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Functional Specification

220 kV/ 400 kV Gas Insulated Switchgear (GIS)

Revision	Date	Description	Originator	Reviewer	Checker	Approver
R0	31/05/2022	First Issue	Vitali Garon	Daniele Giustini Niall McMahon	Leon Notkevich, Neil Cowap	Aidan Corcoran, Richard Blanchfield
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1 INTRODUCTION

This Functional Specification is applicable for use in offshore wind transmission links delivered by the Customer as Contestable Works, to be owned and operated by EirGrid.

The following specification outlines the requirements for the design, procurement, construction/assembly and commissioning of 220 kV and 400 kV Gas Insulated Switchgear for use in onshore compensation compounds (OCC) and the Offshore Substation Platform (OSP).

This specification should be read in association with the project specific contestable works pack and project documentation and all other relevant functional specifications as issued by EirGrid.

For the purpose of this specification the term Customer shall refer to Offshore Wind Power Developers, Independent Power Producers responsible for the design and build of assets to be handed over to EirGrid.

In addition to the requirements of this specification, the equipment shall comply with:

- EirGrid Functional Specification OFS-SSS-400 for OCC General Requirements, and other applicable EirGrid requirements including but not limited to those listed in section8.
- EirGrid 220kV and 400kV Gas Insulated Switchgear Technical Schedule[1]

For offshore wind power projects both single and double busbar configurations are acceptable at OCC and OSP.

This specification references SF6 throughout, as this is the industry standard. However alternative Gas Mixtures such as a C3F7CN/CO2 will be considered. Subject to the completion of relevant type tests. The introduction of this new technology will require approval from EirGrid.

[1] All references to Technical Schedules within this document refer to OTS-SSS-413 for Technical Schedules for Gas Insulated Switchgear. The Customer shall submit a completed set of Technical Schedules for Eirgrid review

2 ABBREVIATIONS

Abbreviation	Meaning
BCU	Bay Control Unit
CB	Circuit Breaker
CE	European Conformity
CIGRE	International Council for Large Electric Systems
CO_2	Carbon Dioxide
CT	Current Transformer
DRA	Design Risk Assessment
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EN	European Normalised Standard
EPC	Engineer, Procure, Construct – International Federation of Consulting Engineers (FIDIC) definition
EU	European Union
GIS	Gas Insulated Switchgear
GWP	Global Warming Potential
HV	High Voltage (above 1 kV per IEC 61936-1)
ICP	Integrated Control and Protection
IEC	International Electrotechnical Council
IPP	Independent Power Producer
LCC	Local Control Cabinet
LOTO	Lock Out Tag Out
MEWP	Mobile Elevated Work Platform
MTS	Mixed Technology Switchgear
NCC	National Control Centre
OEM	Original Equipment Manufacturer
PAPR	Powered Air Purifying Respirator
PD	Partial Discharge
PPE	Personal Protective Equipment
RCC	Regional Control Centre
REACH	Registration, Evaluation, Authorisation, and Restriction of Chemicals
RTU	Remote Terminal Unit
SCS	Station Control System
SF_6	Sulphur Hexafluoride gas
SLD	Single Line Diagram
SVL	Sheath Voltage Limiter
SWL	Safe Working Load
TAO	Transmission Asset Owner
TEV	Transient Enclosure Voltage
UK	United Kingdom

Abbreviation	Meaning
VFTO	Very Fast Transient Over-Voltage
VT	Voltage Transformer

3 NETWORK PARAMETERS

The equipment shall be suitable for installation on the Transmission system.

The GIS technical parameters are further detailed in the GIS Technical Schedules OTS-SSS-413.

The Customer shall submit fully completed and signed set of technical schedules for EirGrid review in advance of equipment order.

3.1AC SHORT-CIRCUIT BREAKING CURRENT

The design parameters are specified in EirGrid's OCC General Requirements functional specification OFS-SSS-400 and the project specific Single Line Diagram and protection specification.

3.2DC TIME CONSTANT OF THE RATED SHORT-CIRCUIT BREAKING CURRENT

As outlined in IEC 62271-100, there maybe be instances where standard value DC time constants are inadequate and special case DC time constants may be required.

In certain designated nodes on the transmission system (for example in Dublin area where there is a high X/R ratio), circuit breakers and current transformers shall be designed to accommodate DC time constants in excess of 45 ms.

The Customer shall clarify with the EirGrid project team if a special case DC time constant (X/R ratio) above 45 ms is applicable for the respective project.

The Customer shall provide evidence that the selected circuit breaker and current transformers meet both the AC and DC short circuit current requirements for make and break duty.

4 LEGISLATION, CODES AND STANDARDS

4.1LEGISLATION

Equipment offered shall be compliant with the provisions of the latest applicable versions of all relevant Irish legislation and directives of the European Union.

These include the following or latest versions/ amendments at time of issue of this specification as appropriate:

SI No. 132	Safety signs regulations 1995
SI No. 291	Safety, Health and Welfare at Work (Construction) Regulations
SI No. 299	Safety, Health and Welfare at Work (General Application) Regulations 2007
SI No. 445	Safety, Health and Welfare at Work (General Application) (Amendment) Reg. 2012

Reg (EC) No 1907/2006	Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)
Reg (EC) No 1272/2008	Classification, Labelling and Packaging of Substances and Mixtures
Reg (EU) No 517/2014	Fluorinated greenhouse gases and repealing regulation (EC) No 842/2006
Reg (EU) 2015/2068	Format of labels for products and equipment containing fluorinated greenhouse gases
Reg (EU) 2015/2065	Format for notification of the training and certification programmes of the Member States
Reg EU 2015/2066	Minimum requirements and the conditions for mutual recognition for the certification of natural persons carrying out installation, servicing, maintenance, repair or decommissioning of electrical switchgear containing fluorinated greenhouse gases or recovery of fluorinated greenhouse gases from stationary electrical switchgear
Directive 2011/65/EU	Restriction of the use of certain hazardous substances in electrical and electronic equipment (ROHS)
Directive 2012/19/EU	Waste electrical and electronic equipment (WEEE)
Directive 2014/30/EU	Harmonisation of the laws of the Member States relating to electromagnetic compatibility
ECE/TRANS/275	Vol. I and II ("ADR 2019") European Agreement Concerning the International Carriage of Dangerous Goods by Road

GIS equipment shall carry the CE Mark in accordance with Directive 768/2008/EC and the EU Construction Products Regulation (No. 305/2011 – CPR), adequate documentation to demonstrate full compliance should be obtained by the Customer and issued to EirGrid. This documentation will have to be included in the Safety File.

4.2 National, International and Other Applicable Standards

Except where otherwise stated in the functional specification, materials shall be designed, manufactured, tested and installed according to relevant IEC and/or EN standards.

Where available, the Irish adaptation of European standards (IS EN version), including any national normative aspects shall be applied.

Where no IEC standard or EN standard has been issued to cover a particular subject then an international or British Standard shall be applied. The latest edition and amendments shall apply in all cases.

The equipment shall comply with the latest editions of the international standards, codes and normative references indicated below, and the latest editions of the standards that they reference.

In case of conflict with international or national standards, EirGrid specifications shall take precedence.

ET103	National rules for electrical installations – Power installations exceeding 1 kV AC
IS 10101[2]	National Wiring rules for electrical installations
EN 50110-1	Operation of electrical installations. General requirements
EN 50052	Specification for high-voltage switchgear and controlgear for Industrial use. Cast aluminium alloy enclosures for gas-filled high-voltage switchgear and controlgear
EN 50064	Specification for wrought aluminium and aluminium alloy enclosures for gas-filled high-voltage switchgear and controlgear
EN 50068	Specification for wrought steel enclosures for gas-filled high-voltage switchgear and controlgear
EN 50069	Specification for welded composite enclosures of cast and wrought aluminium alloys for gas-filled high-voltage switchgear and controlgear
EN 50089	Specification for cast resin partitions for metal-enclosed gas filled high-voltage switchgear and controlgear
EN 50089	Cast resin partitions for metal enclosed gas-filled high-voltage switchgear and control gear.
EN 50110-1	Operation of electrical installations – General requirements
IEC 60034	Rotating electrical machines
IEC 60060	High Voltage Test Techniques
IEC 60068	Environmental testing
IEC 60099-4	Surge Arrestors – Part 4: Metal-oxide surge arresters without gaps for AC systems
IEC 60137	Insulated bushings for alternating voltages above 1000 V
IEC 60255-5	Insulation Tests for electrical Relays
IEC 60265	High-voltage switches
IEC 60270	High-voltage Test Techniques, - partial discharge measurements
IEC 60376	Specification of SF_6 for use in electrical equipment
IEC 60480	Guide to checking of SF_6 taken from electrical equipment
IEC 60507	Artificial pollution tests on high-voltage insulators to be used on a.c. systems
IEC 60529	Degrees of protection provided by enclosures, control gear standards
IEC 60694	Common specifications for high-voltage switchgear and controlgear standards
IEC 60859	Cable connections for gas-insulated metal-enclosed switchgear for rated voltages of 72.5 kV and above
IEC 61462	Composite Hollow Insulators
IEC 61869-1	Instrument Transformers, Part 1 general requirements

[2] IS10101 does not apply to internal wiring of equipment. Final low voltage installations of which GIS equipment are a part shall meet IS10101 for protection of persons from risk of injury and damage to equipment from normal operation, faults, overloads, voltage disturbances and electromagnetic disturbances.

IEC 61869-2	Instrument Transformers, additional requirements for current transformers
IEC 61869-3	Instrument Transformers, additional requirements for inductive voltage transformers
IEC 61869-5	Additional requirements for capacitor voltage transformers
IEC 61869-7	Additional requirements for electronic voltage transformers
IEC 61869-11	Additional requirements for low power voltage transformers
IEC 62067	Power cables with extruded insulation and their accessories for rated voltages above 150 kV - Test methods and requirements
IEC 62271	High voltage switchgear and control gear; - parts 1 to 310 all relevant parts and clauses, including but not limited to the following:
IEC 62271-1	High-voltage switchgear and control gear – Part 1: Common Specifications
IEC 62271-4	High-voltage switchgear and control gear – Part 4: Handling procedures for sulphur hexafluoride (SF_6) and its mixtures
IEC 62271-100	High voltage switchgear and controlgear;-High-voltage alternating current circuit breakers.
IEC 62271-102	Alternating current disconnectors and earthing switches
IEC 62271-110	Inductive load switching
IEC 62271-203	Gas – insulated metal enclosed switchgear for rated voltages above 52 kV
IEC 62271-301	Dimensional standardisation of terminals.
IEC 62271-306	Direct connection between power transformer and gas insulated metal-enclosed switchgear for rated voltages of 72.5 kV and above.
IEC 62474	Material declaration for products of and for the electrotechnical industry

4.3 OTHER REFERENCES

CIGRE Brochure 234	SF_6 Recycling Guide. Re-use of SF_6 gas in electrical power equipment and final disposal (Revision 2003) - 2003
CIGRE Brochure 276	Guide for the Preparation of Customised “Practical SF_6 Handling Instructions” – 2005
CIGRE Brochure 430	SF_6 Tightness Guide – 2010
CIGRE Brochure 567	SF_6 Analysis for AIS, GIS and MTS - 2014

5 HEALTH AND SAFETY

Please refer to Health and Safety requirements as outlined in EirGrid Safe by Design Methodology XDS-SDM-00-001-R0.

It is the responsibility of the customer to produce a suitable & sufficient design risk assessment.

It is the sole responsibility of Customer to produce a suitable & sufficient design risk assessment of the GIS design in association with the GIS equipment layout. Any additional control measures deemed applicable shall be mutually agreed with EirGrid.

The risk assessment must ensure that the design is safe and without risk to health when properly used by a person at a place of work, considering the initial installation, time-based inspection, time-based maintenance requirements, operation activities, decommissioning and future extension of the switchgear.

A design risk assessment template can be found the Safe by Design Methodology XDS-SDM-00-001-R0.

Particular safety hazards to be noted include:

- SF_6 is heavier than air and can present a hazard due to asphyxiation where it displaces oxygen, in particular in cable basements and other low-lying parts of GIS installations.
- In addition, gases including methane, radon and CO_2 may accumulate in basements and other confined spaces.

A register of the hazards shall be submitted and shall include those hazards associated with the physical arrangement of the equipment (e.g. trip/fall hazards) which may pose a danger during off-load maintenance access, and those associated with the in-service operation of the equipment (e.g. stray magnetic fields, high temperatures, fluid leaks, presence of dangerous voltages).

There shall be compliance with the provisions of all relevant Directives of the European Communities relating to work equipment, i.e. regarding safety of personnel who operate and maintain the equipment.

6 SERVICE CONDITIONS

For OCC, the GIS shall be installed indoors on a concrete floor, positioned over a cable room/basement in a substation building and all equipment provided shall be capable of operating satisfactorily as specified in EirGrid General Requirements specification OFS-SSS-400.

Condensation in substation buildings shall be considered in the overall design of the building.

6.1 CORROSION PROTECTION

Corrosion of both ferrous metals and of aluminium and aluminium alloys is a particular problem in Ireland, even indoor. Experience has shown that extreme precautions are necessary, because of the high humidity, to prevent the aggressive ingress of moisture between flange plates, around gaskets and O-rings, at insulator / flange interfaces, etc.

All externally exposed ferrous parts shall be hot-dip galvanised to comply with EirGrid Specification OFS-SSS-420. Nuts, bolts and washers shall be stainless steel of suitable grade for the outdoor conditions as stated.

Corrosion protection of all switchgear components and fittings, e.g. transformer busducting to outdoor AIS bushings shall be designed to achieve a High Durability (minimum of 15 years) coating to Category C5-M (ISO 12944-2) suited to environments with high condensation, pollution and salinity. Evidence of compliance to C5-M standard according to ISO or IEC test methods (e.g. Accelerated ageing and humidity) shall be provided.

To assist in the exclusion of moisture between flange plates, around gaskets and O-rings, at insulator / flange interfaces, etc. all outdoor flanges shall have silicon grease applied during assembly in the factory or at the site of installation. Flanges shall be designed to allow the injection of grease during assembly and topping up during regular maintenance works.

All externally assembled flanges shall be treated following installation to C5-M standard to eliminate moisture ingress.

7 SERVICE EXPERIENCE

The GIS equipment supplier shall have:

(a) At least 10 years' experience in the production of the gas-insulated switchgear specified for use on 220 kV, 400 kV networks as applicable,

(b) Service experience:

- A minimum of 50 bays in service across a minimum of three European Union (EU) / European Economic Area (EEA) Utilities.

And

- Minimum of 200 bay-years' service experience of the product range of at least 5 years duration in these EU utilities of at least 100 GIS bays. Utilities not referenced in tender submission may be used by the Employer in the evaluation of this criterion at their discretion

(c) As an alternative to such experience within the EU, similar experience with UK, Swiss, Japanese, Australian, South Korean or US /Canadian utilities would be considered.

(d) At least 5 years production of the particular plant proposed is required. If the production of the GIS is relocated to another existing plant used for the production of GIS at the same or higher voltages, then the combined production time of both plants would be considered.

(e) The GIS on offer in compliance with this specification must be manufactured in the same plants which produced the products cited as meeting the service experience requirements outlined in (b) and (c) above

8 GENERAL REQUIREMENTS

8.1 GENERAL

The GIS switchgear shall be designed for safety, reliability, maintainability and ease of

operations as the primary considerations, with due consideration for the environment.

Gas Insulated Switchgear shall have an anticipated asset life of not less than 40 years.

All equipment and materials shall be new and of the highest quality and shall be capable of withstanding the electrical and atmospheric environmental conditions on site over the anticipated GIS switchgear life.

The Customer shall have available reliability statistics for the GIS on offer in terms of total bay-years in service experience, mean time between failure (MTBF) statistic and failure rate (1 /100 years) as defined in CIGRE 3rd Survey WG A3.06, 10 / 2012; Calculations based on CIGRE 513; Table 5-52.

8.2 Quality Assurance

Quality Assurance requirements shall be as outlined in EirGrid OCC General Requirement's functional specification OFS-SSS-400.

The Customer shall ensure the switchgear is manufactured in accordance with the requirements of this specification.

Any deviations to the Functional Specifications shall be outlined in the TECHNICAL SCHEDULES for EirGrid review prior to equipment ordering.

Where deviations are proposed in the design the Customer shall submit a formal Derogation Request outlining an explanation of why the non-compliance is expected and any additional information to support the request for EirGrid to consider. Further information is outlined in EirGrid's Derogation Process OFS-GEN-024.

Documents and all details necessary to complete the detailed design and construction of the installation shall show switchgear / cable arrangements, clearances, mounting of structures on the foundations, structure details and loadings to demonstrate to how the switchgear / cables will fit in the switchgear building.

The drawings shall include all necessary horizontal and vertical clearances to walls and roof and to the hook of the travelling crane which will be used for erection and subsequent maintenance of the switchgear.

8.3 Design Documentation to be provided

Please see below a non-exhaustive list of the documents to be supplied by the Customer for EirGrid review and required for installation, operation and maintenance:

1. Single line diagrams of switchgear and gas compartments.
2. Outline dimension drawings of complete equipment, section and plan view drawings of the equipment within the GIS room.
3. Outline dimension drawings of complete equipment.
4. Outline dimension drawings weights of transport modules of plant.
5. Dimensions of the necessary door opening to admit the largest module.
6. Weight and dimensions of largest component to be lifted by travelling crane.

7. Position and dimensions of openings for the exit bushing ducting.
8. Weight of largest unit to be lifted inside the building.
9. Weight of largest unit to be lifted outside the building.
10. Crane lifting capacity required for positioning of complete transport unit into building.
11. The value and position of all static and dynamic floor loadings of the complete installation.
12. Dimensional details of all support steelwork and floor fixings.
13. Civil works tolerances, particularly in the elevation of positions of installation of the GIS.
14. Location of power cable floor ducts.
15. Details of the power cable floor penetrations and of the GIS manufacturers' side of the GIS / cable interface design.
16. Location of control cable floor ducts.
17. Method of off-loading and positioning of switchgear.
18. Ventilation requirements.
19. Schematic diagrams showing the individual operation, control, monitoring, alarm and CT and VT circuits complete with terminal numbers.
20. Overpressure calculation for the switchroom to determine the requirements, if any, for pressure relief vents to reduce internal room pressure to safe levels.
21. Layout and detailed design drawing of the earthing system and connection points to the GIS. Details of transient earthing and any special measures required to mitigate EMI and VFTOs.
22. LCC layout, wiring diagrams, secondary wiring diagrams, secondary wiring termination locations and terminal layouts.
23. Interlocking conditions.
24. Gas compartment layouts, CB and disconnector control schematics and wiring diagrams.
25. Timing diagrams showing relation between main contacts and auxiliary switches (including trip coil contacts) for closing, tripping and auto-reclosing cycles.
26. All remaining drawings pertaining to the plant, including final details of all aspects of the plant including gas-handling plant.
27. Detailed Schedule of Tests.

9 Operation, Maintenance and Service Continuity

9.1 Layout and access to the GIS

The layout of the GIS shall be designed for the ultimate development of the station, considering the physical constraints of the site to ensure future works and maintenance activities can take

place with minimum disruption to the initial development. Refer to Service Continuity requirements in section 9.4.

The design shall ensure maximum safety of personnel during operation and maintenance.

All parts of main circuits to which access is required shall be capable of being earthed.

To ensure safety of personnel during maintenance, the GIS and switch room shall be arranged to facilitate safe and direct personnel access to all locations as follows;

1. Electrical and mechanical points of control of the GIS (disconnectors, earthing switches and circuit breaker mechanical trip mechanism)
2. Mechanical position indication of circuit breakers
3. Mechanical position indicators of disconnectors and earth switches
4. Inspection windows to verify position of disconnectors and earth switches (if provided)
5. Gas density monitors, pressure transducers and filling points
6. Circuit breaker spring status mechanical indication
7. Current transformer secondary connection terminal boxes
8. Voltage transformer secondary connection terminal boxes

The Customer's design risk assessment shall identify the location of all components listed above.

Where the layout consists of two or more bays coupled to each other via the busbar, the busbar shall incorporate an additional buffer or spacer compartment to allow movement of personnel in between the bays to access any components located to the side of bays to carry out the activities 1 to 8 as listed above. An illustration of this requirement is shown in Figure 1 below.

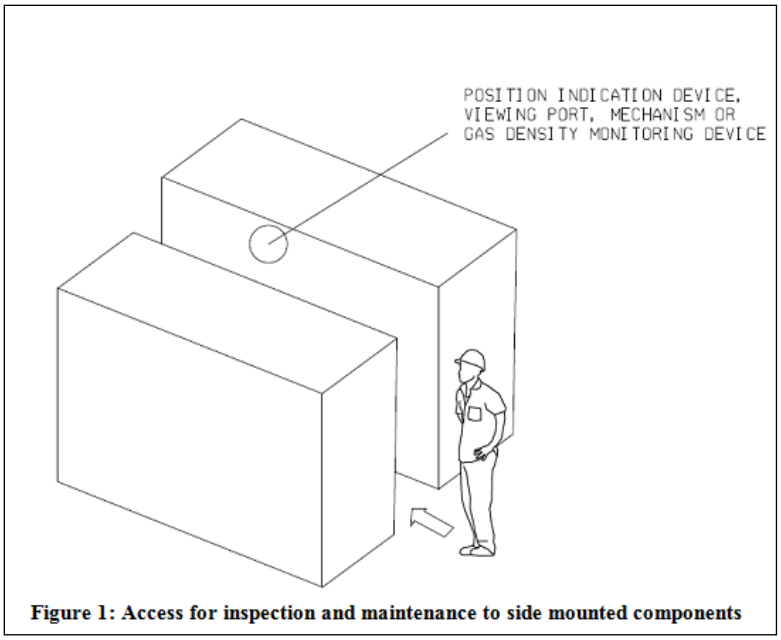

Figure 1 - Access for inspection and maintenance to side mounted components

The additional buffer compartment shall be provided where the proposed equipment does not provide an access route between the bays. The buffer or spacer compartment shall be suitably sized such that **a minimum of 600 mm width** spacing is provided between bays to allow access and movement of persons carrying out operations, regular inspection and maintenance tasks.

Free standing LCC's shall be positioned over a cable or floor opening to accept the low voltage control cabling.

In OSP Stations LCC cabling top entry may be considered, to be discussed with EirGrid.

The cabinet shall be swing frame type with door opening outwards to the left-hand side. All points of control shall be located on the front of the cabinet to allow operation and inspection without stepping inside the cabinet. Refer also to OFS-SSS-402 specification.

The interior of the cabinet shall be equipped with a light. Removable gland plates shall be labelled with permanent stickers identifying the Safe Working Load (SWL) that the plate may bear.

Adequate safety screens shall be provided for all moving parts.

Provision shall be made for carrying out primary injection tests on all current and voltage transformers without requiring internal access to any gas compartment.

The HV cable screen termination box in the HV cable room should be accessible from ground level.

9.2 Access Platforms

Fixed platforms or walkways shall be provided to facilitate operation, inspection and

maintenance of the GIS as referenced in Table 1 “Operation, Inspection and Maintenance Activities”. Platforms shall be sourced from an approved supplier (subject to EirGrid review) and installed before commencement of final commissioning.

Platforms shall be designed to take account of additional necessary requirements when working at height as per SI 299 Part 4.

Handrails shall be provided on the platforms where necessary to achieve safe access to LCCs, CB mechanism boxes, VT's and all other relevant equipment on the GIS switchgear.

The use of handrails and/ or catenary harness system shall be considered to ensure the safety of personnel for all activities while on the platform.

A platform/ catwalk serving two or more operating positions shall have two stairways to the operating floor. Any external gas pipework shall be mechanically protected and arranged so that it cannot be damaged by operating staff in the course of their duties. The general layout of the plant shall be such as to permit replacement of any faulty component while maintaining the service continuity of the bays not directly affected.

Lifting eyes shall be provided on all GIS components or removable catwalk sections which cannot be lifted safely by other means.

Access platform design shall be incorporated into the overall switch room design by the Customer. The design shall be coordinated with the location of emergency exits and shall allow for future extension to cater for the ultimate development of the station.

To adequately protect personnel the exhaust direction of the rupture discs location along the switchgear access platform shall be directed away from the access or walkway.

9.3 Operation, Inspection and Maintenance Requirements

The GIS installed shall be subject to regular local operation, inspection and time-based maintenance intervals in accordance with maintenance plan.

The maintenance plan / schedule shall be discussed and agreed with the Customer / manufacturer. EirGrid have a current GIS maintenance policy and it is outlined in Table 1 as an example only. Additional maintenance requirements may apply according to the type and nature of the GIS offered.

The Customer shall be cognisant of these requirements when designing the GIS equipment and when completing the required Design Risk Assessments (DRA’s).

The frequency of the tasks below shall be accounted for in DRA to be developed by the Customer for the installation.

Activity	Frequency	Tasks to be performed
GIS Operation	May occur daily	- Electrical operation of disconnectors / earth switches at LCC. - Visual confirmation of CB, disconnector and earth switch. - Attachment of lock and notice (LOTO system as outlined in specification OFS-SSS-400) on mechanisms of disconnectors and earth switches. - Confirmation of voltage / currents locally at LCC
Inspection	Monthly	- Record pressures of all SF_6 density monitors - Visually inspect CB drive mechanism - Visually confirm position of all MCB's and fuses, including those within VT secondary boxes - Confirm heaters operating in all drive and marshalling boxes - Record CB operation counters
Maintenance	Annually	- Electrical operation and functional tests of switching devices - PD & thermography - Gas leak detection – all flanges and insulators
	Every 4 or 5 years	- Mechanical Operation and functional test of all mechanisms - Inspect and lubricate drives and mechanisms
	Every 6 years	- Calibration of SF_6 density monitors
	Every 8 or 10 years	- CB timing and contact resistance tests - Gas sampling and testing - CT and VT injection tests - Disconnector contact resistance tests
	Every 20 years	- Change Gas desiccant / moisture absorbers
Fault Finding	Ad Hoc	- Circuit tracing, mechanism / relay checks and tests

Table 1 - Operation, Inspection, Maintenance and Repair Activities

Platforms shall be provided to safely perform the operation and inspection tasks as outlined in section 9.2.

Mobile Elevated Work Platforms (MEWP's) may be proposed to fulfil requirements outlined above subject to satisfactory risk assessment provided by the customer and reviewed by EirGrid.

9.3.1 LOCK-OUT, TAG-OUT PERMIT TO WORK SYSTEM

The switchgear shall be operated in accordance with Lock-Out, Tag-Out (LOTO) permit to work system as detailed in EN 50110-1:2013 section 6.2 (the “five safety rules‟).

The Switchgear shall be capable of facilitating dead working using a Lock-Out, Tag-Out (LOTO) and permit to work system in accordance with EN 50110-1 in the following specified sequence (also known as the “5 golden rules” for electrical safety):

1. Disconnect completely
2. Secure against re-connection (i.e. lock-off disconnector mechanism and electrical control of disconnector)
3. Verify absence of operating voltage
4. Carry out earthing and short-circuiting
5. Provide protection against adjacent live parts

9.3.2 SPECIAL TOOLS & EQUIPMENT

The Customer, in consultation with the manufacturer, shall submit details of all tools and spares required for correct operation and maintenance for a 40-year expected lifetime of the switchgear.

Special equipment shall include all hoists, jigs, special tools, templates and gauges required for the erection and subsequent maintenance of the switchgear. These shall be included in the supply and shall not be returnable.

Any special tools required for maintenance of the equipment shall be listed in the TECHNICAL SCHEDULES. A complete set of tools, including special tools, shall be provided with the GIS gear and stored, following manufacturer guidance, in the OCC workshop.

9.3.3 SPARE PARTS

The Customer / OEM shall guarantee the continuing availability of the complete range of spare parts for the equipment offered.

The Customer Supplier (manufacturer) shall identify those spare parts which they recommend should be held. The spare parts recommended shall be clearly identified on the drawings and maintenance instructions provided by the supplier. Spare part requirements shall be driven by a Reliability, Availability, Maintainability study to be prepared by the Customer and provided to EirGrid for review.

Refer to OFS-GEN-009 for more details.

9.3.4 HEATERS

To prevent condensation, heaters, suitably protected shall be fitted where necessary. The live parts of the heaters shall be enclosed with degree of protection IP2X.

The supply voltage for heaters shall be 230 V AC.

9.4 SERVICE CONTINUITY

For single busbar GIS installations, outages shall be limited to one bay during any works on the bay circuit breaker or any other gas compartments on the line side of the circuit breaker.

Outages on the operational section of the GIS shall be avoided for addition of another section of busbar (disconnector to be installed in advance where future busbar extension is planned, this case will be identified by EirGrid and communicated to the Customer).

Additional gas compartments shall be provided as required to ensure that the above availability is achieved allowing for the following constraints:

a) It shall be possible to earth all internal components and completely depressurise any compartment to gain access for maintenance.

b) Adjacent compartments shall have their pressure reduced (see also section 12.1).

c) Disconnects in reduced pressure compartments may not be used to provide isolation from live parts – i.e. isolation from live parts must be provided by a disconnect in a fully pressurised compartment.

The Customer can propose any additional features to achieve the service continuity requirements.

The Customer shall submit the details of the methodology utilised to achieve the required service continuity level, and the approach used shall in accordance with Annex F of IEC 62271-203 of 2011.

9.4.1 HIGH VOLTAGE WITHSTAND TESTING

It is a requirement that every new piece of HV equipment added or replaced is to be subjected to a high voltage withstand test after installation on site as quality assurance verification and additional reassurance for the manufacturing warranty.

The Customer shall detail the service continuity achieved during HV testing of replacement components and shall also provide a risk assessment demonstrating how this work (i.e. replacement of circuit breaker, CT and busbar disconnector) can be carried out in a safe manner.

Details of additional gas partitioning compartments or isolation devices proposed for this purpose shall also be provided by the Customer.

If required, test bushings and adequate clearance around the location of the test bushing for testing shall be provided while maintaining the required service continuity of adjacent equipment.

9.4.2 ADDITIONAL REQUIREMENTS FOR CIRCUIT BREAKER REPLACEMENTS

Cable connected feeder bays shall be designed so that the interrupter or circuit breaker pole may be removed and replaced on site during the lifetime of the GIS without disconnection or removal of the HV cables connected to the same bay.

The design shall incorporate a disconnection facility between the circuit breaker and HV cable box compartment to facilitate this. De-gassing of the cable box when replacing a circuit breaker

is permissible during these works however disconnection or removal of the cables shall be avoided.

9.4.3 BARRIER AND SUPPORT INSULATORS

Gas zone partitions shall be capable of withstanding the following pressure differentials in both directions according to European regulations CENELEC EN 50089- 1992 / A1:1994:

- Rated filling density on one side and vacuum on the other
- Maximum pressure rise resulting from an internal arc on one side and atmospheric air on the other side

In line with service continuity requirements it shall be possible to open any compartment without impacting on the availability of adjacent bays and only one busbar section at a time shall be affected.

The manufacturer shall describe any design features of the insulator, gas sealing system and 'O' ring positioning that may impact on this requirement and identify additional necessary measures to eliminate such impacts (i.e. additional buffer compartments, gas valves or density monitors).

The location and design of spacers / barriers shall be such as to minimize the possibility of particle collection.

The Customer shall provide physical designs of the switchgear showing locations and orientation of insulators in relation to switching devices.

Suitable measures shall be taken to ensure enclosures and compartments are potentially bonded where separated by insulating spacers to prevent external or internal flashovers due to very fast transient voltages (VFTO's) being induced on the enclosure during switching.

Any specific requirements and procedures relating to earthing of the GIS shall be provided by the Customer.

10 GIS - PRIMARY PLANT

The GIS primary plant shall include all items of equipment and support structures, configured and assembled together in accordance with the project specific single line diagram.

The nominal and short time withstand current of HV primary plant (instrument transformers, circuit breakers, disconnectors) and busbar ratings shall be as shown in the single line diagrams (SLDs) and in the TECHNICAL SCHEDULES.

The GIS shall include the control and marshalling cabinets complete with interconnecting cables, support structures and, when required, necessary provision for future extensions

The building, control room and switchgear shall be designed and suitably sized to facilitate the ultimate development of the station including all future and spare bays as illustrated in the project specific SLD.

For OCC, the GIS building layout shall be designed in accordance with EirGrid's latest GIS standard layout drawing OFD-SSS-503. The Customer shall submit their GIS station layout design for EirGrid review to incorporate technical feedback in advance of finalising planning submission.

10.1 AUXILIARY SUPPLIES

The following are the auxiliary supplies available. Operating coils and other auxiliary equipment shall be designed accordingly:-

Table 2 Auxiliary Supplies

Voltage	Application
220 V DC	All tripping and closing circuits, direct drive motors (Circuit Breakers, Disconnectors, earth switches etc.)
220 V DC	Signal and alarm circuits
230 / 400 V AC, 50 Hz	Circuit breaker compressor or spring winding motors, heaters, internal lighting, etc.

Refer to OFS-SSS-403 "Auxiliary Power Supplies" for further details of station auxiliary power supplies.

10.2 LABELLING AND NAMEPLATES

Each individual piece of switchgear shall be provided with a nameplate bearing information as specified by the relevant IEC Publication.

Individual equipment nameplates shall contain the actual type tested current / voltage ratings of the equipment.

The switchgear shall be labelled to show (but not limited to);

1. The insulating gas being used
2. Insulating gas quantity (kg)

3. Global Warming Potential
4. CO_2 equivalent
5. The text “Contains fluorinated greenhouse gases covered by the Kyoto Protocol” (where SF_6 is used)
6. Where applicable the text “hermetically sealed”, a reference that the switchgear has a tested leakage rate of less than 0.1%.

The following is a non-exhaustive list of the required labels:

1. Each GIS bay and its LCC shall be identified according to the bay designation on the SLD.
2. Each HV switching device, including earth switches, shall be clearly labelled to indicate its function and bay.
3. Each phase of the GIS bays and busbar shall be identified with appropriate phase reference at each point where it may be accessed.
4. Each partition between gas volumes shall be identified.
5. Each gas density / pressure monitor shall be identified with a label containing a reference to the gas volume being supervised.
6. Each valve shall be labelled identifying its function.

A labelling schedule shall be submitted by the Customer at detailed design stage for EirGrid’s review.

The labelling schedule shall include:

- The label text, text size, material and mounting location for each item of equipment. The label text shall incorporate bay codes and names from the single line diagram.
- A statement of compliance with OFD-SSS-511, with any deviations or additions noted.

10.3 Partial Discharge and Radio Interference Voltage Measurement

Each item of switchgear shall meet the requirements specified in the appropriate IEC Publication for partial discharge (PD) and / or radio interference voltage (RIV) for that item.

10.4 Circuit Breakers

10.4.1 Ratings and Switching Requirements

Circuit Breakers shall comply with IEC 62271-100 and the following:

- First pole to clear factor: 1.5
- Rated Operating Sequence: O-0.3 s-CO-3 min-CO

  From the Open position (with the springs wound / with the operating mechanism charged) the circuit breakers should be capable of carrying out the following cycle:

- Close, Trip immediately (e.g. in 2 cycles – 40 ms), be available to Close again after 300 ms (to achieve a dead time[3] of ~ 500 to 600 ms) and Trip Immediately.
- The circuit breaker shall be capable of carrying out a further close and immediate trip after a period of 3 minutes.

Circuit breakers shall be single pole (independently) operated. Single pole operated circuit breakers shall have mechanical endurance class M2. Details of type test certification shall be available. Details of type test certification for M2, C2 and CC2 testing shall be made available.

10.4.2 Point On Wave Switching

Single pole operation circuit breakers with associated point on wave relay may be required to switch capacitor banks, transformers, shunt reactor banks and other reactive compensation devices. This ensures the circuit breaker is synchronised (soft) closed and / or opened by means of control switching relays.

The control relay for synchronised operation shall be included in the project specific protection specification. The Customer shall supply the necessary relay integrated in the LCC and licenced copies of any software required to configure the timing settings.

Capacitive switching currents may compromise part or all of the operating duty of a circuit breaker. The following ratings of the circuit breaker for capacitive current switching shall be stated in the TECHNICAL SCHEDULES:

1. Rated line-charging breaking current
2. Rated cable-charging breaking current
3. Rated single capacitor bank breaking current
4. Rated back-to-back capacitor bank breaking current
5. Rated single capacitor bank inrush making current
6. Rated back-to back capacitor bank inrush making current.

Values of rated capacitive switching currents shall be as given in IEC62271-100.

The associated maximum switching overvoltage shall be stated in the TECHNICAL SCHEDULES.

The circuit breakers shall be class C2 very low probability of restrike when breaking the full range of capacitive switching currents up to and including the rated values.

10.4.3 Transient Recovery Voltage and Rate of Rise of Recovery Voltage

The Transient Recovery Voltage (TRV) shall be in accordance with IEC 62271-100, with first-pole-to-clear factor of 1.5 for all test duties.

[3] Time from Trip to Closed position.

The details of any device incorporated in the circuit breaker to limit or control the Rate of Rise of Recovery Voltage (RRRV) across the circuit breaker contacts or to divide the voltage across multiple series breaking contacts shall be made available.

10.4.4 Inductive and Capacitive Current Switching

The over-voltage associated cable charging current shall be in accordance with IEC 62771-100.

The Customer shall also ensure that all circuit breakers are suitably rated for capacitive charging breaking currents as outlined in the associated EirGrid TECHNICAL SCHEDULES.

Note that EirGrid also request the Customer to provide the maximum cable capacitance per phase and max charging current per phase in the EirGrid 220 /400 kV Cable TECHNICAL SCHEDULES. EirGrid do not prescribe a value for Max Phase Capacitance (µF/km) and Max Charging current per phase (A/km) in the Cable TECHNICAL SCHEDULES as the value required is bespoke, i.e. it depends on the breaker rating and the length of the cable and capacitive contributions from other sources. Therefore the Customer must consult with EirGrid on a project specific basis prior to order of Circuit Breakers to ensure that Cable and Circuit Breaker requirements are aligned and that there are no impacts on existing Circuit Breaker installed in the Network in the substation connected to the OCC i.e. existing circuit breaker ratings are not exceeded for new long cable lengths installed.

10.4.5 Switching small inductive currents

The over-voltage associated with small inductive current switching shall be in accordance with IEC 62771-100.

The Customer shall calculate the amplitude of overvoltage’s generated by switching inrush currents associated with transformers of the ratings illustrated on single line or equipment diagrams. The purpose of this exercise is to advise on the necessity or otherwise of fitting surge arresters on cable / transformer connections.

10.4.6 Circuit Breaker Operating Mechanism Type

Circuit breakers shall be suitable for triple-pole or single-pole rapid auto-reclosing.

The operating mechanism shall be of the stored energy motor spring wound type. Other types may be acceptable with the exception of compressed air mechanisms.

The mechanism shall be trip-free in any position and shall include an anti-pumping facility.

Circuit breakers having individual drives per pole shall be provided with automatic tripping on pole discrepancy.

The operating mechanisms of circuit breakers designated for use on capacitor bank and reactor switching shall be mechanical endurance class M2.

The mechanism shall be equipped with an emergency mechanical trip mechanism to allow operation of the trip coil in event of auxiliary supply failure or blackout restart procedures of islanded systems.

10.4.7 Control

A +10%/ -20% tolerance applies to DC supplies. A full description of the drive mechanism shall

be provided as part of the TECHNICAL SCHEDULES submission. All motors shall be protected by an MCB located in the Local Control Cubicle (LCC). The MCB shall be equipped with auxiliary contacts for signalling and alarm purposes.

Two electrically independent[4] tripping coils and one closing coil shall be provided, all suitable for 220 V DC operation. Both positive and negative poles of the closing coil shall be switched by all operating devices supplied in the switchgear.

A separate and independent control switch shall be provided at the bay LCC to isolate both the positive and negative supply to the close coils.

Circuit breakers shall have two independent trip coils and one close coil per pole.

An automatically controlled anti-condensation heater (230 V AC) shall be provided in mechanism box(es).

10.4.8 POLE DISCREPANCY

Circuit breakers shall be provided with automatic tripping on pole discrepancy. The tripping device shall have a time delay, which is adjustable from zero to one second. The discrepancy trip devices shall operate both trip coils.

10.4.9 SHIELDING OF MOVING PARTS

The operating mechanism shall be arranged so that no moving parts are accessible when locally mechanically operating the circuit breaker in emergencies.

The height of mechanical operating facilities should be suited to the level of effort required. Where possible operating facilities which require significant effort should be located at a height of approximately 1 m from operator standing height.

Where controls and mechanisms accessed during operation of the switchgear are located in the same box containing moving parts there shall be shields fitted internally to guard against accidental contact. An operator shall be able to insert the manual winding handle without exposure to moving parts. Note that heaters and MCB's located within the mechanism boxes require regular inspection as they are susceptible to failure.

10.4.10 AUXILIARY CONTACTS

A minimum of eight normally-open and eight normally-closed auxiliary switches shall be provided and shall be wired to individual terminals in the bay LCC.

10.4.11 MECHANICAL POSITION INDICATION

A mechanical position indicator of the main contact of the circuit breaker shall be provided and must be visible to a person electrically operating the bay at the LCC.

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[4] The circuit breaker shall operate correctly when either trip coil operates. Each trip coil is supplied from a separate 220 V DC supply.

If marking is not provided by OEM, it shall be marked as follows:

- The word **'ON'** in white letters on a red background shall be used to indicate the breaker is in the closed position
- The word **'OFF'** in white letters on a green background shall be used to indicate the breaker is in the open position

An operations counter shall also be included and be clearly visible from the operating floor.

10.4.12 SPRING MECHANISM POSITION INDICATION

A status indicator for the stored energy spring shall be provided at the circuit breaker mechanism box. It shall be possible to verify the status of the spring (charged or discharged) without opening any doors or removing mechanism covers. A suitable external indicator or viewing window on the mechanism box shall be provided on all mechanisms. The indications shall be clearly marked 'CHARGED' and 'DISCHARGED' to indicate the status of the spring.

10.5 DISCONNECTORS

10.5.1 RATINGS

The disconnectors shall comply, in general, with IEC Publication 62271-102.

The nominal and short circuit ratings of disconnectors shall be as specified in the project specific SLD.

The disconnectors, in addition to their continuous current rating shall be capable of switching the busbar capacitive currents, of withstanding the induced very fast transient switching over-voltages and of withstanding the DC trapped charge which may remain on the busbars.

Particle generation by disconnector operation shall not reduce the dielectric strength of the installation.

Disconnectors shall be rated to make and break capacitive and inductive charging currents in accordance with the rated voltage and rated current of the installation, in accordance with IEC 62271-102.

Disconnects shall have a minimum bus-transfer voltage rating as stated in Table 3.

Item	220 kV	400 kV
Standard Disconnects	20 V	30 V
Disconnects to AIS busbars	200 V	300 V

Table 3 - Min Rated Bus-Transfer Voltage

The rated bus-transfer current shall be marked on the nameplates of the relevant disconnectors (if applicable).

All busbar and sectionaliser disconnectors shall have a rated bus-charging current of 0.1 A as per IEC 62271-102. The rated bus-transfer current shall be marked on the nameplates of the relevant disconnectors.

10.5.2 CONTROL

Each disconnector shall be equipped with a dedicated 220 V DC motor driven mechanism which will normally be operated electrically from a remote-control position, SCADA and from the bay LCC.

All drives shall be provided with hold-on arrangements to extend the open and close electrical command impulses until operation is completed.

Electrical operation shall require a double-pole command i.e. both the positive and negative sides of the electrical command impulse shall be switched.

Disconnectors shall be capable of being operated manually for maintenance and adjustment operations. Automatic lock-out of the power drive when the manual lever is engaged shall be provided.

The drive mechanism control shall ensure that each disconnector reaches the fully open and fully closed positions at all times.

The drive mechanism shall also have the facility to attach a 'Hold Off' notice as per the LOTO permit to work system herein.

10.5.3 POSITION INDICATION

It shall be possible to obtain positive confirmation (clear indication) of the position of all disconnectors either through easily accessible inspection windows, an approved kinematic chain, or through some other method. The proposed method should be certified, type tested and is subject to EirGrid acceptance.

The Mechanical Position Indication shall be marked as follows:

- The word **'ON'** in white letters on a red background shall be used to indicate the disconnector is in the closed position
- The word **'OFF'** in white letters on a green background shall be used to indicate the disconnector is in the open position

An operation counter shall also be included and be clearly visible from the operating floor. The position indication text shall also be clearly visible from ground level.

10.5.4 LOCKING ARRANGEMENTS

Locking arrangement in both the ON and OFF position by means of padlocks is required.

The locking arrangement shall be capable of accepting a padlock with a shackle bend radius of 30 mm, shackle length of 23 mm and cross-section of 6.3 mm.

The locking arrangement shall prevent both electrical and mechanical operation of the disconnect.

A dimensioned drawing of the locking arrangement shall be provided by the customer to EirGrid for review.

10.5.5 AUXILIARY CONTACTS

Minimum of eight normally open and eight normally closed auxiliary switches shall be provided

and wired to individual terminals in the LCC.

The number of auxiliary contacts proposed shall exclude those supplied and incorporated in circuits for the safe operation and position indication of the disconnectors.

The Supplier shall state the number of auxiliary contacts operated directly by the disconnector mechanism in the compiled Technical Schedule. The minimum requirement is two normally open and two normally closed 'direct acting' contacts.

Where designated as 'direct acting', the auxiliary switches shall be positively driven in both directions by the main drive mechanism. The Supplier shall state if contacts are not direct acting, e.g. if reproduced by latching relays.

One of each normally open and normally closed auxiliary contacts referred to above are to switch according to the following sketch in Figure 2:

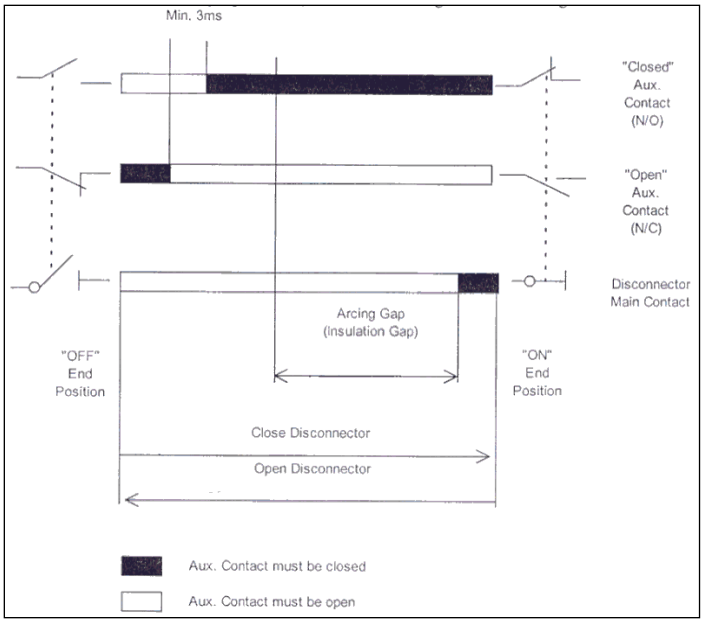

Figure 2 - Operating sequence of normally open and normally closed contacts

<u>During closing</u>

- The N/C contact must open at least 3 ms before the closing of the N/O contact.
- The N/O contact must close before the main contact reaches the insulation breakdown gap.

<u>During opening</u>

- The N/O contact (“Closed” signal) must not open before the main contact has passed the contact gap at which re-ignition can occur.
- During the closing operation the N/O contact must close before the main contact reaches the insulation breakdown gap.

These special contacts shall be directly driven from the disconnector mechanism and are not required on earthing switches.

The quantities apply per pole for disconnectors and having individual drives per pole; otherwise the quantities apply per triple-pole unit.

10.5.6 DISCONNECTORS AS THREE POSITION SWITCHES

It shall be possible to lock-off disconnector mechanisms and isolate the electrical control supply to disconnector drives while retaining electrical or manual control of the maintenance earthing function.

This is to allow maintenance testing of the circuit breaker while maintaining service continuity requirements.

It shall be possible to open the disconnector, lock-off the disconnector mechanism, isolate the electrical supply to the disconnector drive and then close the maintenance earth switch, either electrically or manually.

Where manufacturer's switchgear cannot operate in accordance with this procedure, additional earthing switches with isolation facilities must be included within designated bays, in particular busbar coupling bays or line/cable disconnectors for single bay GIS gear.

10.6 FAULT MAKING EARTHING SWITCHES

10.6.1 RATINGS

All busbar earth switches and HV Line / Cable and Transformer bay earth switches must be isolatable high-speed fault-making earthing switches and shall comply in general with IEC Publications 62271-102.

They shall be capable of making the peak withstand current (fault-making) and carrying the short time-current for 1 second and shall also be capable of interrupting induced (inductive and capacitive) currents

The induced-current switching class shall be either Class A or Class B as specified in the project requirements, and as defined by IEC 62271-102. Class B is required for circuits having relatively long sections of line or high coupling to adjacent circuits.

Particle generation by fault making earth-switch operation shall not reduce the dielectric strength of the installation.

The full energy required for a high-speed closing operation must not be stored when the earthing switch is Off (open) but shall be accumulated after the On (close) command is given and before the On operation takes place.

Short circuit making capability shall be class E1 type.

10.6.2 CONTROL

Each earthing switch shall be equipped with a dedicated 220 V DC (+10 / -20%) motor driven mechanism which will normally be operable electrically from a remote-control position and also from the bay LCC.

Drives shall be fitted with external hold on circuitry such that the command to open or close motorised disconnects from the Bay Control Unit will proceed to completion even in the event that the Bay Control Unit fails after giving the initial command.

Electrical operation shall require a double-pole command i.e. both the positive and negative sides of the electrical command impulse shall be switched.

The earthing switches shall be capable of being operated manually for maintenance and adjustment operations. Automatic lock-out of the power drive when the manual lever is engaged shall be provided.

The drive mechanism control shall ensure that each disconnector reaches the fully open and fully closed positions at all times in accordance with the interlocking requirements.

Where control mechanisms, accessed during operation of the switchgear, are located within boxes containing moving parts, shields shall be fitted to guard against accidental contact.

An operator shall be able to insert the manual operating handle without exposure to moving parts and have the facility to attach a “Hold Off” notice as per LOTO permit to work system.

10.6.3 Position Indication

The requirements as outlined in section 10.5.3 for Disconnector Position Indication shall also apply for Earthing Switches.

10.6.4 Locking Arrangements

The requirements as outlined in section 10.5.4 for disconnectors shall also apply for Fault Making Earthing Switches.

10.6.5 Auxiliary Contacts

Minimum of eight normally open and eight normally closed auxiliary switches shall be provided and wired to individual terminals in the LCC.

The number of auxiliary contacts proposed shall exclude those supplied and incorporated in circuits for the safe operation and position indication of the earthing switches.

The customer shall state the number of auxiliary contacts operated directly by the switch mechanism. The minimum requirement is two normally open and two normally closed 'direct acting' contacts.

Where designated as 'direct acting', the auxiliary switches shall be positively driven in both directions by the main drive mechanism.

The customer shall state if contacts are not direct acting, e.g. if reproduced by latching relays.

10.6.6 Test Facilities

To facilitate tests on individual phases of equipment and outgoing cables, the maintenance earthing switches shall have the earth connection brought out through insulated bushings (minimum of 10 kV withstand) and the three phases connected together and earthed externally with removable connection.

The relevant insulation level (AC and DC) of the earthing connection (when removed) shall be stated.

It shall be possible to obtain positive confirmation (clear indication) of the position of all Maintenance Earthing Switches either through easily accessible inspection windows, an

approved kinematic chain or through some other method.

The proposed method should be certified, type tested and is subject to EirGrid review.

10.7 MAINTENANCE EARTHING SWITCHES

10.7.1 RATINGS

All the maintenance earthing switches shall comply in general with IEC Publication 62271-102. They shall be capable of carrying the short-time current for 1 sec. and should also be capable of interrupting induced (inductive and capacitive) currents. The switching capabilities of proposed devices shall be provided by the Customer to EirGrid.

Particle generation by maintenance earth switch operation shall not reduce the dielectric strength of the installation.

10.7.2 CONTROL

Each maintenance earthing switch shall be equipped with a dedicated 220 V DC motor driven mechanism which will normally be operated electrically from the LCC.

All drives shall be provided with hold-on arrangements to extend the open and close electrical command impulses until operation is completed.

Electrical operation shall require a double-pole command i.e. both the positive and negative sides of the electrical command impulse shall be switched.

The earthing switches shall be capable of being operated manually for maintenance and adjustment operations. Automatic lock-out of the power drive when the manual lever is engaged shall be provided.

The drive mechanism control shall ensure that each disconnector reaches the fully open and fully closed positions at all times in accordance with the interlocking requirements.

Where control mechanisms, accessed during operation of the switchgear, are located within boxes containing moving parts, shields shall be fitted to guard against accidental contact.

An operator shall be able to insert the manual operating handle without exposure to moving parts and have the facility to attach a “Hold Off” notice as per LOTO permit to work system.

10.7.3 POSITION INDICATION

The requirements as outlined in section 10.5.3 for Disconnectors shall also apply for Earthing Switches.

10.7.4 LOCKING ARRANGEMENTS

The requirements as outlined in section 10.5.4 for Disconnectors shall also apply for Maintenance Earthing Switches.

10.7.5 AUXILIARY CONTACTS

The requirements as outlined in section 10.6.5 for Fault Making Earthing Switches shall also apply for Maintenance Earthing Switches.

10.7.6 TEST FACILITIES

The maintenance and service continuity requirements found in this section shall apply to all installations.

It may be necessary for maintenance earth switches to be equipped with insulated bushings for test purposes.

The customer shall provide isolatable maintenance earths where required. The relevant insulation level (AC and DC) of the earthing connection (when removed) shall be available.

10.8 INSTRUMENT TRANSFORMERS

This section should be read in conjunction with OFS-SSS-424 and the project protection specification, these documents provide ratings and general requirements for instrument transformers.

This specification provides additional particular requirements for the construction and interfacing of instrument transformers with gas-insulated switchgear.

10.8.1 TERMINAL BOXES

Secondary windings shall be wired and connected to the terminal boxes and from there to the marshalling cabinet/ LCC.

Terminal boxes of instrument transformers shall be located outside the high voltage enclosure.

Means for short circuiting and earthing shall be provided in the LCC. The terminals and their arrangement shall be submitted to EirGrid for acceptance.

The terminals in the LCC shall be as outlined in EirGrid specification OFS-SSS-402 and mounted in accessible terminal boxes.

Where ring CT's are used for billing and check metering applications, the secondary terminals shall be brough to the Metering Marshalling Kiosks in the Cable room as illustrated in Photo 1.

Where billing and check metering CT/ VTs are installed in the switchgear, the secondary terminals shall be located in separate, sealable and accessible terminal boxes.

The Customer shall ensure that the star point wiring is implemented at the base of the CT terminals in the Metering marshalling kiosk enclosure for Metering Circuits.

10.8.2 CURRENT TRANSFORMERS

Current transformers shall meet the general requirements of IEC 61869-1 and IEC 61869-2 and the requirements of OFS-SSS-424 specification.

Suitable measures shall be taken to prevent induced current in the enclosure interfering with the performance of the current transformers. The method shall be described by the supplier.

In the case of direct connection of gas insulated switchgear to power transformers, provision shall be made for a CT in the bus duct section between the bay earth switch (DEM4) and the transformer bushing for busbar protection or Circuit Breaker Failure purposes (in line with EirGrid protection requirements).

10.8.3 Ring Type Current Transformers

Where Applicable a separate protection ring type current transformer shall be mounted around the outgoing cable or cables together with a copper earth return or bonding lead. Split core CTs are not acceptable.

Supports, when incorporated onto cable termination support steelwork shall be designed to avoid circulating currents.

The manufacturer shall confirm the window diameters of the current transformers offered. Minimum inner window diameters are indicated in OFS-SSS-424 specification.

Photo 1 Ring CTs and Metering marshalling kiosk

10.8.4 Voltage Transformers

10.8.4.1 General Requirements for Voltage Transformers

Voltage transformers shall meet the requirements of IEC 61869-1 IEC 61869-3 and OFS-SSS-424..

VTs shall be mounted directly on the high voltage enclosure with plug-in contacts that allow easy removal.

Revenue metering VT secondary terminals shall be located in separate, sealable and accessible terminal boxes.

Optional measures designed to prevent ferro-resonance in VTs, where necessary, shall be proposed and described in the tender.

Voltage transformers shall be capable of discharging safely the connected cable capacitance.

10.8.4.2 PROTECTION OF SECONDARY WINDINGS

Refer also to OFS-SSS-424 specification. The MCB for downstream protection of VT circuits shall be located in the LCC.

10.8.4.3 OPEN-DELTA / RESIDUAL VOLTAGE SECONDARY WINDINGS

Refer also to OFS-SSS-424 specification. The single pole MCB for downstream protection of the open-delta circuit shall be in the LCC on the ‘a’ side only.

10.8.5 HV CABLE TEST REQUIREMENTS FOR GIS

HV cables are generally connected directly to the GIS switchgear without open air terminations.

HV cable withstand tests shall be performed in accordance with IEC 62067 at varying frequencies between 20 Hz and 300 Hz.

It shall be possible to perform routine high voltage commissioning tests on the connecting underground cables utilising a connection point on the GIS without having to remove the cable termination.

The line/cable disconnector between the circuit breaker and cable shall be opened during this test. The Customer shall be in a position to confirm the suitability of the cable connection compartment for the application of the varying frequency voltage.

During the test the voltage transformers at each bay shall be isolated to facilitate the application of a varying frequency voltage in the range of 20 Hz to 300 Hz onto the HV cable while connected to the GIS.

It shall be possible to disconnect the inductive voltage transformers from the HV bay by removal or disconnection of an internal link within the gas compartment. The disconnection shall be able to withstand the test voltage as per IEC 62067.

Each feeder bay shall facilitate removal/disconnection of the voltage transformer to allow connection and testing of HV cable.

During a HV cable test at the remote station end, assuming it is also a GIS station the voltage transformer shall be disconnected by removal of an internal link within the gas compartment. When removing and inserting the link, the voltage transformer may be de-gassed but not the rest of the bay. The voltage shall be applied onto the cable utilising the connection flange for the voltage transformer.

The Customer shall provide one AIS test bushing and GIS adaptor per installation to connect onto the flange in place of the voltage transformer for application of the voltage in accordance with rated test voltage.

Details and drawings of the adaptor proposed shall be available.

As part of the switchgear assembly works the Customer shall facilitate training in connection requirements for HV cable testing for removal / disconnecting voltage transformers and connecting HV cable test kits.

10.8.6 POWER VOLTAGE TRANSFORMERS

Customer may provide the optional feature for supply of a power voltage transformer which may

be used to perform dielectric testing (power frequency withstand tests) on the GIS installation without additional equipment in the future.

The power VT's shall be fitted to a nominated bay(s) in place of the conventional VT and suitable for performing the withstand test on any busbar section and a bay connected to the busbar.

The customer shall state the capacitive limitations of a single VT in accordance with the project specific SLD and advise the minimum number of power VT's required.

10.8.7 HV CABLE / CAPACITOR BANK DISCHARGE CAPABILITY

Some voltage transformers may be required to discharge long lengths of high voltage cables or high voltage capacitor banks. The cable or capacitor discharge capability at different voltages shall be outlined in the TECHNICAL SCHEDULES.

Typical requirements (to cover maximum cable lengths) on the networks covered by this specification are as follows, the Customer shall ensure that cables or capacitive devices connected as part of the Offshore connection development are considered when determining the specific project requirements:

Rated Primary Voltage kV	Discharge Capacitance μF	
	XLPE Cable	Capacitor Bank
110/ √3	6.0	13.0

Table 4 - Voltage Transformer Discharge Capacitance

10.8.8 BUSBAR VOLTAGE SENSORS – LOW POWER INSTRUMENT TRANSFORMERS

Capacitive or field probe voltage sensors shall be installed for the purpose of measuring power flow indication across the busbar.

These non-conventional instrument transformers or low power instrument transformers as defined by IEC 61869 shall be incorporated into a suitable gas compartment of the relevant bay(s) and calibrated on-site by the customer.

The customer may offer dedicated window or probe type sensors contained within gas compartments other than the circuit breaker compartment.

Alternatively, it will be acceptable to utilise a sensor on the switchgear, intended for the purpose of periodic partial discharge measurement, as the voltage sensor during normal service.

Any necessary converter electronics for the sensor shall be housed within the LCC of the bay supplied with the switchgear.

The manufacturer may supply a passive voltage sensor for direct connection to the Integrated Control and Protection (ICP) relay, or a complete system compromising of the sensor and converter electronics.

The system supplied shall include all necessary shielded cabling of fixed lengths to interconnect

the sensor to the integrated or standalone LCC included in the GIS scope of supply.

The system (sensor + converter) shall be capable of providing the required voltage output to the customer's ICP relay located within the bay LCC.

Fixed external capacitors for the system shall be connected via industry standard BNC connections directly at the switchgear. They shall be housed within robust sealed packages easily removable for test, calibration and replacement purposes. The package shall be clearly marked with the value of capacitance and rated voltage. An insulated earth lead of minimum 6 mm^2, coloured yellow and green shall directly bond the capacitor to the frame of the bay.

One spare external capacitor shall be supplied with each installation. Where different values of capacitance are used on coupler and sectionaliser bays one of each shall be supplied.

The sensor or system shall provide an output signal in accordance with one of the following options:

1) The sensor or system shall provide a secondary voltage of 0 to 100 V/√3 to the Customer's ICP relay for the rated operating voltage.

   - Secondary output voltage 0 – 100 V/√3
   - Overvoltage capability 1.9 x UN for 30 seconds.
   - Input burden of the relay 0.06 VA at UN = 100 V/√3
   - Class accuracy of the system CL 2 or better

   The sensor shall be calibrated so that accuracy is maintained at switch room ambient temperatures of -5 °C to + 25 °C.

   Where the specified secondary voltage output of the system is not possible, the manufacturer may, subject to approval by the Customer, alternatively offer the following secondary output(s);

   - -20 to +20 mA input burden of relay 121Ω
   - + 4 to 20 mA as above
   - -10 to + 10 V input impedance 11.3 kΩ @ ±10 V

   Where a system is proposed to fulfil the requirement of this specification the auxiliary voltage supply for the converter shall be 220 V DC (+10 / -20 %).

2) An EN 61850-8-1 data bus serial communications port to connect to the bay control device.

3) An EN 103 slave protocol serial communications port to connect to the bay control device.

10.9 SURGE ARRESTERS

Surge arresters may be required in some installations.

The Customer shall indicate how GIS Surge Arresters can be installed at cable sealing ends and SF_6 / Air bushing interfaces.

The arrestors shall be in separate gas compartments to the busduct and bushings.

Surge Arresters fitted to GIS shall comply with requirements of IEC Publication 60099-4 and

shall be gapless metal oxide.

220 kV surge arresters shall have a reference voltage of 228 kV, LIPL (max) of 592 kV, nominal discharge current 10 kA and IEC Discharge Class 2 as a minimum.

400 kV have a reference voltage of 396 kV, LIPL (max) of 1029 kV, nominal discharge current 20 kA and IEC Discharge Class 5 as a minimum.

Bay Local Control Cabinets (LCC)

10.10 Access and Layout Requirements

LCCs are required for local plant operation during commissioning, testing and maintenance.

In all GIS OCC, the switchgear in each bay shall be locally controlled at the GIS switchgear by its own individual bay local control cabinet (LCC) located in close proximity to the switchgear preferably integrated within the GIS switchgear as shown in Figure 3.

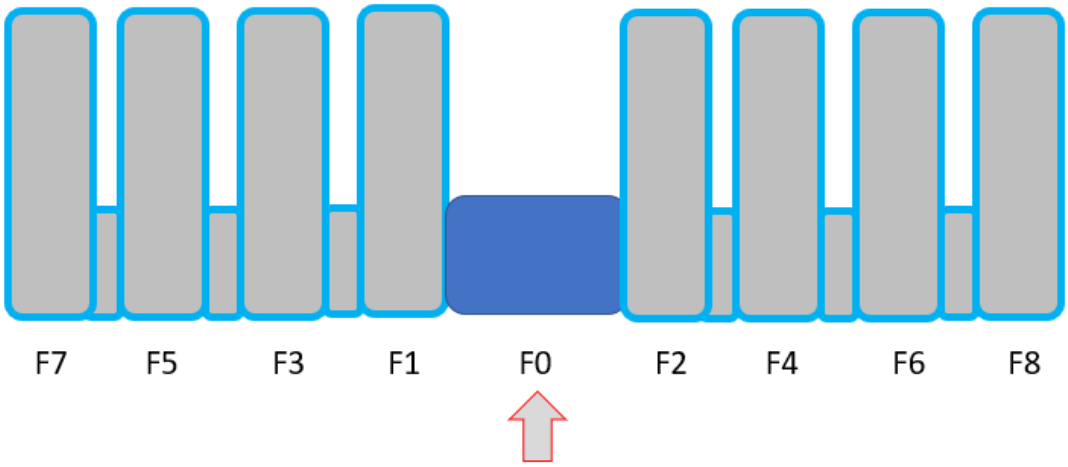

Figure 3: Representation of LCCs integrated in GIS switchgear

Where free standing LCCs are specified for use for a particular installation they shall be installed directly opposite the corresponding GIS switchgear bays, and the operator viewpoint shall be towards the LCCs as indicated in Figure 4.

LCCs to the left from the operator's viewpoint shall have odd numbers and those to the right shall have even bay numbers.

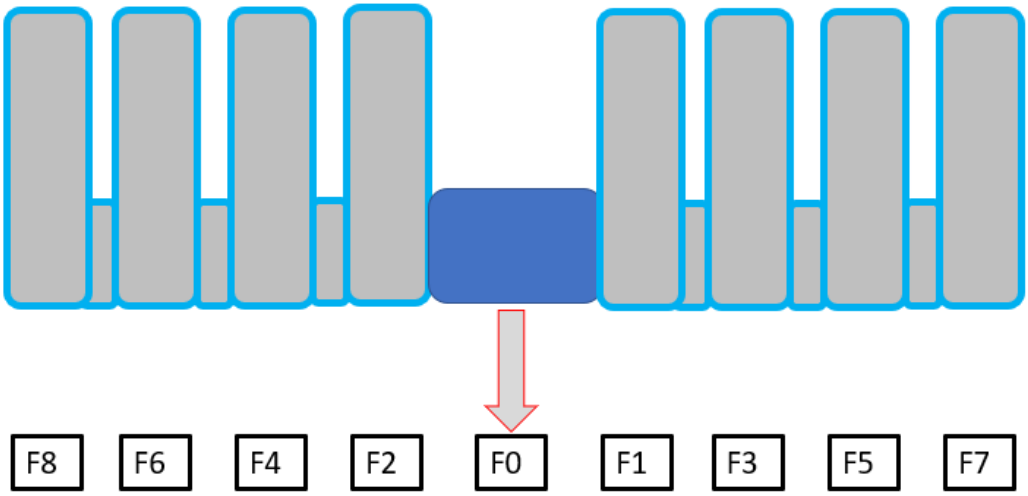

Figure 4 Representation of free standing LCCs in front of GIS switchgear

10.11 PHYSICAL REQUIREMENTS

LCC cabinets shall be arranged to accept control cables from the switchgear at the rear of the cabinet on gland plates. Cabinets shall be swing frame type with door opening outwards to the left-hand side. All points of control, including AC, DC and VT MCBs shall be located on the front of cabinets to allow operation and inspection without stepping inside the cabinet. Removable gland plates shall be labelled with permanent stickers identifying the Safe Working Load (SWL) that the plate may bear.

All points of control within LCCs shall be located at a height of less than 1800 mm above operator standing level.

The Customer shall;

A. Design, supply and install access platforms, placing all control points within 1800 mm from the access platform standing level – (see also section 9.2).

   or

B. Supply and install freestanding cabinets mounted separately to the switchgear with all controls within 1800 mm of ground level.

10.12 SCS LCC APPLICATIONS

A single Bay Control Unit (BCU) is mounted in the bay specific LCC, the control of which is provided for by the LCD HMI mimic.

The LCC mimic shall be designed with clear positioning and labelling of control switches, semaphores ***only*** as per project specific SLD and signals list. IEC designations shall not be installed on LCCs.

In double busbar stations, the “A” busbar shall always be shown on top of the “B” busbar.

Photo 2 - SCS Application

10.12.1 LCC CONTROL SWITCHES & CONTROL ON / OFF SWITCHES

Operational control of the HV plant will be provided via the LCD HMI mimic.

Control On/ Off switches for all HV Plant circuit breakers, disconnects and earth switches (maintenance and high speed) shall be installed on the LCC mimic (as illustrated in Photo 2 - SCS Application).

Where separate motors are provided for disconnectors and maintenance earth switches the customer shall install separate control switches; On/ Off switches.

Position indication of the Control On/ Off switches shall be ganged in series for each bay to provide position indication to the National Control Centre (NCC) of the remote-control status. The NCC shall receive Double Point Status Indications if one or more of the switches are in “Off” position, which will be further outlined in the project specific signal list.

10.12.2 LOCAL / REMOTE CONTROL KEY SWITCH

A dedicated key-switch to permit selection of local or remote control shall be installed in the LCC for each bay. The facility to attach a hold-off notice using a cable tie or similar fastener shall be provided on this key-switch.

This switch is used as a last safeguard for personnel working on HV equipment with full knowledge that all remote commands are blocked and the equipment is safe to carry out commissioning, testing or maintenance.

The switch shall operate as follows:

- In **Local position** operational control can only be performed locally at the LCC. Remote operational control is not possible from the Station Control Cabinet (SCS HMI) or from NCC/Offshore control room.
- In **Remote position** (Normal operating position) operational control can only be performed remotely via the Station Control Cabinet and NCC/Offshore control room. Local operational control is not possible from the LCC.

10.12.3 EARTH UNLOCK KEY SWITCH

The SCS system's own command logic shall provide an additional step for operators (to stop and think) before operating an earth switch (i.e. if the system requires the operator to go through a two or three step decision process to operate the earth switch this is deemed to provide an equivalent level of protection).

10.13 CONTROL WIRING AND MARSHALLING

Suitable EMC-shielded control cabling between the switchgear and LCCs shall be installed and they shall be BLACK in colour.

The pre-cut lengths of control cable shall arrive pre-terminated on the switchgear or incorporate plug and socket systems to facilitate plug-in connection to the switchgear (excluding CT and VT circuit wiring).

All current and voltage transformer secondary connections, controls, alarms, indications, AC and DC supplies shall be wired to file terminals.

Where necessary, provision shall be made at the file terminals for connecting and earthing multi-core screened 6 mm^2 (CT and VT circuits) and 1.5 mm^2 control cables.

Spare auxiliary switch contacts shall also be wired to the file terminals.

Adequate space shall be provided for the termination and connection of the additional cables required for external future interlocking.

Spare terminals shall be provided (10%) for future use.

File terminal type shall be as follows:

- Terminals for CT secondary circuits shall be Phoenix UGSK / S and URTK / SP.
- Terminals for VT secondary circuits shall be Phoenix URTK / S.

The customer shall submit drawings clearly identifying the physical layouts of the proposed cabinets including all terminals, location of devices, size of trunking, etc.

PVC trunking fitted with PVC covers shall be used within the LCC.

The trunking must be sized to accommodate all the wiring with sufficient spare capacity for future wiring installations.

The proposed cabinet arrangement drawings will be subject to detailed design review.

It shall be possible to bridge-out i.e. short-circuit the current transformer secondary circuits at

each of the relevant file terminal blocks.

All interconnections between LCC's for common supplies, position indication, voltages etc. shall be connected via isolatable type terminals.

Terminals and connections used in the LCC shall be designed to minimise potential disruption when extending the station to incorporate additional future bays, if required. (Particular emphasis is required when designing busbar and interlocking schemes to ensure that the expansion of these schemes allow for the ultimate GIS development.)

This means the terminals and connections used shall be designed to facilitate the disconnection, bypass and removal of a bay and its associated LCC without disruption to the secondary control systems and functioning of adjacent LCC's.

LCC wiring from which extension is to take place shall have disconnector type terminals on critical circuits in order to provide 'minimum disruption' e.g. no disabling of interlocking and busbar protection associated with initial GIS development.

10.14 LOCAL METERING

The local metering shall be made available in the BCU on the LCC.

10.15 FAULT SIGNALLING

In addition to any alarm and display of switchgear faults provided locally, each fault device shall have a voltage-free N/C contact, wired to terminals for connection to the substation signal system.

10.16 ADDITIONAL REQUIREMENTS

Fixed lamps with door switches shall be provided in all cabinets.

230 V AC anti-condensation heaters shall be installed in each cabinet.

A pre-wired plug and socket arrangement is the preferred method of wiring (excluding CT & VT circuit wiring).

11 INTERLOCKING

The interlocking conditions are designed to prevent:

- The operation of disconnectors under load.
- The operation of earthing switches on to a locally energised circuit.

An interlocking scheme must be designed so that it is fail-safe i.e. the failure of any part of the scheme must not allow an inadvertent operation.

Primary contacts from the high voltage switchgear shall be used for position indication to the interlocking scheme. Where auxiliary relays are incorporated in the interlocking scheme, they shall be operated in a fail-safe mode. The use of auxiliary relays must be accepted by EirGrid.

The interlocking design for the station shall be designed to allow for the ultimate development of the station by considering future interlocking modifications during future phases, if required.

The interlocking design for initial phases shall be future proofed in a fashion to limit disruption to

existing interlocking circuits when extending the scheme for future bays.

For example, future bay busbar disconnect interlocking coupling conditions in particular shall be designed with a view of minimising modifications to existing interlocking circuits in the live stations.

12 SF_6 GAS AND PD SYSTEMS

The Customer shall have available details of all external devices and sub-suppliers, e.g. SF_6 Density meter or PD Sensor, which the manufacturer proposes to use on the switchgear and have available details of all design provisions taken to prevent corrosion, moisture ingress into the devices and durability for the required lifetime of the switchgear.

12.1 GAS SYSTEMS

The switchgear shall be divided into individual, separately monitored, gas tight compartments so that maintenance may be carried out on the equipment in one compartment with the remainder of the plant in service. See also section 9.4 for service continuity requirements.

The customer shall demonstrate that SF_6 gas barriers provided are designed and tested to withstand the differential pressure resulting from this requirement.

This is required for example to maintain a bay with the busbar still being in service. Where this cannot be achieved normally, extra gas compartments must be included to meet this requirement in the case of double busbar or ring busbar installations. The equipment shall be designed to minimise the outage requirements associated with the construction and commissioning of future substation extensions.

The circuit breaker compartment shall have filters for removal of gas contaminants. Filters shall be accessible for replacement and identifying labels placed on the compartment indicating their location.

The Customer shall submit the details of the methodology utilised to achieve this service continuity level.

12.1.1 GAS MONITORING

12.1.1.1 GENERAL REQUIREMENTS

A stainless-steel plate showing the pressure/temperature characteristics for the SF_6 in the equipment at normal, alarm and insufficient / lockout SF_6 density shall be affixed to the inside of the control cabinet or appropriate location to ensure easy viewing by an operator. The plate shall state the quantity of SF_6 contained in the equipment in kg.

Flanges on all compartments shall incorporate non-return valves to allow transducers to be removed and tested while the compartment is fully gassed and energised. In compliance with EU Regulation S17/2014 covering greenhouse gases it shall be possible to remove, re-calibrate and replace the gas density relays, pressure transducers and to extract gas samples with the main equipment in service – i.e. without the need for evacuation of the gas, disassembly of the equipment or removal of the density monitor.

Calibration certificates for all transducers shall be provided with the technical documentation of each order.

For circuit breaker compartments, the second stage of monitoring shall prevent any further operations of the equipment through a fail-safe lock out device.

Easy access to gas density relays and gas filling points shall be provided while minimising the lengths of piping required.

A gas schematic drawing showing all HV functional devices (SF_6 barriers, compartments, SF_6 filling points and associated labelling) shall be displayed on the wall opposite the HV plant for operators and maintenance personnel.

The drawing shall conform (as closely as possible) to the physical layout of the GIS equipment and shall show all gas barriers, valves, piping and monitors.

12.1.1.2 LOCAL GAS DENSITY/PRESSURE GAUGES

Each SF_6 compartment shall be fitted with a gas density monitor(s) and associated gauge(s) to provide local pressure indication and remote indication of pressure status.

Gauges shall indicate 'gauge' pressure in kPa, i.e. pressure relative to atmospheric pressure, and shall be temperature compensated for a temperature of 20ºC.

Scales shall have sufficient gradations to facilitate visual confirmation of pressure changes over a period of time and shall be coloured in accordance with the gas operating levels and alarms as follows:

Green:	Correct operating pressure range
Yellow:	Low gas pressure corresponding to first stage alarm
Red:	Insufficient gas pressure corresponding to second stage alarm (and lockout for circuit breakers):

Where gauges are of the analogue type they shall be fitted with a mechanical pointer, damping mechanism and scaled faceplate. The Customer can propose digital gauges providing the same level of information / visualisation for EirGrid review.

Gauges shall be clearly visible from ground level.

Gauges positioned below 1800 mm shall not protrude outwards into walkways surrounding the switchgear. This is to prevent strike damage from moving equipment such as trollies and gas carts. Protective shields shall be otherwise provided and fitted.

Local gauges have three or four voltage free contacts for alarm and tripping purposes, arranged as follows:

<u>Non-Circuit Breaker compartments</u>

- The first stage alarm contact shall operate when the gas has dropped below "normal operating pressure".
- A second stage alarm shall operate when the gas reaches the limit for safe operation of the equipment. Two contacts shall operate at this gas level
- An alarm shall operate when the pressure increases to the overpressure limit.

Circuit Breaker compartments

- The first stage alarm contact shall operate when the gas has dropped below “normal operating pressure”.
- Two second stage contacts shall operate when the gas reaches the limit for safe operation of the equipment.

  One of these contacts will be used for alarm purposes and the other for tripping/ lockout.

12.1.1.3 DIGITAL MONITORING SYSTEM

A complete system shall be provided for remote monitoring of SF_6 gas pressure in each compartment, including hybrid type density/pressure sensors, transducers and associated works. The system shall interface with SCADA and alarm any abnormalities.

Density/ pressure sensors shall have a leakage detection accuracy of 0.5 % or less, or 0.1 % or less in the case of a hermetically sealed system.

The output of transducers shall be an industry standard non-proprietary or non-OEM specific analogue or digital signal suitable and shall be interfaced to an appropriate data collection unit in the LCC.

Full information of signal formats, protocols etc. shall be provided as part of the design information to enable operators to replace sensors and transducers where required.

Digital monitoring and display units shall be provided per bay.

Each digital display unit shall:

1. Provide a digital visual display showing all gas compartments, the pressure of each compartment in kPa and a colour coded indication of health – corresponding to the coloured pressure ranges indicated in 12.1.1.2
2. Provide voltage-free contacts for first and second-stage pressure alarms and over pressure alarm.

Digital systems shall be self-monitoring incorporating processor, watchdog alarm i.e. they shall generate an external alarm via voltage free contacts in the event of auxiliary supply loss, transducer failure or processor failure.

All data shall be accessible via a non-propriety or non-OEM specific (i.e. open source) interface.

Data shall be downloadable in an open source data format file, e.g. .xml or .csv and capable of being remotely accessed via mobile networks directly by the Employer. SIM cards for mobile service providers shall be provided by the Employer where required. The monitoring data shall be directly accessible by the Employer and not via OEM specific cloud-based services.

12.1.2 GAS SERVICE CART AND CONNECTIONS

The gas service connection for each gas compartment shall be readily accessible without the use of special access equipment.

A gas filling / sampling valve, type DILO DN20 shall be fitted to the equipment. These shall be directly incorporated onto the switchgear compartment casings at manufacturing stage. The

provision of adaptor valves or similar transition fittings to facilitate this type of connection is not acceptable. Gas-tight covering caps shall be provided for all fittings.

The Customer shall supply a DILO type SF_6 service cart for the installation and maintenance of the equipment on handover of the station with the following;

- Gas compressor, oil free suction and vacuum pump 380 Vac operating voltage
- Dry filter, particle filter, evaporator, SF_6 bottle scale
- 10 m long interconnecting hoses with DN20 fittings
- Pre-filter unit and on-board storage tank

The gas cart shall be on a chassis suitable for lifting by forklift and stored in a suitable indoor location in the station.

12.1.3 SF_6 Gas Alarm System

The Customer shall connect each gas density alarm to the station alarm system. Facilities shall be provided to allow temporary blocking of density alarms from an individual gas compartment.

12.1.4 Sealing

The enclosures shall be designed to limit the gas leakage within the anticipated life-span to very low levels. The lifetime of the gas tight seals shall be at least equal to the anticipated lifetime of the plant (i.e. 40 years).

The GIS equipment shall have a maximum annual gas leakage not exceeding 0.1 % per annum per compartment.

The Customer shall submit the following information in their Submission:

1. Static positions, i.e. Pipe flanges etc.
2. Dynamic positions, i.e. Disconnector / Earthing Switch Drive shafts, etc.
3. Design life of seals
4. Drawing and detail of the ‘O’ ring sealing design used
5. Details of gas detection methods
6. Details of gas sampling methods with the plant in service
7. Details of Gas pipework and connectors

12.1.5 Pressure Relief

The Customer shall provide details of the pressure relief system design including the basic principle of its design and operation.

The pressure relief system shall allow operation under normal conditions and first-stage protection to clear a fault before pressure-relief device operation.

Pressure relief devices shall operate before burn-through.

The Customer shall demonstrate coordination of overpressure relief devices with protection in

accordance with Table 4 and Annex D of EN 62271-203.

Overpressure resulting from an internal arc shall not result in hazardous emission of decomposition products or material fragments of the equipment.

Pressure relief devices shall be equipped with a deflector to control the direction of emission to effectively manage any danger to operators.

The location of pressure relief devices and vents shall be coordinated with the wider installation design, platform / walkways, including room design and building services as part of the overall system risk assessment.

12.1.6 GAS SPECIFICATION

All SF_6 gas used to fill/top up equipment shall comply with IEC 60376.

New gas within the switchgear shall comply with Table 5 when sampled from the compartment after filling:

Minimum % SF_6 purity and quality	99 %
Minimum Dew point value measured at 20 C and 1 bar atmospheric pressure	- 36°C (200 ppmv)
Maximum SO_2 value	0 ppmv

Table 5 - SF_6 purity and quality Specification

Documentation shall be provided for each installation and item of equipment filled on site with SF_6. The documentation shall record the above measurements, the quantity of gas placed in each compartment in kg and the total overall volume of SF_6 in the equipment.

Details shall be provided of the degree of gas deterioration which can be tolerated in circuit breaker interrupter compartments and the recommended time interval between replacement of any absorber material. Details of necessary absorber material and gas treatment shall be given.

12.1.7 TESTING QUALITY AND HANDLING

Testing quality and SF_6 handling work shall be performed in accordance with IEC 62271-4 with consideration of CIGRE best practice. Where a discrepancy exists between the IEC and the quality limits as specified in12.1.6, the latter shall apply.

12.2 PARTIAL DISCHARGE SENSORS

The Customer shall incorporate partial discharge sensors within the switchgear at manufacturing stage. The sensors shall be UHF or other similar type that may be connected to the station monitoring system at a future stage of the switchgear lifetime. Barrier or window type sensors may be utilised.

An external monitoring system is not required at this stage. The purpose of the sensors shall be to detect internal PD activity when the switchgear is in service and not under test conditions.

Connection of an external monitoring system to the sensors shall be facilitated via an industrial standard shielded connector (BNC coaxial or similar) externally located on the switchgear

casing. No additional wiring or connections are required.

. The Customer shall include single sensors on each bay and busbar phase at suitable locations. Locations of the sensors shall be indicated on physical drawings of the switchgear.

13 VENTILATION AND SAFETY CONSIDERATIONS

13.1 SF_6 SAFETY NOTES

CIGRE Document TB 276 states the following:

- "Pure SF_6 is odourless, tasteless, non-toxic, non-corrosive, non-flammable and chemically inert at ambient temperature. It does not support combustion.
- "Although the gas is non-toxic, it does not support life, as it is not oxygen. Equipment containing SF_6 must not be entered without adequate ventilation and personal protection equipment."
- "As the gas is heavier than air, areas below ground level, poorly ventilated or unventilated areas (i.e. cable ducts, trenches, inspection pits, drainage system, etc.), may remain full of SF_6. Personnel must be aware of the danger of asphyxiation in such places"
- "like any gas but oxygen, a concentration greater than 19% of SF_6 in the air is considered as potential risk of asphyxiation."

Training is mandated for work in the vicinity of SF_6 switchgear.

PPE is mandated for opening of SF_6 gas compartments and work on open compartments.

13.2 RISK ASSESSMENT

The Customer shall provide a design risk assessment addressing the following hazards:

- Accumulation of SF_6 gas in low lying areas[5].
- Presence of heavier than air gases other than SF_6 e.g. radon, methane etc[6].

The results of this assessment shall be considered as part of the overall decision of whether or not to provide mechanical ventilation systems for some areas of GIS substations. The Ventilation system, shall be design and constructed in accordance with the relevant regulations.

Refer to OFS-SSS-418 for further criteria to be applied when making this decision.

Where the use of personal oxygen monitoring devices is recommended for certain tasks this shall be reflected in appropriate signage.

[5] Different scenarios leading to possible exposure to SF6 shall be considered separately in the risk assessment – e.g. normal inspection, filling with SF6, examination of chambers etc.

[6] Different scenarios leading to possible exposure to heavier than air gases shall be considered separately in the risk assessment – e.g. normal inspection and works in the cable pit, works required to be carried out in a prone position etc.

13.3 ENVIRONMENTAL IMPACTS

The requirements of F-gas Regulation (EU No 517/2014) shall be adhered to, see the EPA guidance document for additional information[7]

14 COMPARTMENTS

Compartments forming part of gas insulated switchgear shall comply with IEC 62271-203 and the relevant European standards. Compartments shall be designed so that pressure rises caused by internal arcs are limited to a safe level. The method used shall be described. Where pressure release devices are used, they must be installed so as to eject debris away from normally accessible areas to minimise danger to personnel.

The method of bolting adjacent compartments shall ensure long-term electrical conductivity to allow the flow of sheath induced currents and shall ensure continuous impedance for transient switching over-voltages. The design shall compensate for thermal expansion if necessary. If electrical segregation is necessary, special precautions shall be considered to avoid sparking across the flanges.

15 EARTHING

The building / room provided for the switchgear shall have an earth conductor around its perimeter.

Refer to OFS-SSS-407 specification for Earthing and Lightning Protection in OCC station and to OFS-OSP-135 for earthing in OSP stations, and OFD-SSS-513 General Arrangement Earthing Practice Drawings.

Provision shall be made for connecting the GIS switchgear to the OCC or OSP substation earthing system so that touch and step voltages are kept at safe levels.

The steps taken to minimise the Transient Enclosure Voltage (TEV) shall be described by the Customer.

As a minimum, suitable Surge Voltage Limiters (SVLs) shall be installed between the GIS enclosure and cable terminations on each feeder and transformer bay.

If a number of compartments form one earthed unit, earth continuity shall be ensured across the flanged connections. An earthed unit shall be earthed at one position only.

Control units and mechanism boxes not earthed through connection to the main casing, shall have appropriate earthing terminals provided.

An earthing layout drawing, identifying all points of connection of the switchgear to the earth grid shall be provided with the detailed design.

During the laying/construction of the earth grid the Customer shall keep Earthing Quality

[7] https://www.epa.ie/publications/compliance--enforcement/climate-change/9--IRL-Summary_Guidance-Operators-of-Equipment-Containing-SF6-and-PFCs-V1.0.pdf

Assurance records of the earthing system as it is laid or constructed, including photographic evidence of joints and details of types of crimps and connections used.

15.1 ELECTROMAGNETIC COMPATIBILITY (EMC)

Attention should be given to the design of the earthing system and to the shielding of cables, cubicles, cabinets and marshalling kiosks to reduce the risk of EMC problems.

16 CIVIL REQUIREMENTS

The equipment shall be arranged for erection indoors on a clear slab foundation in a building to be provided by the Customer. This is applicable to OCC installations only.

It is essential to coordinate the design and orientation of GIS switchgear and associated equipment within the larger context of the OCC building / OSP cabin and the routing of incoming and outgoing HV circuits.

Civil design requirements are given in OFS-SSS-417 Substation Building and Civil Works for OCC installations.

The Customer shall ensure that

- The layout is compatible with the Single line diagram
- The design allows for full foreseen development of the substation.
- The design avoids external crossing of HV circuits
- The design respects HV cable bending radius requirements
- Switchgear manufacturer's recommendations are followed – e.g. in relation to floor levels, loadings, location of termination points, earthing, secondary cable management. etc.
- HV Cables are adequately supported and delivered vertically through the ring CTs in the cable room / pit to their point of termination on the gas insulated switchgear.

The Customer shall provide an interactive 3D model file (e.g. 3D pdf or similar format) of the cable room / pit, HV cables, supports, cleats, current transformers and cable bridges to demonstrate the feasibility of the final design.

- Adequate space is provided at each end of the switchgear for HV testing, including an allowance for future bays.
- HV cable opes and aux cable openings are fire sealed using industry approved firestop methods and materials to prevent fire spread.

For OCC building services requirements please refer to OFS-SSS-418 Outline Design & Functional Specification.

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17 GIS CONNECTION METHODS

17.1 GIS CONNECTION TO HV CABLES

The assignment of responsibilities in the area of the GIS switchgear / HV cable interface shall be agreed between the Customer and EirGrid (or shall be the responsibility of Customer where they are responsible for the delivery of both) and shall be in accordance with IEC 62271-209.

The Customer shall ensure the switchgear supplier co-ordinates the design of the cable sealing end housing with the HV cable supplier.

Adequate space shall be provided at the rear of the GIS cable compartment for practical and safe installation of cable terminations. Removable floor covers shall be provided behind the GIS to facilitate insertion of HV cable terminations by an installer standing on a temporary platform in the cable room / pit. Solid floors shall be installed rather than steel meshed flooring between the GIS hall and the HV cable room / pit to mitigate risk of falling objects into the HV cable room / pit.

The design shall take account of the movement, vibration and expansion variations. If the earthing system of the GIS and the HV cable are isolated from each other the open connection shall be protected against over-voltages by suitably rated sheath voltage limiters.

Provision shall be made at the HV cable compartment to allow isolation of the cable from the GIS circuit with the minimum dismantling of plant and no requirement for the evacuation of SF_6 gas.

This should be achieved with g-in type connectors. In this case, the switchgear manufacturer shall provide the sealing end housing factory fitted with integrated plug-in sockets.

Cable connection terminations shall be plug-in type connectors according to IEC 62271-209. The following examples are standard cable size connections currently installed on the Irish transmission system for reference only:

Typical Pfisterer Connex terminations for Land cables:

- 220 kV: 1,600 mm^2 Cu XLPE (Size 6S)
- 400 kV: 1,600 mm^2 Cu / PB XLPE (Size 8)
- 400 kV: 2,500 mm^2 XLPE (Size 8)

Typical NKT KSEV terminations for Land cables:

- 220 kV: 1,600 mm^2 Cu XLPE (Size 6)
- 400 kV: 1,600 mm^2 Cu /PB XLPE (Size 9)
- 400 kV: 2,500 mm^2 XLPE (Size 9)

For OSP where the Customer propose to terminate the submarine cable directly onto the GIS CSE the terminations shall be reviewed by EirGrid.

The cable termination box support steelwork shall be designed by the manufacturer to allow entry and connection of the incoming cable without removing the box from the switchgear. The support steelwork shall be designed to ensure sufficient clearance is available to install and retract the cable plug.

Provision shall be made to ensure the cable box and connected cables remain in position in the event of a circuit breaker replacement being carried out.

17.2 GIS DIRECT CONNECTION TO TRANSFORMERS

The assignment of responsibilities in the area of GIS switchgear / transformer interface shall be agreed with EirGrid and the Customer and shall be in accordance with IEC / TS 61639.

The Customer will be required to co-ordinate the design of the transformer bushing / cable box housing with the transformer supplier where applicable.

17.3 GIS CONNECTION TO OVERHEAD LINES (WHERE APPLICABLE)

SF_6 / Air Bushings shall comply in general with IEC Publications 60137.

The bushings may be condenser type, either non oil-filled condenser graded insulation type or insulated with SF_6 gas. Graded insulation bushings shall be equipped with a measuring tap for the measurement of the capacitance and power factor of the bushing.

High Voltage bushing insulator housings shall be of composite insulation and silicon rubber sheds.

The terminals, which shall comply with IEC 62271-301, shall be flat with hole/ holes 14 mm diameter at 50 mm centres or, alternatively, 30 mm diameter round terminals. The Customer shall include full particulars of the proposed terminals in the TECHNICAL SCHEDULES.

The minimum rated static cantilever load for bushings at 220 kV and 400 kV shall be as follows:

- Static cantilever load 4 kN *

* per IEC 60137 this requires a 2,000 A rated bushing for heavy load level II.

17.3.1 220 KV CLEARANCES

Clearances relating to 220 kV bushings shall be as indicated in Table 6.

Minimum height above ground of bottom of insulator bushing	2300 mm
Minimum height above ground of live parts of bushing	4700 mm
Minimum distance between live parts of Bushings connected to adjacent phases	2700 mm
Minimum distance between live parts and earth	2400 mm

Table 6 - Clearances for 220 kV Bushings

A higher RUSCD value for very heavy pollution level 53.7 mm/kV is required.

17.3.2 400 KV CLEARANCES

Clearances relating to 400 kV HV bushings shall be as indicated in Table 7

Minimum height above ground of bottom of insulator bushing	2300 mm
Minimum height above ground of live parts of bushing	6400 mm
Minimum distance between live parts of Bushings connected to adjacent phases	4750 mm
Minimum distance between live parts and earth	4100 mm

Table 7 - Clearances for 400 kV Bushings

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A higher RUSCD value for very heavy pollution level 53.7 mm/kV is required.

17.4 GIS CONNECTION TO AIS EQUIPMENT

Where connection to HV AIS equipment is involved, EirGrid will advise on the Customer requirements. Reference should be made to the latest revision of the applicable Single Line Diagram.

18 TESTS

18.1 TESTING OF COMPONENTS

Tests shall be carried out in accordance with the appropriate IEC publications and OEM recommendations, unless stated otherwise. Customer shall submit ITPs (inspection and test plans) and testing / commissioning procedures to EirGrid for review.

Type tests shall be performed on one of each type to be delivered. Type tests are not required if the Customer provides type test reports for the specific equipment, provided the type tests are fully applicable to the specific equipment.

All equipment must be subjected to and pass the specified type tests at an accredited testing laboratory in accordance with the relevant IEC Publication, and the test certificates or reports obtained shall be submitted to EirGrid for review.

As EirGrid may wish to witness type, routine and special tests, or visit the factory during the manufacture of the GIS equipment, minimum four weeks' notice of tests and manufacturing programmes shall be given.

All functional testing shall be executed and recorded on the Plant and Materials installed during the commissioning, under normal and possible fault conditions.

18.2 TESTING RESPONSIBILITIES

The Customer shall perform all testing including the performance verification and acceptance tests. All tests that require connection of the GIS Switchgear to EirGrid's system may be witnessed by EirGrid.

Energised system testing shall be kept to a minimum.

The Customer shall provide commissioning procedures as part of the Commissioning Test Plan to EirGrid for review.

The Customer shall provide all necessary labour and test equipment / material to perform all tests and inspections that are the Customer's responsibility.

18.3 INSPECTION AND TEST PLAN (ITP)

The Inspection and Test Plan shall be in accordance with OEM recommendations, these EirGrid's Requirements and shall cover all aspects of testing and inspections. The ITPs shall be submitted to EirGrid and shall include a schedule of all factory, pre-commissioning and commissioning tests. All plant and material forming part of the GIS switchgear system shall be included in the ITP.

Test procedures shall be developed and submitted to EirGrid for review.

The Customer shall provide Declaration of Fitness for all GIS switchgear system components

that have been commissioned.

18.4 GENERAL TEST REQUIREMENTS

All equipment must be subjected to and pass the specified routine tests in the factory of manufacture before delivered to site.

All equipment must be subjected to and pass the specified type tests at an accredited testing station in accordance with the relevant IEC Publication, and the test certificates or reports obtained shall be submitted for review. Separate type tests may not be required on items of equipment that are of the same design, insulation class and comparable rating. Existing type test reports may be accepted if the equipment tested was identical to the equipment offered, the equipment is to be under the same or less stresses than the equipment already tested, and the relevant equipment standards have not changed. A comprehensive report describing the past tests and how they can be applied to the new equipment shall be provided.

EirGrid may wish to witness type and /or routine tests or visit the factory during the manufacture of the switchgear.

All the individual items of equipment offered such as circuit breakers, instrument transformers, disconnectors and earthing switches shall have been fully type-tested at an independent testing station in accordance with the relevant IEC Publication, and the test certificates or reports obtained shall be submitted for acceptance by EirGrid.

Voltage transformers shall have been type-tested to prove their capacity to discharge cable capacitances.

18.4.1 ROUTINE TESTS

All of the tests prescribed in the relevant IEC Publication shall be made on each assembled unit before shipment.

Routine tests of the equipment shall include gas leakage testing. Details of the routine gas leakage test shall be submitted to EirGrid.

In the case of the instrument transformers, winding tests and coil tests shall be carried out.

Certificates/Reports containing full details of type tests shall be issued to EirGrid for review.

Full details of any modifications (no matter how minor) which have been made to the GIS switchgear system since the full set of type test was carried out shall be submitted together with the reports on the tests which were carried out to prove the modification.

The acceptance of any equipment may be made conditional on further tests being performed at an independent testing station and EirGrid may witness such tests. The equipment available for type tests shall be identical in all respects to those to be supplied to EirGrid.

In the event of a type test failure, EirGrid shall not be charged for any additional type tests.

All of the routine tests prescribed in the relevant IEC Publication shall be made on each assembled unit before shipment.

18.4.2 TESTS AFTER ERECTION

After erection on site, the customer shall subject the complete HV switchgear to on-site tests as

detailed in IEC 62271-203.

These tests shall include:-

- Power Frequency withstand voltage tests at 80 % of full value (for HV circuits).
- Partial Discharge measurements (for HV circuits).
- Special Tests as outlined below.

The necessary plant to carry out the prescribed test must be provided by the Customer for the duration of the test.

No changes to the equipment shall occur on site without agreement in advance.

Any proposed changes to the technical records provided prior to equipment delivery must be communicated clearly and agreed in advance.

18.4.3 Special Tests

In additional to the on-site IEC recommended tests the following requirements apply:

- Two hundred (200) mechanical switching operations to be performed on the circuit breakers on site prior to the Power Frequency Withstand Voltage test.

  This test may be witnessed if applicable.

- Compartments shall be opened and cleaned as per the specified procedure utilising the correct equipment and procedures.

  The time durations for the HV test with PD measurement shall be extended so that the switchgear is subjected to 1.1 Un for a minimum of 60 minutes after the stress voltage. PD monitoring shall take place over this extended period.

  The purpose of this test is to determine if particles are created by these operations and alternatively to enable the removal of any particles left over during assembly and shaken out by transport to site or dislodged due to these mechanical operations. Particles found shall be retained for analysis.

- The customer shall provide permission for the site HV tests, to be performed only on completion of the additional operations test. Should any flashovers occur during the subsequent HV test the customer will specify additional cleaning and test procedures.

19 Installation

19.1 Installation Services

19.1.1 Supply, Installation and Assembly Service

The Customer is responsible for the supply, delivery and installation of the switchgear and associated control cabinets onsite.

All necessary tools, gas handling equipment, outdoor crane, forklift and lifting facilities shall be provided by the Customer.

As a minimum the Customer shall complete the following works as part of the installation and

assembly service;

a) Delivery, offloading, installation and assembly of the switchgear.

b) Installation of all switchgear, control cabinets and cabling between switchgear and local control cabinets.

c) Gas filling to rated operating pressure.

d) Functional checks and verification of the mechanical and electrical operation of all disconnectors, fault-make and maintenance earth switches, circuit breakers.

e) Electrical operation of all disconnectors, fault-make and maintenance earth switches, circuit breakers from the LCC.

f) Verification and function of all mechanical position indication devices.

g) Verification and function of all auxiliary contacts wired to local control cabinet.

h) Circuit breaker spring charging circuits.

i) Primary injection of each phase current transformer to confirm ratio and polarity.

j) Primary injection of each phase voltage transformer to confirm ratio and polarity.

k) Verification of current and voltage measuring circuits to the bay control units.

l) Functional checks and verification of inter-bay and in-bay interlocking scheme.

m) Functional checks and verification of all gas monitoring relays and auxiliary contacts.

n) Functional checks and verification of all alarms, (including SF_6 pressure alarms), signals and position indication contacts to the local control cabinet.

o) Gas quality tests – dew point and % SF_6.

p) Calibration tests of density monitors and pressure sensors.

q) Confirmation of all rating plate information as per approved documentation.

r) Tests after erection as per IEC requirements.

s) Gas tightness and seals check. Confirm integrity of all seals, joints and valves are free of SF_6 leakages following filling to rated pressure.

t) Complete site test documentation detailing all functional checks and tests carried out on each individual bay and the entire installation.

Upon completion of on-site testing of the assembled switchgear the customer shall pre-commission and commission the GIS plant. EirGrid will witness tests, pre-commissioning and commissioning activities, testing. ITP (inspection test plan) and testing procedures will be required for EirGrid's review.

The customer shall provide a full set of documentation including factory and on-site testing, pre-commissioning, commissioning test records.

20 TRAINING

The Customer shall submit a training plan which shall describe in detail how the Customer proposes to train EirGrid staff for operation of future EirGrid assets.

Training requirements will be detailed further in OFS-GEN-009 - Operation and Maintenance General Specification.

21 RESPONSE TO EQUIPMENT FAULTS PRE-HANDOVER PERIOD, PPE

In the event of fault occurring, SF_6 by-products may be produced and lie within the faulted compartments.

The risk of contaminants being released to the environment shall be minimised and the safety of all staff shall be ensured in accordance with safe working practices.

The requirements for Personnel Protective Equipment (PPE), monitoring, disposal of tools and equipment used shall be adhered to. At a minimum, the required PPE shall include:

1. A PAPR (Powered Air Purifying Respirator) unit
2. Filters
3. inner and outer gloves
4. inner and outer chemical protective suits
5. wellington boots
6. set of safe working procedures - communication, signage, first aid kit.