the motor drive unit panel shall be equipped with a three (3) position selector switch "Off - Local - Remote". The motor drive and control panel shall also be equipped with two (2) push buttons used in conjunction with the "Local" position of the selector switch, for raising and lowering the voltage step of the OLTC.

b. Emergency control: Emergency control is required and for this reason the motor drive control panel shall be equipped with an emergency push - button for emergency stopping of the motor drive.

c. Supply Voltage for the control circuits of the motor drive unit: 230V AC.

d. Supply Voltage and frequency: 3ph, 400V AC, 50Hz with tolerances of 85% to 110%.

e. Installation: Outside of the transformer tank and connected to the OLTC by driveshafts and gears.

f. Motor drive and control cabinet: The motor drive and control cabinet of the

motor drive unit shall be of IP55 protection as per IEC 60529.

g. Motor drive and control cabinet equipment: The motor drive and control cabinet besides the "Off- Local - Remote" selector switch, the two (2) push-buttons for raise, lowering and the emergency stop push button shall contain the following:

1. A tap indicator, indicating tap position.
2. Anti - condensation heaters controlled by thermostat.
3. A counter indicating the number of tap - changers accomplished.

h. Manual operation: Operation of the tap - changer manually by a mechanical device blocking at the same time operation by the electric motor.

i. Remote control and indication: The motor drive unit shall be capable of being operated from the substation's automation control system located at the control building of the substation (raise - lowering and emergency stop). Also tap position number of operations and any alarms originated from the motor drive, will have to be displayed in the HMI center of the substation's automation control system.

j. Auxiliary circuits insulation test: 2KV, 1 minute between all live parts of auxiliary circuits and the frame.

2.13 Warranty

The offered **OLTC** shall be **MR of Germany or Hitachi of Sweden,** and a warranty period of **three (3) years** from the received date must be given which shall cover any OLTC damages or damages to the transformer due to OLTC malfunctioning.

2.14 Nameplates

2.14.1 Rating plate

The transformer shall be provided with a rating plate of weatherproof material, fitted in a visible position, showing the appropriate items indicated below. The entries on the plate shall be indelibly marked.

Information to be given in all cases:

a. Kind of transformer (for example transformer, auto-transformer, series transformer, etc.).
b. Number of the relevant standard (IEC 60076-1).
c. Manufacturer's name, country and town where the transformer was assembled.
d. Manufacturer's serial number.
e. Year of manufacture.
f. Number of phases.
g. Rated power (in kVA or MVA).
h. Rated frequency (in Hz).
i. Rated voltages (in V or kV) and tapping range.
j. Rated currents (in A or kA).
k. Connection and phase displacement symbol.
l. Short-circuit impedance, measured value in percentage.
m. Type of cooling. (If the transformer has several assigned cooling methods, the

respective power values may be expressed as percentages of rated power, for example ONAN/ONAF 70/100 %)

n. Total mass.
o. Mass and type of insulating liquid with reference to the relevant IEC standard.
p. Maximum system short-circuit power or current used to determine the transformer withstand capability if not infinite.

2.14.2 OLTC

The nameplate of the OLTC shall be included in the nameplate of the transformer and shall contain the following:

a. Schematic diagram of the OLTC.
b. Tap positions and corresponding voltage.
c. Tapping arrangement.
d. Maximum rated through current for each tap position.
e. Rated voltage.
f. Rated lightning impulse withstand voltage.
g. Maximum number of operations under load.
h. Characteristics of any surge arresters, if existing, built in the OLTC.

2.14.3 Motor Drive

The motor drive control cabinet shall bear o nameplate of non - corrosive material and it shall contain at least the following:

o. Manufacturer's name
b. Type and serial number
c. Supply voltage
d. Frequency
e. Power of motor
f. Runtime per tap operation

2.15 Tests for on-load tap-changers

The transformer manufacturer is obliged to present to Owner's and/or IPTO inspectors OLTC's test reports while the inspector is at the manufacturer's premises for the transformer inspection and testing.

The test reports which are to be presented shall include at least the following type and routine tests according to IEC 60214-1.

2.15.1 Type Tests

o. Temperature rise of contacts
b. Switching tests
c. Short - circuit test
d. Transition resistor test
e. Mechanical tests
f. Tightness test
g. Dielectric tests

2.15.2 Routine Tests

o. Mechanical test
b. Sequence test
c. Auxiliary circuits insulation test
d. Pressure and vacuum tests

3. BASIC EQUIPMENT OF TRANSFORMER ACCESSORIES AND PARTICULARS

3.1 Transformer tank

o. The transformer tank will be of Barrel type.

b. The bell type tank will be connected with the transformer base by bolted flange.

c. The transformer tank will be constructed to withstand vacuum.

d. For lifting purposes, the transformer tank must be provided with suitable lugs. In addition, the transformer shall have pulling eyes or other arrangement for attaching pulling rig for moving the transformer. Furthermore, the transformer shall have jack bosses for handling the entire weight of the transformer.

e. Manholes should be provided on the tank cover and walls dimensioned no less than 50x50cm. At least, two manholes should be required on the tank cover for the access inside the transformer tank.

f. Grounding pads shall be provided near the bottom of the transformer tank. The tank will be grounded in two points at least diagonally. The transformer tank should be designed so that the losses caused by circulating eddy - currents to be minimized and also the creation of onerous temperatures at the tank surface to be avoided.

g. The magnetic core of the transformer will be earthed at only one point. The core earthing will be realized through an insulated conductor, connecting the core to an earthing box, placed externally on the transformer tank. By this way the core earthing could be tested without opening the transformer tank.

h. The cover of the transformer tank should be designed in such a way so the stagnation of the water to be avoided.

i. A climbing ladder will be provided. The ladder shall provide easy access to the tank upper part. It will be equipped with a lockable door, a cage for anti-fall protection and flat anti-slippery footholds. The upper surface of the tank should be treated with anti-slip paint.

j. The manufacturer will propose and prepare for two or more 30x30cm positions on the top of the transformer that will be used for the welding of anchor bases for a portable fall arrest system. The positions should be selected in a way so that the portable fall arrest system used will allow for adequate fall protection of personnel during commissioning and maintenance of the transformer. If such positions cannot be selected the manufacturer will propose and provide anchor points for a horizontal lifeline system (HLL) that will allow for adequate fall protection of personnel during commissioning and maintenance of the transformer.

3.2 Conservator tank

The transformer must be equipped with a conservator tank to accommodate the changes in oil volume caused by the changes of the ambient temperature or the transformer load.

The conservator tank will be composed of one piece ready for installation. It is also accepted one conservator tank with two (2) compartments, one for the tank and one for the OLTC.

The design must be of such a type as the direct contact between air and oil to be avoided. To avoid moisture entering the oil of the conservator tank during the oil volume fluctuations, the tank will be fitted with a breather per separate compartment, which shall contain an absorbent material (silica gel crystals) and a drain age tank. The breathers shall be designed and tested following EN 50216-1 and EN 50216-5 standards.

The test certificates shall be presented to Owner's and/or IPTO inspectors. In addition, for that reason, a dry air cushion will float on the oil surface and will increase or decrease as the oil volume changes. The dry air cushion will be in contact with the breather so that it is always at atmospheric pressure and the incoming air is always dry.

The silica gel crystals must be active in order to be able to absorb moisture and this property will be checked by periodical optical inspections of the silica gel crystals color. Except for the oil level indicator, a drain valve will be mounted on the tank and there will be one Buchholz relay with isolating valves on the tube connecting the conservator tank with the transformer body as it is described in detail in paragraph 3.10.5 of this hereby specification.

3.3 Radiators

The radiators shall be designed and tested following EN 50216-1 and EN 50216-10 standards.

The test certificates shall be presented to Owner's and/or IPTO inspectors.

Radiators shall be detachable and tank connections shall be provided with valves, so that radiators may be removed without draining oil from tank. Each radiator shall be provided with lifting eyes and air release, drain valves or plugs. A lifting plug shall be provided at the highest point of the upper radiator header.
The radiators shall be attached and supported only by the body of the transformer. The radiators support will be realized by mechanical means, separate from the connecting oil pipes to the tank.

3.4 Valves

Each transformer will be equipped with the necessary quantity of valves e.g. for draining the tank, sampling oil, isolating each cooler unit etc. Oil filling valve, filtering valve and vacuum connection valve shall be provided. One oil sampling valve shall be placed at a pipe connecting the cooling system with the transformer tank, at the outlet side of the pumps.
All vacuum valves shall be designed and tested following EN 12266-1, -2 standards.
The butterfly valves shall be designed and tested following EN 50216-1 and EN 50216-8 standards.
The test certificates shall be presented to Owner's and/or IPTO inspectors.

3.5 Connecting material

All connecting material, such as bolts, nuts and lock washers must be according to ISO 898-1 and hot dip galvanized according to ISO 1461.

3.6 Tubing

The tubing on the body of the transformer must be as little as possible and must be arranged in a logical manner.
Under any operating conditions, oil leaks from the tank joints or from joints of the oil circuit are not acceptable.

3.7 Oil-to-Air Bushings

The design of bushings will be in accordance with the IEC 60137 Standard. The bushings of each transformer winding will be of outdoor - immersed capacitance graded oil insulated type with one end exposed in ambient air and the other end immersed in the transformer oil.

The bushings must be type tested. Test reports from ISO 17025 accredited laboratory will be submitted at bid stage for review.

Bushings shall be free from defects.

The outdoor insulators and fittings shall be unaffected by atmospheric conditions due to weather, fumes, ozone, acids, alkalis, dust or rapid changes in air temperature.

The unified specific creepage distance (USCD) of all bushings shall be considered 53,7 mm/kV according to IEC 60137 and IEC 60815-1 (2008) for very heavily polluted areas (site pollution severity class-e).

Bushings shall be arranged to facilitate easy access for mounting and dismounting. Where built-in current transformers are provided, bushings shall be arranged to permit their removal without interfering with the pertinent current transformer.

The core and the active part of the bushing will consist of an insulation of Resin Impregnated Paper (RIP).

The external insulation housing of bushings will be of resin impregnated fiber tube and silicon rubber covering. The composite housing will comply in all relevant respects with IEC 61462.

The space between the active part (core) and the insulating envelope will be oil filled (liquid-insulated bushings).

The bushings of transformer are required to be of the following rating characteristics:

Description (acc. to IEC 60137)	.	M.V.	Neutral HV
Highest rated Voltage (phase to phase) (Um) (KV-r.m.s.)		52	145
Rated phase to earth operating voltage (KV-r.m.s.)		52/sqrt (3)	145/sqrt (3)
Rated current (Ir) (A)		2500	2500
Rated thermal short time current, 1 sec (1th)		25Ir	25Ir
Rated dynamic current (Id)		2.5Ith	2.5Ith
Cantilever operating load (N)		1250	2000

Unified Specific Creepage distance (USCD) (mm) (acc. to IEC 60815-1 & 3)		minimum creepage distance of 53,7 mm/kV	minimum creepage distance of 53,7 mm/kV
Angle of mounting		30°/vertical	30°/vertical
Power frequency withstand voltage (KV) (dry / wet)		105/95	305/275
Lightning impulse withstand voltage (kV)		250	650
Switching impulse withstand voltage (kV)		-	-
Maximum value of partial discharge quantity at Um operating voltage	10pC		
Dielectric dissipation factor (tanδ) at 1,05UmN3 voltage	0,007		

3.7.1 Additional characteristics of bushings

a. Seismic withstand capabilities.

All bushings shall be capable of withstanding the following seismic stresses as per IEC-61463 and IEC-60068-3-3.

1. Horizontally (axes χ and y): 0.Sg (Sm /s^2) (Ground acceleration reference: AGS)
2. Vertically (axe Z): 0.25g (2,Sm / s^2)
3. The frequency range should be fo= SHz to 20Hz and damping d= 3 to 6%.
4. Acceptable methods of seismic qualification are:
   - Qualification by vibration test or
   - Qualification by static calculation or
   - Qualification by dynamic analysis

Contractors are obliged to submit test reports or calculation by dynamic analysis, or static calculation.

Approval or not of all the above lies in Owner's and/or IPTO's judgment.

b. Bushings shall be designed for operation at ambient temperature from -25°C to +45°C and an altitude not exceeding 1000m.

c. The maximum oil temperature under operating emergency conditions will be 115°C.

d. The HV bushings shall have an aluminium terminal of cylindrical shape with diameter of 30mm and length of about 100mm. The LV bushings shall have a tin-plated copper terminal of rectangular shape with dimensions of about 100mm χ 100mm χ 15mm.

e. If the HV bushings are of a drawn lead or drawn rod type, the cross-section of the lead or rod will be selected according to the instructions of the bushing manufacturer, in order the complete bushings to have a continuous current rating of at least 130% of the rated tapping current at the maximum current tap for the HV.

f. If after taking into consideration the above stated operating characteristics, the above indicated bushings rating current is less than what it should, then offerors must offer bushings with suitable rating.

3.7.2 Accessories

Bushings will be equipped with the accessories below:

a. Oil level indicator.
   Test tap (tanδ tap) suitable for measurement of the dielectric dissipation factor, capacitance and partial discharge value of the bushing. The test tap will be electrically isolated from the mounting flange and will be always earthed directly when it is not used.
b. Air release plug.
c. Oil expansion compensator.
d. Oil sampling and oil filling plugs.
e. Lifting lugs if required by the manufacturer and there are no other means of lifting the bushings.

Bushings with insulating housing following IEC 61462, which consists of a resin

impregnated fiber tube and silicon rubber covering can be accepted, providing if they cover the requirements of paragraph 3.7.

3.7.3 Rating plates - markings

The H.V., M.V. and neutral bushings shall carry a rating plate including the following markings.

- Manufacture's name.
- Year of manufacture and serial number
- Maximum operating phase - phase voltage (Um) or rated operating phase to earth voltage and rated frequency.
- Operating rated current (Ir)
- Insulation levels BIL, SIL, P.F.
- Bushings capacitance, dielectric dissipation factor.
- Mass
- Angle of mounting

3.7.4 Tests for bushings

The transformer manufacturer is obliged to present to Owner's and/or IPTO inspectors bushings test reports while the inspectors are at the manufacturer's premises for the transformer inspection and testing.
The test reports which are to be presented shall include the following type, routine and special tests:

The tests will be in accordance with IEC 60137 Standard.

3.7.4.1 Type tests

1. Power - frequency voltage withstand test, wet (not for HV bushings)
2. Long duration power frequency (ACLD) voltage withstand test, with partial discharges measurement (only for HV bushings)
3. Lightning impulse voltage withstand test
4. Switching impulse voltage withstand test, dry and wet (only for HV bushings)
5. Electromagnetic compatibility test (only for HV and neutral bushings)

6. Thermal stability test (only for HV bushings, calculation or test)
7. Temperature rise test
8. Verification of thermal short - time current withstand (calculation or test)
9. Cantilever load withstand test
10. Tightness test
11. Verification of dimensions

3.7.4.2 Routine tests

12. Measurement of dielectric dissipation factor (tanδ) and capacitance at ambient temperature
13. Lightning impulse voltage withstand test (only for HV bushings)
14. Power - frequency voltage withstand test, dry
15. Measurement of partial discharge quantity
16. Test of tap insulation
17. Tightness test
18. Tightness test of the flanges
19. Visual inspection and dimensional check

3.7.4.3 Special tests

20. Seismic test (IEC 61463) (IEC 61463, calculation or test)
21. Artificial pollution test (IEC 60507)

The bushings shall be manufactured from GE or TRENCH or ABB.

3.7.5 Bushing Current Transformers

Terminals	Number per terminal	Ratio	Accuracy
H1,H2,H3	1	**500/1A**	5P20 40VA
H1,H2,H3	1	**500/1A**	5P20 30VA
H1,H2,H3	1	500/1A	5P20 25VA
X1, X3	1	**3000/2A**	15VA 3Fs5
X2	1	**3000/1A**	15VA 3Fs5

All current transformers will follow IEC 61869-1 and IEC 61869-2 standards.

The HV and MV bushing current transformers will have extended current rating of 1.2 times their rated current.

Complete test protocols for the above bushing current transformers shall be available at the time of inspection of the transformers.

Contractor shall verify the burden ratings of the built-in CTs after submission of respective calculation report.

3.7.6 Cable / busduct box

On the group of bushings of each secondary winding a cover box, with IP44 protection, shall be foreseen. The box shall cover the termination kits of the busducts on the phase bushings and the cable on the neutral bushing.

Inspection hole with transparent material shall be foreseen at opposite sides of the box

3.8 Oil-to-Cable Bushings

The HV terminals of the transformer shall be manufactured to accommodate the assembly of male and female terminations of HV single pole XLPE insulated cable (see attached schemes and data sheets)

The manufacturer of the terminations shall be Phisterer Germany or TYCO Germany. Type test certificates shall be submitted

3.9 Transformer oil

The transformer insulating oil will be mineral suitable for transformers and in accordance with the latest edition of IEC60296 Standard. It shall be non-toxic and biodegradable without PCB's, PCTs and corrosive sulphur. The only allowed inhibitors are DBPC and DBP with content within 0.30% - 0.40% in weight. The lowest cold start energizing temperature (LCSET) of the oil shall not exceed -30°C.

Under no circumstances forced oil circulation will create a static electrification hazard in any part of transformer.

The conductors of all windings, as well as all connecting conductors in the tank, will be insulated by thermally upgraded paper (TUP), made by 100% sulphate wood pulp, manufactured and tested according to IEC 60641 series of standards. According to IEC 60076-2, paper is considered as thermally upgraded, if it retains 50% of its original tensile strength after remaining 65000 hours in a sealed tube with mineral oil at 110oC. The paper will contain 1%-4% of organic nitrogen, measured according to ASTM D982.

According to IEC 60076-2, paper is considered as thermally upgraded, if it retains 50% of its original tensile strength after remaining 65000 hours in a sealed tub with mineral oil at 110°C. The paper will contain 1% - 4% of organic nitrogen, measured according to ASTM D982.

Material Safety Data Sheet (MSDS) will be submitted at bid stage for review.

3.10 Cooling system with fans

The cooling system of the transformer will be of Oil Forced - Air Forced type (OFAF).

The transformer shall be equipped with adequate cooling units with one of them to be on standby. The specific number of cooling units shall be calculated by a relevant study of adequacy of the cooling system provided by the manufacturer.

Each cooling unit will be a complete assembled set ready for installation. Each cooling unit shall include radiators, fans and oil circulating pump. All cooling units shall be identical, with the same pump, fans and cooling capacity.

The necessary structures for supporting the radiators, fans, etc. and all connections between the various parts shall also be furnished together with the transformer.

The fans shall be mounted under radiators or on the side of them. The fans shall be designed and tested following EN 50216-1 and EN 50216-12 standards.

The test certificates shall be presented to Owner's and/or IPTO inspectors.

With N-1 cooling units in service, the loss of one unit will not result in changing the transformer's capability to carry its full rated load (340 MVA) and without exceeding the allowable temperature rise limits.

With two (2) cooler units out of service, the transformer shall be able to carry 80% of its full rated load.

Each cooling unit shall include a fixed number of radiators, which will consist of a specific number of elements with specific dimensions, and they will be equipped with air release and a drain valves.

The cooling unit shall include certain number of fans with specific dimensions, mounted below the radiators or on the side of them and will be of sufficient rating for OFAF operation.

For the selection of "automatic or manual" operation of cooling system, a selector switch will be available to permit the automatic or manual operation.

Furthermore, each cooling unit will be equipped with an oil circulating pump of suitable rating for the OFAF operation. The unit must be provided with an oil flow indicator and shut-off valves on top and bottom, so as to make possible the complete isolation of the particular cooler branch, while the transformer is under load. The pumps shall be designed and tested following EN 50216-1 and EN 50216-7 standards.

The test certificates shall be presented to Owner's and/or IPTO inspectors.

The start - up or shutdown of any pump must not cause malfunction of any gas or oil actuated protection device. The oil pumps must have valves at both sides to enable the easy replacement in case of damage.

The replacement or maintenance of the oil pumps should be done without to be necessary to remove the coolers.

The cooling system of each transformer should be divided into two (2) groups for control purposes. Relay control will be provided to start automatically the first group of cooling units as soon as the transformer is energized (first control group).

During the automatic operation and while the first control group is continuously actuated, if the temperature of windings exceeds a predetermined value, a command will be given via the contacts of the series winding temperature indicator and via relays for the automatic energizing of the second control group.

The standby cooling unit will be not included on either control group. It will be started automatically, if there is a fault on any operating cooling unit.

AII the fan and pump motors will be of the squirrel - cage type, three phase 400V AC, of the enclosed design. A voltage and phase sequence monitoring relay will be included in the control cabinet, which will prevent motor operation in case of not suitable voltage supply.

The relay will provide fault signaling by a voltage free contact, suitable for 220V DC, O.5A.

The control voltage of the cooling system will be 230V AC.

AII necessary automatic operation equipment for the fan's operation must be assembled in a metal cabinet with IP55 protection class located on to the transformer.

The control voltage will be 230V AC. The signaling will be realized by voltage-free contacts. The grounding (earthing) of the air fans motors will be done locally and not through the transformer control panel.

Alternatively, the operation of the cooling system with natural circulation or a combination of natural and forced circulation (ONAN or ONAF operation) is permitted for no load and up to a percentage of loading that will be selected by the manufacturer. In any case and as long as the alternative mode of operation of the cooling system is chosen, the manufacturer must provide a relevant study of the adequacy of the cooling system and, in addition, perform the temperature rise test for all modes of operation of the cooling system at the respective maximum loads (ONAN and ONAF).

3.11 Instruments - Relays and transformer protection devices

3.11.1 Buchholz relay

An earthquake proof Buchholz relay of **EMB make** must beprovided and be mounted in the pipe connecting the conservator to the transformer tank. In addition, a bypass pipe of the relay will be installed, in order to facilitate the exchange of the relay with the transformer in operation. The relay shall be designed and tested following EN 50216-1 and EN 50216-2 standards.

The test certificates shall be presented to Owner's and/or IPTO inspectors. Isolating valves will be installed before and after the relay. This relay will be of the double float type with two sets of signaling contacts one for alarm and one for trip.

The relay is full of oil under normal conditions and due to the buoyancy its two float elements will be at the upper level. When a slight or incipient fault occurs inside the transformer, (e.g., local overheating, a small quantity of oil leakage etc), bubbles of gas will be created and trapped in the relay housing, causing its oil level to fall and simultaneously the above situated element to move, resulting in the closing of the alarm contacts.

In case that a serious fault occurs in the transformer (e.g., o leakage of large quantity of oil, short circuits, puncture of bushings), the gas generation will be violent causing a surge of oil inside the relay which will result in the movement of the second float element and the closing of the trip contacts.

The above-mentioned contacts will be suitable for 220V D.C. voltage.

The trapped gas in the Buchholz relay will be possible to be reclaimed through o gas collection device, which will be installed on the transformer at o person's height and will be connected permanently with the relay through a hose.

By-pass pipe with isolation valves will be provided to allow replacement of Buchholz with simultaneous operation of the TF with Buchholz device temporarily removed for maintenance purposes.

3.11.2 Oil Temperature Indicator

Each transformer will be provided with an oil temperature indicator measuring the transformer oil temperature at its hottest part. The indicator shall be designed and tested following EN 50216-1 and EN 50216-11 standards.

The test certificates shall be presented to Owner's and/or IPTO inspectors.

The thermometer bulb is enclosed in o pocket fixed on the tank at the hottest oil region. The connection between the thermometer bulb and dial indicator is made by o flexible

steel capillary tube.

The measurement will be taken via a driving motion operated by the expansion of the fluid inside the bulb and afterwards through the capillary tube will be transferred to the dial pointer.

Moreover, for the transformer oil temperature indicator o telemetering function will be provided for the tele transmission of the measurement from the transformer to the substation's automation control system, by mounting inside the instrument o tele transmitter with transducer of analogue output current 4- 20mA.

Two (2) changeover or N.O. contacts are required to be available, one (1) for alarm and one (1) for trip, suitable for 220V D.C. voltage.

The oil temperature indicator should be of **QUALITROL make, type AKM-OTI, or MR make, type Messko-BeTech.**

3.11.3 Winding Temperature Indicator

The transformer winding temperature indicator will be functionally similar with the Oil Temperature Indicator having in addition only the heating element which is a "thermal replica" of the transformer winding. This element will be connected to a Current Transformer via a matching resistance unit suitably calibrated to measure the current through the transformer winding. In this way, the thermal load and consequently the temperature of the winding will be measured indirectly. The indicator shall be designed and tested following EN 50216-1 and EN 50216-11 standards.

The test certificates shall be presented to Owner's and/or IPTO inspectors.

For the tele transmission of the winding temperature indication from the transformer to the substation's automation control system, the instrument will include o tele transmitter which can be connected with o transducer of analogue output current 4-20mA.

Referring to the electrical contacts, two (2) changeover or N.O. contacts are required at least, one (1) for alarm and one (1) for trip. In addition, for the automatic energization of the transformer fans one (1) changeover or N.O. contact is required.

All contacts will be suitable for 220V D.C. voltage.

The winding temperature indicator should be of **QUALITROL make, type AKM-WTI, or MR make, type Messko-BeTech.**

3.11.4 Oil Flow Indicator

Each cooling unit of the transformer oil forced cooling system will be equipped with an oil flow indicator showing the oil flow in the connecting pipe of each oil circulation pump of the cooling system. The oil flow indicators shall be designed and tested following EN 50216-1 and EN 50216-5 standards.

The test certificates shall be presented to Owner's and/or IPTO inspectors.

One (1) make contact is required for alarm when the oil flow drops below o predetermined percentage value of the full flow.

The contact will be suitable for 220V DC (- 0.5 **A)** voltage.

3.11.5 Shutter – Valve

The transformer will be equipped with o shutter-valve.

The shutter-valve will be mounted in the pipe between conservator and Buchholz relay, checking the flow of the oil from the conservator to transformer tank.

One normally open (NO) contact is required, suitable for 220V D.C.

3.11.6 Oil level indicator

The transformer will be provided with magnetic oil level indicator. The indicator shall be designed and tested following EN 50216-1 and EN 50216-5 standards.

The test certificates shall be presented to Owner's and IPTO inspectors. The indicator will be mounted on the outdoor surface of the conservator having a float located inside the conservator oil. The oil level will order the float movement which by a drive shaft will cause the movement of a pointer in the dial.

One (1) normally open contact will be provided for annunciating o lovv oil level alarm, suitable for 220 V D.C. (- O.5A) voltage.

3.12 Pressu re relief device

Each transformer will be equipped with one at least pressure relief device **QUALITROL make, type XPRD, or MR make, type Messko-LMPRD oil-directed.** The device will be mounted horizontally or vertically on the transformer tank and will operate by o spring mechanism automatically. The mechanism will hold pressed a stainless-steel diaphragm, with one side of which to be exposed to transformer tank pressure. In case of internal over-pressures caused by internal failures, the diaphragm will open and regain its position as soon as the pressure in the tank drops below a set limit. There will also be capability for manual check of the device operation. The device will include a metallic cover with a drain, to convey the oil safely to the ground. The device shall be designed and tested following EN 50216-1 and EN 50216-5 standards.

The test certificates shall be presented to Owner's and/or IPTO inspectors.

For the annunciation of its operation, the pressure relief device will be provided with two (2) N.O. alarm contacts suitable for 220V D.C. voltage.

3.13 Rapid pressure rise relay

The transformer will be provided with a rapid pressure rise relay of QUALITROL make, type 900, detecting the excessive gas pressures caused by internal arcing in the transformer tank. The available trip contacts will not be actuated by normal pressure variations caused by temperature change or other mechanical shock on the transformer body.

3.14 Valves

Each transformer will be equipped with the necessary quantity of valves e.g., for draining the tank, sampling oil, isolating each radiator. Two oil filling valves diagonally situated shall be provided on the transformer cover. Oil filtering valve and vacuum connection valve shall be provided too. The radiator valves shall be designed and

tested following EN 50216-1 and EN 50216-8 standards.

The test certificates shall be presented to Owner's and/or IPTO inspectors.

3.15 Gaskets

Gasketed joints for bushings, manholes and radiators shall be designed so that the gasket will not be exposed to the weather and shall be provided with mechanical stops to prevent crushing of gasket.

3.16 Connecting material

All connecting material that is bolts, nuts and lock washers must be hot dip galvanized.

3.17 Wiring - conductors

All windings' conductors, joints and other connections shall be made of electrolytic copper. All small wire connections from alarm contacts, temperature indicating coils, current transformers, control and other devices, shall be brought to terminal blocks in the fans control cabinet from which control cables to the control room are be connected.

All wiring shall be color coded, moisture resistant wire in galvanized steel conduit.

All terminals shall be suitably identified. Fans control cabinet shall be provided with heat resistance controlled by suitable thermostat.

All L.V. circuits shall be tested with 2kV RMS voltage for 1 min.

3.18 Auxiliary power supply

Available aux. A.C. power supply: three phase voltage 230/400V 50Hz.
Available aux. D.C. power supply: 220V.

3.19 Transformer's condition monitoring system

The transformers condition monitoring system shall supervise the power transformer.

The state-of-the-art transformer on-line condition monitoring system shall be implemented to show the momentary condition of the power transformer, its cooling oil composition as well as long term trends.

The transformer on-line condition monitoring system may consist of sub-systems for specific monitoring tasks and shall comprise at least the following main functions:

- Gas-in-oil by monitoring dissolved hydrocarbon gases in oil.
- Moisture in oil monitoring system.
- OLTC monitoring & diagnostic system.
- Oil, winding and ambient temperature monitoring.
- Cooling system monitoring.
- Load current and voltage.

The following common requirements shall apply to the transformer monitoring system and any sub-systems:

- Monitoring system and its sub-systems shall provide embedded trend analysis and

alarm algorithms. Algorithms shall be based on IEC and IEEE standards that are well accepted in the industry.

- Windows based application software for system configuration and data analysis, permanent data storage, data-interface to the MS-Office world.
- Monitoring system and sub-systems are to be provided with all necessary accessories including the cabling and wiring for the installation and commissioning on-site.
- Monitoring system and sub-systems with complete documentation of hard-ware and software and guidelines for installation, commissioning, operation and maintenance.

An operator station installed inside the control room shall be provided for the implementation of the system or it may be included in the SCADA system which is going to be implemented for monitoring and controlling purposes of the whole substation.

The Contractor will provide three (3) days training for the system. Two days will be devoted to the maintenance of on-site devices, troubleshooting, and basic failures rectification at least as those described in the operation and maintenance manual. One day will be dedicated to software operation in PPC's offices in Greece and especially on software features and troubleshooting of software issues and basic configuration of the system. The training for the system will be performed by technical personnel of the manufacturer. If according to the Contractor's experience or established training practice, additional training is recommended, this should be clearly mentioned in the offer.

The transformer shall be equipped with a continuous conditional monitoring subsystem of Qualitrol QTMS indicative type which shall include at least:

1. A DGA (dissolved gas analysis) module of indicative type Qualitrol Serveron TM8 which will detect and analyze continuously the composite value of eight (8) gases, in the transformer oil, as of the following table:

Seven gases and water content		Fault conditions
H2	Hydrogen	Partial discharge, thermal faults, power discharges, galvanized parts, stainless steel, sunlight by Monitoring H2
CH4	Methane	Low & medium temperature thermal faults by monitoring CH4
C2H2	Acetylene	Hot spot, low-energy discharge, high energy discharge (arc) by monitoring C2H2
C2 H4	Ethylene	Oil overheating > 500°C
C2 H6	Ethane	Iovv & medium temperature thermal faults, local over heating by monitoring C2H6
CO	Carbon Monoxide	Thermal fault involving cellulose, slowly from oil oxidation by monitoring CO
CO2	Carbon Dioxide	Normal aging, thermal fault involving cellulose by monitoring CO2

H2O	Moisture	Cellulose Aging - Leaks into oil

2. Capacitive sensor to continuously monitor the moisture of the transformer oil.
3. Bushing monitoring via bushing sensors for the measurement of dissipation factor (tanδ), capacitance, temperature, leakage current.
4. Direct Temperature monitoring of MV&HV windings, preferably via sensors appropriate for signal transmission through fiber optics.
5. Partial Discharges monitoring via measurement of Partial Discharges through UHF sensors adhered to the transformer tank.
6. AII necessary sensors so as the system shall be capable to calculate at least the following data:
   - calculated hot-spot temperature
   - cooling system efficiency
   - cooling system (fans/pumps) status, operating time for all stages
   - Buchholz relay operation
   - Transformer load (power)
   - moisture in insulation paper
   - bubbling temperature
   - ageing rate
   - lifetime consumption
   - long-time overloading level
   - short-time overloading levels / times

The system's central unit should transfer the measured values to the Transformers' condition monitoring system or to the local Scada system.

The system will be housed on a separate cabinet, installed on the TF body or as standalone freestanding ground mounted cubicle beside the TF or at the same cabinet as the DGA.

The system will import the position of On-Load Tap Changer (OLTC), using o suitable transducer, supplied by the Contractor. It must indicate the current and previous position of OLTC along with the number of operations. Additionally, it will include measurement of the OLTC motor current, using a CT, and of the OLTC motor voltage, so that the motor power is calculated, and the power absorption curve will be presented on the Human-Machine Interface (HMI). The system must detect any anomalies regarding the operation of the OLTC related to mechanical wear through the increased power absorption or variations of operating time. Alternatively, or additionally the system will directly measure and monitor the torque on the transmission shaft from MDU to OLTC gearhead. The system will also calculate the cumulative switched current and monitor the possible overheating of the OLTC. It will use an expert algorithm to assess the used and remaining contact life of the OLTC and estimate the remaining operations until the next service or contact replacement based on wear contact models by the OLTC's manufacturer. It is desirable to incorporate also a vibroacoustic sensor and the relative frequency analysis algorithms for enhanced wear or malfunction detection sensitivity.

The system will have adequate storage capability for archiving the measured data. It will communicate remotely through an Ethernet port and locally through o serial port (preferably USB).

Monitoring systems not mentioned above must fulfill or exceed the above specifications and PPC will examine those for acceptance on technical equivalency

basis.

Other devices are allowed only if their performance in terms of accuracy, stability and analytical capabilities are equivalent or exceeding of the above-mentioned device.
After installation and on-site calibration, if required by the DGA measurement technology, the readings of DGA and moisture sensors will be checked against the analysis of oil samples performed at an accredited insulating oil chemistry laboratory.

The monitoring system and its modules shall be fully wired and be in operation during Factory Acceptance Tests (FATs) for local monitoring.

The Contractor shall submit all wiring drawings, layout drawings, and detailed data sheets of the integrated condition monitoring system and of all its components to PPC for approval. After the commissioning, the Contractor shall provide the as-built drawings of the system. The Contractor shall provide detailed operation and maintenance manuals for all systems and devices. The manual of operation for the software of the system will describe all the functions in each page. Copies of as-built drawings and manuals will be given in editable electronic format (e.g. Autocad, Eplan, Word, Excel, etc.) and one (1) in hard copy.

The Contractor shall provide guarantee of at least two (2) years for all systems, components and software procured and installed. During this period, the Contractor is responsible to keep all the necessary spare parts and personnel available to solve any issues of the system at his own cost.

The Contractor will restore any corrosion protection (painting, galvanizing, etc.) damaged during the installation works.

3.20 Painting requirements for the transformer

The transformer including coolers shall be painted externally with RAL 7040 gray color. The paint system will be suitable for high atmospheric corrosivity (category C4) and it will be of high durability (category H), according to ISO 12944-1, -2, -5 standards. The paint system will include a Zinc-rich primer coat of thickness 60μm and 3 - 4 epoxy or polyurethane paint coats of total thickness 240μm, where the finishing coat will be of polyurethane paint. The transformer shall be painted internally with a white colored oil resistant primer coat of minimum thickness 40μm.

The upper part of the transformer tank will be treated with anti-slip or antiskid paint enriched with aggregates.

3.21 Transportation requirements

The transformers, for transportation purposes, shall be filled with insulating oil and Nitrogen (N_2). It shall be installed also a nitrogen bottle with a pressure monitoring gauge to recover any nitrogen leakage and check the status of pressure during transportation.

The transformer shall be designed and manufactured in order to withstand a constant acceleration of at least 1g in all directions, additionally to gravity, without any damage. The manufacturer should also state the acceleration limits which according to his design are considered to be potentially harmful to the mechanical and electrical integrity of the transformer.

3.22 Short circuit withstand capability

The transformer shall be capable of withstanding under service conditions for 2 (two) seconds, on any tap-setting, short circuit at the terminals of any winding without being damaged due to excessive forces or thermal effects. The thermal ability of the transformer to withstand short circuit shall be demonstrated by calculation, in accordance with IEC 60076-5. The dynamic ability of the transformers to withstand short circuit shall be demonstrated by calculation or by the performance of a special test, in accordance with IEC 60076-5. For the above calculations and the test, the network short circuit levels and Z0/Z+ ratio ranges will be taken into account. The fault will be fed simultaneously from both 30kV and 400kV networks. The following short circuit cases will be taken into account, following IEC 60076-8:

- Three-phase faults at HV, MV terminals (3 cases)
- Single-phase to earth faults at HV or MV terminal (2 cases) - Two-phase to earth faults at HV or MV terminals (2 cases)

3.23 Direct winding hot-spot temperature measurement system

The transformer shall be equipped with a multi-channel fiber optic system of QUALITROL manufacture or equivalent for hot-spot temperature measurement of all windings. The system will include a temperature monitor of type T/Guard 405, as well as fiber optic connected GaAs temperature sensors of type Neoptix T2. According to Annex E of IEC 60076-2, eleven (11) sensors will be embodied in the transformer windings, as follows:

- HV/LV windings – two (2) sensors on central limp and one (1) on each lateral
- Two (2) sensors on core

The GaAs sensors will be installed at the locations of each winding, where the hottest spots are expected to occur. The optical fibers will be terminated at a junction box, located on the transformer tank. An optical cable will connect the junction box with the temperature monitor, which will be also located on the transformer tank. Because of the fragility of the optical fibers, their installation in the windings shall strictly follow the guidance of their manufacturer. The temperature monitor will provide an analogue output of 4-20mA per each temperature sensor for transmission of measurements to the substation’s automation control system.

4. TESTS AND INSPECTION

The tests will be carried out in accordance with the IEC Publication 60076 Standards, unless otherwise specified below. Any limitations regarding testing procedures (e.g test voltage, lightning impulse waveform, etc) should be declared by the relevant Contractor.

Type or special tests which have been carried out to prove the quality of components such as bushings etc. shall be supported by a Certificate to the customer's approval, giving the description, location, date and results of the tests carried out at an approved independent testing authority or witnessed by the representative of an approved independent testing authority.

The tests which will be carried out on the material and equipment shall be attended by Owner's and/or the consultant representatives.

A specific notification period, including essential information about the test and the test shop procedure shall be quoted prior commencement of the tests.

The Contractor shall submit to Owner certified copies of the tests, data and results.

Material, mechanical, hydraulic and electrical tests carried out during manufacture shall be in accordance with the applicable test procedure submitted by the Contractor to Owner to get the approval.

The Contractor shall describe the tests and the equipment to be tested in detail.

Before filling the transformer, before and after acceptance testing, samples of oil shall be taken from the transformer and analyzed for dissolved gases using the procedures specified in IEC Publication 60567 and 60599, water content, voltage dielectric withstand and tanδ.

Results of the above-mentioned tests in the oil shall be included in the Acceptance Test Report.

All tests may be witnessed by the Owner and/or consultant representatives.

All the routine, type and special tests mentioned in the IEC 60076-1 shall be performed during the witnessed Factory Acceptance Tests.

The manufacturer shall demonstrate with calculations the short circuit withstand capability of the transformer according to IEC 60076-5 based also on previous tested transformers.

Tests other than temperature rise tests shall be made at an external cooling medium temperature between 10°C and 40°C. See IEC 60076-2 for temperature rise tests.

The test basis for all characteristics other than insulation is the rated condition, unless the test clause states otherwise.

All measuring systems used for the tests shall have certified, traceable accuracy and be subjected to periodic calibration, according to the rules given in ISO 9001.

Specific requirements on the accuracy and verification of the measuring systems are

described in IEC 60060 series and IEC 60076-8.

Where it is required that test results are to be corrected to a reference temperature, this shall be:

o) for dry-type transformers, the reference temperature shall be according to the general requirements for tests in IEC 60076-11;

b) for liquid-immersed transformers with rated average winding temperature rise less than or equal to 65 K for OF or ON, or 70 K for OD;

- reference temperature is 75°C;
- on request by the customer, reference temperature is rated average winding

  temperature rise + 20°C, or rated average winding temperature rise + yearly external cooling medium average temperature, whichever is higher;

c) for liquid-immersed transformers with other rated average winding temperature rise, the reference temperature is equal to rated average winding temperature rise + 20°C or rated average winding temperature rise + yearly external cooling medium average temperature, whichever is higher.

4.1 Routine tests

It is desirable that the accumulative uncertainty in no-load and lood losses measurement is calculated by the manufacturer, following IEC 60076-19 or EN 50462, prior to the execution of the relevant measurements (par. 1.1, 1.3, 1.4).

4.1.1 Measurement of winding resistance

4.1.2 Check of voltage ratio and check of phase displacement

4.1.3 Measurement of short circuit impedance and lood losses

4.1.4 Measurement of no-load losses and current

Note: In deciding the place of the no-load test in the complete test sequence, it should be borne in mind that no-load loss measurements performed before impulse tests and/or resistance measurements are, in general, representative of the average loss level over long time in service, assuming, that the core is not pre-magnetized.
That means, if no-load tests are carried out after resistance measurements and/or lightning impulse tests, the core of the transformer should be demagnetized by overexcitation before the no-load test is carried out.

4.1.5 Measurement of capacitances windings-to-earth and between windings

Measurement of cap (C1,C2) and tanδ of all bushings.

4.1.6 Measurement of the d.c. insulation resistance between each winding to earth and between windings

The measurements shall be carried out for the following connections and for the

following time periods (15 sec, 30 sec, 45 sec, 60 sec and 600 sec, PI*).

a. HV - (LV + earth)
b. LV - (HV + earth)
c. (HV+LV) - earth
d. HV - LV

The test voltage (DC) for HV side shall be 5kV, unless other values specified by manufacturer.
The test voltage (DC) for LV side shall be 2.5kV, unless other values specified by manufacturer.

(*) PI: Polarization Index - PI=600.Sec/60.Sec

POLARIZATION INDEX GUIDE FOR EVALUATION OF TRANSFORMER CONDITION	
Condition	Polarization Index (PI)
Dangerous	Less than 1.0
Poor	1.0 to 1.1
Questionable	1.1 to 1.25
Fair	1.25 to 2.0
Good	Above 2.0

4.1.7 Measurement of capacitance and dissipation factor

The measurement shall be carried out for the following connections:

a. (HV)-(MV+tank) earthed
b. HV-MV with tank only earthed
c. (HV+MV)-tank earthed
d. HV-MV

The test voltage shall be 10kV, tanδ≤ 0.5%.

4.1.8 Leak testing with pressure for liquid-immersed transformers (tightness test)

4.1.9 Tightness tests and pressure tests for tanks for gas-filled transformers (refer to 60076-15).

4.1.10 Check of the ratio and polarity of built-in current transformers

4.1.11 Check of core and frame insulation for liquid immersed transformers with core or frame insulation

4.1.12 Measurement of dissolved gasses in dielectric liquid from each separate oil compartment except diverter switch compartment before FAT, before dielectric tests, after FAT.

4.1.13 Visual inspection and dimensional check.

4.1.14 Functional tests of all installed equipment (Bucholz relay, Tap changer protection device, oil level gauge, oil temperature thermometer, winding temperature thermometer, cooling system sensors and devices, pressure relief device, OLTC pressure relief device, DGA unit and Insulation test)

4.1.15 Dielectric routine tests (acc. to IEC 60076-3)

Test sequence

The tests shall be performed in the sequence given below:

a) lightning impulse tests (LI, LIC, LIN, LIMT);
b) switching impulse (SI);
c) applied voltage test (AV);
d) line terminal AC withstand test (LTAC);
e) induced voltage withstand test (IVW);
f) induced voltage test with partial discharge measurement (IVPD).

The above tests are applicable according to Table 1, IEC 60076-3.

4.1.15.1 Chopped wave lightning impulse test for the lineterminals (LIC)
4.1.15.2 Switching impulse test for the line terminal (SI)
4.1.15.3 Applied voltage test (AV)
4.1.15.4 lnduced voltage test with PD measurement (IVPD)
4.1.15.5 Auxiliary wiring insulation test (AuxW)

4.1.16 Tests on on-load tap-changers

With the tap-changer fully assembled on the transformer, the following sequence of operations shall be performed without failure:
a) with the transformer de-energized, eight complete cycles of operation (a cycle of operation goes from one end of the tapping range to the other, and back again).
b) with the transformer de-energized, and with the auxiliary voltage reduced to 85 % of its rated value, one complete cycle of operation.
c) with the transformer energized at rated voltage and frequency at no load, one complete cycle of operation.
d) with one winding short-circuited and, as far as practicable, rated current in the tapped winding, 10 cycles of tap-change operations across the range of two steps on each side from where a coarse or reversing changeover selector operates, or otherwise from the middle tapping (the tap changer will pass 20 times through the changeover position).

4.1.17 Calculation of peak efficiency index (PEI) and corresponding load factor

4.1.18 Measurement of frequency response (Frequency Response Analysis or FRA)

A frequency response measurement will be executed on each transformer after all routine and special tests and prior to shipment, following IEC 60076-18. Device electronic output files to be provided after test. Model of testing device to be defined during detail design.

- SFRA on all windings (OLTC positions 1-9-17)
- DFRA and calculation of moisture in paper (limit 1% w/w)
- Check of painting thickness and adhesion (cross-cut or X-cut test metho

4.2 Type tests

4.2.1 Temperature rise test

The test will be carried out in accordance with the IEC-60076-2 Standard.

The temperature rise test will be carried out before the dielectric routine tests.

4.2.2 Determination of sound level (IEC 60076-10) for each method of cooling for which a guaranteed sound level is specified.

4.2.3 Measurement of the power taken by the fan and liquid pump motors, if any.

4.2.4 Measurement of no-load loss and current at 90%, 100% and 110% of rated voltage, including measurement of harmonics.

4.3 Special tests

The special tests shall be carried out on **one (1) only piece of the order.**

4.3.1 Dielectric special tests (IEC 60076-3)

4.3.1.1 Line terminal AC withstand voltage test (LTAC)

4.3.1.2 Lightning impulse test on the neutral terminal (LIN)

4.3.2 Measurement of zero-sequence impedance

4.3.3 Vacuum deflection test on liquid immersed transformers

4.3.4 Pressure deflection test on liquid immersed transformers

4.3.5 Vacuum tightness test on liquid immersed transformers

4.3.6 Check of external coating (ISO 2178 and ISO 240 or as specified)

4.3.7 Measurements of harmonics of the no-load current

The measurement of the harmonics of the no-load current will be performed for the three (3) phases of the transformer and the magnitude of the harmonics will be stated as o percentage of the fundamental component.

4.3.8 Short-circuit withstand test (IEC 60076-5)

4.3.9 Insulating oil tests

The following tests will be performed on oil sample from the transformer tank and the mentioned acceptance levels will apply:

1. Breakdown voltage (BDV) following IEC 60156, with value ≥ 70kV
2. Dielectric dissipation factor (DDF) following IEC 60247 or IEC 61620, with value ≤ 0.005
3. Water content following IEC 60814, with value ≤ 40 mg/kg
4. Interfacial tension (IFT) following EN 14210 or ASTM D971, with value ≥ 40mN/m
5. Particle content following IEC 60970, with value ≤ 1000parts/100ml with size p > 5μm and value≤130parts/100ml with size p > 15μm.

5. SPARE PARTS

Spare parts for each transformer, to be provided as per following tables:

	Commissioning spare parts	
i/n	**Description**	**Quantity**
1	Paint	**21t**
2	Complete set of gaskets	1 set
3	Silica gel	1 filling

	Spare Parts	
i/n	**Description**	**Quantity**
1	Paint	21t
2	Silica gel	2 fillings
3	H.V. bushing complete (male & female)	1 piece
4	L.V. bushing complete	2 piece
5	Neutral bushing complete	1 piece
6	Complete set of gaskets for all bushings, covers, radiator flanges, manholes and handholes for one transformer.	1 set
7	Set of replacement parts for each type of part likely to be damaged upon operation of the relays contactors instruments safety devices etc. Indicatively, the provided parts should be as following: Buchholz relay, oil temperature indicator, winding temperature indicator, pressure relief device, oil level indicator, tap changer protection device, tap changer pressure relief device.	1 piece for each type
8	Tvvo sets of replacement parts of the O.L.T.C. likely to be damaged during operation. (complete set of contacts for the diverter switch)	2 sets
9	Motor drive unit for OLTC	1 piece
10	Cooling fan and motor set	1 piece and 1 set
11	Cooling pump and motor set	1 piece and 1 set
12	Radiator including necessary valves	1 piece
13	TMS recommended spare parts	1 set

6. TRANSFORMER MOVEMENT SYSTEM

Transformers shall be provided with wheels which will permit the movement of the completely filled transformer either in longitudinal or transverse direction. The wheels will run on rails and be able to rotate 90°.

Two shock recorders will be provided and installed on each transformer tank by the manufacturer. The shock recorders will be of digital type and they will include GPS and time tagging of the recordings. They will be of type SMT HYBRID – MONILOG ENDAL or SHOCKWATCH – SHOCK LOG 298 or MESSKO – CARGOLOG or of an equivalent type, subject to IPTO's approval.

The alarm limit of shock recorders will be set below 1g acceleration.

7. PACKING - TRANSPORTATION

The transformer accessories must be packed inside robust, entirely closed wooden boxes of at least 20mm thickness and maximum gross weight of five (5) tons.

The boxes will be of pallet type, and they will be protected internally by an insulating material (e.g. nylon).

The above requirement does not include the bushings of the transformer which must be packed separately, one bushing per one wooden box.

The voltage regulator and its accessories will be supplied in a separate box, suitable for indoor storage.

AII the attached items such as tap-changer, radiator valves, welded piping, etc. shall be protected against damage during transport. AII the removed items shall be packed separately in strong non-returnable cases or crates to protect them against damage by water, transport and outdoor storage. The sides and top of each case shall be clearly marked with the markings and shall be accompanied by a detailed packing note in English. In case of transportation with nitrogen, it shall be installed also a nitrogen bottle with pressure monitoring gauge in order to recover any nitrogen leakage and check the status of pressure during transportation.

Suitable hard-wood or similar supports to raise the base plate of the tank clear of the foundation by 150 mm shall be supplied and installed.

The principal center lines shall be marked on the base plate on each side of the main tank.

For each shipment Iot of transformers, at least one certified shock recorder/impact recorders/accelerometers will be provided and installed by the manufacturer on the transformer tank to monitor the transportation of each transformer. The paper or the memory of recorder shall be capable for at least 120 days of recording (or higher based on the transportation duration).

Prior to delivery, the test results shall have been approved and packaging agreed.

The shock recorders will be of digital type, and they will include GPS and time tagging of the recordings. They will be of type SMT HYBRID - MONILOG ENDAL or SHOCKWATCH - SHOCK LOG 298 or MESSKO - CARGOLOG or of an equivalent type, subject to Owner's and/or IPTO's approval.

8. SUBMITTALS

At least the following documents shall be submitted for approval after contract signing.

1. Schedule for design, construction, and shipment.
2. Progress report.
3. Manufacturing and Quality control plan (QCP) incorporating quality assurance (QA) and inspection and test plan (ITP).
4. Spare Parts List
5. Detailed drawings showing outline and weights of transformer, oil conservator and position of important external features and devices.
6. 3-d transformer layout.
7. Complete civil guide drawings and foundation requirements.
8. Over excitation curves for no load and full load.
9. Diagram showing arrangement of core and windings.
10. Transportation drawing.
11. Painting specification including full description of surface preparation and protective treatment against corrosion of main tank, accessories and coolers and final paint color.
12. Auxiliary equipment list with drawings and leaflets.
13. Bushings datasheets and calculations of sizing.
14. Maximum withstand force at the bushings HV connection terminals during normal (static) conditions (Kn). Maximum withstand force at the bushings HV connection terminals during fault (short circuit) conditions (Kn).
15. Control panel schematics including interface with OLTC.
16. OLTC control panel schematics (manufacturer drawings)
17. Set points and calibration data for all devices, sensors, counters and instruments that are supplied with the transformer. The information can be alternatively incorporated in the control panel schematics.
18. Name plate drawings.
19. Valve plate drawings.
20. Fan motors curves.
21. Thermal withstand curve.
22. Inrush current curve.
23. Temperature rise calculations (oil, winding and hot spot).
24. Thermal and dynamic short circuit calculations.
25. Static or dynamic calculations demonstrating the seismic capacity of the transformer and their associated equipment.
26. Noise calculation.
27. Loss of life calculation.

28. Current transformers characteristic curves showing open circuit secondary saturation, ratio and phase angle correction and secondary resistance.
29. Electrical load list (stand by and running consumption of circuits).
30. Transformer's condition monitoring system technical documentation according to par. 3.18.
31. Operating pressure of all pressure relief devices (main tank and OLTC).
32. Physical and chemical characteristics of the inhibited insulating transformer oil, as specified in IEC 60296, including inhibitor content (DBPC or DBP), measured according to IEC 60666.
33. Physical and chemical characteristics of thermally upgraded paper (TUP), including organic nitrogen content, measured according to ASTM D982.
34. Final Datasheets
35. AII technical specifications as per Attachment 'A" (all fields to be filled in)
36. Detailed packing list.
37. Transportation instructions.
38. FAT detailed procedure and schedule.
39. FAT reports.
40. Transformer Auxiliaries and raw materials routine tests reports (provided by subcontractors)
41. SAT detailed procedures and schedule.
42. As-built drawings.
43. Erection and Commissioning Manual (including detailed list of required equipment for erection and commissioning, detailed procedure of erection of transformer and auxiliaries, detailed procedure of site testing.
44. Operation and Maintenance manuals (including specific inspection procedures to be used to monitor possible degradation conditions and written precautions and limitations for activities could cause severe injury to, or the death of the users, or serious damage to the environment and the equipment).
45. Quality dossier including quality assurance reports.

340/170/170MVA, 400/33/33 kV THREE-PHASE TRANSFORMER
ATTACHMENT "A"
INFORMATION BY SUPPLIER

1. Type of transformer (short description)

Nominal voltage :.....

Number of phases :.....

Rated power (IEC) :.....

Nom amp at HV winding :.....

Nom amp at MV winding :.....

Nom amp at tertiary winding :.....

2. Core type :.....

a. Flux density at rated voltages

(at no load and principal tap position) :.....

b. Number of core limbs :.....

3. Insulation levels :.....

4. Maximum permissible short circuit

duration :.....

5. Over-voltage capability

o) at no load :.....

b) at 340 MVA :.....

6. Long-time emergency overload capability

Maximum current at HV - MV terminals .....% of rated

7. Transformer vector configuration :.....

8. Insulation category of windings (uniform

or non-uniform) :.....
:.....

9. Temperature rise limits : .....K for windings
: ..... K for oil
: .....K for winding hot-spot

10. Thermal model constants
(calculated values following IEC 60076-7):

a. Top-oil to ambient temperature rise with losses (load + no-load) at rated loading of all windings - Δθor :.....K

b. Average winding to oil temperature gradient at rated current - gr :.....K

c. Hot-spot to top-oil temperature rise at rated current - $\Delta\theta_{hr}$:.....K

d. Hot-spot factor – H :.....

e. Exponential power of total losses versus top-oil temperature rise (oil exponent) - χ :.....

f. Exponential power of current versus winding temperature rise (winding exponent) - γ :.....

g. Average oil time constant - τo :.....min

h. Winding time constant - τw :.....min

i. Constant k_{11} :.....

j. Constant k_{21} :.....

k. Constant k_{22} :.....

11. Losses and PEI data

(The guaranteed losses shall be as indicated in paragraph 1.5.12)

11.1. No Load losses and exciting current at principal tap:

Voltage level	No load loss (kW)	Exciting current (% of rated current)
a) 380 kV	:.....	:.....
b) 400 kV	:.....	:.....
c) 420 kV	:.....	:.....

11.2. Load losses at principal tap 400kV and reference temperature 75°C:

Load MVA	Cu losses in kW	Total losses in kW
340		
255		
170		
85		

11.3. Load loss at principal tap and 75°C with 170 MVA on HV and MV1 side and no load on MV2 side..... kW

11.4. Load loss at principal tap and 75°C with 170 MVA on HV and MV2 side and no load on MV1 side ..... kW

11.5. Total losses at principal tap and 75°C with 340 MVA on HV - MV sides and 170 MVA on MV sides
(no-load + load loss) .....kW

11.6. Total cooling system loss
(all cooling units in operation,
excluding standby cooler) .....kW

11.7. Cooling system losses at T/F no-load operation .....kW

11.8. Efficiency Index (EI) at 400/33 kV (H.V./L.V.1, H.V./L.V.2) p.f.=1 p.f. = 0.85

At 170,000 kVA ……. …….
At 135,000 kVA ……. …….
At 70,000 kVA ……. …….
At 35,000 kVA ……. …….

Efficiency at rated Service conditions 400/33/33 kV (H.V./L.V.1/L.V.2) @75°C rated tap
At unity pf:
-At Sn % …….
-At0,75Sn% ……
-At 0,5 Sn % …….
-At 0,25 Sn % …….

At pf 0,85:

-At Sn % ……

-At0,75Sn% ……

-At 0,5 Sn % ……

-At 0,25 Sn % ……

11.10. Peak efficiency index (PEI) according EN 50629 :.....%

11.11. Load factor at HV - MV terminals

at which PEI occurs, at 340 MVA base :..... pu

12. Impedances in (%) at principal tap, at 100 MVA power and rated voltage, corrected to 75°C:

a) H.V. / M.V.1 :.....

b) H.V. / M.V.2 :.....

Impedance at 75°C

-At Sn % :.....

-At0,75Sn% :.....

-At 0,5 Sn % :.....

-At 0,25 Sn % :.....

On extreme upper tap

-At Sn % :.....

On extreme lower tap

-At Sn % :.....

12.1. Positive sequence impedances

a) HV / MV1 :.....

b) HV / MV2 :.....

c) MV1/ MV2 :.....

12.2. Zero- sequence impedances

a) HV (MV open-circuited) :.....
b) HV (MV short-circuited) :.....
c) MV (HV open-circuited) :.....
d) MV (HV short-circuited) :.....

13. Average sound pressure level
Transformer without cooling (no-load) dB(A)
With all coolers at rated power and voltage dB(A)
(excluding standby cooler)

14. Harmonics of no-load current for principal tap (400/33/33kV):
a. Third harmonic :.....% of no-load current
b. Fifth harmonic :.....% of no-load current
c. Seventh harmonic :.....% of no-load current

15. On - load tap changer (OLTC)

a. Manufacturer and type of the OLTC :.....
b. List all parts of the OLTC :.....
c. 1s the OLTC of vacuum switching type? :.....
d. Number of tapping positions :.....
e. Operating temperature

Minimum :.....

Maximum :.....

f. 1s the tap selector and the reversing change - over selector in their own not oil - tight compartment? :.....

g. 1s the diverter switch and the transition resistors in their own oil - tight compartment? :.....

h. 1s the OLTC equipped with its own conservator? :.....

i. 1s the oil of OLTC free from PCBs or PCTs, suitable for transformers and in accordance with IEC 60296? :.....

j. 1s the conservator equipped
with oil level indicator and breather? :.....

k. 1s the diverter switch and transition resistors compartment equipped with o filling and o drain tap? :.....

1. Does the OLTC consist of
o three - phase unit? :.....

m. 1s the OLTC equipped with its own
oil-flow relay? :.....
Describe where it is installed :.....
Type and manufacturer :.....

16. Tapping arrangement :.....

17. Position of regulating winding :.....

18. Maximum rated through current of OLTC : .....

19. Maximum rated step voltage of OLTC :.....

20. Rated frequency of OLTC :.....

21. Rated Voltage of OLTC :.....

22. Supply voltage for the control circuits
of the motor drive unit :.....

23. Rated power frequency withstand Voltage :.....

24. Rated lightning impulse withstand Voltage :.....

25. Describe the oil - flow controlled relay and where it is installed :.....

26. Number of make output contacts of the oil - flow controlled relay :.....

27. Describe the pressure relief device and where it is installed :.....

28. Number of make output contacts of the pressure relief device :.....

29. Time response of the pressure relief device :.....

30. Pressure or vacuum values for the diverter switch compartment and transition resistors :.....

31. Time response of the oil – flow controlled relay :.....

32. 1s the motor drive unit suitable for Local/Remote operation? :.....

33. 1s the motor drive unit equipped with emergency stop? :.....

34. Indicate installation position of the motor drive unit :.....

35. Supply voltage of the motor drive unit motor :.....

36. Frequency of the motor of the motor drive unit :.....

37. IP class protection of the motor drive unit panel :.....

38. 1s the motor drive control cabinet equipped with :

a. Local/Remote selector switch :.....

b. Three (3) Push - buttons for raising, lowering and emergency stop :.....

c. A device indicating tap position :.....

d. Tap counter :.....

e. Anti - condensation heaters controlled via thermostat :.....

f. Supply voltage of the anti - condensation heaters :.....

39. Can the motor drive unit be controlled remotely? :.....

40. Can tap position, number of operations and any alarms be displayed at o remote distance? :.....

41. Power frequency withstand voltage of the auxiliary circuits of the motor drive unit :.....

42. Warranty terms of OLTC :.....

43. Cooling system :.....

a) Type of cooling system :.....

b) Are the coolers separately mounted and not on the tank walls? :.....

c) With how many independent cooling units (one of them on standby)

is the transformer equipped? :.....

d) Does the cooling system meet the requirements of paragraph 1.5.3? :.....

e) Does the cooling system meet the requirements of the paragraph 3.9? :.....

f) Cooling unit data

1. Number of fans per cooling unit :.....
2. Rated power of the fan motor :.....W
3. Power of the fan motor when running :.....W
4. Number of pumps per cooling unit :.....
5. Rated power of the pump motor :.....W
6. Power of the pump motor when running :.....W
7. Oil flow of unit when running :.....lt/min

44. Transformer tank

a. Type :.....

b. Material of the tank :.....

c. Is the transformer tank in accordance with the requirements of paragraphs 3.1? :.....

45. Transformer conservator tank

a. Type :.....

b. 1s the conservator composed of one piece? :.....

c. Describe the method of protection against moisture: :.....

d. Does the conservator meet all requirements of paragraph 3.2? :.....

46. Pressure relief device for the transformer tank

- Type :.....
- Location of installation :.....
- Alarm contacts :.....

47. Valves

- Type :.....
  .....
- Use :.....
  .....

48. Oil of the transformer :.....

a. Type and manufacturer :.....
b. Does the oil contain any PCBs, PCTs :.....
or corrosive Sulphur?
c. 1s the oil of the "inhibited transformer oil (I)"
class in accordance with IEC 60296? :.....

49. Oil-to-Air Bushings M.V HV Neutral

a. Type	……	……
b. Manufacturer	……	……
c. Maχ phase-phase operating voltage (rms)	……	……
d. Rated phase to earth operating voltage (rms)	……	……
e. Rated current (A)	……	……
f. Rated thermal current (A)	……	……
g. Rated dynamic current (A)	……	……
h. Cantilever withstand load (N)	……	……
i. Creepage distance	……	……
j. Angle of mounting	……	……
k. Thermal limits – class	……	……
l. Dielectric dissipation factor	……	……
m. Partial discharges at max operating phase-phase voltage	……	……
n. Insulation levels	……	……
o. Cross-section of drawn lead or rod	……	……
p. Seismic withstand capability	……	……
q. Do the bushings meet the requirements of paragraph 3.7?	……	……
r. Are the bushings interchangeable with any other having the same type, according to CENELEC CLC/TS 50458?	……	……

50. Oil-to-Cable Bushing

Manufacturer :.....

Type :.....

51. Bushings current transformers (Ratio, accuracy class, burden)

- HV :.....
- MV1 :.....
- MV2 :.....

52. Are **all** cables which run on the transformer inside cable trays? :.....

53. Type of material of the winding conductors :.....

54. Type and manufacturer of Buchholz :.....

- Location :.....
- Characteristics of alarm contacts :.....
- Characteristics of trip contacts :.....

55. Type and manufacturer of oil temperature indicator. :.....

- Characteristics of alarm contacts and trip contacts :.....
- Measurements teletransmission capability :.....

56. Type and manufacturer of winding temperature indicator. :.....

- Characteristics of alarm contacts and trip contacts :.....
- Measurements teletransmission capability (Yes or No) :.....

57. Type and manufacturer of oil flow indicator. :.....

- Characteristics of alarm contacts and trip contacts :.....

58. Type and manufacturer of oil level indicator. :.....

- Characteristics of alarm contacts and trip contacts :.....

59. Transformers mass protection system
Current transformer (ratio, burden, class) :.....

60. Type and manufacturer of rapid pressure rise relay :.....
    - Location of installation :.....
    - Characteristics of alarm contacts :.....

61. Type and manufacturer of on-line moisture and dissolved gas monitoring system :.....

62. Net weights and dimensions
- Transportation weight :.....kg
- Core (steel) :.....kg
- Coils (copper) :.....kg
- Tank and fittings :.....kg
- Oil :.....kg
- Total weight :.....kg
- Untanking weight :.....kg
- Active part weight :.....kg
- Overall height (including bushings) :.....m
- Height over tank :.....m
- Projected floor dimensions:
  Length :.....m
  Width :.....m
- Description of the movement system :.....
- Description of the unloading and transportation :.....

63. Tests (acceptance of the specified tests)

(Yes or No) :.....

64. Type and manufacturer of the continuous moisture and gas-in-oil fault monitoring system (description) :.....

65. Color of the transformer :.....

66. State the corrosivity category and durability category of the transformer's painting,
according to ISO 12944 :.....

67. Describe with what the transformer :.....

tank will be filled for transport purposes .....

68. Type of material, manufacturer and country of origin

of the transformer core material :.....

.....

69. Does the transformer accessories

packing follow par.7? :.....

PFISTERER

Technical data of HV-CONNEX size 8

Cable connector – dry type, plug-in

Manufacturer	**PFISTERER Kontaktsysteme GmbH**
Country	Germany
Catalogue name	HV-CONNEX Cable Connector Size 8 up to 420 kV
Type designation	plug-in dry type cable termination
Art.-No.	889 999 XXX
Variant	according to cable data
Applied standard	IEC 62067:2011

Environment Conditions	
Working place	indoor or outdoor offshore on request
Atmosphere pressure	not limited
Environment temperature	-25 .. +50°C up to -45°C on request
Max. humidity	90 %

Electrical levels	
Rated voltage	380-400 kV
Highest voltage	420 kV
Rated design voltage to ground	220 kV

Electrical test level of the type test (IEC 62067:2011 and internal standards)	
AC withstand voltage	440 kV
LI withstand voltage	1425 kV
Heating cycles (AC voltage)	440 kV
Partial discharge test < 5 pC at	330 kV

Electrical routine test (IEC 62067:2011 and internal standards)	
AC withstand voltage (60 min)	440 kV
Partial discharge test < 5 pC at	330 kV

Current	
Max. current rating	same as cable up to 4000 A
Max. thermal short circuit current (3s)	63 kA
Max. dynamic short circuit current	170 kA

Stress control	
Field control method	geometrical
Type	premoulded
Material	silicone rubber
Production method	injection moulding

Termination housing	
Bell flange	metal housing, touch proof

Contact system	
Material	Cu or Al
Diameter over conductor	72.5 mm
Conductor size	max. 3000 mm²
Connection method	compression

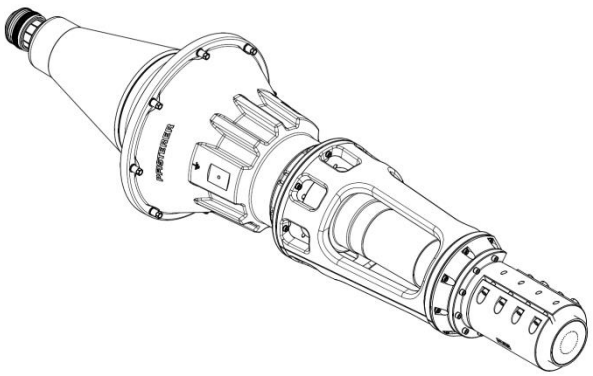
Cable type	
Type	polymeric cables
Screen type	wire, tape, lead alloy, Corrugated Al & Cu
Diameter over insulation	144 mm

Dimensions of the termination	
Length outside the socket (approx.)	1475 mm
Weight of the separable connector	130 kg

Packing	
Type	wooden box
Installation instruction for each kit	1 piece
Gross weight 1pc	approx. 160 kg
Dimensions 1pc / 1case	approx. 1200 x 800 x 1000 mm

Installation	
Site condition	protected against rain and dust
Installation work	by certified fitters
Installation temperature range	0 .. +45°C

Storage	
Guaranteed period after shipment	1 year
Storage time	40 years
Limitation for assembly set	2 years
Expected service life after installation	40 years
Storage temperature range	-5 .. +50°C
Storage conditions	not outside; dry place
Relative humidity	max. 60 %, non-condensing



IEC 62067 | Maintenance Free | 100% Tested

All information subject to change without prior notice

TACX 03/2014 pm

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PFISTERER

Technisches Datenblatt für HV-CONNEX Größe 8

Kabelanschlussteil – trocken, steckbar

Hersteller	**PFISTERER Kontaktsysteme GmbH**
Land	Deutschland
Katalog	HV-CONNEX Kabelanschlussteil Größe 8, bis 420 kV
Typbezeichnung	trockener, steckbarer Kabelendverschluss
Artikelnummer	889 999 XXX
Variante	bezieht sich auf Kabeldaten
Angewendete Standards	IEC 62067:2011

Einsatzbedingungen

Umgebung	Freiluft und Innenraum Offshore auf Anfrage
Luftdruck	nicht begrenzt
Umgebungstemperatur	von -25 bis +50°C bis -45°C auf Anfrage
Max. Luftfeuchtigkeit	90 %

Spannungslevel

Nennspannung	380-400 kV
Max. Betriebsspannung	420 kV
Leiterspannung gegen Erde	220 kV

Elektrische Typprüfwerte (IEC 62067:2011 und interner Standard)

Nennstehwechselspannung	440 kV
Blitzstoßspannung	1425 kV
Heizzyklus (AC Spannung)	440 kV
Teilentladungstest < 5 pC bei	330 kV

Elektrische Typprüfwerte (IEC 62067:2011 und interner Standard)

Nennstehwechselspannung (60 min)	440 kV
Teilentladungstest < 5 pC bei	330 kV

Strom

Nennstrom	wie Kabel, bis 4000 A
Nennkurzzeitstrom (3s)	63 kA
Nennstoßstrom	170 kA

Isolier- und Feldsteuerteil

Feldsteuerung	geometrisch
Typ	vergossen
Material	Silikonkautschuk
Herstellungsverfahren	Spritzguss

Steckergehäuse

Flanschglocke	Metallgehäuse, berührungssicher

Kontaktsystem

Leitmaterial	Kupfer oder Aluminium
Max. Leiterdurchmesser	72,5 mm
Leiterquerschnitt	max. 3000 mm²
Kontaktierung	Pressverbindung

Kabeltypen

Isolation	Kunststoffisoliert
Kabelabschirmung	Draht, Band, Bleimantel, Wellmantel Kupfer + Alu.
Durchmesser der Isolation	144 mm

Abmessung des Kabelanschlussteils

Länge außerhalb der Buchse	1475 mm
Gewicht Stecker	130 kg

Verpackung

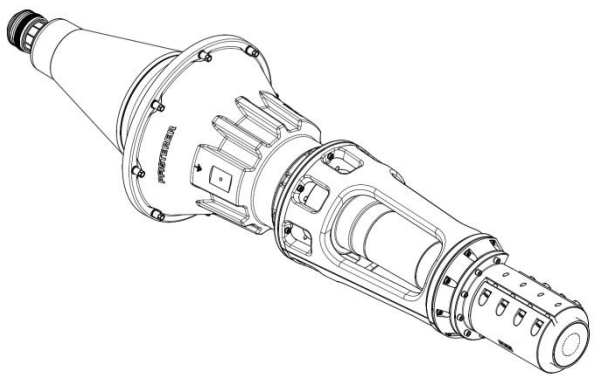
Art	Holzkiste
Montageanleitung für jeden Steckersatz	ja
Gewicht ca.	ca. 160 kg
Abmessung (1St./1Satz)	ca. 1200 x 800 x 1000 mm

Montage

Montagebedingungen	Feuchtigkeits- und Staubgeschützt
Montage	durch zertifiziertes Fachpersonal
Montagetemperatur	min. 0 / max. +45°C

Lagerung und Garantie

Garantie nach Auslieferung	1 Jahr
Lagerfähigkeit	40 Jahre
Limitierung für Montageset	2 Jahre
zu erwartende Lebensdauer	40 Jahre
Lagertemperatur	min. -5/ max. +50°C
Lagerbedingungen	Innenraum, trocken
Luftfeuchtigkeit	max. 60 %



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PFISTERER

Technical data of HV-CONNEX size 8

Socket for Transformer – dry type, plug-in

Manufacturer	**PFISTERER**
Catalogue name	HV-CONNEX Socket Size 8 up to 420 kV
Type designation	plug-in dry type cable termination
Art.-No.	828 081 999
Applicable standards	IEC 62067:2011, IEC 60137:2008 EN 50299:2014

Environment Conditions

Working place	indoor or outdoor offshore on request
Atmosphere pressure	not limited
Environment temperature	-25 .. +50°C up to -45°C on request
Max. humidity	90 %
Max. oil temperature	105°C (Longterm 90°C due to max. conductor temperature)

Electrical levels

Rated voltage	380-400 kV
Highest voltage	420 kV
Rated design voltage to ground	220 kV

Electrical test level of the type test (IEC 62067:2011)

AC withstand voltage	440 kV
LI withstand voltage	1425 kV
SIL withstand voltage	1050 kV
Partial discharge test < 10 pC at	330 kV

Electrical test level of the type test (IEC 60137:2008)

AC withstand voltage (dry)	695 kV
BIL withstand voltage	1425 kV
SIL withstand voltage	1050 kV
Partial discharge test < 5 pC at	364 kV

Electrical routine test

AC withstand voltage	650 kV
Partial discharge test < 5 pC at	590 kV

Current

Max. current rating	same as cable up to 4000 A
Max. thermal short circuit current (3s)	63 kA
Max. dynamic short circuit current	170 kA

Stress control

Field control method	geometrical
Type	pre-molded
Material	epoxy-resin
Production method	injection moulding

Dimensions of the termination

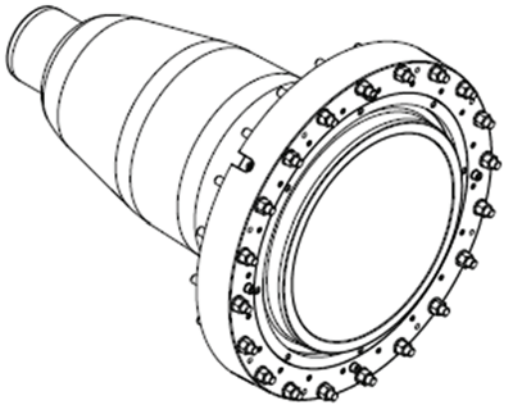
Length inside Transformer	750 mm
Length inside Transformer with short extension	960 mm
Length inside Transformer with long extension	1400 mm
Clamping ring hole diameter	640 mm
Weight of the socket (without extension)	approx. 140 kg

Packing

Type	wooden box
Installation instruction for each kit	1 piece
Gross weight 1pc	approx. 240 kg
Dimensions 1pc / 1case	approx. 800 x 800 x 1300 mm

Storage

Guaranteed period after shipment	1 year
Storage time	40 years
Limitation for assembly set	2 years
Expected service life after installation	40 years
Storage temperature range	-5 .. +50°C
Storage conditions	not outside; dry place
Relative humidity	max. 60 %, non-condensing



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PFISTERER

Technisches Datenblatt für HV-CONNEX Größe 8

Geräteanschlussteil für Transformator – trocken, steckbar

Hersteller	**PFISTERER**
Katalog	HV-CONNEX Geräteanschlussteil Größe 8, bis 420 kV
Typbezeichnung	trockener, steckbarer Kabelendverschluss
Artikelnummer	828 081 999
Anwendbare Standards	IEC 62067:2011, IEC 60137:2008 EN 50299:2014

Einsatzbedingungen	
Umgebung	Freiluft und Innenraum Offshore auf Anfrage
Luftdruck	nicht begrenzt
Einsatztemperatur	von -25 bis +50°C bis -45°C auf Anfrage
Max. Luftfeuchtigkeit	90 %
Max. Öltemperatur	105°C (langfristig 90°C aufgrund max. Leitertemp.)

Spannungslevel	
Nennspannung	380-400 kV
Max. Betriebsspannung	420 kV
Leiterspannung gegen Erde	220 kV

Elektrische Typprüfwerte (IEC 62067:2011)	
Nennstehwechselspannung	440 kV
Blitzstoßspannung	1425 kV
Schaltstoßspannung	1050 kV
Teilentladungstest < 10 pC bei	330 kV

Elektrische Typprüfwerte (IEC 60137:2008)	
Nennstehwechselspannung	695 kV
Blitzstoßspannung	1425 kV
Schaltstoßspannung	1050 kV
Teilentladungstest < 5 pC bei	364 kV

Elektrische Stückprüfwerte	
Nennstehwechselspannung	650 kV
Teilentladungstest < 5 pC bei	590 kV

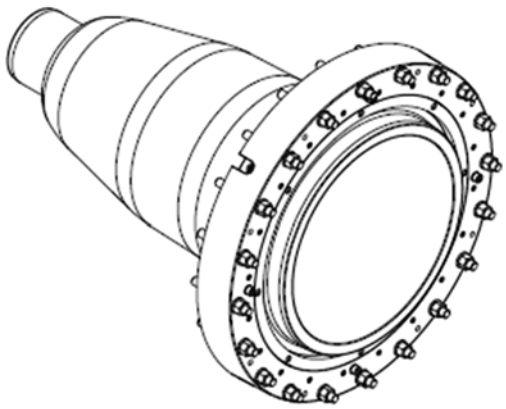
Strom	
Nennstrom	wie Kabel, bis 4000 A
Nennkurzzeitstrom (3s)	63 kA
Nennstoßstrom	170 kA

Isolier- und Feldsteuerteil	
Feldsteuerung	geometrisch
Typ	vergossen
Material	Epoxidharz
Herstellungsverfahren	Spritzguss

Abmessung des Geräteanschlussteils	
Länge im Transformator	750 mm
Länge im Transformator mit kurzer Verlängerung	960 mm
Länge im Transformator mit langer Verlängerung	1400 mm
Lochkreisdurchmesser	640 mm
Gewicht Geräteanschlussteil	127 kg

Verpackung	
Art	Holzkiste
Montageanleitung	ja
Gewicht ca.	240 kg
Abmessung (1St./1Satz)	ca. 800 x 800 x 1300 mm

Lagerung und Garantie	
Garantie nach Auslieferung	1 Jahr
Lagerfähigkeit	40 Jahre
Limitierung für Montageset	2 Jahre
zu erwartende Lebensdauer	40 Jahre
Lagertemperatur	min. -5/ max. +50°C
Lagerbedingungen	Innenraum, trocken
Luftfeuchtigkeit	max. 60 %



IEC 62067 | IEC 60137 | EN 50299 | 100% Tested | Maintenance Free

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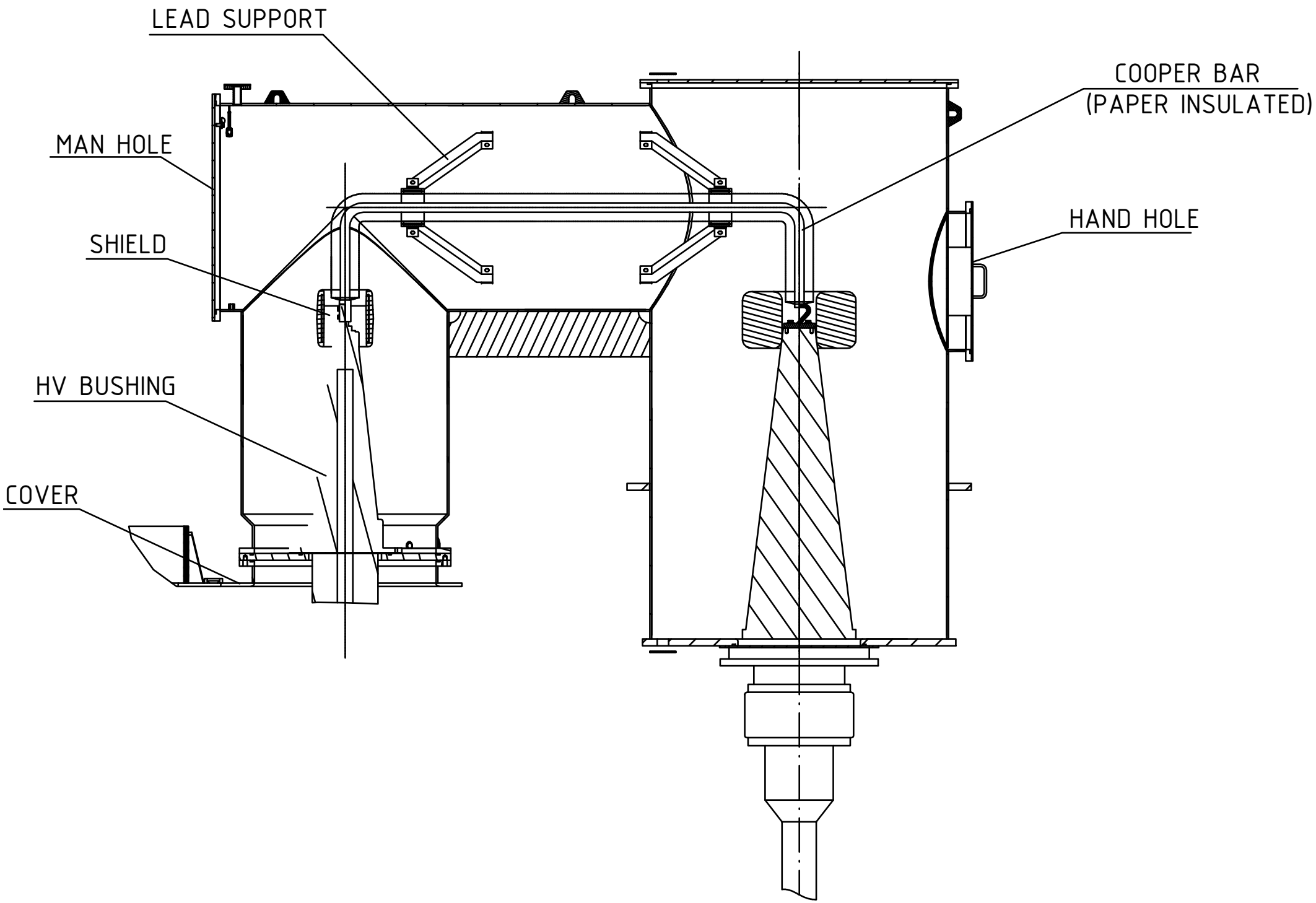
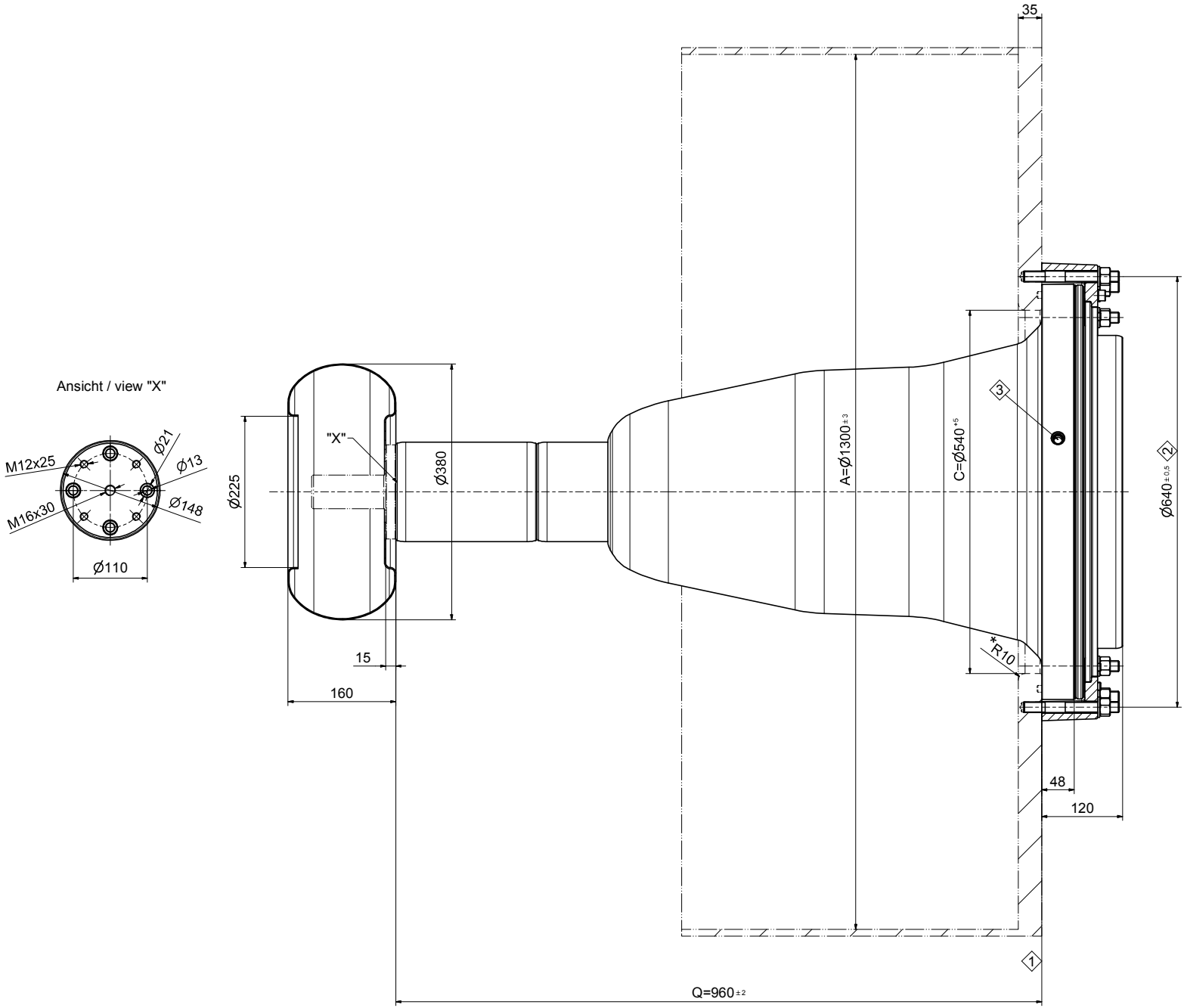


TYPICAL CONFIGURATION OF OIL-TO-CABLE TERMINAL
ON THE TRANSFORMEN BODY



Alle Längenangaben wenn nicht anders angegeben in mm
Measures in mm if not mentioned otherwise.

Ra 1,6 , Rz 6,3 , Rt 6,3

① Dichtfläche Buchse lackiert mit 2K PU-Lack
Sealing Surface socket coated with 2K PU-varnish

Dichtsystem im Lieferumfang des Trafo-Herstellers
Sealing system in scope of supply of transformer manufacturer

② Teilkreisdurchmesser für 20x Gewindebolzen M16x142
Pitch circle diameter for 20x thread bolt M16x142

③ Kapazitiver Spannungsabgriff
Kapazität bei eingestecktem Kabel 3pF; Toleranz ±3%
capacitive voltage tap
Capacity with plugged cable 3pF; Tolerance ±3%

Maße entsprechen EN 50299-2:2014 (Trafo) außer dem mit * gekennzeichnetem Maß
Dimensions according to* EN 50299-2:2014 *(Transformer) except dimension marked with *

Größe	Nr. / No.	max. Um	Isoliermedium /insulating medium
8	828 081 999-00002	420kV	Mineralöl / mineral oil rel. perm 2,2-2,4
8	828 081 999-00008	420kV	Esteröl / ester oil rel. perm. 2,5-3,2

Gewinde / Thread	Drehmoment / Torque
M10	ca. 35Nm
M12	ca. 50Nm
M16	ca. 50Nm

Maßstab / scale: 1 : 3
Gewicht ca. / weight ca. (g): 135200

	Name / name	Datum / date
Erstellt von / created by	Kuna	2014-06-30
Geprüft von / approved by	Mirau	2014-06-30

Beschreibung / title:
EHV-CONNEX Geräteanschlussteil Gr. 8/9
für ölisolierte Anlagen, Variantenartikel
EHV-CONNEX socket size 8/9
for oil insulated equipment, variant article

Ersatz für / replacement for:
Dokumentart / type of document: Für Kunden
Dateiname / filename: S02-156133
Format / size: A1
Blatt / pc: 1/1

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Änd.nr. / rev. no.	Änd. datum / date of issue	Name / name	Index / rev.	Dokument-Nr. / document no.
	2017-03-02	Ferenci	04	828081999A2

Technical Specification for MV GIS switchboard 33kV

Date: April 2026

Revision: 0

Table of Contents

1. General features of Switchgear

1.1 Basic design of Switchgear

Supplier should offer Gas Insulated Switchgear according to all current valid standards and terms, factory-assembled, offered as single busbar Switchgear with Vacuum or SF6 Insulated Circuit Breaker and combined disconnector / earthing switch without solid insulated interconnection modules.

The switchgear is to be designed as indoor switchgear for installation in a closed electrical operating site.

The installation of the switchgear shall be in a row on a base frame fixed e.g. on a concrete floor.

The Switchgear construction must ensure that during the entire life-time of this switchgear.

Gas-filling and gas-tightness test must be part of the factory routine test.

In the case of an internal arc, rapid return to service of the adjacent intact cubicles is to be proven.

To ensure maximum security for personnel, all handling and service actions and cable connections shall be done with inner cone cable plugs from the bottom side.

The applicable IEC standards shall be listed and named in the offer and relevant Declarations of Conformity should be provided for performances listed in this specification.

1.2 Cladding and compartments

The Switchgear shall be three-pole encapsulated.

The Switchboard with single busbar configuration must be designed with the following compartments as a minimum:

Busbar with combined disconnector / earthing switch	
MV compartment, not accessible	gas insulated
Circuit Breaker, MV compartment, not accessible	gas insulated
Cable connection, MV compartment, interlock accessible	(air insulated)
Low voltage cabinet	(air insulated)
Drive mechanism	(air insulated)

The cladding of the cubicle must have the following features:

- well arranged mechanical assembly
- short easy to access drive mechanism.
- minimum use of bushings allowing the mechanical driving mechanism to pass the movement into the gas compartment.
- fully gas insulated between the busbar compartments and the circuit breaker compartment (no air gap allowed)

The gas insulated busbars shall be connected with single-pole solid insulated connection links outside the gas compartment. End caps shall be available with secure voltage resisting close-offs.

For site connection of the busbars, the number of electrical joints should be minimized. Solutions are preferred which require only one joint per phase for each cubicle during switchgear erection & assembly.

The cable connection area must have a removable cover for access.

1.3 Gas compartment technology and control

The gas compartments shall be filled with the insulation gas SF6 and shall be designed as sealed pressure systems, according to IEC 62271-1.

Circuit breaker and busbar compartments are separated gas-filled compartments per cubicle.

The temperature compensated gas pressure monitoring device and gas valve has to be visible directly from the central position at the respective front side of the switching unit, without opening doors or covers. The system for monitoring the gas pressure must provide three limit values (low, very low, high), which are available for onward report. Auxiliary contacts should be provided for remote signalling. The device should be self monitored.

The operational leakage rate for the gas isolation must not exceed 0.1% per year.

For the expected service life of the switchgear, under typical indoor operating conditions, re-filling insulation gas should not be essential.

To guarantee maximum operating reliability and easy decommissioning of the Switchgear, the number of gaskets, static bushings and pressure relief devices are to be kept to a minimum. All three circuit breaker poles of each switchgear shall have only one combined gas-tight bushing.

Static bushings shall be gasketed with pressure rated packing (Elastomer-gasket system) for the service life of the switchgear.

In order to ensure simple recycling at end of life-time, a recovery valve per compartment shall be provided, which allows easy extract of the gas with standard tools.

1.4 Internal Arc fault classification

The internal arc fault classification is defined in accordance with the latest version of IEC 62271-200.

The rated short circuit current must correspond at least to the rated short circuit current of the whole switchgear. The internal arc duration is to be 1 s.

The Internal Arc classification shall be IAC [AFL] or [AFLR]

The distance from switchgear rear side to the building wall shall be [100mm +- 30mm for AFL] or [800mm for AFLR]

The distance from the left/right side of the switchgear to the building wall shall be [100mm +- 30mm for AFL] or [800mm for AFLR].

Covers from the switchgear side wall to the building walls are part of the switchgear manufacturer.

1.5 Operation and control

On-site operation under normal service conditions of the switching unit shall be done via an intelligent bay module, installed in the low voltage cabinet.

All operation and service actions must be practicable from the front of the cubicle operating side.

Mechanical Operation should also be provided for use when the auxiliary supply is unavailable.

The mechanical operation points and the mechanical switch position signals must be placed within a synoptic mimic diagram on a clear to use operator panel. It shall be at an acceptable operation height and size. The front of the switchgear is to have a uniform, flush, appearance.

Great importance is attached to maximum clarity and intuitive operator guidance of the Switchgear for mechanical on site operation. The mechanical operation and indicator devices must be visible and available at the front, without opening of doors or coverings.

Functionally dependant elements, such as the operating device for the switchgear and the mechanical switching indicator, should be placed directly adjacent, visually linked with reasonable and clear imagery. The respective details in the IEC recommendation shall be followed.

Depending on the type of functional unit the operator panel/mimic diagram shall contain the following operation and indicators:

- Push Button for mechanical operation of the circuit breaker On and Off
- mechanical display of circuit breaker spring charging status
- mechanical spring charge accumulator for circuit breaker
- mechanical switching cycle counter for circuit breaker
- Separate operating ports for mechanical hand operation of the combined disconnector / earthing switch (ON / OFF and earthed).
- 2 / 3-position switch to operate manual and motor operation for the disconnectors and earthing switch function respectively.
- During operation of the earthing switch the vacuum circuit breaker must be switched on automatically with a mechanical link inside the drive mechanism
- mechanical position indicators display for all switching devices
- remote control with motor drive: circuit breaker, busbar disconnectors and earthing switch
- double-side interlock between the cable box cover and outgoing earth switch - (for cable tests special equipment for unearthing the outgoing cables must also be available)

1.6 Interlocking system

To ensure maximum operator safety, the switchgear must be equipped with a comprehensive interlocking system of excellent design.

This interlocking system is to integrate the cable connection compartment systematically.

Actuation of the mechanical operating lever should follow the interrogation interlock principle.

1.6.1 Mechanical interlock

Cubicle Internal mechanical interlocks:

- Mechanical operation lock for all switchgear operation, interlocked and synchronised with any remote control.
- Mechanical interlock between the functions of disconnecting and earthing
- No direct interconnection switching between earthing and disconnecting
- Operation of the circuit breaker only in defined positions of the combined disconnector / earthing switch ON or OFF
- With operation of the earthing switch mechanism the circuit-breaker must close automatically by mechanical connection. With the earthing switch is in close position, automatically by a mechanical latch, switching off or tripping the circuit-breaker must be interlocked. Using pad-locking for interlocking the circuit-breaker is not permitted.
- Actuating levers are allowed to be inserted and removed only in defined positions ON or OFF. Only 1 element shall be actuated at any time
- -double-side interlock between the cable box cover and outgoing earthing switch - (for cable tests special equipment for unearthing the outgoing cables must also be available)
- in no case a force which could damage the drive mechanisms should be applied. This is to be realized by an interrogative interlocking system.

A manual operation must be available in the event of auxiliary supply failure. Additionally, the MV cubicle must be equipped with an undervoltage relay so as in case of auxiliary supply failure, the circuit breaker will open automatically.

In order to protect the operators on-site from remote activations, the control voltage must be disconnected automatically when manually operating switchgear elements.

1.6.2 Electrical interlock (over several cubicles)

The bay unit for control & monitoring ensures that necessary interlocks are provided by a wire-bound ring cable on the binary input contacts.

All further special interlocks are to be clearly specified during the engineering phase, in the case of order placement.

1.7 Checking of Voltage presence (VDS-system)

The check of voltage presence shall be done with an electronic and integrated voltage test system, in line with valid standards and instructions.

The indication should be derived from a capacitive voltage divider in the cable connection compartment.

The situation “voltage present” rather “voltage not present” must be indicated clearly.

The maintenance-free voltage detection system must work without any external energy and should monitor its connected test circuits continuously.

The status of the health of integrated voltage test systems must be monitored. Device failure should be shown clearly.

Optionally the integrated VDS-system shall be fitted with an auxiliary switch for signal and interlock purposes (VDS-indicator with auxiliary supply)

For phase comparison, suitable connections shall be provided, which have to be covered during general use.

1.8 Cable connection compartment

The cable connection compartment should be large, permitting the connection of multiple single-core cables, or three-core cables or Solid Insulated Busbars or Medium Voltage GIL.

All types of insulated, connecting systems should be accommodated.

It is not permitted for depth to be enlarged, when 2 or 3 cable systems per phase are attached.

All cubicles have to permit inner cone connection according to valid standards and instructions.

For the inner cone the bushings are front accessed and placed one behind another per phase. The cable connection is to be a minimum 425 mm from the bottom edge.

A phase change of previously connected high-voltage cables must be possible without additional cabling.

Cable checking:

For cable checking a facility shall be available for the connection of test equipment for measurement of voltage and insulation.

a) without interfering in to the gas compartment

b) without disconnecting the cables.

For the easy performance of cable testing, it is necessary, that the voltage transformer is easy to disconnect.

For busbar connection, special appropriate connectors shall be foreseen at the incoming feeder and supplier should provide his Switchgear configuration solution, clearly depicted in relevant SLD.

1.9 Low voltage compartment

Every functional unit shall have a separate, closed and shockproof low voltage compartment with mechanical and electrical interface for housing secondary equipment for control, protection, signalling and measuring.

Equipment may be built in to the compartment door, which must be buckle resistant.

The low voltage compartment should have a minimum height of 800 mm and a minimum depth of 350 mm.

For transport and exchange request, the low voltage compartment has to be easy removable and mountable. This has to be documented in the respective manuals.

The fitting of mechanical drive sections in the low voltage compartment is not allowed.

1.10 Corrosion protection and lacquering

Corrosion endangered steel components of the switchboards must be protected with zinc phosphate, unless made of stainless steel.

Large areas of externally visible front parts, such as doors or covers, shall have an additional scratch-resistant textured finish.

Paint coating shall be in the colour RAL 7035

Other RAL colours are available on request.

1.11 Transformers

The insulation material used in the construction of current and voltage transformers must be reduced to a minimum.

Transformers must be suitable for all commercially available digital protective relays.

All instrument transformers must be installed out-side the gas-tank for easy access. Changing instrument transformer must be possible without any gas-works.

All transformers shall be of conventional type. Current and voltage sensors or low power transformers are not accepted.

1.11.1 Ring core current transformer (CT)

The switchgear shall be equipped with low voltage insulated ring core transformers for outgoing current measurement outside the gas compartment. They shall be installed on adaption bushings. It must be possible to easily retrofit or replace the transformer, without intervention into the gas compartment as far as possible.

The transformer must be placed between the circuit breaker and the cable connection (needed for switchgear interlocking). The transformers have to be connected to earth potential.

The core performance shall be engineered according to the required measurement and protective device,

P transformer > P consumer

Overburdening of the transformers shall be avoided.

1.11.2 Voltage transformer (VT)

Voltage transformers (disconnectable) for busbar metering, installed in a separate measuring cubicle, are foreseen.

All voltage transformers shall be installed in the factory prior to dispatch of the panels. The installation of the VTs on site is not accepted.

2. Instructions, rules and standards

The offered medium voltage switchgear must meet all the valid norms and standards:

Environmental and operating conditions:	IEC 62271-1 / EN 62271-1
Switchgear:	IEC 62271-200 / EN 62271-200
Circuit breaker:	IEC 62271-100 / EN 62271-100
disconnector and earthing switch:	IEC 62271-102 / EN 62271-102
Current transformer:	IEC 61869-2
Inductive voltage transformer:	IEC 61869-3
Voltage test system:	IEC 61243-5 / VDE 0681

Contact, contaminant and waterproofing:	IEC 60529 / EN 60529
Assembling:	HD 637 S1
Operation of electrical switchgears:	EN 50110-1
Device connection:	IEC 50181 / EN 50181

3. Switchgear

3.1 Circuit breaker

The Circuit Breaker shall have a breaking capacity equivalent to the system fault level.

The vacuum circuit breakers must have a minimum life of 10,000 cycles at rated current (p.f. 0.7) and a minimum of minimum 50 times short-circuit breaking current without maintenance.

It is to be considered that:

- drives are placed outside the gas compartment;
- drives shall be fitted both with manual and motor drive and shall have
- auto reclosing capabilities
- low voltage connection shall be carried out as plug type

3.2 Three-position combined disconnector / earthing switch

Setting of the three-positions:

On: The connections between busbar and circuit breaker are closed.

Off: The connections between busbar and circuit breaker are opened.

Earthed: The contacts are linked with the earth contact and the outgoing (cables) is earthed by an automatic closing of the circuit breaker.

It is to be considered that

- drives are placed outside the gas compartment;
- drive mechanism shall be fitted both with manual and motor;

- low voltage connection must be carried out in plug type.

In addition to integral earthing, the switchgear must also be mechanical operated via a three-way switch and vacuum circuit breaker, like conventional switchgear.

4. Auxiliary Circuits

4.1 Wiring

Wiring shall be done using flexible, black or green-yellow insulation material halogen free with the following cross sections:

- Control	1.0	mm^2
- Voltage transformer wires	2.5 mm^2 (from LV circuit breaker 1.0 mm^2)	
- Current transformer wires	2.5	mm^2
- Ring wire	2.5 mm^2	

The terminal strip material shall be Phoenix type.

4.2 Protection and Control System (IED)

The protection relay associated with each circuit-breaker shall be digital. The relay manufacturer shall have a valid ISO 9001 and ISO14001 certification.

The relay manufacturer shall have a long term experience, at least 10 years, in designing and manufacturing Digital Protective Relays linked to switchgear applications and have relevant business volume and references in order to provide credibility in his commitments and at least 10 years of support capability.

The manufacturer/supplier shall have a permanent representative office with a trained and skilled support staff, in the country or in the region where the Digital Relays are delivered, in order to prove his commitment for local or regional support and to provide a channel for communication.

The manufacturer shall be able to offer commissioning of the Digital relay to be carried out by the local or regional office.

One common relay's management software (based on standard Windows operating systems) shall provide all necessary tools and functions to operate the devices. Via the management software relay parameters, configurations and recorded data can be exchanged between PC and the device.

The devices shall meet the applicable IEC design standards, **IEC 60255 range, according to functionality.**

4.3 Voltage Presence Indication System – VPIS

Each switchgear function shall be equipped with a VPIS (Voltage Presence Indication System) according to IEC 62271-206 having the following characteristics:

VPIS will allow the visualisation of Voltage presence on each phase with LED indication. They shall be fitted with:

- 3 dedicated plug points for connection of a Phase Concordance Unit (PCU). These plugs shall include a system to protect them from humidity, salted spray or pollution when PCU is not connected as well as designed in such a way that short-circuit or failure on the PCU or its plugs does not disrupt LED display. Supplier shall propose a Phase Concordance Unit to work with his VPIS.
- Additionally to the 2 previous functions, as a specific VPIS option, outputs to Voltage presence relay
  As component, their characteristics shall cover:
- Operating temperature range from -25°C to +85°C according to IEC 60068-2-14
- Conformance to EN 60068-2-11 for salt fog test up to 192 hours at 35°C
- Compliant to EMI/ EMC as per IEC 61000-4-2 Criteria B with ±8kV discharge (air) & ±6kV discharge (contact)
- necessary distance between switchgear and walls

5. Technical characteristics

5.1 Switchgear

rated voltage	36 kV
rated operational voltage	33 kV
rated frequency	50 Hz
rated short-time withstand current	25 kA
rated short-circuit duration	3 sec
busbar rated current (natural cooled)	>3.150 A
insulating medium	SF_6
SF6-operating relative pressure at 20°C	500 hPa
Auxiliary supply for:	
control	220 V DC
signalling	220 V DC
activating	220 V DC
motor	220 V DC

Degree of protection	
degree of protection MV-parts	IP65
degree of protection drive	IP3X
degree of protection LV cabinet	IP3X
degree of protection cable connection	IP3X
Internal Arc fault Classification	IAC AFL 20 kA, 1s
Ceiling height of substation	2.8 m

Service conditions	
height of installation	1000 m over Sea level
ambient temperature	max. + 40°C; max 24h- +35°C; min. -5°C

Dimensions	
panel width (incomer, outgoings)	max. 600 - 900mm
switchgear height	max. 2400 mm or 2800 mm
switchgear depth	max. 1600 mm

5.2 Three-pole vacuum circuit breaker

According to IEC 62271-100 / EN 62271-100
with 1 shunt release ON
with 1 shunt release OFF
with auxiliary switch
with manual and motor drive
with mechanical operating cycle counter
with auto reclosing possibility

rated short-time withstand current	25 kA/1sec
rated peak withstand current	>50 kA

5.3 Three-position combined disconnector / earthing switch

According to IEC 62271-102 / EN 62271-102
settings ON, OFF, EARTHED

with manual or motor drive for disconnection
with manual or motor drive for earthing
with auxiliary switch for disconnection
with auxiliary switch for earthing

6. Cubicle Configuration

The required boards shall be grouped in **four (4)** switchgear assemblies
The configuration of each switchgear is as below:

6.1 Incoming cubicle(s) from Power Transformer secondary (1 pc per assembly)

The cubicle(s) shall be configured to connect single-phase solid cast regin impregnated busducts approaching from the top

Rated current 3.150 A or higher

The rated operational current must be achieved permanently, without the use of forced cooling, according to IEC-conditions.

Equipment

1	3-pole vacuum circuit breaker motor drive 220V DC 1 switch-on auxiliary actuator 220V DC 1 switch-off auxiliary actuator 220V DC auxiliary switch 16-pole
1	3-pole three-position switch for disconnection and earthing motor drive 220V DC auxiliary switch 12-pole
3	voltage transformer, built in the outgoing 1-pole insulated conversion: $/\ \frac{0,1}{\sqrt{3}}\ /\ \frac{0,1}{3}$ kV winding 1 : category 1 75 VA da-dn-winding: 3P 60VA
1	damping resistance
3	ring core current transformer conversion: 3.000/5 A core 1 0.2 FS 5 20 VA core 2 0.2 FS 5 20 VA core 3 5 P 20 15 VA
1	3-pole cap. voltage test system in the outgoing

Built into the low voltage compartment (example)

1	device for control and supervision
1	Multimetering device for A, V, kW, kWh (voltage values from the voltage metering transformers ahead the breaker
2	2-pole automatic circuit breaker for motor drives

1	2-pole automatic circuit breaker for control/signalling
1	3-pole automatic circuit breaker for voltage transformer
1	1-pole automatic circuit breaker da-dn-winding
...	diverse control and auxiliary relays for message preparation rather control

includes necessary clamps and incidentals
freight, packing, delivery, installation,
documentation and on-site assembling

Note for Solid insulated busbars:
In case the supplier cannot provide one single panel appropriate for solid insulated busbar in the cable compartment, he shall propose a configuration of panels that will consist minimum of the above described equipment, i.e

- 3-pole circuit breaker
- 3-pole three-position switch for disconnection and earthing
- voltage transformer
- damping resistance
- ring core current transformer
- 3-pole cap. voltage test system

6.2 Outgoing feeder ULM (13 pcs per assembly)

Rated current 630 or 800 A

The rated operational current must be achieved permanently, without the use of forced cooling, according to IEC-conditions.

Equipment

1	3-pole vacuum circuit breaker	
	motor drive	220V DC
	1 switch-on auxiliary actuator	220V DC
	1 switch-off auxiliary actuator	220V DC
	auxiliary switch	16-pole
1	3-pole three-position switch for disconnection and earthing	
	motor drive	220 DC
	auxiliary switch	12-pole
3	ring core current transformer	
	conversion:	300 or
	400/5 A secondary switchable	
	core 1 0.2S FS 5	10 VA
	core 2 5 P 20	15 VA

Cable connection for maximum 2 cables/phases

up to 800 mm² 1x type C bushing per phase

excluding cable fixing facilities with horizontal and vertical moveable cable fixings for installing the outgoing cable.

Locking on the mechanical operating interface through a round profile cylinder for the whole mechanical operating interface

In the low voltage compartment are built in:

1	IED device for control and supervision
1	Multimetering device for A, kW, kWh (voltage values from the busbar voltage metering compartment
2	2-pole automatic circuit breaker for motor drives
1	2-pole automatic circuit breaker for control/signalling
...	diverse control and auxiliary relays for message preparation rather control

includes necessary clamps and incidentals
freight, packing, delivery, construction,
documentation and on-site assembling

6.3 Bus Voltage Measurement Compartment (1pc per assembly)

3	voltage transformers, outside the gas compartments 1-pole insulated, built-on the busbar conversion: $\frac{10}{\sqrt{3}} / \frac{0,1}{\sqrt{3}} / \frac{0,1}{3}$ kV		
	winding 1:	0.2	60 VA
	winding 2:	0.2	60 VA

6.4 Busbar Isolating device (1pc per assembly)

A busbar isolating device must be installed in one end of each switchgear in order to extend the switchgear without shutting down the existing boards. This provision shall be adopted to the supplier provisions

7. Switchgear attachments

End walls on the left and right hand side of the switchgear

1	supports for operation cranks
2	operating cranks for circuit breaker
2	operating cranks for disconnector and earthing switch
4	two-bit key

Specific conditional attachments and tools, which are not listed, but are obligatorily needed, must be included as a separate surcharge in the correspondence and considered in the price composition.

8. Documentation

The construction documentation of the specification has to include as a minimum the following components:

- Installation drawing including information about base frame and floor openings
- Single line diagram
- LV circuit diagram with connecting/terminal connection tables and equipment list

The documentation components (wiring diagram, terminal connection and operating resources diagrams) have to be designed in CAD-format.

The construction documentation has to be created after the commissioning and filed for the approval.

Other documentation components:

- instruction handbook
- assembly instructions
- routine test reports
- transformer test records

The exact details of the documentation preparation have to be agreed in detail with the buyer after order placement.

The seller has to provide the complete documentation and local training to the buyer after the successful commissioning and building site revision.

[Factory approval

For the medium voltage switchgear a re-inspection (final acceptance) in the factory as routine test shall be provided.

9. Freight, packing, delivery

Valid for all freight methods:

- packing for truck transport,
- freight and delivery with truck

The dimensions and weights of the transported units must be included in the offer.

10. Warranty

The seller must provide to the End User at least 24 months after the installation or 32 months after FAT (whichever occurs first) guarantee of normal operation.

Warranty Terms and Conditions shall be enclosed with the offer.

11. Content of offer

The offer for the implementation of this project shall cover:

- price for Design, Manufacture, delivery and installation of a metal-clad, factory-built, type-tested, gas insulated single busbar switchgear with fixed integrated switching devices included
- accessories
- freight and packing
- electrical and mechanical documentation
- transport into switchgear room and supervision of installation on-site
- documentation / installation site inspection

The switchgear is to be designed to comply with the detailed requirements of the technical instructions and specifications of this contract document. Product specific variances must be detailed and explained in the offer.

Extensive documents, such as brochures, system configurations, a single-line circuit diagram, overview of the offered system configuration and a drawing showing the necessary minimum space requirement in the switchboard room must be enclosed in the offer.

The plan view drawing must contain the following information:

- required length, width, height and footprint of the switchboard room
- required double floor height, or cable trench details
- placement of the switchgear in the mechanical room