

## Technical Standard

# General specification. Gas Insulated Switchgear

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This document specifies the minimum technical requirements for qualification, design, engineering, manufacture, installation, inspection, testing and performance of gas insulated metal-enclosed switchgears (GIS), to be installed indoors (with or without having outdoor terminations and associated exit bus ducts) intended to be used in the transmission system of Statnett, Norway.

Revisions of this document prior to Revision 1.0 are located in Statnett IFS document #2017408.

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## 1 INTRODUCTION / SCOPE

This specification is generic and therefore requires the addition of the Special Technical Specification (project specification) that contain general layout, single line diagram with the number of bays, gas rooms segregation specification, architecture, cable of OHL lines feeders, lines routing plans, site arrangement, interface information, project specials ratings/performances; instrument transformer requirement and any non-standard requirements that are project related.

This general technical specification is based on the requirements of International Electrotechnical Commission (IEC) and other International and National Standards. This document was prepared in accordance with The Norwegian Directorate for Product and Electrical Safety - Regulation for electrical installations – Systems for generating transmission and distribution (FEF) regulations and recommendations for high voltage equipment.

## 2 SCOPE

This specification applies to Gas-Insulated metal-enclosed Switchgear (GIS), where the insulation is carried at least partially by an insulating gas other than air at atmospheric pressure, voltage assigned to 72,5kV or above , and at operating frequency of 50 Hz.

This document forms the general minimum set of equipment's requirements for GIS system deliveries to Statnett.

## 3 STANDARDS AND REQUIREMENTS

Except where modified by this specification all equipment and materials shall as a minimum be in accordance with all applicable IEC (International Electrotechnical Commission), ISO (International Standards Organization), NEK and FEF 2006 standards and recommendations, and comply with all relevant legal and statutory regulations.

All aspects, performances, design, ratings, tests, etc., shall be executed according to the latest published issue of official document, or otherwise approved standards referred to the edition in use at the date of tender submission.

Standards and official publications for GIS equipment are, but not limited to:

IEC 62271-1 High-voltage switchgear and controlgear-Part 1: Common specifications

IEC 62271-203 High-voltage switchgear and controlgear-Gas-insulated metal-enclosed switchgear for rated voltages above 52 kV

IEC 62271-100 High-voltage switchgear and controlgear- Alternating current circuit-breakers

IEC 62271-102 High-voltage Switchgear and controlgear-Alternating current disconnectors and earthing switches

IEC 62271-110 High voltage Switchgear and controlgear- Inductive load Switching IEC (TR) 62271-310 Electrical Endurance for circuit Breaker

IEC (TR) 62271-302 High-voltage switchgear and controlgear – Part 302: Alternating current circuit- breakers with intentionally non-simultaneous pole operation

IEC 61869-1 Instrument Transformers

IEC 61869-2 Additional requirements for current transformer

IEC 61869-3 Additional requirements for inductive voltage transformer

IEC 61869-5 Additional requirements for capacitive voltage transformer

IEC 61869-5 Capacitive voltage transformers

IEC 61869-6 Additional general requirements for LPIT

IEC 61869-9 Digital interface for instrument transformers

IEC 61869-10 Requirements for low-power passive current transformers (LPCT)

IEC 61869-11 Requirements for low-power passive voltage transformers (LPVT)

IEC 63360 Fluids for electrotechnical application: Mixtures of gases alternative to SF<sub>6</sub>

IEC 60099-4 Surge arresters- Part 4: Metal-Oxide Surge Arresters Without gaps for a.c. Systems IEC 60099-5 Surge arresters-Part 5: Selection and Application Recommendations

IEC 62271-209 High voltage Switchgear and controlgear-Cable connections for gas-insulated metal- enclosed switchgear for rated voltage above 52 kV-Fluid filled and extruded insulation cables-Fluid filled and dry-type cable – terminations

IEC 62271-211 Direct connection between power transformers and gas-insulated metal-enclosed switchgear and for rated voltages of 72,5kV and above.

IEC 60137 Insulated bushings for alternating voltages above 1000kV

IEC 60076 Power Transformer

IEC 60071-1 Insulation co-ordination part 1: Definition, principles and rules. IEC 60071-1 Insulation co-ordination part 2: Application guide.

IEC 61850 Communication networks and systems in substations

IEC 60445 Basic and safety principles for man-machine interface, marking and identification- Identification of equipment terminals and conductor terminations

IEC 60529 Degrees of protection provided by enclosure (IP code) IEC 60255 Electrical Relays (Applicable Parts)

IEC 60376 Specification of technical grade sulfur hexafluoride (SF<sub>6</sub>) for use in electrical equipment

IEC 60480 Guide to the checking of sulphur hexafluoride (SF<sub>6</sub>) taken from electrical equipment.

IEC 63360 Fluids for electrotechnical application: Mixtures of gases alternative to SF<sub>6</sub>

IEC 63359 Fluids for electrotechnical application: Specifications for the re-use of mixtures of gases alternative to SF<sub>6</sub>

IEC/TR 62271-303 : High voltage switchgear and controlgear- Part 303 : use and handling of sulphur hexafluoride (SF<sub>6</sub>).

NEN 143.80 SF<sub>6</sub>-gass i elektriske anlegg. Handling of SF<sub>6</sub> gas in electrical equipment. NEK 440 Power installations exceeding 1 kV a.c.

NEK-EN 50052 Høyspennings koblings- og kontrollutstyr. High-voltage switching and control equipment. Kapsling av aluminium for gassfylt høyspenningsutstyr.

FSE (Norwegian) " Forskrift om sikkerhet ved arbeid i og drift av elektriske anlegg." Regulations concerning safety at work in and operation of high-voltage systems with instructions and user's manual.

<http://www.lovddata.no/for/sf/jd/xd-20060428-0458.html>

NVE 2012 12 07 "Forskrift om forebyggende sikkerhet og beredskap i energi-forsyningen" (beredskapsforskrift)

FEF 2006 The Norwegian Directorate for Product and Electrical Safety - Regulation for electrical installations – Systems for generating, transmission and distribution

<http://www.lovdata.no/cgi-wift/ldeles?doc=/sf/sf/sf-20051220-1626.html> NVE 2003 Regulations for emergency power supply <http://www.lovdata.no/for/sf/oe/oe-20021216-1606.html>

Cigre 23-10 Earthing of GIS – an application guide.

Cigre C4.302 : Insulation Co-Ordination related to Internal Insulation of Gas Insulated System with SF<sub>6</sub> and N<sub>2</sub>/ SF<sub>6</sub> Gas Mixtures under AC Condition.

F-Gas regulation + amendment

Quality assurance system and environmental management system shall comply with applicable ISO- standards (ISO 9000, ISO 14000 series).

Equipment shall be deemed to be in accordance with the specifications including appendixes, standards and codes referred to therein.

Notwithstanding any descriptions, performances, ratings, drawings or illustrations mentioned in both general and special specification, must be detailed in Appendix D, 'Deviations from the Technical Specification' and approved by Statnett.

## 4 PRODUCT ACCEPTANCE PROCEDURE / QUALIFICATION

Statnett have establish a product acceptance procedure for new equipment installed in the grid. Contractors that enter into the tender phase, accept this process of product and factory qualification. The procedure will be applied, to all contractors, on all voltage range of GIS products. This process could (at the manufacturer's risk) be executed during the project, if the qualification process of the product was not provided or finished before the tender award.

Under a brief preview of the different steps of product qualification process:

1. Documentation and verification of test type reports
2. Repetition or new type tests
3. Bay design review / design freeze. Accept for starting production of the first bay
4. Factory acceptance test on the first manufacture complete bay
5. Validation or not to start production of complete delivery & Shipment release
6. Site acceptance tests

The program shall be included in Contractor's schedule/plan and Statnett shall be notified according to the contractual regulations.

### 4.1 Documentation and verification of test type reports

All type tests prescribed in the relevant IEC standards, detailed in appendix A (Performance and type tests), shall be performed on a complete functional assembly of one identical representative bay or on representative assemblies or sub-assemblies, having same design, version, arrangement, drives, minimum & rated pressures, materials and ratings as of those to be supplied to Statnett for the project. Type tests shall be conducted with a certain level of independence of testing as specified in appendix A.

Type tests proved by certified test reports on tests previously performed on a component with identical or equivalent design and rating may be accepted as type test report, when no changes in manufacturing process or materials have been made. The delivery will only be considered complete once approved test reports are available.

Contractor must clearly identify in a separate list for which components type tests from previous projects will be proposed. In addition, a Type Test Verification Report is required for Statnett's evaluation. The Type Test Verification Report, including the list of referred type tests and the relevant type test protocols, shall be delivered in accordance with the specific Schedule for the delivery, to Statnett for approval. The Type Test Verification Report shall for each test verify that any previous test performed is also adequate for the specific delivery. If the design of the specific unit to be delivered is beyond the design of the previous tested unit, the previous type test will not be accepted as type test for the unit to be delivered (for example busbar current rating).

Type tests applicable to metal-enclosed switchgear, as well as constituent elements and item such as drive or monitoring equipment, are listed in Appendix A.

These type tests request an independent level, as explained in the Appendix. Table shall be entirely filled by the contractor and sent jointly with tender proposal.



If type test is missing, manufacturer shall propose a testing date and invite Statnett representative to witness the test in the appreciated lab. The cost of missing or uncomplete type tests related to the above standards shall be supported by the manufacturer.

## 4.2 Repetition or new type tests

Additional type tests may be required by Statnett, if for example the documents submitted by the supplier do not meet the national and international standards, Statnett requirements, specific project requirement or independence level of type test.

Statnett reserves the right to request manufacturer to perform any type test until final qualification of the equipment is pronounced. The cost for the type tests shall be covered by the manufacturer.

Additional or missing tests must be performed in presence of Statnett witness and meet the independent level specified in the Appendix A specification. The GIS equipment could receive Statnett qualification only after approval of all type tests.

## 4.3 Transfer of production/manufacturing facilities or supplier from one site to another

In case of transfer of production/manufacturing from one site (city/country) to another, new type tests shall be performed.

Audit of the new manufacturing facilities could be requested by Statnett if the production place have not been prequalified earlier. It remains manufacturer responsibility to organize and coordinate the audit with the project delivery and corresponding schedule.

Items listed above are also applicable to instrument transformer sub supplier, bushings, ZnO blocks, insulating materials (such as cones and parts) and aluminium enclosure.

If major subcomponent sub suppliers are changed, Statnett might request manufacturer to perform new type tests.

Example of major components (but not limited to):

- drives sub suppliers or design changes (disconnectors, earthing switch, circuit breakers)
- circuit-breaker isolators
- epoxy insulators and insulating materials
- gas barriers (open and close)

Statnett reserves the right to approve the equipment on a case-by-case basis based on the documentation availability.

## 4.4 Design review / Design freeze

Design review meeting(s) for the GIS bays and busbar architecture must be held before start of production.

Design Review meeting(s) (DR), shall control all details of the bay and the GIS substation, including secondary circuits, bay cabinet design (LCC), functionalities and HSE aspects.

DR shall include a review of a 3D drawing of the entire GIS. Accessibility to the drives, manometers, hand crank, filling valves, catways/platforms and view ports shall be presented and agreed during this meeting.

Contractor shall confirm dimensioning (in watts) of the different heating elements (drives/LCC), including the settings of the thermostats. Additionally, for each substation, contractor shall also provide a calculation of the total power necessary for the complete substation when all heating elements will be on. This document will help us to correctly dimension the maximum power supplies which is out of contractor scope.

GIS manufacturer has the responsibility of arranging the GIS DR meetings early enough in order to not delay the production and potentially the project.

#### 4.5 Factory acceptance test on the first complete bay

For the benefits of both parties, an inspection and validation by Statnett of the first GIS bay or shipping units assembled and produced by the manufacturer at the GIS factory must be executed. If the same product with the same layout have been delivered to Statnett already, Statnett will most likely not attend the FAT. It remains the project's decision to attend the FAT or not.

The contractor shall propose a full test program on the first complete bay produced by the manufacturer. Detailed test program shall be sent together with a proposal for testing dates.

Dates shall be proposed to Statnett representatives at least 2 months in advance. Statnett shall have the possibility, after discussion with the manufacturer, to adjust the proposed FAT dates according to personnel availability

The FAT shall be performed on half bay (for double breaker system) equipped with drives, monitoring (GAS and UHF), platforms, labels, and bay cabinet (LCC).

Half bay means busbar elements, bus bar disconnectors and earthing switches (if any), circuit breakers, current transformers, earthing switches and disconnectors, inductive voltage transformer (if any), fast acting earthing switches, and necessary connecting elements such cable box.

FAT for bushings, instrument transformers, surge arresters or equivalent could be made separately after agreement with Statnett.

To validate the specified leakage rate, during the routine test and FAT, gas tightness test shall be performed via the cumulative method on a half bay at nominal filling pressure with all accessories (including and but not limited to manometers and gas density switches). No SF6 shall be used for such tests.

Under example of some of the points that will be part of this final validation:

- Accessibility to control
- Verification of the control and command equipment according to "Notat 1".  
"Prinsippøsninger for kontrollsystem i Statnetts stasjoner" - Principal solutions for control system in Statnett substations", SDOK-83-5 and SDOK-83-7.
- Gas monitoring, gas filling valves access, position indicating devices
- Access to voltage and current transformers secondary
- Orientation of gas deflectors

- Access to the drive and padlocking
- Movable platform and walkways with the necessary earthing connections
- Padlocking on drives
- Use of hand crank for circuit-breaker, disconnecter and earthing switches drives
- Manometer on all the gas room, demonstration of verification of threshold of the pressure gauge
- Labeling and ratings plates to be presented
- General interventions and maintenance on the structure (dismantling of a circuit breaker, dismantling of a disconnecter).
- View ports (if any)
- Presentation by the manufacturer of all the tools and maintenance modules, platforms, etc...
- Dismantling of one circuit breaker and one disconnecter shall be part of the FAT program
- Security

Modification list is written during this FAT, presentation/review ; manufacturer shall modify the first presented bay and following bays to be produced according to this list.

Modifications-list shall be checked and signed by both parties during commissioning (Site Acceptance Test) of the installed switchgear.

#### 4.6 Routine tests

The routine tests shall be performed on all components of the **gas-insulated metal enclosed switchgear and its controlgear**. Depending on the nature of tests, some tests **may** be performed on components or transport units.

No SF6 gas shall be used during the whole production and testing process.

The routine tests shall be performed according to the newest edition of IEC 62271-203 §8 with the following additions :

- Gas technical grade :

For GIS designed to use any other gas than SF<sub>6</sub>, the necessary technical grade and the characteristics of the gas / gas mixture used for the routine testing shall be defined and documented by the manufacturer of the GIS and documented in the routine test reports. The technical grade and characteristic shall have be within the tolerances stated and proposed by the manufacturer for each gas molecule.

- Tightness test:

The tightness test shall be performed at filling pressure pre.

The only accepted method is the cumulative method. This warranty at the GIS is gas tight prior shipment.

Sniffing method is not accepted.

The test shall be carried out at standardized ambient temperature of 20 degree Celcius (+/-3 Celcius).

The relative leakage rate allowed from any single compartment of GIS to atmosphere and between compartments shall not exceed:

0,1 %/year for SF6 switchgear and 0,2% for SF6 switchgear with a gas compartment containing less than 1kg.

0,3 %/year for other gas mixtures switchgear with a GWP < 1000. Another gas such helium should be used to verify the adequacy of compliance.

- Dielectric test :

For alternative gas technology, all the power frequency routine test (including the FAT) shall be performed with 72 seconds (instead of 60 seconds).

Manufacturer shall send a summary of dielectric failure statistics for the complete project production.

#### 4.7 Shipment release

The GIS equipment can be supplied to site only after Statnett fulfilments of all type tests, all routine tests, reports including FAT documentations and final qualification documentation at manufacturer place.

Modifications list written during the inspection of the first bay (FAT) at the manufacturer location is also part of product acceptance.

#### 4.8 Site acceptance tests

The contractor shall propose a program for the Site Acceptance Tests.

A detailed program for tests and for acceptance of tests is to be agreed by Statnett prior the site test start.

A meeting on this matter shall be initiated by the contractor at least one week prior to the SAT.

Parts and components that cannot take place in the site tests shall be identified, if any (transformers, cable, voltage transformers, secondary equipment etc.). Coordinating dismantling and connection must be taken into account in the GIS manufacturer proposed test program.

Site tests shall include, but not be limited by, the following tests:

- Checks and verifications of proper function of circuit breakers and switches, interlocking functions and control and protecting devices etc.
- Time and movement/displacement measurements of circuit breakers including traveling curves for O and C operations.
- Gas tightness tests of all seal flanges with gas leakage detectors
- Gas quality verification tests
- Site test shall be performed as a part of the delivery by the contractor

- as specified in IEC 62271.203 §10.2.101 Tests after installation on site.
- Partial discharge test shall be performed with the conventional method proposed in IEC 60270 in order to demonstrate that the level of partial discharge in pC is lower than the required criteria.
  - UHF spectrum fingerprint for each installed UHF antennas shall be measured as reference. For more details see §15 UHF measuring system in this specification
  - Measurements of the resistance of main circuit via IFES (Insulated Fast acting earthing switches) and ES for each bay and each phase. Measurements shall be agreed with Statnett prior the measurements. Dedicated report shall be issued by the manufacturer and shall include also the results from the FAT measurements.
  - Control of earthing connections
  - Contractor shall provide all necessary equipment, instruments etc. and skilled personnel.

High voltage test for new substation and extension or repair must be performed by the contractor as per IEC 203 § 11.101.2. HV test shall be a part of the offer.

Contractor must prepare protocols and SAT reports in electronic and paper format.

In case of failure during site acceptance test, contractor have the obligation to stop the work on site and call for a clarification meeting with Statnett project management on a short notice.

The contractor is responsible for cost of failure reparation (material, hours and outages).

In case of HV cable interface, GIS supervisor shall be present during the cable installation to supervise the gas handling of the GIS cable box, installation of the cable and testing of the cable interface.

## 4.9 Interchangeability

All bays components qualified of the same type and rating shall be respectively interchangeable both electrically and mechanically and when so interchanged shall perform their function equally well in every respect. All dismountable parts, of the same type and rating, shall also be interchangeable for all switchgear components and, when so interchanged, shall perform their function equally well in every respect.

Manufacturer shall inform Statnett of any modification or material change in the qualified design (as specified in §4).

Official letter from manufacturer shall be submitted to Statnett for each delivery, to confirm or not the interchangeability parts between one to another substation already delivered to Statnett by the same manufacturer.

## 5 EQUIPMENT REQUIREMENTS

The switchgear shall be fully metal-enclosed, single-phase for operating voltage equal or above 220 kV and three-phase enclosed for operating voltage lower than 220 kV with gas as insulating medium, and gas or vacuum as breaking medium. The switchgear shall include all equipment and materials to form a functional, safe and reliable switchgear system.

All equipment shall be designed and manufactured to minimize any risk of short circuits, to facilitate inspection, cleaning, repair and maintenance and to ensure absolute personal and operational safety under all operation and fault conditions as well as during inspection and maintenance.

The switchgear shall be designed for continuous operation at full load for at least 20 years without interruptions in operation for maintenance, unless the number of permissible switching operations or electrical wear is exceeded.

The main switchgear shall be designed for indoor installation, except the outgoing ducts and associated steel works and outdoor bushings or cable connections.

In case of Transformer/Shunt reactor connections see corresponding chapter.

The switchgear shall be of modular design, and as such, shall offer maximum flexibility from the point of view of design, operation, maintenance, extension of substation and possible repairs.

The enclosure shall be capable of sustaining without damage all mechanical, electrical and thermal shocks that may occur in service during normal and extreme climate conditions and also under fault conditions, including pressure effects of internal fault arc current of specified short circuit level and time.

### 5.1 SF<sub>6</sub> and alternative gas mixtures

SF<sub>6</sub> usage should be reduced to a minimum in order to limit the environmental footprint of the switchgear.

For operating voltage including and lower than 420 kV, no SF<sub>6</sub> gas shall be proposed for active and passive equipment of the proposed GIS switchgear.

- Active equipment is defined as circuit-breaker, disconnector, earthing switches, surge arrester and instrument transformers.
- Passive equipment is defined as gas insulated line (GIL), gas insulated bus duct (GIB) and other connections such as busbar where no active parts equipment is present.

For IPO circuit-breaker application at 145/132 kV operating voltage, SF<sub>6</sub> filled self-blast circuit breaker could be proposed.

For 220, 300 and 420 kV switchgear, SF<sub>6</sub> alternative gas mixture is expected for the busbar, OHL feeder and other passive components such as GIL (GAS Insulated Line) and GIB (Gas Insulated Busduct).

For the above mentioned equipment, SF6 shall be replaced by an oxidizing gas (OG) or gas mixture of non-oxidizing gases (NOG) such N2, CO2 or CF4.

SF6 gas shall be reduced as much as possible in order to limit the environmental impact.

Fallback solution to complete SF6 shall be possible without dismantling the GIS or changing the gaskets or gas tightening systems.

The manufacturer must inform about any requirements for replacing the density switches, filling valves, moisture absorbers or other items. Labellings shall be replaced.

This point shall be confirmed by the manufacturer during the tender phase.

The lifetime of the proposed gas mixtures must be aligned with the expected lifetime of the HV equipment, at least 40 years.

The manufacturer shall clearly state with the offer the type of gas and gas mixture, the exact constitution and the minimum functional gas composition (in %) for each component.

Clear limits and tolerances regarding the functional gas composition must be specified for operation per individual compartment if requested.

Each gas compartment shall be monitored independently. All indications and gas pressure gauges shall be installed in good and visible location from the ground level or permanent platform for operators.

No ladder or temporary catways shall be used to check the pressure on the control equipment.

Pressure gauge shall be temperature compensated and with a high quality measuring display. Measuring of vacuum, for maintenance and repair reasons shall be also possible.

Units shall be in bar absolute with different colours according (green/orange/red) to the pressure of gas. Unit of measurement shall be written on the display of the pressure gauge.

It shall be possible to test each pressure gauge and thresholds of the density switch/relay without loss of gas, while the GIS is energized and pressurised. This test shall be possible to be performed without removing the pressure gauge from its support. Pressure gauge shall be mounted on a connecting system assembled on the GIS enclosure. This connecting system shall be equipped with a shut-off valve and a filling port.

Checking of the leakage detection system as specified in the F-gas regulation 517/2014 shall not take more than 4 minutes per pressure gauge.

The GIS shall be fully gas tight. Gas relative leakage rate for each gas compartment shall not exceed 0,1% per year for SF6, for other gas mixtures with GWP global warming potential higher than 500. For other gas mixtures (with GWP global warming potential less than 500) the permissible leakage rate shall not exceed 0.3 % per year.

All gas compartments shall contain suitable agents to absorb moisture and any other decomposition products of the gas. Type of filter employed shall be molecular sieve.

The GIS shall be designed to minimize leakage as well as gas-handling losses during service life. It implies that the number of gasquets, pipes and connecting elements shall be as small as possible.

All piping for insulation and breaking gas, hydraulic operating mechanism including their fittings shall be made of copper, brass or stainless steel.



Tests and maintenance procedures for minimizing gas-handling losses shall be specified. Gas losses associated with each procedure shall be identified.

The GIS bay shall be sectionalized for each equipment into modular units or compartments, separated by solid gas barriers with an effective sealing system. Each gas compartment shall be provided with evacuation/refilling port with self-closing non-return valves. Sampling, evacuation and refilling of gas and gas mixtures shall be carried out without evacuation of any other section or loss of gas.

Gas barriers and sealing systems shall have adequate mechanical strength to withstand the dynamic forces caused by short circuits, and effects of internal arc faults as well as maximum pressure differential that could exist between adjoining compartments, i.e. with full vacuum drawn on one side of the barrier and 2 times the operating pressure on the other side.

Filters shall be inserted in all gas compartments in addition to circuit breaker compartment. For gas compartment re-opened on site during installation the static filters provided inside the high-voltage enclosure shall not be shipped already fitted, but packed separately in airtight sealed tin-cans and marked conspicuously.

The gas decomposition product filter shall be effective for the duration of time between major overhauls. The design life time of moisture absorbent shall be at least 25 years for each compartment.

## 5.2 Max volume of compartment

The biggest compartment in terms of gas and gas mixtures volume shall not exceed for each voltage rating level, the following values :

145 kV		300 and 420 kV (1 phase)	
SF <sub>6</sub>	Alternativ gas	SF <sub>6</sub>	Alternativ gas
60 kg	20 kg	150 kg	65 kg

## 5.3 Gas filling valves

Each gas compartment shall be provided with evacuation/refilling port with self-closing non-return valves.

SF<sub>6</sub> and other gas mixtures valves shall have as a minimum a diameter of 20mm.

All SF<sub>6</sub> and other gas mixtures filling valves shall be delivered with a good access from the ground or the floor level.

Access from permanent platform could be accepted if the operator can have a safe position for filling the gas compartment.

### Gas filling valve labeling:

A fixed and permanent labelling close to each filling valve shall be delivered.

This labelling shall mention for the concerned compartment:

- the name of the gas room (as specified in SDOK-41-52) for example  
"420SO1GR9"



- Gas description (SF<sub>6</sub> or other gas mixtures with the detailed composition in % and tolerances in %)
- CO<sub>2</sub> equivalent and GWP (as per actual F-gas regulation).
- Gas quantity in kg (at rated filling pressure and 20C)

#### 5.4 Environmental product declaration (EPD)

An Environmental Product Declaration (EPD) shall be delivered at tender stage.

If different solutions or options as proposed, a study for each solution shall be delivered during tender.

One typical complete bay (2 circuit breaker for 420kV) of the project tendered shall be the reference for the note.

Name and type of the bay of the project shall be declared in the document.

The EPD shall be in accordance to IEC 62271-320 Part 320: Environmental aspects and life cycle assessment rules for high-voltage switchgear and controlgear.

The results could be given according to ILCD 2011 methodology as recommended by the European Commission.

It shall clearly detail the scope of the study, the assumptions considered for the calculation.

The material composition (aluminum, epoxy, copper, Steel, Stainless Steel, etc...) and weight (in kg) shall be included into the report. Detailed global bill of materials including clearly the nature as well as the recyclability rate for each element.

The EPD shall at least cover A1-A4 1), and the environmental parameters in the EPD must be made separately for A1, A2, A3 and A4.

Note 1) A1 = raw material extraction, A2 = transport to manufacturing, A3 = manufacturing, A4 = transport of finished material to site.

The EPD shall be based on delivery at port of Bergen/terminal of Bergen, Norway.

#### 5.5 End of life manual

The manufacturer must provide in the End of Life manual report, all elements related to eco-design, in particular: disassembly, recyclability and possibility or not of separability.

It shall include instructions concerning disassembly and end of life procedures for the different components of the equipment.

One typical complete bay (2 circuit breaker for 420kV) of the project tendered shall be the reference for the note.

Name and type of the bay of the project shall be declared in the document. This document (End of life manual) must be delivered with the tender.

#### 5.6 Thermal losses Calculation

The enclosure assembly, material and design shall be such as to minimize induced electrical losses and heating effects which could occur in service under normal and fault conditions.

Thermal losses calculation for one bay (including the busbar) shall be performed with the two following cases\_

- 80% of time 25% (1250Amps) of I<sub>n</sub> and 20% of time 60% (3000Amps) of I<sub>n</sub>

- 100% of time 100% In

Results shall be based on the contact resistance measurement realized during type tests and routine tests.

Additionally, the results shall include all the heating pads losses specified for the drives and LCC.

## **5.7 Special requirements for environmental protection and corrosion protection**

Environmental conditions shall not cause corrosion or deterioration of the gasket and/or mating material of gasket joints. All enclosures, panels, cabinets, etc. which are not of corrosion resistant metal, shall be thoroughly cleaned, primed and painted (if necessary).

If any, the interior coatings shall not deteriorate when exposed to the SF6 or other gas mixtures and other vapors, arc products decomposition such as CF4 or SO2 that may be present in the gas compartment. They shall also not contain any substances which could contaminate the enclosed SF6 or other gas mixture affecting insulation properties over a period of time.

All exterior surfaces shall be coated with a corrosion inhibitor.

All structural support and associated steelwork, as well as the connection bolts, shall be hot dip galvanized according to ASTM A123 or ASTM A386.

A small quantity of touch-up paint, identical to the specific finish coat, shall be furnished with the equipment.

All steel structures shall be hot-dip galvanized in accordance with EN-ISO 1461. Other types of surface treatment are subject to Statnett's approval. All steel parts shall be clean and free from rust before galvanizing. No drilling of holes is permitted after galvanizing unless special repair methods are applied. Such methods to be approved by Statnett.

Statnett requires a ten-year guarantee against corrosion penetration. The rust penetration shall be measured according to ISO 4628/3-1982. After ten years the rust penetration shall not exceed Ri 2. Ri 3 shall entitle Statnett to repair the surface at the expense of Contractor.

Bolts/nuts shall be hot dip galvanized in accordance with DIN 267 part 10.

## **5.8 Special gas mixture requirements test for environmental**

Environmental tests, as described in IEC 62271-1, Clause 7.10.4.1, shall be made on a representative compartment in order to assure that the mixture will not change due to these extremes of high and low ambient temperatures.

As an addition, the following tests shall be performed on the same test object:

- The cold test shall be performed according to Clause 7.10.4.2.
- The dry heat test shall be performed according to Clause 7.10.4.3.
- Final condition check shall be performed according to Clause 7.10.4.6.

During these operation tests at extreme temperatures, the tightness tests shall be performed.

As an additional obligation, after the final condition check the mixture composition shall be verified, as some of the components may have leaked more than others.

## 5.9 Requirements for mechanical dimensioning

All systems, sub-systems, structures and equipment shall be designed to manage stress caused by short circuit forces as well as forces caused by ordinary operation including connection and disconnection. Occurring vibrations in the ground caused by rock-blasting shall also be considered. A minimum of 0,2g shall be used to design the GIS system.

## 5.10 Requirements for lifting

All equipment shall be prepared for lifting. Any special tools or lifting device needed for maintenance and/or replacement of indoor og outdoor equipment shall be included and delivered on site at the takeover.

Certificate according to applicable HSE regulations shall follow the delivery of any lifting device.

## 5.11 Rating plates

Text on rating plates stamped with rating data for the specific equipment shall be in Norwegian language. Type and content of insulation fluid shall be stated where applicable.

The nameplate of switchgear assembly shall have all the information written in the relevant switching device standard, (i.e for circuit breaker IEC 62271-100 Table 10, for disconnectors and earthing switches IEC 62271-102 table 4, etc..) details along with the weight of the transformer bay, line bay, feeder bay and complete switchgear.

Rating plates shall always display the maximal ratings (short circuit current, rated current, rated duration of short-circuit, etc.) of the equipment, independent of Statnett requirements. For example if the switchgear bay feeder has 5000 A design, this value shall be written on the rating plate even though Statnett requirement is 4000 A.

The operating mechanisms and motor drives shall also bear its own nameplate.

The current transformer nameplate shall contain the information listed for all taps. The subsupplier of cores shall be mentioned on the rating plate.

The name plate material shall be stainless steel or non-corrodible non-plastic material, UV resistant and shall be fastened to the equipment by stainless steel screws or rivets. All markings shall be engraved or etched in black and shall be non-fading.

## 5.12 Operational labelling of GIS

The operational labelling shall give all phase conductors, bays, breakers, switches and main components in the substation an unique identity.

The signage shall be performed in such a way that no doubt occur between different parties at oral or written communication.

This is particularly important during the interaction between people at the system control center and in the substation when operating breakers and switches, and also when work is going on in the substation.

Appendix I with Specification [SDOK-47-10](#) is applicable with the following additions:

The substation bays labelling plates shall include the name of the bay, the current rating at 40 deg C, the short circuit rating and the global amount of SF<sub>6</sub> and other gas mixtures inside the bay at 20deg and rated filling pressure.

This busbar rating plates shall include the name of the busbar, the current rating at 40 deg C, the short circuit rating and the global amount of SF<sub>6</sub> and other gas mixtures filled inside the busbar at 20deg and rated filling pressure.

All above information on labelling and rating plates (§ 6.8) shall be located at an optimized place and visible location. In a way that operators could read the rating plate easily from the floor or a permanent platform "in normal working height".

Form, wording and localization is subject for Statnett's approval.

### 5.13 GIS Substation information plate

A general substation GIS information plate with the minimum dimension of 2m x 1,5m showing all primary functional devices of the substation (SLD) within their gas compartments shall be provided. This diagram should be made to conform (as closely as possible) to the physical layout (Square or Long) of the equipment and should show all gas barriers (close) and insulator support (open), gas valves, pippin and/or gas monitoring locations.

The gas schematic diagram should be permanent and mounted in the GIS room close to the main entrance door of the GIS hall for the use of operating and maintenance personnel

This substation information plate for the complete installed switchgear shall include:

- name of the substation and year (s) of installation
- numbers of bays and names
- rated voltage(s)
- rated short circuit current
- rated current at 40 deg C and 30 deg C
- for each gas compartment the amount of SF<sub>6</sub> and other gas mixtures in kg, ppmw and the rated filling pressure at 20 deg C and CO<sub>2</sub> equivalent and GWP (as per F-gas regulation)
- SF<sub>6</sub> gas and alternative gas mixture exact constitution (in %) including minimum functional gas composition and technical grade shall be stated.
- Clear limits (% tolerances) regarding the functional gas composition must be specified for operation per individual compartment.
- The global amount of SF<sub>6</sub> and other gas mixtures filled inside the global GIS (at rated

filling pressure and 20 deg) and its corresponding maximum leakages rates.

### 5.14 Marking of enclosure

One bay, (1 phase for single phase GIS) of the substation, shall have the enclosure marked with a single line diagram (or mimic diagram on the enclosure), showing the equipment inside the GIS tank (disconnecter, earthing switches, circuit- breaker breaking unit(s)) and also clear indication of position of gas-tight and open gas barrier.

The location of gas tight barrier insulators shall be clearly and permanently colour marked.

The location of gas through barriers shall also clearly and permanently colour marked, with a different colour of the finished external surface of the GIS enclosures flange.

### 5.15 Bay design and layout

Special technical specification (project specification) is applicable with the following additions:

The design of the bay and building shall be made in a way that all circuit breakers (enclosure, active part and drive), disconnectors and earthing switches shall have an easy access for maintenance and repair purposes.

Vital components shall be easily accessible for inspection and service.

Necessary clearance shall be highlighted on the drawing at tender stage.

Layout of the GIS equipment proposed shall be made in a way that the requested space on the side of the GIS equipment is significant to perform maintenance. For example, remove of one circuit breaker without touching any of the other phases for 420kV equipment or touching any other bay for 145kV equipment. Necessary space shall be provided on bay layout/design for civil work realization.

Figure 1,2 and 3 illustrate the required and necessary space requirement for 420kV architectures to perform maintenance and repair.

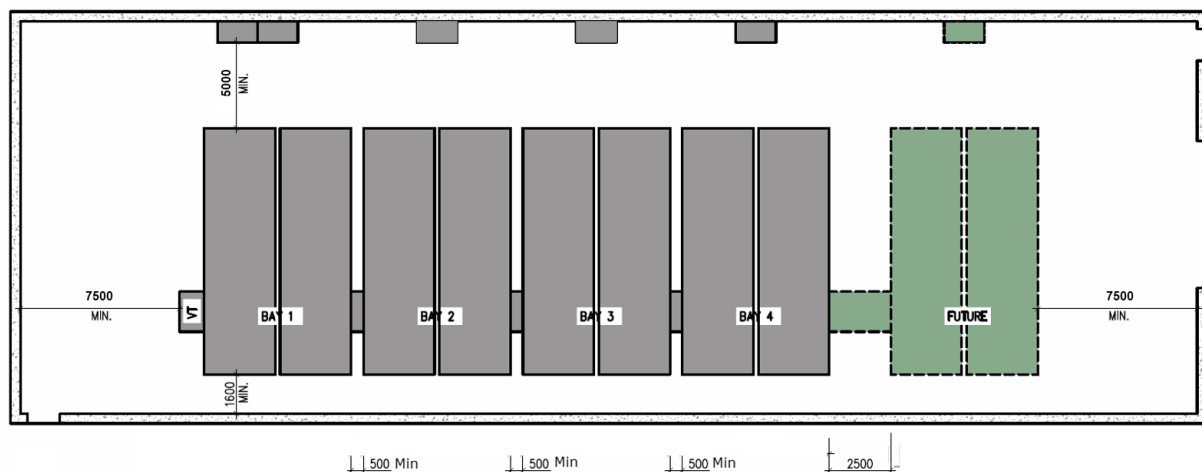


Figure 1: Minimum free space requirement (in mm) for 420kV GIS with 2 busbars and 2 circuit breakers with a Long Layout

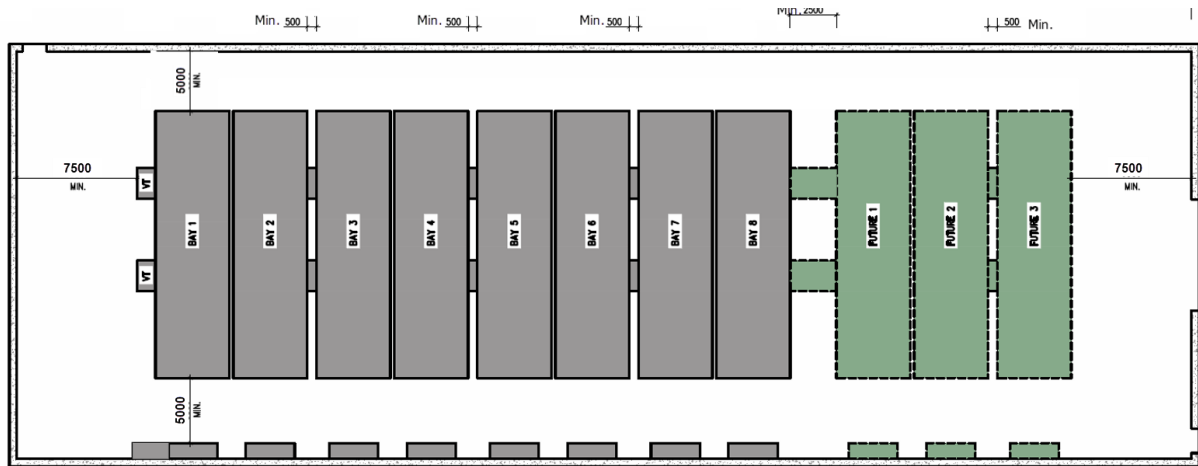


Figure 2: Minimum free space requirement (in mm) for 420kV GIS with 2 busbars and 2 circuit breakers with a Square Layout

Figure 3 and 4 illustrate the required and necessary space requirement for 145kV architectures to perform maintenance and repair.

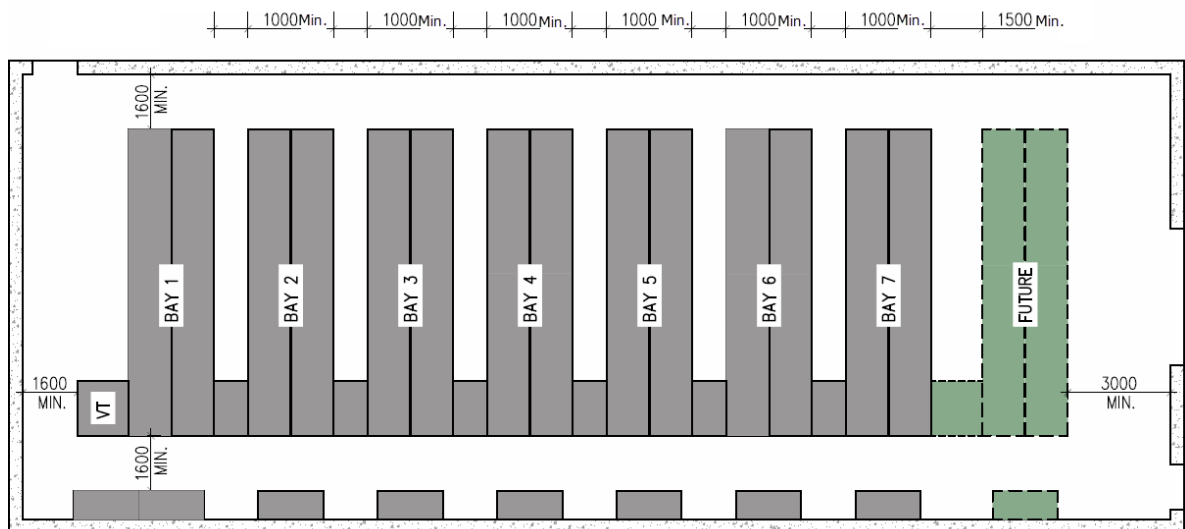


Figure 3: Minimum free space requirement (in mm) for 145kV GIS, 2 busbars and 2 circuit breakers Long Layout

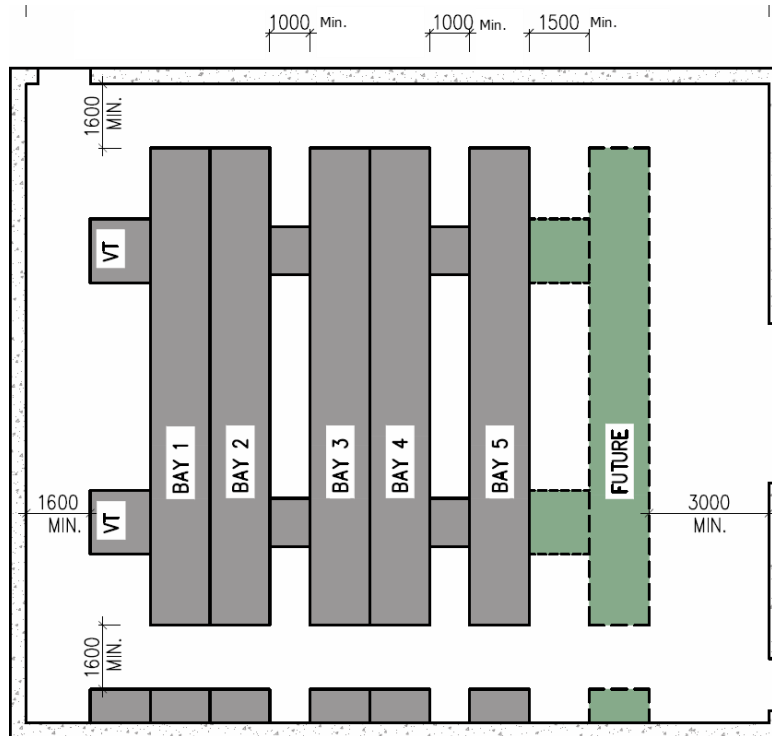


Figure 4: Minimum free space requirement (in mm) for 145kV GIS, 2 busbars and 2 circuit breakers Square Layout

The proposed architecture/design, shall fulfill Statnett safety requirement (no mechanical work allowed on a vicinity of a close barrier fully pressurised) and manufacturer requirement (if more severe than Statnett's).

- Dismantling of one circuit breaker (active part and enclosure including the insulating cone) shall not generate an outage on the line/feeder (when double circuit-breaker layout).
- Dismantling of one busbar disconnecter (if any) shall not generate an outage on the line/feeder.
- Dismantling of one feeder/line disconnecter shall not generate any outage in any busbar (for 420kV GIS).

This refers to Statnett standard layout and gas room partitions ([SDOK-41-52v](#)).

Any deviation from these layouts and gas rooms partitions shall be officially approved by Statnett.

In case of presence of direct connection between the GIS equipment to Power Transformer or Shunt reactor, care shall be taken for Gas Insulated bus duct connections to the outdoor wall-mounted bushings and the switchgear feeders with regard to an imaginable differential settlement of the concrete floors of switchgear-building and transformers/shunt reactors or supporting structures, respectively.

## 5.16 Walkways and stairs

All necessary elements such as movable platform, walkways, stairs (with handrails on both side) for common use of the switchgear, including maintenance and repair shall be provided with the equipment.

Accessibility of each drive, sensors, manometers and filling valves shall be possible and with an easy access.

Walkways, platforms and stairs shall be removable in case of maintenance or repair.

For operators' safety, permanent and movable platforms shall have two earthing connections in order to prevent floating or induced potentials.

Walkways shall follow national regulations.

To ensure security of workers, walkways shall be design so that, no parts could fall through or on the side of the platforms.

For GIS substations, walkways shall have access from both sides of the switchgear using stairs or ramps (non-vertical). The walkways shall also be accessible from the middle if the GIS has more 6 or more bays for long layout, or 8 or more bays for square layout.

### 5.17 Degree of protections

Degree of protection for all operating and driving mechanism shall be for indoor application at least IP21 as per IEC 60529.

For outdoor application drive and cubicle, the international protection (IP) marking shall be at least 54.

### 5.18 Internal GIS Interlocking

All disconnectors and earthing switches shall be equipped with mechanical padlock interlocking system to prevent accidental electrical or manual operation.

Padlocks for mechanical locking of disconnectors, earthing switches shall be delivered.

The Contractor shall provide the locks and a board with mimic diagram for suspension of locks dedicated to each switch and disconnectors.

This mimic diagram and locks shall be installed in the GIS hall.

For control system interlocking: See chapter 7 "Control system Requirements"

### 5.19 Electromagnetic compatibility

All electrical equipment shall comply with EMC requirements as stated in IEC 62271-1.

Shielding, termination and protection of secondary cabling and control cabinets and other secondary equipment must be coordinated with Statnett. See Statnett "Notat 1".

Special precautions to minimize influence from electrical transients from switching of disconnectors and other switches, as well as shielding of instrument transformers shall be described in the tender.



## 5.20 Internal Arc

The effect of an arc shall be confined to the compartment in which it has been initiated and under no circumstances shall be allowed to spread out to adjacent compartments or other parts of the switchgear. The minimum burn-through withstand time for the GIS enclosures shall be 300ms for all the enclosures at Statnett rated short circuit current (See special specification).

Manufacturer shall present the proof of burn-through withstand at  $I_{cc}$  max for 300ms for each enclosure design type (casting or forge/welded) on both vicinity of insulating cone.

IEC 62271-203 Bibliographie : RGE: 04/82, Electrical faults mastery in high voltage SF6 insulated substations, by Gilles Bernard, EDF, France. Published in Générale de L'Electricité RGE 4/82, April 1982, could be used as a base of demonstration.

The over pressure created by internal arcing faults shall in no case be allowed to exceed the withstand capability of the enclosure which could lead to fragmentation. Proof shall be sent to Statnett. Appendix D of IEC 62271-203 could be used.

Rupture discs/pressure relief devices shall be fitted in each gas compartment including GIS surge arrester (if any) to relieve over pressure created by internal arcing faults automatically and instantaneously.

Orientation of deflector must be adjustable on site during with the gas compartment energized/under filling pressure.

## 5.21 Thermal capability, and main current specification

All current carrying parts shall be made of electrolytic grade copper or aluminum alloy. All interconnecting sections of current transferring parts shall be silver-plated.

The switchgear shall be capable of carrying the specified rated current continuously at 40 deg C without temperature rise of various parts exceeding the limits stated in Table-3 of IEC 62271-1.

Appendix B dealing on permanent and temporary over load shall be filled in and submitted with the offer.

Special care shall be taken concerning the current transformer. Short and long term over load capability shall include the potential limitation of the secondary part of the current transformers.

Accessible parts should not have a higher temperature than 80 deg C, based on the fact that if the part needs to be touched or disabled, no current shall flow. (IEC62271-1 §4.4.2 Table 3).

Impact of the solar radiation on the outdoor equipment must be taken into consideration for the outdoor feeder duct and bushings. (The solar radiation shall be selected at 1000 W/m<sup>2</sup>.)

Air turbidity could be taken into consideration (IEC 60721-2-4) in order to reduce the solar radiation.

## 6 REQUIREMENTS FOR CIRCUIT BREAKER

### 6.1 General requirement for circuit breaker.

Circuit breaker shall have modular design of the operating mechanism for rapid replacement.

The total interrupting time at all currents less than the rated short circuit interrupting current shall not exceed the rated maximum interrupting time specified by the manufacturer in Appendix A.

Neither restrikes nor re-ignitions shall occur during any type of load switching and fault interruption.

If restrike or re-ignition have been recorded into the type test, Appendix D shall be filled in and it shall be described the measure that shall be implemented to protect the circuit breaker and the network for such an application.

#### First pole to clear :

- For 420kV the first pole-to-clear factor (kpp) shall be 1,3 in amplitude and in accordance with the arcing window of kpp = 1,3.

Envelop type test performed with 1,3 as arcing window and 1,5 in amplitude are accepted. Type test performed with kpp = 1,5 and arcing window 1,5 are not accepted.

- For 145kV the first pole-to-clear factor (kpp) shall be 1,5 in amplitude and in accordance with the arcing window 1,5 for circuit breaker equipped with MPO (multiple pole operated).

Due to the possible change in earthing configuration in the 145kV Norwegian network, (from a non- effectively neutral system to a effectively earthed neutral system), circuit breaker equipped with IPO (Independent Pole Operated) drive mechanism shall demonstrate the corresponding breaking capability (Kpp=1,3, and the corresponding arcing window Kpp1,3)."

For 145kV equipment, for some substation IPO drive mechanism for the circuit breaker could be necessary. Please refer to special specification

The circuit breaker shall have a rated duty cycle O-0.3 sec-CO-1 min.-CO.

Circuit breaker shall have duplicated circuits for signalling of phase discordance situations. Time delayed 3-pole tripping of the circuit breaker will be provided by external phase discordance protection (not part of the GIS installation).

The operating mechanism shall be preferably motor-wound spring-operated.

Single pole circuit breaker employing single-pole operating mechanism shall be electrically coupled for synchronous three-pole operation. The level "spring charged" is to be used as positive condition. Additionally signals shall be issued in case of uncharged spring.

Each breaker operating mechanism shall be equipped with a non-resettable mechanically actuated five- digit operation counter to indicate the number of opening operations performed by the circuit breaker.

This counter shall not be reset during the manufacturing nor routine process nor FAT.

Each housing shall have a removable conduit plate or sufficient conduit knockouts for bringing in wiring conduit.

The energy storage of a motor-wound spring-operated circuit breaker shall be sufficient for an "open- close-open operation" without replenishing the stored energy.

Means shall be provided to prevent overcharging of spring.

Mechanical indication of spring(s) for both "charged" and "discharged" states shall be provided and easily available on the drive cabinet. If the circuit breaker is equipped with a closing and an opening spring it shall be clearly illustrated the energy status of each spring and in which position the drive is fully unenergized.

Provision shall also be made for remote indication of spring charge fail condition.

Provision for manual spring charging and discharging shall be provided, which shall automatically cut-off the power supply to the motor and the tripping supply to the coils during manual charging/discharging.

Plate indicating the sense of rotation of the hand crank shall be in the vicinity of the hand crank drive access.

3 travelling kit sensors tool dedicated to the type of circuit breaker delivered shall be delivered in order to allow Statnett to measure traveling curve of one circuit breaker (3 phase) during maintenance.

The circuit breaker shall be supplied with two (2) electrically independent 220V DC shunt trip coils and one closing coil per operating mechanism. Trip and close coils shall be independent

per phase (IPO). Operation and supervision shall be according to SDOK-83-12 for 420/300kV GIS and SDOK-83-11 for 145kV GIS.

Correct identification and labelling of open and close coils shall be available in the vicinity of both types.

For maintenance purpose it shall be possible to control/test and replace close and tripping coils easily.

The circuit breaker shall have mechanical position indicators for the contacts (main and arcing contacts). The mechanical position indicator shall indicate the open and closed positions of the circuit breaker. The markings shall be in white letters as "UTE" on a green background for open position and "INNE" with white letter on a red background for closed position.

Anti- condensation :

Anti-condensation heater shall be provided within the housing of each motor driven operating mechanism. *The heating system shall be governed by temperature inside the cabinet such thermostat to ensure the minimum indoor temperature required for their guaranteed operation*

*The system shall be design in a way to preserve and warranty the lifetime of the proposed cabinet at least equivalent to the equipment HV parts expected lifetime.*

*The proposed values (in W) shall be selected by the manufacturer based on outdoor and indoor temperature in a way at moisture is avoided and accelerated ageing of the cabinets components doesn't take place. Their power must also take into account the maximum interior temperature reached for guaranteed operation of low-voltage, electronic, digital and high-voltage components relay, at maximum ambient temperature.*

For maintenance purpose it shall be possible to control/test anti-condensation heaters easily.

## 6.2 Mechanical performance

Circuit breaker active part and circuit breaker drive shall be maintenance free.

Type test report of extended mechanical endurance tests on class M2 shall be supplied to Statnett.

As maintenance free circuit breaker, no program of maintenance shall have been performed during the 10 000CO operation.

If program of maintenance performed, Appendix D shall be filled in and documentations shall be sent with the tender for revision and approval.

After the extended mechanical endurance type test, the insulating properties of the circuit breaker in open and close position shall be in the same conditions as before the tests. Voltage test at 100% shall have been performed before the contact inspection.

Partial discharge measurement shall not be more than 5 pc after the test.

If only inspection was performed after the test, Appendix D shall be filled in with relevant information and data.

Circuit breakers shall be equipped with anti-pumping function.

### 6.3 Capacitive breaking and making suitability

Full compliance to class C2 (Test duties LC1, LC2, CC1, CC2, BC1 and BC2) as per IEC standard. Capacitive voltage factor  $k_c$  shall not be less than 1,4 for cable and line switching.

For capacitor bank (back to back and single) duties, GIS manufacturer and Capacitor bank manufacturer shall execute a declaration of suitability of the breaking chamber of the circuit breaker used for switching and adequacy of all approved TRV suppression measures implemented, either jointly or separately, together with the main contractor.

The technical note shall include the optimum arcing time for this application, the RRDS and RDDS of the breaker and the temperature compensation curves for open and close operations.

All evidences including Type Test, TRV on the circuit breaker terminals, switching voltage transient, suitability for inrush current shall be submitted to Statnett for review and approval.

### 6.4 Shunt reactor suitability

Circuit breaker shall be designed to perform connection and disconnection of shunt reactor to the grid. Circuit breakers shall have passed the full sequence test according to the latest IEC 62271-1. No puncture or defect of isolating property shall be observable after the test.

Based on the type test report, a technical note shall be prepared and submitted to Statnett. The document shall demonstrate the suitability of the circuit breaker to operate the project dedicated shunt reactor. It shall include the calculation of the chopping factor ( $\lambda$ , AF-0,5) and an estimation of the over-voltage generated to the shunt reactor and the main grid. The technical note shall include the optimum arcing time for this application, the RRDS and RDDS of the breaker and the temperature compensation curves for open and close operations.

Type test shall have been performed without point of wave equipment.

According to Statnett's procedures, point of wave equipment will be bypassed in case of failure on the busbar. Therefore, point of wave equipment shall not be mandatory and shall be considered to reduce the stress on the circuit breaker, and therefore reduce the maintenance time intervals.

## 6.5 Electrical endurance performance

In case of single break circuit breaker, Statnett requests the manufacturer to realize electrical endurance test according to IEC 62271-310. Edition 2008.

The test has to be handled at the  $I_{sc}$  specified for the proposed product.

Detailed documentation shall be sent to Statnett, presenting the minimal electrical endurance of the CB in  $kA^2 \cdot s$ .

For self-blast circuit-breaker using alternative gas as breaking and insulating medium, this type test shall be performed in presence of Statnett.

## 6.6 Isolating distance

In case of single gap circuit breaker (circuit breaker with only one breaking chamber), the circuit breaker might have the isolating property of a disconnecter. In open position, with minimum filling pressure, the circuit breaker must be able to withstand in new condition the column 3 and 5 of table 102 for rated voltage equipment lower or equivalent to 245kV, or column 3, 6 of table 103 of IEC 62271-203.

## 6.7 Short Line fault performance

Circuit breaker shall have successfully passed Short-Line fault tests according to §6.109 of IEC 62271-100.

L95, L75 and L60 type tests shall be realized, on a base of the  $I_{cc}$  written in the specification and shall be submitted for approval.

L60 type test shall be performed for selfblast circuit-breaker SF6 free type.

Time delay shall be 0,5 micro sec for GIS, and 0,1 micro sec for dead-tank and hybrid applications.

## 6.8 Phase Opposition performance

Proof of performance of phase discordance (OP1 and OP2) with minimum factor of 2,0 for 420kV and 2,5P.U for 145kV shall be submitted to Statnett for approval.

The type test shall have been performed preferentially with two different voltages generator as in real live conditions. The non-performance shall be confirmed or not-confirmed in the Appendix D.

## 6.9 Non critical current demonstration

Circuit breaker shall not have any critical current at 40kA.

Hence type test according to IEC 62271-100 §6.107.2 shall be done. If type test was not performed Appendix D shall be filled in.

## 6.10 Single-Phase and double-earth fault performance

Circuit breaker shall have pass the type test §6,108 of IEC 62271-100. Type test report shall be delivered to Statnett.

If type test was not performed Appendix D shall be filled in.

## 6.11 Warning sign

Warning sign for emergency operation of the circuit-breaker shall have the following text. Inside the drive:

*Nødbetjening  
Skal ikke betjenes ved trykk lavere enn blokkeringstrykk*

Outside the drive, close to the drive handles:

Warning sign for emergency operation of the circuit-breaker shall have the following text.

*Dette utstyret inneholder mekanisk energi, bevegelige deler  
og fare for elektrisk støt  
Før vedlikehold, se bruksanvisningen.*

Form and localization is subject for Statnett's approval.

## 7 REQUIREMENTS FOR DISCONNECTORS

Disconnectors shall be three pole mechanically gang operated or preferably three single-pole electrically gang operated, no-load break, single stroke type, and shall comply in design, performance and type test with the requirements of IEC 62271-102 except as specified otherwise in this specification and IEC 62271-203.

The design shall incorporate features, which shall reduce or eliminate very high frequency voltage transients during disconnection and connection operation (bus charging).

The disconnector shall be motor driven with provision for manual operation and equipped with adjustable, self-aligning, high pressure type copper or aluminium silver-faced contacts. The contacts shall be capable of carrying full rated and short circuit currents without over heating or welding.

All disconnectors shall be equipped with local as well as remote controlled power-operated mechanism. DC power supply to the mechanism shall be automatically disconnected and local/remote electrical operation shall be prevented when manual operating device is engaged. The power to disconnect or connect in the enclosure shall be transmitted via gas-sealed pressure-resistant shaft.

Once initiated, the motor mechanism shall complete an open or close operation without requiring the initiating contact to be held closed.

Disconnector shall be class M2. Type test presenting the extended mechanical endurance with 10 000 CO operation shall have been performed on same equipment proposed by the manufacturer.

Gas tightness via the accumulative method test must have been performed after the type test.



Contact resistance measurement realized before the temperature rise type test, for rated current of the equipment, shall be the maximum admitted criteria value during FAT and routine tests.

Disconnectors shall have mechanical position indicators for the main contact open and closed positions, directly coupled to the driving shaft and clearly readable by the operator standing on the substation floor near the equipment. The markings shall be in white letters as "UTE" on a green background for open position and "INNE" with white letter on a red background for closed position.

Operating drive shall be as close as possible of the GIS equipment to reduce the length of shaft. Cord and chain driver for gang operation of operating mechanism are not acceptable.

Plate indicating the sense of rotation of the hand crank shall be in the vicinity of the hand crank drive access.

Test to verify the proper functioning of the position indicating device must have been done according to EC 62271-102, §6.105, Appendix A with at least coefficient of 1,5 of the strain limiting device of the drive. Statnett reserve the right to accept or ask the repetition of this type test in presence of a third party at the manufacturer cost.

In case of double bus-bars, single circuit-breaker design bay, all bus-bar disconnectors shall have the performance to bus-transfer switching as specified in the latest edition of IEC 62271-203.

For Hybrid technology or GIS connected to a conventional (AIS) bus bar, AIS bus bar current values shall be selected.

Disconnector shall have the performance of bus charging current with a current not higher then 0,5 amps. In case of fast acting disconnector (speed  $\geq 1\text{m/s}$  at arcing contact separation), 200 make and break operations shall be demonstrated.

Disconnectors and power operating mechanisms shall be lockable in end position (open/close).

### **Anti- condensation :**

Anti-condensation heater shall be provided within the housing of each motor driven operating mechanism. The heating system shall be governed by temperature inside the cabinet with a thermostat to ensure the minimum indoor temperature required for their guaranteed operation

The system shall be designrf in a way as to preserve and warranty the lifetime of the proposed cabinet at least equivalent to the equipment HV parts expected lifetime.

The proposed values (in W) shall be selected by the manufacturer based on outdoor and indoor temperature in a way at moisture is avoided and accelerated ageing of the cabinets components doesn't take place. Their power must also take into account the maximum interior temperature reached for guaranteed operation of low-voltage, electronic, digital and high-voltage components relay, at maximum ambient temperature.

For maintenance purpose it shall be possible to control/test anti-condensation heaters easily.



## 8 REQUIREMENTS FOR EARTHING SWITCHES

Earthing switches shall be three pole mechanically gang-operated or preferably three single-pole electrically gang-operated, no-load break, single stroke type, and shall generally comply in design, performance and type test with the requirements of IEC 62271-102 except as specified otherwise in this specification and IEC 62271-203. All Maintenance Earthing switches shall be motor driven type.

Earthing switches shall be lockable in end position according to IEC 62271-102.

Incoming line or cable termination point Earthing switches (High Speed Earthing Switches) shall have snap spring operated high speed operating mechanism located in each earthing switch, in order to have low motions on each shaft from the drive to the fast acting earthing switch.

A manual operating device shall also be provided for all earthing switches.

Incoming line or cable termination point earthing switches shall be capable of closing against the peak of the rated short circuit making current of the switchgear. All earthing switches shall have the same or higher short time current rating as that of the switchgear.

Earthing switches installed at each termination point of GIS shall be capable of breaking the induced capacitive and inductive currents per IEC 62271-102 according to Class B.

DC power supply to the mechanism shall be automatically disconnected and local/remote electrical operation shall be prevented when manual operating device is engaged. The power to earth via earthing switch in the enclosure shall be transmitted via gas-sealed pressure-resistant shaft. Once initiated, the motor mechanism shall complete an open or close operation without requiring the initiating contact to be held closed.

Fast acting earthing switches shall be E1 class, B class and have a mechanical endurance of at least 2000 CO.

Maintenance earthing switches shall have a mechanical endurance of 10 000 CO operations.

All earthing switches shall have mechanical position indicators for the main contact open and closed positions, directly coupled to the driving shaft and clearly readable by the operator standing on the substation floor near the equipment. The markings shall be in white letters as "UTE" on a green background for open position and "INNE" with white letter on a red background for closed position.

Vital components shall be easily accessible for inspection and service.

Cables shall enter the cabinet from the bottom. Cables shall be correctly attached to the GIS enclosure in a way that no cables could accidentally be pulled.

Electrically operated devices shall be equipped with a crank handle for manual operation.

Crank handles for manual operation shall not be connected to the motor. It shall be possible to operate an earthing switch by crank within 60 sec without any auxiliary tools.

A plate indicating the direction of rotation of the hand crank shall be in the vicinity of the hand crank drive access.

Busbar earthing switches shall have separate operating mechanisms and shall have separate operating discrepancy switches at local and remote panels. The discrepancy switch and SF6/other gas mixtures alarms shall be in the Bus Section panel. Each bus bar earthing switch shall have a separate cubicle.

The design of all fast acting earth switches shall be such that the charging of spring shall be only after the "close" command. In other words, the spring must not be charged until signal to operate the switch is given.

The line earthing switches installed at each termination point of GIS shall be capable of breaking the induced capacitive and inductive currents per IEC 62271-102: Class B.

All fast acting earthing switches, including busbar earthing switches, shall all be equipped with the possibility to be isolated (10kV) from the tank.

#### **Anti- condensation :**

Anti-condensation heaters shall be provided within the housing of each motor driven operating mechanism. The heating system shall be governed by the temperature inside the cabinet with a thermostat to ensure the minimum indoor temperature required for their guaranteed operation.

The system shall be designed in a way as to preserve and warranty the lifetime of the proposed cabinet to at least equivalent to the equipment HV parts expected lifetime.

The proposed values (in W) shall be selected by the manufacturer based on outdoor and indoor temperature in a way that moisture is avoided and accelerated ageing of the cabinets components doesn't take place. Their power must also take into account the maximum interior temperature reached for guaranteed operation of low-voltage, electronic, digital and high-voltage components relay, at maximum ambient temperature.

For maintenance purpose it shall be possible to control/test anti-condensation heaters easily.

## 9 REQUIREMENTS FOR CURRENT TRANSFORMER

The current transformers shall be ring core type and comply with the requirements as specified in the data schedule and IEC61869-1, IEC61869-2.

The CTs shall be designed for satisfactory and reliable operation in conjunction with the gas-insulated switchgear under all rated and fault conditions. The CTs shall have a fault current rating equivalent to the switchgear rating.

CT secondary winding shall be positioned within the GIS enclosure such that the current in the enclosure does not affect the accuracy and the ratio of the device and does not distort the conductor current being measured.

GIS Instrument transformers enclosure shall be airtight. Inner insulation shall be protected against penetrating moisture. GIS CT enclosure shall be designed in a way that it has enough room to have up to 6 cores as specified in the project special specification.

Secondary side (magnetic core) shall be outside the insulating gas for 420kV GIS.

Connection box for secondary terminals shall be easily accessible, including during operation. All terminals shall have unique labelling and earthing terminals shall be arranged as described SDOK-41-9 (Instrument transformers - General Technical Specification).

The connection box shall include a wiring diagram of the complete secondary cable terminals.

Current measuring circuits shall be earthed in the connection box and not in the bay cabinet.

Temperature rise type test must have been performed with the current transformer enclosure filled with cores and connected to their main burden.

Class of isolation of the CT materials shall be at least equal to F class. Please refer to project special specification for ratio and ratings of the CT's.

## 10 REQUIREMENTS FOR INDUCTIVE VOLTAGE TRANSFORMER

Usually, only Air Insulated capacitive voltage transformers (CVT) are used in Statnett substations, but for special application such as bus bar, cable application etc... , inductive voltage transformer shall be supplied.

Inductive voltage transformer shall be single-phase or three-phase, inductive type; SF6 or other gas mixtures gas-insulated and have its own individual gas compartment.

Voltage transformers shall have an integrated disconnect-link (to be hand-operated from GIS exterior) or separate disconnect switch with positive mechanical and electrical indication of close/open to provide disconnecting means for HV system/power cable dielectric tests. This disconnect-link/switch shall have the capability of locking in the open or closed position.

If above facility is not available, GIS manufacturer shall officially confirm that such disconnecting equipment is not necessary for the live time of the GIS, including HV and cable site test. (Appendix D).

Please refer to project special specification for ratio and ratings of the VT.

The voltage transformers shall comply with the class from minimum to maximum burden.

GIS inductive voltage transformer shall be designed as to avoid Ferro-resonance effects and shall be provided with adequate Ferro-resonance-suppressor (if required) on the secondary windings. An electrostatic shield shall be employed between the windings of voltage transformer to prevent coupling of the very fast transients, generated in the GIS switching devices.

Voltage measuring circuits shall be earthed in the connection box and not in the bay cabinet.

Connection box for secondary terminals shall be easily accessible also during operation. All terminals shall have unique labelling and earthing terminals shall be arranged as described in SDOK-41-9 (Instrument transformers - General Technical Specification)

The connection box shall include a wiring diagram.

As specified in the memo no1: Principles for local control systems in Statnetts substations, all cables shall be halogen free, flame retardant type with double isolated Radox 4GKW-AX/S EMC or equivalent type for voltage measuring circuits between voltage transformer and MCB located in the bay cabinet. In regard of double insulation the conductor in the cable should be connected directly to the MCB's in the bay cabinet, and not via terminal blocks. There shall not be any fuses in the circuits before the MCB's in the bay cabinet.

All inductive voltage transformer shall be equipped with numerical shock sensor in X Y Z. GIS manufacturer shall fix the limit of shock. It remains the manufacturer's responsibility to verify and present to Statnett that no shock above mentioned limit have been observed or recorder during the transport.

## 11 REQUIREMENTS FOR CABLE CONNECTION

Suitable SF6 or other gas mixtures gas-filled cable connection shall be provided, if specified in the layout and project, for accommodating XLPE or SCFF/LPOF copper or aluminium cable terminations.

The cable boxes shall be designed to accept the cable along with its terminations cone from below, above or horizontal position.

GIS shall also be flexible in a way as to accept 2 cable per phase. Correct design and possibility to test each cable independently of the GIS shall be possible. An isolating link or removable link equipped with a telescopic enclosure shall be provided between each cable box. This to allow to disconnect one cable box from the other in case of failure.

The scope shall also include all necessary cable supports and cable grounding facilities. All coordination with cable and cable termination suppliers shall be made for proper electrical and mechanical interface in accordance with IEC 62271-209.

All cable terminations of SCFF (self contained fluid filled) or LPOF (low pressure oil filled) cables shall be located outside the substation building or main GIS building fire zone.

In case of dry type plug-in GIS/Cable connections, the insulator assembly (provided by the cable manufacturer) shall be assembled in the GIS cable box and routine tested by the GIS manufacturer in their test facility prior to the delivery on site.

GIS manufacturer is responsible to coordinate the design pressure of the insulating cone and the cable box for SF6 and other gases and gas mixtures.

The cable termination design and connections shall generally comply with IEC 62271-209 or class 1 of IEEE 48 and IEEE 1300.

The Gas-to-XLPE and Gas-to-oil bushing top end in the cable box termination shall have a removable link for site-testing purposes. This removable conductor between the cable insulating cone electrode and the GIS duct shall be possible to be dismantling without removing the cable nor the cable box enclosure.

The cable box enclosure shall be designed in a way it could be implemented a test bushing on the cable box enclosure to permit HVAC field testing of the cable or the GIS. Test bushings shall be able to connect without dismantling any associated equipment such as inductive voltage transformer, disconnectors, earthing switches, etc.

GIS manufacturer shall propose and deliver a maintenance earthing link, which would allow earthing of the cable while doing the site test on the GIS equipment.

Gas-to-oil bushings for terminations of SCFF/LPOF cables shall be provided with barriers, which will prevent oil migration into switchgear in case of porcelain failure.

Effective and long life gas-tight seals shall be provided between the cable sealing end and the cable termination enclosure. It shall be possible to accommodate high voltage cables of all types as specified in the data schedule.

The cable box shall be dimensioned in a way it could receive a cross-section of 2500mm<sup>2</sup> for 145kV and up to 3200mm<sup>2</sup> for 300 and 420kV.

All terminations to gas insulated switchgear shall employ, as a minimum, double sealing per IEC 62271-209 to prevent leakage of gas. The seals shall have a life expectancy of not less than 40 years.

All the GIS apertures intended for future cable terminations shall be sealed with effective cover plates to safeguard against Gas leakage.

The cable sheath shall be isolated from the cable enclosure and any support structures.

Adequate clearance between floor, building wall and cable compartment shall be provided for easy installation, maintenance and repair of cable terminations/sytem.

Necessary clearance shall be highlighted on the drawings at tender stage.

GIS manufacturer supervisor shall be present during the HV cable installation and test.

See the special project specification for more details.

## 12 REQUIREMENTS FOR BUSHING

Bushings shall be designed to withstand wind and snow load taking account of a frost layer 30 mm in the calculation of the surface exposed to the wind increased efforts.

For connecting overhead lines with the GIS, Gas-to-Air outdoor bushings shall be mounted on suitable steel structures. GIS manufacturer shall design the necessary foundations and earthing.

The Gas-to-Air terminations shall include all necessary materials such as gas interface bus duct, gas monitoring devices and removable links to ensure complete termination.

Bushings shall be of composite type.

The colours of the composite insulators is determined in harmony with the colour of the material, or with the colour of the building.

GIS manufacturer shall prove via technical note that no liquefaction nor modification of the mixture composition will occur in the GIS bus duct and bushing at the minimum temperature specified in the specific/project specification.

In case of liquefaction process, GIS manufacture shall select a dry type bushing.

Bushings terminals shall be made of plate aluminium alloy defined according to IEC60518.

In case of horizontal bushing (including 45degree), demonstration of dielectric conditions with heavy and polluted snow shall be made via a technical report and a test. Mechanical test must have been performed according to level II described in IEC 60317 latest version.

GIS manufacturer is responsible to place and position outdoor GIS bushings at a correct geographical position which match with outdoor equipment such as gantries, AIS capacitive voltage transformer or AIS surge arrester (if any).

## 13 REQUIREMENTS FOR GIS CONNECTION TO POWER TRANSFORMER / SHUNT REACTOR

Direct single phase GIS bus duct connection between power transformer or shunt reactor to GIS substation is usually not Statnett's standard.

However, if this would be the case based on contractual or special project request, suitable Gas/SF6-to-Oil transformer / reactor terminations shall be provided.

The limit of supply and requirements specified in the relevant IEC standards (IEC 62271-211 + IEC 62271-209) are applicable with the following additions:

SDOK-41-52 sheet 7-1 "Power transformer GIS connection" describe the GIS arrangement that shall be provided by the GIS manufacturer.

In order to facilitate testing of transformers, an insulated fast acting earthing switch and a disconnect switch shall be included in the design the GIS connections. Both elements shall be as close as possible to the transformer or reactor Oil/Gas bushing.

The fast acting earthing switch shall be equipped with an isolated link allowing isolation from the earthed enclosure. The isolation level shall be at least 5 kV.

The design of the GIS and the steel structure shall allow maintenance personell to have easy access to the DS and IFES drives, sensors (gas and UHF), filling valves and earth switch(es) insulation flanges.

SF6 and other gas mixtures manometers shall follow §6.33 Monitoring / control of gas compartments and shall be positionned in a way that it could be read from ground or corresponding platform. Special attention shall be payed to the orientation and alarm settings of theses manometers proposed by the GIS manufacturer, in order to avoid false SF6 and other gas mixtures alarms.

Impact of the solar radiation must be taken into consideration (the solar radiation shall be selected at 1000 W/m<sup>2</sup>). Air turbidity could be taken into consideration (IEC 60721-2-4) in order to reduce the solar radiation.

Accessible parts should not be in service at the maximum continuous current at higher temperatures than 70 deg (IEC62271-1 Table 3).

No opening of the GIS for testing of the power transformer or reactor shall be necessary to avoid or reduce the gas handling losses, potential intrusion of particuls and reduce outage time of the equipment.

The design of this GIS system shall be as compact, light, reliable and easy to remove as possible in order to allow easy replacement of any transformer bushings. A method for performing the work of dismantling the GIS link shall be provided to Statnett for review. This document shall indicate all the required equipment and necessary vertical free space above the transformer or reactor tank to remove this GIS link.

The isolating flange between the GIS enclosures and the power transformer (or shunt reactor tank) shall be designed in a way that it is isolated for at least 5kV rms to avoid any circulating



current between the transformer tank and the GIS earthing circuit. Non-linear resistance/surge arresters are to be provided symmetrically across the insulating joints of the GIS enclosures as specified in §12 : earthing of the GIS.

The position of the isolating flange shall be as close as possible to the transformer.

Effective gas tight seals shall be provided between the duct enclosure and the Gas-to-Oil bushing.

Gas-to-Oil transformer/reactor terminations shall include all necessary materials such as Gas interface bus-duct, potential removable links, bellow assembly and flexible interconnecting copper straps to minimize vibration transfer from the transformer/reactor to the GIS system.

The 90 deg enclosures and the GIS bellows shall be self-compensated or compensated in compression by tie-rods or springs to allow an error of the civil work, missalignment or non exact placement of the transformer. The transformer will be placed on wheels.

Necessary supporting steel structures of the complete GIS system are parts of the GIS delivery.

GIS manufacturer has the responsibility to arrange a dedicated or combined GIS DR meeting with the power transformer manufacturer and Statnett early enough in order to not delay the production and potentially the project as specified in the chapter 4.3.

A dedicated rating plate including but not limited to the specific quantity of SF6 and other gas mixtures, and the maximum continuous current ratings of the busduct and connections shall be delivered with this GIS system.

## 14 REQUIREMENTS FOR ZNO SURGE ARRESTER

GIS surge arrester is usually not part of Statnett's standard GIS solution.

Insulation co-ordination shall be performed during the project engineering in order to assess the need for surge arresters.

If the project requests GIS surge arresters, these shall be metal-oxide type. Arresters shall be designed and tested per IEC 0099-4.

Insulation co-ordination study of the GIS shall be performed to ensure the adequacy of protective margin, location and number of surge arresters to be provided in the GIS.

The energy rating chosen for the SF6 and other gas mixtures surge arresters shall be adequate to dissipate the energy under normal conditions, and also the energy generated in case one of the circuit breaker poles fails to close and the circuit is opened by the poles discrepancy protection after a time delay.

SF6 and other gas mixtures surge arresters must be of either plug-in construction or the disconnecting-link type to provide disconnecting means for system dielectric tests.



The surge arrester ground connection must be insulated from the enclosure in order to permit monitoring of the leakage current. The ground connection shall be dimensioned for the fault level of the GIS.

For site GIS testing purposes, it shall be possible to easily remove a conductor connection link between GIS insulating cones and surge arresters' active part without removing the active part (i.e ZNO blocks) or surge arrester enclosure.

During transportation, all metal oxide surge arrester shall be equipped with numerical shock sensor in X Y Z.

It remains manufacturer's responsibility to verify and present to Statnett that no shock above mentioned limit have been observed or recorder during the transport.

## 15 DIELECTRIC BEHAVIOR IN CASE OF GAS LEAKAGE

In the event of gas leakage, all parts of the switchgear (switching devices in close position) in the affected compartment shall be able to withstand continuously the operating voltage (243kV for 420kV rating and 77kV for 132kV rating) at a frequency rated voltage (50Hz) with with a factor of  $k=1,1$  for 120 minutes.

Proof of dielectrical performance shall be sent to Statnett for the complete bay.

If the equipment is not withstanding such a performance, Annex D shall be filled in.

## 16 GAS ROOMING

The GIS shall be designed and constructed to avoid personnel or material damages in case of internal pressure rise.

Division in gas compartments shall be designed to optimize revision, maintenance and fault localization as well as ordinary operating performance.

Drawing showing gas compartments and localization of gas pressure relieves shall be forwarded with the tender, see project special specification.

Procedures for maintenance and repair work with other compartments/parts of the GIS in service shall be described and provided during the project execution.

In addition to IEC 62271-203, following partitioning of the equipment applies:

- Circuit Breaker: separate compartment.
- Disconnecter: separate compartment and one compartment for the common point/feeder.
- Busbar: shall have separate compartments, one gas room partition every second bay as a minimum (see gas room partition drawing for more details)
- Current and voltage transformers: separate compartment. The instrument transformers shall not be placed in any switching compartment (circuit-breaker, disconnecter, earthing switch, etc..). Current transformer could be installed in the same gas room partition of the CB if vacuum technology is

used.

- Earthing switch: separate compartment or associated to a disconnecter with the proviso that the maintenance of the earthing switch can be achieved without outage of the other busbar.
- Fast Acting Earthing Switches (FAES) shall be installed on each busbar and on each feeder. It shall have its own gas room partition.
- Surge arrester (if any): separate compartment.

See appendix F, SDOK-41-52.

A partition separating a compartment filled with insulating gas from a neighbouring compartment such as a cable box, filled with liquid, shall not show any leakage affecting the dielectric properties of the two insulations.

A coloured diagram with legends showing various gas compartments, piping, interconnections, valves, orifices and isolations to prevent current circulation, necessary controls and monitoring systems etc. together with normal and alarm ranges shall be mounted near each control cubicle for ease of monitoring.

Conductor length shall not be longer than 10 m for 420kV, 245kV and 145kV GIS.

MRE calculation as specified in annex F shall be provided with the tender with the proposed architecture.

## 17 MONITORING / CONTROL OF GAS COMPARTMENTS

Gas control and monitoring is made by 3 different functions and equipment:

1. Visual Manometer
2. Density Switch
3. Density sensor (serial or analogue)

Each gas compartment shall be monitored by temperature-regulated gas density guards. Each phase (300 and 420kV) shall have separate system. For 145kV and lower there will be a common gas monitoring system for all the three phases.

Manometers shall be scaled with different colours according to the different density of gas.

Unit with scale (bar relative or absolute unit) shall be clearly indicated on the gas monitoring sensor.

It shall be possible to test and replace each pressure gauge and the density switch/relay without loss of gas or de-energizing the compartment. Function tests on density guards with energized GIS shall be possible without removing pressure gauge, density switch or manometer.

Density guards shall be equipped with potential free contacts, one contact for pre-warning and two contacts for blocking.

SF6 or other gas mixtures in each individual compartment shall be monitored by suitable temperature-compensated pressure gauges and two-stage temperature compensated pressure (gas-density continuous monitoring) switches/relays to monitor the loss of gas. The

dial of the pressure gauges shall be graduated to read pressures and coloured green, yellow and red to indicate normal, Alarm Stage I (or non-urgent) and Alarm Stage II (or urgent) pressure conditions. The gas-density monitors shall be capable of being calibrated with the monitored equipment in service. Each pressure relay shall be provided with two convertible potential-free auxiliary contacts for two-stage alarm initiation as mentioned below. These alarm contacts shall be wired to the respective GIS bay cabinet.

Filling pressure and Alarm II (block) shall have at least 1 bar difference.

Stage I: Alarm at  $[(\text{nominal density} - \text{minimum density}) / 2]$

Stage II: Alarm in the event of gas density falling below the minimum safe operating limit (and block breaker tripping, or maintain breaker open).

For the gas compartment adjacent to gas room compartment with higher gas pressure, such as circuit breaker, these compartment shall also be equipped with high pressure alarm sensor warning, in addition to low pressure ones.

## 18 OVERPRESSURE RELIEF AND GAS DEFLECTOR

Each compartment shall be equipped with a pressure relief device limiting the pressure rise in case of internal fault.

These devices must be arranged so that they avoid gas and materials projections in the areas provided for the operation and routine maintenance. These devices shall be made in a way that the orientation of the deflector is able to be changed on site without de-energizing the concerned compartment.

Deflector shall be designed to deflect the biggest compartment volume in case of internal arc at the maximum short-circuit current. Proof of above shall be provided to Statnett.

Outdoor compartment rupture discs shall be designed in a way that no moisture, water, birds nest or animals could approach this security item.

Gas deflectors shall each be fitted with rupture disc/pressure relief devices to eliminate hazards to personnel and other equipment due to gases or vapours under pressure.

## 19 CONTROL SYSTEM REQUIREMENTS

### 19.1 General

General requirements that applies to local control systems are found in the SDOK-83-5 "Memo no.1 - Principles for local control systems in Statnetts substations"

Contractor shall specify an interlocking system based on existing Statnett standards/principles (Appendix E).

Interlockings for the switching components such breakers, disconnectors and earthing switches will be placed in the relay cabinet in the control room and not into the bay cabinet.

Each bay of the switchgear shall be provided with a bay cabinet. The bay cabinet shall be delivered without any form for alarm annunciators. The bay cabinets shall be placed adjacent to their respective GIS bays. Embedded cabinets into the bays are not permitted for 420kV GIS.

As a principle, each bay (with one or two circuit breakers) shall have only one LCC per bay.

For some special substations with square layout with two circuit breakers for exemple, it could be necessary to provide two LCCs. This shall be clarified with Statnett during detailed engineering.

Measuring bay (busbar voltage transformers) and busbar fast acting earthing switches shall have their own and separated LCCs.

In case of gas online monitoring system a minimum of one LCC dedicated to this function shall be installed in the GIS hall.

Bay cabinets shall be equipped with a bay diagram on its front door (single line diagram including the gas room partitions) presenting the position (close or open) of the different equipment bays including operating panel for circuit breakers, disconnectors and earthing switches. Push button shall be equipped with cover in order to avoid any unintentional operation.

Push buttons in the LCCs shall also have interlockings from the control system, not locally in the LCC. Therefore there shall not be any interlocking on/off or remote/local switches in the LCC as such switches is located in the control system.

The markings of the push button shall be in white letters as "UTE" on a green background for open position and "INNE" with white letter on a red background for closed position.

Bay cabinet shall be equipped with analog instruments displaying measured current and voltage for each base on the associated bay.

The bay diagram shall be protected with a durable, non-fading material, suitable for the specified climatic conditions.

Statnett shall approve schematic diagram of the part of the control system, local to the bay cabinet, identifying various components within the cabinet and the respective switchgear bay and referring to the appropriate drawings and instruction manual shall be affixed inside of the cabinet access door.

Interface between GIS and control-system for the substation must contain not less than:

- indications to control-room
- all error messages to control-room including breaker pole discrepancy and trip circuit failures
- commands from control-room

- measuring values from current- and voltage transformers
- gas warning and critical level (Inn/Out blocking) for each gas section

Each bay cabinet shall have a name plate on each cabinet showing the name/number of the bay connected.

Reference and operational labelling of cabinets, fuses, operating gear, i.e shall be in Norwegian language and be approved by Statnett before mounting. Labelling of operating equipment is to be made of engraved plates, calottes or equivalent.

For 420kV GIS the bay cabinet shall be freestanding. For 145kV GIS the bay cabinet could be embedded on the GIS. The bay cabinet shall be made of sheet steel and provided with lockable- hinged door and door operated lights. The cabinet shall be self-contained, fully assembled and factory wired for the required application and designed per IEC 61439. Local control cubicle or so called bay cabinet, shall be painted with the same project indoor GIS color. The bay cabinets shall have a degree of protection at least equal to IP21.

All electronic components inside the bay control cabinet shall be designed to work satisfactorily for the specified ambient temperature.

The cabinet shall be provided with one thermostatically controlled anticondensation space heater rated 230 VAC designed for continuous operation with a manual on/off control switch. For outdoor applications, an additional heating element without thermo shall also be provided.

For maintenance purpose it shall be possible to control/test anti-condensation heaters easily. Interior lighting with door switch and manual on/off control switch supplied with 230 VAC.

One 16 A, 230 VAC 50Hz tandem slot according to Norwegian standard.

A copper ground bus bar of suitable dimensions shall be provided in the bay cabinet for grounding. The hinged door of the panel(s) shall be grounded by a flexible grounding connection.

All cabinets must have adequate ventilation and drainage.

## 19.2 Wiring between bay cabinets and GIS-apparatus/functions

All wiring between GIS and the bay cabinets shall be done by the Contractor.

All cables are to be labelled in both ends, in an easily readable way. Naming and numbering of the cables must be co-ordinated with the system used by the provider of the local control system. All cables shall be halogen free in accordance with [SDOK-83-5](#) cha. 1.3.

Cable terminals and blocks shall be in accordance with the newest revision of [SDOK-83-5](#) chapter 2.

By insertion in wall mounted cabinets labelling outside the cabinet are accepted, if it is not convenient to do the labelling inside. For all other types of cabinets labelling are required to be done inside.

Wiring plans shall be approved by Statnett.

Final approval of bay cabinets and equipment drive cabinet is subject to Statnett's final approval during the final qualification of the equipment at the manufacturer's location.

## 19.3 Point on wave switching device

Circuit breakers shall be prepared for any type of point on wave switching for the following's applications:

- Power cable lines
- Power Transformers
- Shunt Reactors
- Capacitor banks

The device is part of the protection and control contract (if not otherwise specified in the scope of work). The CSD will be installed by the C&P contractor based on the information an requirement for the GIS manufacturer. It remains the responsibility of Circuit-breaker manufacturers to provide necessary information in due time on requirements.

THE CSS (Controlled Switching System) will be commissioned by the GIS contractor.

Point on wave switching devices shall enable circuit-breakers making or breaking at a specified point-on-wave for all three phases to reduce the effect of switching disturbances and preserve the insulating materials of the circuit-breakers.

The function shall take into account the dielectric and mechanical parameters of the circuit-breaker.

The function shall be provided with compensation facilities for external factors such as temperature, charging state of operating system, idle time characteristics, operation coil terminal voltage and interrupter dielectric characteristics etc... which influence the circuit-breaker operating time.

The transducer inputs and reference data required to achieve satisfactory compensation shall be clearly defined.

For each circuit-breaker operation, the function shall adjust the switching instant based on signals from these transducers.

The function shall be provided with an adaptive control facility.

Settings parameters (necessary arcing time, RRDS, RRRS) shall be a part of the delivery.

Commissioning of the point on wave switching device coupled to the circuit breaker shall be performed in presence of Statnett during the commissioning phase of the project.

The point on wave switching device combined with the circuit-breaker shall be capable of achieving a making and breaking operation at a specified point-on-wave with a tolerance of  $\pm 1$ ms.

The point on wave switching device shall be located in the relay & protection room, never in the bay cabinet (LCC).

Test requirement:

Tests shall be carried out on the point on wave switching device in order to demonstrate that it meets the performance requirements specified above and in this standard.

Type tests according to IEC 62271-302 shall be carried out to demonstrate the combination performance of the point of wave switching device and the proposed and qualified circuit-breaker.

As per IEC 62271-302, circuit-breaker operation shall be carried out under the effect of influencing factors such as temperature, charging state of operating system and operating coil terminal voltage etc. so the compensation facilities of the function can be checked.

Type test documentation and proposed arcing time shall be delivered and available during the commissioning of the circuit-breaker and point on wave switching device.

## 20 INSTALLATION

### 20.1 General

Before the start of site operations, the Contractor must inspect the site area. As part of the site inspection, the Contractor shall check the earthing system and connection points.

Prior to the installation work, the delivered materials shall be checked for completeness and transport damages.



The Contractor shall install all equipment related to this delivery and provide local transportation, unpacking, temporary storage, as well as all necessary temporary equipment such as construction power, telephone facilities, etc...

The Contractor is responsible for all installation work on site which includes:

- Complete delivery of all necessary components to site.
- Lifting, sliding and moving incl. all tools and machinery.
- Installation, testing and commissioning of all primary system components including connection to the primary interfaces on site.
- Installation, testing and commissioning of all secondary system components including connection to the cabinet for termination in the module.
- Installation and testing of all gas components.
- Installation and testing of the earthing systems.

The Contractor shall provide accommodations and transportation for its own crew.

All work shall be planned and carried out in cooperation with Statnett. The work shall be carried out according to all relevant regulations in Norway.

The Contractor shall provide all necessary tools, equipment and material for the completion of the work even if this is not specified in detail for the object to be installed in order to make the installation complete.

Overhead travelling crane will be installed in the GIS building by Statnett or another contractor in case of non-turnkey project. This crane shall be dimensioned according to the layout and the biggest compartment, equipment or module to be lifted.

Other lifting devices for installation shall be provided by the Contractor. The Contractor shall provide necessary scaffoldings etc.

The contractor is fully responsible for design, procurement, delivery and installation in accordance with Statnett specifications and requirements. This responsibility also includes all tools, machinery and auxiliary material. The Contractor is responsible for delivery on site, storage on site, packing and disposal of waste material.

## 20.2 Workmanship

All work, methods of work and workmanship, whether fully specified herein or not, shall be of the highest order. In all respects, the generally accepted requirements and commonly recognized good practice for first class work of this nature are to be adhered to. All work shall be to the satisfaction and approval of Statnett. Such approval will not release the Contractor from his responsibilities arising from damages and liabilities due to poor workmanship.

## 20.3 Earthing of GIS

Earthing of the GIS shall be done by the GIS Contractor.

Contractor is responsible for designing and dimensioning of the GIS earthing system, including earth connection of 420 kV cable connection and transformer connection. In case of non turn-



key project, the GIS manufacturer is responsible for providing Statnett or the construction company with the necessary information required for the earthing system.

All earthing shall be in accordance with FEF 2006 and comply with any requirements from the Control System Contractor.

Necessary terminal pads and connectors suitable for accommodating 120mm<sup>2</sup> to 2x240mm<sup>2</sup> stranded copper conductors shall be provided at a number of points on the GIS enclosure/support structure to effectively connect switchgear enclosure to the substation earth mesh.

The grounding connections must meet the requirements of IEEE 80 and IEEE 367. Earthing for mitigating over-voltages during disconnect switch operation shall be provided considering the transient increase of potential of the GIS enclosure relative to the substation ground. If necessary, isolating means shall be provided to avoid current loops via other substation equipment, such as transformers or separate switchgears at HV and EHV levels. All support structures of GIS shall have earthing provisions.

For the interconnection of enclosures, frames, etc., fastening (e.g. bolting or welding) is acceptable for providing electrical continuity. The continuity of the earthing circuits shall be ensured taking into account the thermal and electrical stresses caused by the current they may have to carry.

All auxiliary equipment such as operating mechanism boxes, terminal boxes and control cabinet, shall be provided with suitable connectors for independent earthing.

Shorting straps or suitable electrical conducting parts shall be provided at all flange joints if flange-to-flange continuous connections of enclosures are not provided, to allow safe passage for fault-currents without exceeding the permissible limits of enclosure temperature and to reduce electromagnetic interference. 120° bends in grounding bars shall be avoided.

GIS manufacturer shall recommend the energy absorption and voltage rating of the non-linear resistance/surge arresters to be provided symmetrically across the insulating joints of the enclosures, flanges at cable termination with shield break and Gas-to-Oil transformer termination to bypass very fast transients generated in GIS per IEC 62271-209, IEC 62271-211 or IEEE 1300. Calculation for non-linear resistance/surge arresters sizing shall be furnished for Statnett review. Metallic base of Gas-to-Air Overhead Line Termination shall be properly grounded to mitigate the effect of very fast transients generated in GIS.

The GIS enclosure shall be safe to touch and fully ensure operational security and personnel safety under all normal and fault conditions with the maximum allowed induced voltage in the enclosure of 65 volts.

Technical note on the maximum touch voltage possible on the proposed layout shall be sent to Statnett during contract stage.

The Contractor shall check that the earthing system and connection points according to Statnett specification for earthing.

For detailed instructions and descriptions of necessary materials and process for installation, see Statnett's technical installation specifications Appendix G (SDOK-47-51 and SDOK-47-52).

Contractor shall demonstrate by tests or calculations the capability of earthing circuits to withstand the rated short-time and peak withstand current of the earthing system (CF IEC 62271-203 §6.6.102).

## 20.4 Gas handling during installation

The switchgear shall be filled in with gas (SF<sub>6</sub>, or other alternative gas) only when online monitoring system is operative (when ordered), information's posters and other gas related labelling for each gas chamber has been installed (see following chapters "operational labelling of the GIS" and "Gas rooming").

The switchgear shall be completely installed at specified site, gas filled, pressurized, gas tight, tested and ready for operation.

The switchgear assembly supplies shall include the complete filling of gas for the assembly and potentially gas lost/leakage during installation and commissioning procedures.

The quality of insulation and breaking medium (such as SF<sub>6</sub>) provided by the contractor shall comply with a manufacturer and IEC technical grade gas requirements.

Contractor must be able to, on demand, present a system for keeping accurate track of the quantity of gas (such as SF<sub>6</sub>) used.

All personnel or fitters working with SF<sub>6</sub> gas related equipment, such as filling, evacuation, testing (quality, humidity, purity, etc..) must have a SF<sub>6</sub> certification (EUR-Lex - 32014R0517) up to date and also valid during the complete period of the work. Certificate in English might be requested at any time by Statnett personal.

In addition, gas reserve in liquid form corresponding to the biggest gas compartment (1 phase for 420) of SF<sub>6</sub> or other gas mixtures including a monitoring equipment (manometer) shall be supplied. If two insulating and/or breaking gas are provided in the substation, one reserve gas for each gas shall be provided.

If SF<sub>6</sub> gas leaking occurs during the erection, testing or reparation of the GIS, the work must be stopped and Statnett's project manager must be informed immediately. Detailed report shall be sent by official letter to Statnett in order to establish the root cause and determine with precision the quantity of SF<sub>6</sub> that have been released into the air. Work should not start again before approval from Statnett.

### **SF<sub>6</sub> and gas losses penalty during erection and testing :**

If during the entire contract execution, the contractor releases a gas quantity (SF<sub>6</sub> or alternative) above 0,1% of the total gas mass (SF<sub>6</sub> or alternative) engaged in the project, the contractor is subject to a penalty corresponding to the CO<sub>2</sub> tax and corresponding GWP (of the gas or gas mix) specified in IPCC – AR5 Climate Change at the closing of the project.

### **20.5 5 years gas leakage warranty extension**

GIS manufacturer is responsible for 5 years gas leakage warranty on the complete GIS.

This is an addition to the standard warranty provided though the GIS contract.

In case of gas leakage, Statnett will inform the GIS manufacturer with the available information (online monitoring system, measurement, photos etc..).

GIS manufacturer shall call for a meeting for a repair proposal plan two weeks after receiving the information from Statnett. During this meeting, Statnett and the manufacturer are to agree on a date of repair (outage availability and parts availability).

### **20.6 Finalization of installation work**

A commissioning report shall be submitted as soon as the final testing is completed, and all documentation shall be revised during a dedicated meeting in accordance with the work carried out. A set of provisional drawings and reports shall be made available to Statnett in the period between the departure from the construction site of the person in charge of installation, erection and/or commissioning and upon receipt of the final as-built documentation.

At the delivery date, a list describing all remaining items shall be prepared by Contractor and shall be signed by the parties. During the guarantee period, the list of remaining activities shall be continuously updated.

The Contractor shall be responsible for updating the documentation until all remaining activities are completed.

## 21 BUILDING WORK

All necessary finitions and dimensions concerning space, surfaces, foundation, strength, trenches, recesses or other requirements to be specified by GIS manufacturer during the Tender.

Detailed information on necessary height for crane to enable installation and removal of all parts for repair work shall be included.

In addition, maximum weight of the equipment that must be lifted in case of a failure shall be provided.

Foundation plans showing point of contact with floor, and dynamic and static forces, as well as the resonant frequency spectrum of the GIS shall be given with the tender. Calculations shall be done assuming all the circuit-breakers trip on one busbar (not both).

Dimension drawings shall include trenches for Gas duct (GIL/GIB) for transformer connection, and wiring between GIS and local bay cabinets, high voltage cable route etc...

Fire class shall be upheld, even when going through walls.

4 weeks before takeover of the civil and building, the GIS manufacturer shall check and control that the civil work have been done according to the GIS equipment recommendations.

If civil work modification are necessary due to lack of control or provided information from GIS contractor, requested modification of the civil work or GIS equipment shall be supported by the GIS contractor.

For detailed instruction and descriptions of GIS Building, see Statnett technical specifications Appendix J (SDOK-119-34).

## 22 SPARE PARTS FOR MAINTENANCE AND REPARATION

The switchgear and all its components and accessories shall be designed for minimum maintenance during service.

The manufacturer shall state the minimum interval between:

- minor inspections (which will be restricted to visual checking and adjustments of external parts only) and
- major inspection/overhaul, including refilling or replenishment of gas and cleaning of the contaminant or filter in the circuit breaker chamber(s).

Suitable openings shall be provided in the circuit breaker, disconnect and grounding switch modules for major inspection/adjustments. All motors shall be in accordance with IEC 60034. The bearings and other such parts shall be permanently lubricated for the entire service life. Padlocks shall be furnished and be made of stainless steel or brass.

To facilitate transport and handling of spare parts, lifting eyes or other suitable attachments shall be provided with each GIS module.

Each module of switchgear, consisting of individual elements intended to be directly connected together, shall be constructed as a transportable assembly suitable for shipping and transportation without being dismantled.

All new gaskets, sealants and desiccants for permanent sealing of all field joints and all access covers, removed during assembly, shall also be provided.

Mandatory list of spare parts for each project.

- Four open support insulators including electrodes/contacts system and corresponding gasquets shall be provided.
- Four partition insulators (gas tight) including electrodes/contacts system and corresponding gasquets shall be provided. Circuit breaker hand crank and tools allowing manual charging or discharging of the breaker drive energy shall be part of the maintenance part delivery.
- Disconnecter hand cranks (2 sets) shall be part of the maintenance and spare part delivery.
- Earthing switch hand cranks (2 sets) shall be part of the maintenance and spare part delivery.
- Fast acting Earthing switch hand cranks (2 sets) shall be part of the maintenance and spare part delivery.
- A small enclosure with its own filling valve and local gas monitoring system shall be provided for maintenance reasons. This temporary enclosure shall also (if necessary) provide the electric shield to be set onto the conductor or electrode of the insulating cone. This spare part enclosure would allow the bus bar or bus duct to be re-energized while failed equipment is replaced. This enclosure shall have the same mechanical characteristics as requested for mechanical, pressure and internal arc effects.
- All special tools required for the purpose of installation, maintenance, overhauling and testing of GIS including operating mechanisms shall be also provided.
- 3 travelling kit sensors tool dedicated to the type of circuit breaker delivered shall be delivered in order to allow Statnett to measure traveling curve of one circuit breaker (3 phase) during maintenance.
- A tool trolley on wheels equipped with basic tools shall be delivered.

Tenderer shall provide a list of recommended spare parts for the GIS.

Spare parts must be prepared for minimum 25 years of storage without degrading.

## 23 EXTENSION MODULES (OPTION)

Future extensions can be undertaken in one direction by the same GIS manufacturer or GIS manufacturers other than the original manufacturer.

Separate GIS bus link module with separate gas compartment shall be provided at one end of the GIS station for future extension of the GIS, if the building and civil work is prepared to.

See option 2 in SDOK-41-52.

## 24 BUSBAR SECTIONIZER (OPTION)

For important substations, continuity of supply and maintenance purpose, it could be required to have manual sectionizer in the busbar. This removable link offering a isolating distance function shall not limit the busbar ampacity and shall not increase the risk of failure of the complete bus bar.

When this isolating link is removed it shall offer a dielectrical insulation distance function such as a disconnector (IEC 62271-102).

GIS busbar manual sectionizer that includes a mechanically removable link with separate gas compartment shall be provided as an option.

See option 1 in SDOK-41-52.

## 25 UHF MEASURING SYSTEM

Internal built-in UHF antennas shall be installed during the assembly of the GIS, in order to control PD activity during routine, FAT, SAT and regular maintenance/control.

Placement of UHF antennas into the GIS equipment shall be positioned in order to cover and control the complete delivered GIS equipment.

UHF spectrum fingerprint for each antenna coupled with external noise signature rejection at the instant of record of the fingerprints after commissioning of the GIS is a parts of the contractor deliverable. Format of fingerprints delivery for each antenna shall be based on common agreement between GIS manufacturer and Statnett.

The UHF spectrum fingerprints shall allow asset-owner to compare spectrum evolution through the years.

### Portable monitoring system: (Option 1)

As an option, bidder shall propose a portable offline monitoring system.

This device shall allow the asset owner to perform UHF spectrum measurement on the complete delivered and energized GIS on a regular basis.

Portable offline monitoring system shall allow easy comparing of two results measured on the same antenna at different time interval (including the fingerprint recorded during commissioning) and potentially two different ambient noises. The system shall be designed to observe potential evolution of UHF activity over time for each antenna.

### On-line monitoring system: (Option 2)

As a second option, bidder shall propose an online UHF detection and monitoring system.

The equipment shall be designed to be able to record at least 3 years of data and observe trend curves including event historical recordings. This system shall also allow for rejection of external noise.

A fault detection and localisation system shall also be proposed if not included in the UHF online or gas monitoring system (option).

## 26 GAS ON-SITE MEASURING DEVICE

Tenderer shall deliver suitable portable device in the substation for on-site gas-quality measuring.

It shall including the following equipment :

- SF<sub>6</sub> and other gas mixtures leak detector (high accuracy sniffing device)
- SF<sub>6</sub> and other gas mixtures content measuring device (purity and content in %) including but not limited to CO<sub>2</sub>, O<sub>2</sub>, N<sub>2</sub>, etc..
- Dew point meter or moisture content
- Decomposition gas (including but not limited to SO<sub>2</sub>, CO)
- High accuracy temperature compensated pressure/density tester

## 27 GAS ON-LINE MEASURING DEVICE

Tenderer shall propose an online computer based system that allow monitoring of all the gas room densities/pressures of the substation.

The proposed system shall allow recording and observation of trends for any potential leakage larger than 0,1 %/year of the gas volume. In the event of a leakage, the proposed system shall provide the amount of SF<sub>6</sub> or alternative gas in kg released in the atmosphere.

The proposed equipment shall also allow identification of the compartment location of any internal arc.

Equipment shall be designed to be able to record a minimum of 5 years of data for the complete substation.

The control and power supply connection shall be separated and different from the density switches.

The equipment shall have cybersecurity measures preventing unauthorized access to, or modification of data, logic or system configuration.

Both measurements (raw data) and aggregates (calculated data) shall be available in a secure manner to the various users at the proper levels of identity or role-based accessibility, using open industry standard interfaces and protocols.

The system shall be based on commercially available components allowing for adaptations and extensions to the system to include monitoring of additional gas compartments.

Equipment shall include tools and ethernet based interfaces in order to allow for remote monitoring, system maintenance, alarm configuration, fault management and diagnostics.

Equipment shall be delivered with an HMI interface that allow to monitor the gas trends locally in the substation.

The edge device (Bwatch/MSM) should have output in IEC104 or IEC61850.

An extra network segmented communication for data transfer of pressure time series data points (and maybe alerts from the edge device)



## 28 GAS HANDLING EQUIPMENT (OPTIONAL)

Complete gas handling equipment for evacuation, filling, recovery, storage and filtering of gas shall be offered as an option.

The equipment shall include pre-filtering and filtering units, vacuum pump, compressor, SF6 or other gas mixtures suction pump (1 mbar) and storage container (for liquid storage, min 600l).

The equipment shall have valves of at least 20mm and connections and metal piping. User manuals for the gas handling equipment shall be in Norwegian.

## 29 MAINTENANCE PROGRAM

A detailed maintenance program with the required intervals for the GIS shall be attached with the tender.

Cost for each item shall be stated, as well as special tools needed (see also Section 4.4 on factory acceptance test on the first complete bay).

The operation and maintenance description shall include:

- Revision procedures, equipment characteristics and functionality.
- Revision and maintenance interval.
- Specifications for lubricants, solvents, spare parts, gaskets, any special tools and other material required
- Handling instruction and Material Safety Data Sheet for the insulation fluids

After contract award, the final documentation shall be submitted in 1 paper copy and one in digital format.

The final documentation shall be presented to Statnett for approval according to the Delivery Schedule.

## 30 REPAIR PROCEDURES

A complete set of repair documentation shall be provided for each project.

The repair documentation shall contain the detailed description and procedure for repair of the following elements:

- Replacement of a circuit-breaker
- Replacement of a bus bar disconnector (only 420kV) and a line disconnector
- Replacement of a current transformer

The documentation shall include all the necessary tools and steel supports to realise this component exchanging.

The description and corresponding drawings in the documentation shall be illustrated with the specific project layout.



The final documentation shall be submitted in one (1) paper copy and one in digital format.

## 31 DEVIATIONS FROM REQUIREMENTS

Manufacturer is invited to describe or indicate in Appendix D, all deviations of the equipment and accessories from all requirements in Statnett specifications (including appendixes).

In case no deviations are mentioned it will be understood that Manufacturer's offer entirely complies with all requirements in this specification.

In case of failures or defects observed during operation, it remains the liability of manufacturer to provide the necessary measures to cope with this specification and potential additional type tests.

## 32 TRAINING (OPTION)

The tenderer shall propose a complete training program that covers all aspects of operation and maintenance of the GIS. It shall also cover major repairs.

The training could be realised on Statnett half bay after or before the FAT.

If not, the training shall be realised on the same equipment (in model/type and generation).

The training program shall include and not be limited to :

- General interventions and maintenance on the structure (dismantling of a circuit breaker, dismantling of a disconnector).
- Presentation by the manufacturer of all the tools and maintenance modules, platforms, etc...
- Dismantling of one circuit breaker and one disconnector shall be part of the FAT program

The tender shall include in the detailed training program any limitations to number of participants, a time estimate of completion and the cost of the training program.

In addition, operating personnel from Statnett shall have the possibility to participate in the installation work in addition to Contractors personnel. Statnett shall cover travel costs as well as salaries for Statnett personnel.

## 33 DOCUMENTATION

Documentation of general interface nature (such as bushings terminals, cable terminals, etc..) shall be forwarded to Statnett for acceptance prior to implementation in production. Reference is made to Progress schedule and Invoice schedule.

The documentation system for drawings is AutoCAD, DWG format, 3 Dimensional Model, in the relevant and current edition. If nothing else is agreed other documentation shall be in pdf format. In addition to the requirements of the documentation set in the governing documents of the various specifications, the following regulations and standards are mentioned in particular:

- Forskrift for elektriske forsyningsanlegg (FEF:2006)
- NEK 440:2011 " Stasjonsanlegg over 1 kV"
- IEC NEK 61936-1:2010 "Stasjonsanlegg over 1 kV" including the Norwegian A-deviations.

Documents in digital format shall be named: Manufacturer\_Type\_Description Projects name  
Documentation shall be delivered both digitally and as hard copies.

Plant specific documents shall, unless otherwise agreed, be supplied with Statnett's logo and, if necessary, a document number given by Statnett. All documentation should be on paper in 2 copy sets for each substation.

Documentation shall be in files with a large plastic pocket on the back and front and 4 rings  
The maximum width of the file shall be 75 mm. All files shall be delivered with a directory. Template for this directory will be provided by Statnett later.

All documents shall also be handed over in the following digital formats:

Description	Software	Version
Text	Microsoft Word	≥ 2010
Spreadsheet	Microsoft Excel	≥ 2010
Drawings	AutoCAD	≥ 2012
Data sheets, circuits drawing and product sheets	Adobe Acrobat (pdf)/ Design Web Format (dwf)	≥ Version 9/ 2011
Signed letters	Adobe Acrobat (pdf)	≥ Version 9

The files shall also be delivered on project documentation system(e-room) with the same structure as the files mentioned above.

### 33.1 Documentation for performance of the Work:

The following documentation is required and considered part of the delivery, and shall be submitted to Statnett for verification according to the delivery schedule:

- Arrangement and assembly drawings with dimensions, electrical circuit schematics, gas compartments schematics, clearings distance when SF<sub>6</sub> Bushings are applied.
- Final, complete circuit diagrams, connection tables and binding dimensional diagrams to serve as a basis for plot plans and foundation drawings.
- Detailed progress schedule
- Quality plan and HSE plan
- Instructions for transportation and storage, as well as descriptions and instructions required for installation and start-up in Norwegian language.
- Instructions for transportation and storage, as well as descriptions and instructions required for installation and start-up in the originating language, if different from Norwegian.
- Instructions for any necessary lifting arrangements and lifting procedures.
- Routine test protocol.
- Design Report.
- Type test verification report including type test protocol.
- Material specification.

### 33.2 Final documentation:

As built documentation shall be delivered as described, and with the various requirements as set out in the specifications. The Contractor shall submit a complete commentary version of as built documents as one paper copy to Statnett for comments. The commentary version shall be submitted at most 1 month after commissioning.

Statnett shall check and comment the as built documentation within 1 month after reception. Final as built documentation shall be re-submitted no later than 3 weeks after Statnett's review.

- As-built versions of above mentioned documentation for performance of the work.
- As-built 3D drawing in autocad or compatible version
- Necessary drawings for operation and maintenance
- List of necessary spare parts
- Detailed operation and maintenance manuals in Norwegian and English language
- Manuals for components delivered by subcontractors shall comply with the above requirements and shall updated and complete.
- A signed and dated commissioning test protocol shall be submitted after adjustment and testing at the station
- Required certificates

As part of the delivery, the contractor shall deliver a reduced model in 3D of the delivered substation.

Material selected to realize the reduced model is at the GIS manufacturer choice. The size of the mock up shall not be lower than 20cmx10cm.

## 34 RISK ASSESSMENT

Before any engineer of electro technical installation commence, the Contractor shall prepare a risk assessment in compliance with "Forskrift om Elektriske Forsyningsanlegg", § 2.2., (Regulations concerning Electricity Supply systems).

This risk assessment shall prove that the selected solutions meet the requirements stated in the regulations, and shall be submitted to Statnett for comments.

All necessary electro technical calculations shall be made by the Contractor in accordance with applicable regulations.

The Contractor shall prepare a detailed construction methodology and submit this to Statnett for comments. The construction methodology shall, as a minimum, comprise of:

- Description of the works to be performed, and any special considerations.
- Necessary drawings/sketches.
- References to instructions given by the Contractors of the various components.

Interface handling.

Complete construction methodology including comments shall be submitted to Statnett 4 weeks prior to start of installation. Prior to commissioning, the Contractor shall deliver technical data. The data shall be delivered in predefined Excel sheets, and shall be submitted to Statnett 4 weeks before start of commissioning.

## 35 DECLARATION OF COMPLIANCE

Declaration of compliance (Samsvarserklæring in Norwegian) according to §3-1 shall be delivered by all contractors performing engineering, installation, testing and commissioning subject to the requirements in Regulations concerning Electricity Supply Systems ("Forskrift om Elektriske Forsyningsanlegg") issued by the Directory for Civil Protection (DSB). The Contractor shall incorporate Statnett's requirements and engineering in the Declaration of compliance. Declaration of compliance related to the engineering must be done by a company who is qualified in accordance by DSBs regulations (FKE) and registered in DSBs registry (Elvirksomhetsregister).

Declaration of compliance for Installation must be done by a person who is qualified in accordance by DSBs regulations (FKE).

For all subcontractors that are subject to the requirements stated above, a "Declaration of Compliance" shall be submitted. It is the Contractor's obligation to ensure that all compliance statements are prepared.

## 36 LIST OF ATTACHED APPLICABLE DOCUMENTS

Appendix	Document number	Designation
<b>Appendix A</b>	<a href="#">SDOK-41-51</a>	Appendix A Performance and type test table
<b>Appendix B</b>	<a href="#">SDOK-41-50</a>	Appendix B Permanent and temporary overload
<b>Appendix C</b>	<a href="#">SDOK-41-49</a>	Appendix C Manufacturing details
<b>Appendix D</b>	<a href="#">SDOK-41-48</a>	Appendix D Deviations from the General GIS Technical specification
<b>Appendix E</b>	<a href="#">SDOK-83-5</a> <a href="#">SDOK-83-58</a>	Memo no. 1 – Principles for local control systems in Statnetts substations Interlocking of disconnecting switches. GIS systems
<b>Appendix F</b>	<a href="#">SDOK-41-52</a>	Layout and gas compartment standard 1- Double busbar layout and gas compartment standard 2- Square layout and gas compartment standard 420kV 3- Long layout and gas compartment standard 420kV 4- Square layout and gas compartment standard 145kV 5- Long layout and gas compartment standard 145kV 6- One circuit breaker bay 145kV 7- Power transformer GIS connection
<b>Appendix G</b>	<a href="#">SDOK-47-51</a> <a href="#">SDOK-47-52</a>	Technical specification Earthing in substation – General part Technical specification Earthing in substation –Special part
<b>Appendix H</b>	<a href="#">SDOK-41-9</a> <a href="#">SDOK-41-17</a>	Specification for measuring transformer General part Specification for measuring transformer Special part
<b>Appendix I</b>	<a href="#">SDOK-47-10</a>	Specification for labelling / Krav til driftsmerking for stasjoner
<b>Appendix J</b>	<a href="#">SDOK-119-34</a>	Specification for substation building

## 37 REVISION LOG

Date	Nr.	Revision log
	10	<ul style="list-style-type: none"> <li>- 5: Added possibility of vacuum breaker, gas room partitions with vacuum CB, tolerances in % on the gas mixture, filling valves, seismic requirement,</li> <li>- 5.16: Changed requirements for access to walkways - Cha 37: Removed reference to SDOK-83-7</li> <li>- 4.4: Added requirement for documentation of heating elements</li> <li>- 15: Dielectric behaviour in case of gas leakage</li> <li>- 19.1: Changed the standard number of heating elements in LCC to one, but with an additional uncontrolled heating element for outdoor applications</li> <li>- 19.3: Control switching device requirement clarification</li> <li>- 20.5: gas leakage warranty extension</li> <li>- 22: tools box in the spare for maintenance</li> </ul>
17.04.2023	9	<ul style="list-style-type: none"> <li>- Some wording have been changed</li> <li>- Fixed chapter numbering</li> <li>- Cha. 19.2: Requirement for halogen free cables and LCC terminals/blocs added.</li> </ul>
14.09.2022	8	<ul style="list-style-type: none"> <li>- Change relative to alternativ gas solutions</li> <li>- Gas leaking test during routine tests</li> <li>- Penalty on gas leaking during erection and testing</li> <li>- Spare parts</li> <li>- Anti-condensating resistance</li> <li>- Labelling</li> <li>- Max volume of compartment</li> <li>- Gas filling valves</li> <li>- EPD Study</li> </ul>
24.08.2021	7	<ul style="list-style-type: none"> <li>- Introduction of a new chapter on gas leakage waranti extension</li> <li>- Certification exigences for the personal fylling GIS with gas</li> <li>- Clarification on when the GIS shall be filled with gas.</li> <li>- Clarification on quatity of hand crank sets and traveling sensors (CB) that shall be delivered by station.</li> <li>- New chapter (21) : 7 years Gas leakage waranti extension (optional)</li> <li>- Small and editorial changes</li> </ul>
04.03.2021	6	<ul style="list-style-type: none"> <li>- Introduction of a new chapter on transfert of production/manufacturing facilities</li> <li>- New chapter on Sf6 and gas mixture with NOG and OG</li> <li>- Maximum compartment is increased to 150 kg</li> <li>- Special gas mix requirement tests</li> <li>- Chngement for the position indicator labeling I/O to Inne Ute</li> <li>- Cable box requirements on insulator and coordination of design pressure</li> <li>- Gas leakage test with accumulativ method and nominal filling pressure at FAT</li> <li>- Small and editorial changes</li> </ul>

# Technical Standard

## General specification. Gas Insulated Switchgear

### Revision log SDOK-41-38:

Revision	Approved	Approved by	Description
<a href="#">11.0 Show changes</a>	10.12.2025	<a href="#">Gabriella Larsson</a>	Added possibility of vacuum breaker, gas room partitions with vacuum CB, tolerances in % on the gas mixture, filling valves, seismic requirement, - 5.16: Changed requirements for access to walkways - Cha 37: Removed
<a href="#">10.0 Show changes</a>	24.08.2023	<a href="#">Anders Læg Reid</a>	Requirements for halogen free cables added Requirements for terminal blocks added.
<a href="#">9.0 Show changes</a>	11.05.2023	<a href="#">Anders Læg Reid</a>	Small changes. No major technical changes.
<a href="#">8.0 Show changes</a>	30.10.2022	<a href="#">Anders Læg Reid</a>	- Change relative to alternativ gas solutions - Gas leaking test during routine tests - Penalty on gas leaking during erection and testing - Spare parts - Anti-condensating resistance - Labelling - Max volume of compartment - Gas filling valves
<a href="#">7.0 Show changes</a>	26.08.2021		Certification exigences for the personal fylling GIS with gas, clarification on when the GIS shall be filled with gas, new chapter om
<a href="#">6.0 Show changes</a>	05.03.2021		- New chapter on Sf6 and gas mixture with NOG and OG - Transfert and production facilities - gas Compartment increase - Small