PR-NET-OSM-050

ACCESS TO AND OPERATION OF PLANT AND APPARATUS CONTAINING SF6 GAS

OPERATIONAL SAFETY MANUAL - SECTION 6.8

Scottish & Southern Electricity Networks

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CONTENTS

1 Introduction

1.1 This document defines the **Approved** Procedure for the access to and operation of **Plant** and **Apparatus** containing SF6 gas.

1.2 SF6 gas is an inert, stable, colourless, odourless, non-toxic, non-flammable gas. It is approximately five times heavier than air and will displace air in confined areas.

1.3 At high temperatures and when exposed to sustained or intense electrical arcs, SF6 decomposes, forming sulfur-fluoride gases and metal-fluorides, which are toxic. If moisture is present, the decomposition by-products might also include sulfur-oxyfluorides, hydrofluoric acid and sulfuric acid. The presence of these by-products can be readily detected by a white or grey powdery substance or a very pungent odour similar to rotten eggs.

1.4 Compliance with the following procedure **Shall** enable staff to work safely and reduce the risk of injury to themselves and their colleagues.

2 Scope

2.1 The scope of this document **Shall** be limited to persons who hold the appropriate competence and authorisation to access Substations and switching sites including those containing SF6 gas.

2.2 The procedures included herein have been developed to minimise incidents associated with human error by ensuring that:

- A consistent approach is maintained for the safe access to Substations and **Switching** stations that contain SF6 gas
- At all times consideration is given to the operating characteristics of the **System** and the **Dangers** imposed

2.3 This document applies to Substations and switching stations energised at a nominal **System** voltage up to and including 132 kV.

2.4 This document **Shall** be read in conjunction with Clause 5.6.3 of the **Operational Safety Rules** and the **Approved SSEN-D** procedures defined within.

3 References

The documents detailed in Table 3.1 - Scottish and Southern Electricity Networks Documents,

Table 3.2 - Corporate Documents, and Table 3.3 - External Documents should be used in conjunction with this document.

Table 3.1 - Scottish and Southern Electricity Networks Documents

Reference	Title
PR-NET-OSM-006	SSEN Distribution Operational Safety Rules – Operational Safety Manual – Section 1.1
PR-NET-OSM-028	Switching Terminology and Approved Abbreviations - Operational Safety Manual - Section 4.4
PR-NET-OSM-026	High Voltage Switching and Earthing - Operational Safety Manual - Section 4.2
PR-NET-OSM-043	Access to Substations and Switching Sites - Operational Safety Manual - Section 6.1
PR-NET-OPS-008	Requirements for Management and Handling of Sulphur Hexafluoride (SF6) Related Activities
WI-NET-OSM-002	Personal Protective Equipment and Workwear for Live Environments
N/A	SSEN SHE Handbook (Held in Safety, Health and Wellbeing SharePoint Site)

Table 3.2 - Corporate Documents

Reference	Title
RF-SHE-402	A-Z of Common SSE Wastes

Table 3.3 - External Documents

Reference	Title
F Gas Regs	European Fluorinated Greenhouse Gases Regulations No 517/2014
SI 2015 / 310	The Fluorinated Greenhouse Gases Regulations 2015

4 Definitions

4.1 The words printed in bold text within this document are either headings or definitions. Definitions used within this Approved procedure are defined within the list presented immediately below, or within Section 2 of the **OSR**.

4.2 **Operational Safety Rules (OSR)**

The **SSEN-D** Distribution set of rules, as read with related documents and procedures, that provide generic safe systems of work on the **System** therefore ensuring the health and safety of all who are liable to be affected by any **Danger** that might arise from the **System**.

5 General Responsibilities

5.1 Persons who are required to operate and undertake work on the **System Shall** have a thorough understanding of the work and ensure on-site risks are suitably assessed and appropriate control measures put in place before, during and after all activities.

5.2 Persons **Shall** ensure that, at all times during the work (or associated testing), **General Safety** arrangements are maintained and that other work areas are not adversely affected by the activities for which they are responsible.

5.3 **SSEN-D** is obligated under the following Standard License Condition (SLC) reporting rules to report SF6 gas data:

- SLC 46. Regulatory Instructions and Guidance (E & I Pack)
- SLC 47. Environmental Reporting
- SLC 50. Business Plan Commitment Report

5.4 In addition, SSE must report Greenhouse Gas emissions through The Companies Act 2006 (Strategic Report and Directors' Reports) Regulations 2013.

6 Authorisation

6.1 Persons who are required to access and operate Plant and Apparatus containing SF6 **Shall** hold the appropriate competence and authorisation to carry out specified duties.

6.2 Persons who work with or transport SF6 gas **Shall** have successfully completed an **Approved** Fluorinated Gas (F Gas) training course/assessment and have current certification in accordance with the F Gas Regulations.

6.3 It **Shall** be the responsibility of the individual to ensure that any actions performed are within the bounds of their competency and authorisation level.

6.4 Competence and authorisation certificates **Shall** be retained personally and be made available upon request.

7 Records

7.1 Records **Shall** be kept of all **Plant** and **Apparatus** that contain SF6. Asset data, including the weight of SF6 **Shall** be subject to the requirements of PR-NET-OPS-008 and held in the fixed asset database. Records **Shall** be kept for the life of the asset and updated in-line with commissioning and decommissioning requirements.

7.2 SF6 data **Shall** be used to report annual SF6 emissions including holdings, the amount of fluorinated greenhouse gas emissions and the amounts of SF6 gas recovered. Reporting **Shall** be subject to the requirements of PR-NET-OPS-008.

8 Personal Protective Equipment

8.1 Persons who are required to work or carry out **Switching** on or near the **System Shall** wear suitably **Approved** Personal Protective Equipment (PPE). Furthermore, where warning labels or signs identify the existence of a particular hazard, additional and appropriate PPE **Shall** be worn. (see section 10.6.5).

8.2 As a minimum, PPE **Shall** meet the requirements of WI-NET-OSM-002.

9 General Requirements

9.1 The Fluorinated Greenhouse Gases Regulations 2015 (as amended) place a mandatory requirement on operators of switchgear to prevent leakage of SF6 from **High Voltage** switchgear, to check leakage detection systems periodically and to repair abnormally high leaks without undue delay. **SSEN-D** recognises its commitment to minimising environmental impacts and **Shall** ensure robust procedures are in place to deliver the appropriate level of action where needed.

9.2 SF6 switchgear energised at voltages at or above 33kV **Shall**, where practicable, be equipped with monitoring devices that provide continuous monitoring and local indication of gas density or temperature compensated gas pressure in each compartment.

NOTE: Older switchgear designs energised at voltages at or above 33kV may be fitted with gas pressure gauges that are not compensated for temperature.

9.3 Each monitoring device **Shall** be equipped with a two stage pressure switch / alarm for low density or pressure. The pressure switch / alarm **Shall** be configured to give early warning of falling pressure. Where the rated filling density or pressure differs between adjacent compartments, a third pressure switch / alarm, “high density or pressure” may be provided to indicate failure of the gas-tight bushing.

9.4 SF6 ground mounted switchgear energised at voltages below 33 kV **Shall** be equipped with similar monitoring devices, however switchgear with an insulation capability only, may only be provided with a single pressure switch / alarm corresponding to the minimum functional pressure (density).

9.5 SF6 pole mounted switchgear energised at voltages below 33 kV **Shall** be equipped with a single pressure switch / alarm for minimum functional gas pressure. Additionally, an

indication of gas pressure and / or pressure switch operation **Shall** be made available. Typically, this indication is found in the accompanying control cabinet.

NOTE: Older designs of ground mounted and pole mounted switchgear below 33 kV may only be provided with the facility to measure gas pressure and may not have an alarm monitoring feature.

9.6 Where no pressure switches are fitted, or no facility exist for remote alarm indication, pressure monitoring **Shall,** where practicable, be achieved through manual on-site pressure monitoring. Leakage rates **Shall** be compared / verified against manufacturer expected ranges.

9.7 Where SF6 gas pressures are required to be inspected, consideration **Shall** be given to gas pressure being affected by variations in ambient temperature, heat from normal load current, fault current and from solar radiation.

9.8 Where gas pressure gauges are not temperature compensated (older switchgear designs), they **Shall** be manually compensated for temperature variations using the nominal value of +20°C. Manufacturer pressure/temperature compensation charts **Shall** where practicable accompany the switchgear. An electronic copy **Shall** also be available for use.

10 Procedure

10.1 General

10.1.1 SF6 gas in switchgear and other equipment acts as an insulator and arc extinguishing medium.

10.1.2 SF6 gas is an inert, non-toxic, colourless gas which is heavier than air and will not support human life at high concentrations.

10.1.3 All **High Voltage** SF6 switchgear supplied since 2007 **Shall** include a data plate stating that the **Apparatus** contains a fluorinated greenhouse gas, along with the quantity of gas contained.

10.1.4 Working with new SF6 gas is harmless if the following safety practices are observed:

- Wear suitable PPE (see section 8)
- Carry out work only in well-ventilated areas
- Maintain high standard of personal hygiene; do not eat or drink in the work area and avoid wiping nose, eyes or face other than with clean paper tissues
- Prior to entering enclosed areas where accumulation of SF6 is suspected, a test for oxygen deficiency may be necessary before entry. If SF6 is present, use forced ventilation to disperse the gas
- Do not smoke during the work and avoid direct or indirect sources of heat (open-flames, heaters, engines, welding machines, etc.) in the vicinity, as SF6 gas may decompose when exposed to heat at relatively low temperatures

10.2 Access to Substations and Switching sites containing SF6

10.2.1 Access to Substations and switching stations **Shall** be carried out in accordance with the **OSR** and subject to the requirements of PR-NET-OSM-043 Access to Substations and Switching Sites - Operational Safety Manual – Section 6.1.

10.2.2 Larger sites at which SF6 is present **Shall** be identified using an **Approved** and permanently fixed warning sign. On smaller sites, labels **Shall** be affixed to the relevant **Plant** and **Apparatus** (see Appendix A).

10.2.3 As part of a person's entry procedure, particularly when entering an enclosed Substation, the risk of leaking SF6 gas and the reduction of oxygen in the atmosphere **Shall** be considered.

10.2.4 For Primary and Grid substations, prior to entry confirmation **Shall** be sought from the **Control Engineer** that no SF6 alarms are active. In practice such information is relayed via the substation access notification procedure adopted by **SSEN-D** Control Centre(s) and operated by persons on behalf of the **Control Engineer**.

10.2.5 The person entering the Substation **Shall**, where reasonably practicable, check any SF6 gas pressure / density gauges to confirm normal pressure, if the reading is abnormal, see section 10.4.

10.2.6 The person entering the Substation **Shall** confirm the presence of any unusual odour in the atmosphere. The smell of rotten eggs is symptomatic of the release of low concentrations of SF6 gas and its decomposition by-products. High concentrations of SF6 gas may cause irritation to the eyes, nose, throat and lungs.

10.2.7 The person entering the Substation **Shall** check for any visible solid by-products such as white, grey, or tan powder compounds. Solid by-products could be toxic and irritating to exposed skin.

10.2.8 Providing none of the signs in 10.2.4 and 10.2.5 are detected, persons may safely enter the Substation or switching station without the use of specialist PPE.

10.2.9 Where evidence indicates the existence of SF6 decomposition products, the Substation or switching station affected **Shall** be immediately vacated, secured and assistance sought.

10.3 Operational Switching

10.3.1 The **Switching** of **High Voltage Plant** and **Apparatus Shall** be subject to the requirements of PR-NET-OSM-026 **High Voltage Switching** and Earthing - Operational Safety Manual - Section 4.2.

10.3.2 Where practicable, immediately before and following operation of the switchgear, the SF6 gas pressure indicator associated with the gas filled container **Shall** be examined to check that the gas pressure is within the operating range. Any abnormality **Shall** be immediately reported to the **Control Engineer** and the Substation vacated until a suitably trained person confirms the area to be safe.

NOTE: Depending on the switchgear design, pressure or density monitoring devices and associated pressure switch/alarm functions may differ.

10.3.3 When using SF6 switchgear as a point of isolation, the pressure of the SF6 gas **Shall**, where practicable, be checked and verified as normal, prior to the issue of any **Safety Document** within the established zone of work.

10.3.4 SF6 switchgear **Shall** not be used as a point of isolation, or operated **Live** where:

- The SF6 gas pressure cannot be confirmed as indicated by the gas pressure gauge, remote or local alarms or other indications
- Uncertainty exists as to whether the SF6 gas pressure indicated is outside the acceptable operating range
- The switchgear cannot be operated electrically, indicating the device may be in the locked-out state

10.4 Actions following the loss of SF6 Gas

10.4.1 Where the loss of SF6 gas from **Plant** or **Apparatus** has been confirmed the following actions **Shall** be carried out by a suitably trained person on-site:

- Ventilate the area to ensure any gas is dispersed
- Notify the **Control Engineer**, reporting any alarms or automatic operation
- Determine whether moisture has entered the switchgear SF6 gas chamber
- If there is no obvious failure to the gas enclosure, valves or pipework, that would prevent safe operation of the **Plant** or **Apparatus**, take appropriate actions to ensure the SF6 gas is replenished in accordance with PR-NET-OPS-008, with the consent of the **Control Engineer**
- Record and report the amount of SF6 gas replenished in the affected unit and where possible, the location on the **Apparatus** where the leak has occurred
- Where provided, record details in the Substation log book
- Arrange to investigate the source of the leak, make a repair or record the leak location

10.4.2 Where the loss of SF6 gas from **Plant** or **Apparatus** has been confirmed the following actions **Shall** be carried out by the **Control Engineer**:

- Confirm the **Apparatus** is not being used as a point of isolation in accordance with clause 10.3.4.

NOTE: If the affected **Plant** or **Apparatus** is being used as a point of isolation, appropriate steps **Shall** be taken by the **Control Engineer** to inform the recipient of the associated **Safety Document** to suspend work until alternative measures are in place.

- Request a **Competent Person** who has been suitably trained in SF6 management, attends the site to inspect and report on the condition of the switchgear
- Confirm whether the affected switchgear may be operated without **Danger** and where necessary annotate the control diagram to indicate **Dead** operation only
- Arrange for the **Apparatus** to be **Isolated** and, if appropriate, gas replenished as soon as is reasonably practicable
- Inform the appropriate Area Manager that remedial action is required.

10.5 Consequence of SF6 Gas Loss

10.5.1 Following the loss of SF6 gas, switchgear insulation values and arc quenching capabilities will be affected. Where SF6 gas pressure falls below the manufacturer defined safe operating level, correct operation of the affected switchgear will be inhibited where it has a lock-out function. Depending on the make and type of switchgear, the following operational restrictions **Shall** apply:

NOTE: Certain Distribution switchgear might not have a lock-out function.

- Where switchgear without an external pressure gauge operates, the switchgear may remain in-service with low SF6 gas pressure, provided that the pressure is restored before the switchgear is operated
- Where the switchgear incorporates an external pressure gauge and the SF6 gas pressure has dropped below the safe operating pressure, the switchgear **Shall** not be operated **Live**
- Where the switchgear SF6 monitoring equipment has indicated a ‘falling’ SF6 gas pressure but no ‘low pressure’ alarm, this is warning of a leak but it is still acceptable to operate the switchgear **Live** providing the pressure is above the minimum

operating pressure. The gas pressure **Shall** be restored to the normal operating level as soon as reasonably practicable

- Where the switchgear SF6 monitoring equipment has indicated a 'low pressure' alarm, the switchgear **Shall** not be operated **Live** and the SF6 gas pressure must be restored to the normal operating level before any Switching operation is carried out

10.5.2 In all cases, if the SF6 gas pressure has fallen to atmospheric pressure then the operator must be aware that moisture or oxygen may have contaminated the remaining SF6 gas. In these cases, manufacturer advice **Shall** be sought.

10.5.3 Where atmospheric pressure has occurred, the switchgear **Shall** be made **Dead** from remote points on the **System** in order to avoid **Danger**.

10.6 Working in SF6 Compartments

10.6.1 Any person working in an SF6 compartment or handling SF6 gas **Shall** be trained and certified in the F-gas Regulations.

10.6.2 If an SF6 compartment is opened after the switchgear has been energised, there is the possibility that solid by-products will be present.

10.6.3 The likelihood of decomposition products being present will depend on the function; a busbar chamber would be expected to have very low levels of solid by-products, a circuit-breaker under normal operating conditions would be expected to have higher levels of by-products.

10.6.4 Following an internal fault there is the possibility of significantly higher levels of by-products.

10.6.5 When working in or near open SF6 chambers, suitable additional PPE should be worn which **Shall** include, but not be limited to:

- Respirator.
- Goggles.
- Disposable overalls.
- Nitrile Gloves.
- Rubber Boots.

10.6.6 Eye wash bottles or a ready supply of clean running water should be available in the immediate area.

10.6.7 On completion of works and before leaving the work area, staff **Shall** clean themselves and their equipment using disposable materials:

- Remove protective clothing and wash themselves thoroughly as soon as possible after having left the work area; and
- Ensure that clothing, tools and components which have been in contact with by-products are securely packed in sealed bags and are subsequently treated to neutralise any residues.

10.6.8 Reusable equipment and/or tools **Shall** be washed and neutralised in a water/soda solution with 10% by weight liquid soda or equivalent and then rinsed with clean water.

10.6.9 Table 10.1 gives an overview of the potential risks, control measures as well as safety equipment and tools required when opening and/or entering a gas compartment.

Table 10.1 - Control Measures when Accessing Gas Compartments

Situation	Risk	Control Measures	Safety Equipment and Tools
Any compartment which contained normally or heavily arced SF6	Fumes of cleaning substances. O2 starvation. Remaining used SF6. Residual reactive gaseous by-products. Solid by-products and adsorbed materials .	Removal of solid by-products and adsorbed materials. Ventilation. Measurement of O2 concentration when entering. Wear PPE. Protect solid by-products from hydrolysis.	Suction ventilator or vacuum cleaner. O2 concentration measuring device. Single use protective overalls, protective footwear, hair cap. Acid proof safety gloves. Full face mask (preferred) or, at least, breathing protective mask. Protective goggles. Environmental protection against rain and/or wind (outdoor only) .
Any compartment which contained non-arced SF6	Fumes of cleaning substances. O2 starvation. Remaining used SF6 or other gas from production process.	Ventilation. Measurement of O2 concentration when entering.	Suction ventilator or vacuum cleaner. O2 concentration measuring device.

11 SF6 Switchgear Failures

11.1 In the event of a SF6 switchgear failure it is possible that SF6 solid and gaseous by-products may be released. See PR-NET-OPS-008 for capturing failure losses.

11.2 Most modern Distribution and Primary switchgear hold only small amounts of SF6 and are likely to produce very small amounts of decomposition by-products.

11.3 Any indoor area **Shall** be vented to remove any possible gaseous by–products.

11.4 Appropriate PPE must be worn by all personnel entering the area.

11.5 Any white or grey dust should be treated as toxic and the area **Shall** be washed down with a neutralising solution.

11.6 Switchgear **Shall** be made safe prior to any person accessing it.

11.7 Cleaning operations and sealing of the SF6 equipment for transport **Shall** be carried out by someone who has received the appropriate training.

12 Neutralising SF6 By-Products

12.1 As metal fluorides can react with water to form hydrofluoric acid, it is necessary to treat the solid by-product to neutralise the acid components. The resultant sludge can then be safely disposed of although as hazardous waste; see RF-SHE-402.

12.2 Prior to disposing of disposable overalls, cleaning materials and any filters and filter materials they **Shall** be treated in the manner detailed in Table 12.1.

Table 12.1 - Neutralising SF6 By-Products

Active Agent	Concentration kg/100 litres	Soaking Period Hours	Recommended Application
Sodium Carbonate (Washing Soda)	1.1	24	Used for soaking and neutralising contaminated material.
	10	0.25	Used only if contaminated material must be neutralised in a very short time. Note care must be taken to avoid contact with skin, eyes, etc.
	3	Wash	Used for washing contaminated tools, footwear, equipment etc.
Sodium Bicarbonate	1	Wash	When the supply of clean fresh water is limited, this weak solution is used to rinse area of skin that may be contaminated

13 Potential Hazards Associated with SF6

13.1 Asphyxiation

13.1.1 Although pure SF6 is non-toxic, it acts to asphyxiate in high concentrations by reducing the oxygen content of air. It has no other additional adverse physiological effects.

13.1.2 Being five times heavier than air, SF6 gas will normally accumulate temporarily in low lying areas until it diffuses into the surroundings and become uniformly dispersed, although under certain wind currents, the gas may be whipped up temporarily into gas blankets above low levels.

13.1.3 Simple asphyxiates exert their effect solely by decreasing or excluding oxygen from the work environment, thus leading to suffocation.

13.2 Cold Burns

13.2.1 Liquefied gases such as SF6 can cause cold burns and freezing skin tissue because of the extremely low temperatures which can be generated during gas handling by its rapid evaporation qualities.

13.2.2 Gas filling through pipework should always be conducted in a controlled manner to avoid the excessive formation of ice on the gas storage vessel and/or associated pipework and fittings.

14 First Aid Measures Associated with SF6

14.1 Inhalation of SF6 Gas

14.1.1 Symptoms associated with inhaling SF6 are:

- Pale or blue skin
- Headaches
- Sluggishness
- Tingling in the arms or legs
- Altered hearing
- Possible unconsciousness

14.1.2 Actions to take if a person is exhibiting symptoms:

- Remove or loosen restrictive clothing
- If practicable remove person to fresh air
- Keep person still and under observation
- Summon medical assistance and give artificial respiration if breathing fails

14.2 Eye Contact with Liquid SF6

14.2.1 Symptoms associated with eye contact with liquid SF6 are:

- Frostbite
- Redness
- Pain
- Blurred vision or loss of vision

14.2.2 Actions to take if a person is exhibiting symptoms:

- Treat the eye or eyes immediately, irrigate the eye with large amounts of saline solution (from an eyewash bottle), or clean water if eyewash is not available, for a minimum of 10 minutes. The eyelid should be held open if possible to aid the cleaning action, the water should be directed in from the side, so that the flow is over the surface of the eye. The water jet should not be directed at the front of the eye
- Seek medical help

14.3 Skin Contact with Liquid SF6

14.3.1 Symptoms associated with skin contact with liquid SF6 are:

- Frostbite
- Redness
- Pain
- Open wounds

14.3.2 Actions to take if a person is exhibiting symptoms:

- Treat the affected area immediately, by applying large amounts of clean fresh water. Do not apply direct heat or rub the affected area
- Seek medical help

14.4 Contact with SF6 Arc Residue

14.4.1 Symptoms associated with contact with SF6 arc residue are:

- Redness
- Pain
- Irritation
- Swelling

14.4.2 Actions to take if a person is exhibiting symptoms:

- Treat the affected area immediately, by applying large amounts of clean fresh water
- Remove contaminated clothing so that skin does not become irritated

- Again, flush with water
- When clean fresh water is limited, a weak solution of sodium bicarbonate can be used to rinse the affected area
- Seek medical help

15 Revision History

No	Overview of Amendments	Previous Document	Revision	Authorisation
01	New document created	NA	1.00	Richard Gough
02	Minor revisions made	PR-NET-OSM-050 (Rev1.00)	1.01	Richard Gough
03				

Appendix A Substation and Switching Stations SF6 Identification Example Labels

Typical SF6 warning label permanently affixed to the substation or switching station's structure.

Figure A.1 - Typical SF6 Warning Label