

## ESR Supporting Procedure 8

### Equipment Containing SF<sub>6</sub>

## SHEQ/HS/TCSESR/SP/001-2.0

#### DOCUMENT AUTHORISATION SHEET

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## 1 ADDITIONAL ABBREVIATIONS AND DEFINITIONS

Terms printed in bold type are as defined in the TCS Electrical Safety Rules.

<i>Gas Zone</i>	Discrete sections of SF <sub>6</sub> <b>Equipment</b> which may comprise of one or more compartments and can be independently isolated and evacuated of SF <sub>6</sub> A Gas Zone may comprise of:- <ul style="list-style-type: none"> <li>• A single-phase enclosure</li> <li>• A single enclosure containing the three phases of an item of <b>Equipment</b></li> <li>• Three single-phase enclosures of a common item of <b>Equipment</b> connected by inter-phase pipe work</li> </ul>
<i>Designated Gas Zone Access Point Notice</i>	A notice which shall be attached to a Gas Zone access point(s) which requires venting prior to access
<i>Vented Gas Zone Access Point Notice</i>	A notice which shall be attached to a Gas Zone which has been <b>Vented</b> and can be entered
<i>Purged</i>	A condition of <b>Equipment</b> from which any dangerous contents have been removed
PPE	Personal Protective Equipment
ppm	Parts Per Million (by Volume)
RAMS	Risk Assessment and Method Statement
STEL	Short Time Exposure Limit
TWA	Time Weighted Average exposure
<i>Vented</i>	Having an outlet to the atmosphere so that pressure is equalised to atmospheric pressure

## 2 PURPOSE AND SCOPE

This procedure describes the process for applying principles established under the **TCS** Electricity Safety Rules (**TCS** ESRs), Safety Rules Supporting Procedures (SRSPs) and **TCS** Policies to achieve **Safety from the System** for personnel working on **Equipment** containing or which has contained Sulphur Hexafluoride (SF<sub>6</sub>) gas.

This Safety Rules Supporting Procedure (SRSP) does not apply to the following situations:-

- When working on Air Insulated Switchgear (AIS) or Gas Insulated Switchgear (GIS) and internal access to a *Gas Zone* is not required
- When performing operational and safety switching in accordance with SRSP 2 “Operational and Safety Switching”
- Routine topping up and sampling of *Gas Zones* in accordance with a routine risk assessment and method statement (RAMS)

The SRSPs seek to compliment and apply detail to Approved Code of Practice (ACOP) documents published by the HSE. Although ACOP's are not law if not followed, you will be required to demonstrate that your safe system of work is of an equal or higher standard.

## 3 DANGERS

The **System Danger(s)** to personnel from **Equipment** containing SF<sub>6</sub> gas are asphyxiation, electric shock, stored energy, poisoning and burns.

These **Dangers** can arise from

- a) Oxygen deficiency within a confined space
- b) Failure of a **Point of Isolation** or inadvertent re-energisation
- c) Contact with SF<sub>6</sub> by-products (poisoning and burning)
- d) Failure to control energy within spring/hydraulic mechanisms, face plates under pressure
- e) Failure of a gas barrier
- f) The presence of electrical trapped charge or capacitive stored energy arising from the electrical arrangement of the SF<sub>6</sub> filled **Equipment** and the quality of the SF<sub>6</sub> as a dielectric.

## 4 GENERAL REQUIREMENTS FOR WORK

The **Senior Authorised Person** *shall* carry out a Risk Assessment and produce a Method Statement (RAMS) to decide on the general requirements for the work.

Work areas *shall* be clearly demarcated and carried out in accordance with SRSP 4 – “Demarcation in Substations”.

**Equipment** containing SF<sub>6</sub> is not classed as a pressurised system, and is therefore exempt from the Pressure Equipment Regulations 1999 and the Pressure Systems Safety Regulations 2000. However, the use and movement of bottles containing the SF<sub>6</sub> and Nitrogen (N<sub>2</sub>) should not be assumed to be exempt, and the principles within HSE Guidance Document INDG261 - Pressure Systems: A Brief Guide to Safety, should be followed where possible and appropriate.

When depressurisation is not required to allow work to be done, the following precautions *shall* be taken to achieve **Safety from the System**:-

- a) Limiting the work or work area, followed by the issue of a **Limitation of Access (LOA)** if appropriate

- b) Applying appropriate safety precautions, followed by the issue of a **Permit to Work** or **Sanction for Test**

#### 4.1 Limiting the Work Area

Where depressurisation is not required, and the work and work area can be limited, the **Senior Authorised Person** *shall* decide upon the controls required to achieve **Safety from the System**.

Where the RAMS sufficiently controls all **Safety from the System** hazards there is no requirement to issue a **Limitation of Access**.

When the means of achieving **Safety from the System** is by limiting the work or work area, a **Senior Authorised Person** *shall* confirm these instructions in writing by the issue of a **Limitation of Access**.

Examples of work where **HV** safety precautions are not required are:-

- Timing an SF<sub>6</sub> circuit breaker where all test leads are external to the *Gas Zone* and no earth connection is required e.g. via:-
  - Optical Interface
  - Electrical Transducer
  - Mechanical transducer
- Topping up a *Gas Zone* where **Safety Distance** is not infringed and no **Point(s) of Isolation** are established
- Work on **LV** electrical **Systems** where **Safety Distance** and integrity of the *Gas Zones* are not compromised
- Work on mechanical **Systems** where **Safety Distance** and integrity of the *Gas Zones* are not compromised e.g.:-
  - Written Scheme of Examination on safety valve / local air storage vessel
  - Topping up the hydraulic system
  - Topping up an accumulator
  - Replacement of hydraulic pressure switch / mechanism

As **HV Equipment** also contains, **LV** and mechanical components safety across control boundaries *shall* be established and maintained.

If the **HV Equipment** is required for a short duration outage to enable non-intrusive **LV / Mechanical** work to be undertaken the following process *shall* be adopted:-

- The **Control Person** for the **LV / Mechanical Equipment** *shall* contact the **Control Person** for the **HV Equipment** and receive an instruction as per SRSP 2 “Operational and Safety Switching”, to “Select to Local” and “Operate as Required” for the relevant **HV Equipment**
- The relevant **HV Equipment** *shall* then be selected to local control at either the substation control point or the local control point by the **Authorised Person** and **LV** and mechanical safety precautions *shall* then be established as per the requirements of the Safety Rules
- On completion of the work the **Control Person LV / Mechanical** *shall* contact the appropriate **Control Person** to return control of the relevant **HV Equipment** via an instruction as per SRSP 2 “Operational and Safety Switching”.

## 4.2 Applying Appropriate Safety Precautions When Depressurisation is not Required

Where depressurisation is not required, but appropriate safety precautions need to be applied to achieve **Safety from the System**, the **Senior Authorised Person** *shall* issue a **Permit to Work** or Sanction for Test.

Where work is on **LV** or mechanical parts of the **HV Equipment** and there is:

- No depressurisation of the *Gas Zone*
- No **Danger** from infringement of the **HV System**
- No operation of **Earthing Device(s)**

then there are no requirements to establish **HV** safety precautions and limiting the work and work area is sufficient.

## 4.3 Applying Appropriate Safety Precautions When Depressurisation is Required

Where depressurisation of a *Gas Zone* is required, a **Person**, that has received suitable training in the use of SF<sub>6</sub> testing and filling equipment and is authorised by the **Company**, *shall* establish the toxicity of the gas contained within the *Gas Zone* prior to evacuation.

The **Person**, under the **Personal Supervision** of a **Competent Person**, *shall* ensure the gas is drawn through a dry filter to avoid contaminating the gas handling equipment.

## 4.4 Determination of the Presence of Hydrogen Flouride (HF) and Sulphur Dioxide (SO<sub>2</sub>)

The unlikely presence of significant quantities of these gasses may be determined by use of a stain tube indicator or gas titration. The method of use is described in the literature that comes with the tubes. It should be remembered that Hydrogen Fluoride is produced when the arc products make contact with moisture.

Once moisture is introduced into the *Gas Zone* e.g. after breaking vacuum with air, the Hydrogen Fluoride readings may change due to the introduction of moisture. Therefore measurements will need to be taken both inside the chamber and in the vicinity of the arc products exposed to ambient air to determine if **Danger** exists.

Workplace Exposure Limits are:-

Substance	Exposure Levels (ppm)		Notes
	TWA (8 hr period)	STEL (15 mins)	
HF	1.8	3.0	(1)
SO <sub>2</sub>	0.5	1.0	(2)
SF <sub>6</sub>	1000	1250	(1)

Notes: -

- (1) HSE Publication - EH40/2005 Workplace exposure limits (2011 2<sup>nd</sup> Edition)
- (2) HSE Publication - HSL/2002/23 Draft 2nd Indicative Occupational Exposure Limit Value (IOELV) List : Workplace Measurement Method Summaries (2002)

## 5 INTERNAL ACCESS TO A GAS ZONE

### 5.1 Access to Internal Gas Zone

When internal access to a *Gas Zone* is required the following *shall* apply: -

- a) Detailed RAMS *shall* be produced. The **Senior Authorised Person** *shall* assess the work and RAMS to ensure that **Safety from the System** is achieved. The RAMS *shall* detail the hazards and controls appropriate to the work, including the stages at which the *Gas Zone* *shall* be refilled with the appropriate gas to prevent moisture ingress, and subsequently *Vented* and *Purged* to allow safe internal access.
- b) The **Senior Authorised Person(s)** *shall* ensure that trapped/ capacitive charge is fully dissipated prior to the commencement of work, all **HV Equipment**, associated contacts and conductors to be worked on *shall* be **Earthed** to ensure adequate dissipation of trapped/capacitive charge on every part of the **HV Equipment**. This may be achieved by closing the circuit breaker to solidly earth all modules within the circuit breaker.

The dissipation of trapped charge is an *Operational Switching* requirement. It prevents debris build-up on barrier plates from electrostatic action, and subsequent flashover on energisation when the trapped DC voltage 'adds' to the peak closing AC voltage. The dissipation of trapped charge is therefore the responsibility of the **Control Person** undertaking the *Operational Switching* to release the **HV Equipment**.

If not completed the trapped charge is an electrocution hazard to personnel accessing the **HV Equipment**. The **Senior Authorised Person** *shall* remove the hazard by requesting the **Control Person** to dissipate trapped charge if it has not been recorded on the **Switching Schedule** as being completed.

The **Senior Authorised Person** *shall* record the dissipation of trapped charge as an action taken to avoid **Danger** by draining, venting, purging and dissipation of stored energy.

- c) The **Senior Authorised Person** *shall* prepare a **Permit for Work** or **Sanction for Work** as appropriate.
- d) The **Senior Authorised Person** *shall* clearly identify each required access point into the *Gas Zone(s)* and ensure the appropriate notices are displayed.
- e) Gas Insulated Switchgear (GIS) is divided into discrete *Gas Zones* by cast resin barriers (partitions). The majority of **Equipment** is manufactured to safely withstand full differential pressures across the barrier (i.e. pressure on one side and a vacuum on the other).

Operation and Maintenance Manuals *shall* be consulted to confirm full differential pressure can be withstood across the barrier. The adjacent *Gas Zone(s)* *shall* be reduced to atmospheric pressure where it is found full differential pressure cannot be withstood across the **HV Equipment** barriers, or cannot be confirmed it can be withstood. Where it is not reasonably practicable to reduce the adjacent *Gas Zone* to atmospheric pressure, work *shall* only be undertaken, provided all the following conditions have been met.

- A vacuum of -1 bar(g) has been drawn and maintained in the enclosure to be worked in for 1 hour with the pump **Isolated**
- There is no known or suspected mechanical or electrical damage to the pressurised barrier within the enclosure remaining pressurised
- No known electrical flashover has occurred
- No work on the busbar or barrier which may cause stress to the pressurised barrier *shall* be undertaken
- A safe system of work is devised and implemented, which shall include, the use of suitable protective equipment to prevent damage to the pressurised barrier

At each stage of the works requiring evacuation of the gas, the recipient of the **Safety Document** shall ensure that any SF<sub>6</sub> in the *Gas Zone* is recovered in accordance with **TCS SF<sub>6</sub> Gas Policy**, **TCS Environmental Policy**, relevant manufacturer Operation and Maintenance Manuals and gas processing equipment instructions.

- f) Before opening any designated access point(s) the recipient of the **Safety Document** shall ensure that the relevant *Gas Zone(s)* is *Vented* and Section (A) of “Gas Zone Access Control” form in Appendix 1 is completed.
- g) The recipient of the **Safety Document** shall ensure that relevant *Designated Gas Zone Access Point Notice(s)* are replaced with *Vented Gas Zone Access Point Notice(s)*. The recipient of the **Safety Document** can then give permission for members of the **Working Party** to open the access point(s) of the relevant *Gas Zone*.
- h) Following opening of the access points, but before personnel access into the *Gas Zone* is permitted, the recipient of the **Safety Document** shall confirm that the *Gas Zone* is **Purged** of SF<sub>6</sub> and N<sub>2</sub> and verify by measurement the Oxygen (O<sub>2</sub>) content is between 19%-21% within the *Gas Zone*. Section (B) of “Gas Zone Access Control” form in Appendix 1 shall be completed.
- i) If toxic breakdown products are detected at this point, access to the *Gas Zone* shall be restricted until removal of the breakdown product has been achieved. Refer to Appendix 2 for the process to be followed when SF<sub>6</sub> by-products are detected.
- j) When the work requires the *Gas Zone* to be pressurised or drawn under vacuum, the recipient of the **Safety Document**, shall ensure that all members of the **Working Party** are accounted for prior to securing the designated access points. The recipient of the **Safety Document** shall then withdraw the **Working Party** and replace the *Vented Gas Zone Access Point Notice(s)* with *Designated Gas Zone Access Point Notice(s)*.

The **Working Party** shall then be informed of the change in state of the *Gas Zone* and Section (C) of “Gas Zone Access Control” form completed. The *Gas Zone* may then be pressurised, or drawn under vacuum.

- k) The requirements of points (f/g/h) shall be repeated each time that the method statement requires depressurisation to open any designated access point.
- l) The requirements of point (j) shall be repeated each time that the method statement requires the *Gas Zone* to be pressurised or drawn under vacuum.
- m) Upon clearance of the **Safety Document**, the **Competent Person** shall state the condition of the *Gas Zone* by completing Section (D) of the “Gas Zone Access Control” form immediately prior to the **Safety Document** clearance or surrender.





**APPENDIX 1 - GAS ZONE ACCESS CONTROL FORM**

Initial Condition of <i>Gas Zone</i> e.g. SF <sub>6</sub> / N <sub>2</sub> / O <sub>2</sub> / and pressure Positive / Negative:	
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Safety Document Number:	Location:	Circuit:	Gas Zone Identification:

A. Confirmation <i>Gas Zone Vented</i>				B. Confirmation <i>Gas Zone Purged</i> of SF <sub>6</sub> (if internal access required Oxygen [O <sub>2</sub> ] %)					C. Confirmation Designated Access Points Secured and <b>Working Party</b> withdrawn prior to pressurisation			
Name	Signature	Date	Time	Name	Signature	Date	Time	O <sub>2</sub> %	Name	Signature	Date	Time

**D. Condition of *Gas Zone* at Safety Document Clearance:** \*Delete as Appropriate

<b>Competent Person Surrendering Safety Document</b>								<b>Safety Document Number</b>		
Name	Signature	Date	Time	Condition of <i>Gas Zone</i>	Gas present within <i>Gas Zone</i>		Pressure			
					SF <sub>6</sub> */N <sub>2</sub> */O <sub>2</sub> */Open to Atmosphere*			Positive*/Negative*/Atmospheric*		

## APPENDIX 2 – ENTRY PROCEDURE WHERE SF<sub>6</sub> BY-PRODUCTS MAY BE PRESENT

### PROCEDURE FOR ENTRY INTO A CHAMBER WHERE THE EXISTENCE OF BY-PRODUCTS IS SUSPECTED OR HAVE BEEN FOUND

This includes routine entry into any circuit breaker or disconnecter *Gas Zone* containing contacts/interrupters, as well as emergency work following a fault.

An HF and SO<sub>2</sub> test if practicable should be carried out on the gas in the *Gas Zone*. This is to determine if significant abnormal levels of arc product gases are present and assist in fault location. After a fault, e.g. post arc, at least 24 hours should be allowed to let the molecular sieve absorb gas arc products and then a further period of 1 hour after breaking the vacuum, to allow solid contaminants to settle, before personnel are exposed to the post arc environment.

The procedure to open an SF<sub>6</sub> chamber *shall* be followed only after the aforementioned periods have elapsed.

If the chamber or a bursting disc has ruptured, in order to establish the integrity of the *Gas Zone(s)* the following shall apply:-

- A **Permit for Work** *shall* be issued
- Use of appropriate PPE to control any exposure to by-products
- Check SF<sub>6</sub> wash-down facility is in service and route is clear
- Bursting disc(s) shall be replaced
- Draw a vacuum to determine integrity of the chamber / gas barriers



Figure 1 – SF<sub>6</sub> By-products contamination following arcing

It will not normally be necessary for the access point to be tented to exclude contamination of the surrounding area, unless advised by the **Senior Authorised Person**. Tenting may however be necessary to provide a clean environment for subsequent work on the **equipment**.

The vacuum *shall* be broken to dry air.

A **Permit for Work** will be issued. The RAMS for the work *shall* take into account the confined space of the SF<sub>6</sub> chamber if the chamber is to be entered by individuals; this includes the upper torso and head only entering as the risk of asphyxiation or poisoning is possible. One point of access shall be identified by a *Designated Gas Zone Access Point Notice* and opened for the initial inspection by the **Senior Authorised Person** prior to work commencing.

To assist in the opening of the access point, the chamber should be at a very small positive pressure (a few millibars). This pressure *shall* be released by slackening all the bolts on the access cover (**DO NOT REMOVE ANY BOLTS AT THIS STAGE**), breaking the seal on the point of entry, then completely releasing the retaining bolts. This process may result in the release of a small quantity of by-products.

Suitable PPE *shall* be worn by personnel involved who may be exposed to SF<sub>6</sub> by-products as detailed in **TCS** Personal Protective Equipment Policy.

The **Senior Authorised Person** *shall* identify from his initial inspection whether it is necessary for an initial clean to remove arc products. At this stage, if white metal fluorides are observed in small quantities, the **Equipment** should be cleaned using a high efficiency vacuum cleaner with micro-filtration by personnel wearing appropriate PPE.

It will not be necessary to tent the area unless a considerable amount of metal fluoride is present, and there is a likelihood of the dust being dispersed beyond the immediate confines of the switchgear. If outdoor the weather conditions (windy/rainy etc) *shall* be taken into account and also considered in the RAMS.

Once the **Senior Authorised Person** is satisfied that metal fluorides are not present in visible quantities the safety precautions adopted for SF<sub>6</sub> by-products need no longer be taken and work can proceed after a new **Permit for Work** detailing the revised further precautions is issued. Clean conditions clothing shall be worn when working in SF<sub>6</sub> switchgear.

The waste must be disposed of at a registered waste disposal site capable of accepting these hazardous compounds, and in according with **TCS** Environmental Policy.