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VOLUME 1 HOLDERS

ALAN MITCHELL

BRIAN KENT

S1-025

HANDLING OF CONTAMINATED SF6 GAS AND ASSOC. DECOMPOSITION PRODUCTS

Attached is Australian Standard 2791-1989 for handling of contaminated SF6 gas and associated ARC decomposition products in or from electrical equipment.

This standard sets out the procedures to be followed for the handling of contaminated SF6 gas and associated ARC decomposition products.

This Standards Bulletin supersedes S1-021 dated 11/9/87, which was an interim instruction and specifically addressed the problem associated with SF6 self contained moulded switch assemblies.

BRIAN KENT
STANDARDS MANAGER POWER

Australian Standard®

Recommendations for the handling of contaminated SF_6 gas, and associated arc decomposition products, in or from electrical equipment

This Australian Standard was prepared by Committee EL/7, Power Switchgear. It was approved on behalf of the Council of Standards Australia on 18 November 1988 and published on 13 March 1989.

The following interests are represented on Committee EL/7:

Australian-British Chamber of Commerce
Australian Electrical and Electronic Manufacturers Association
Confederation of Australian Industry
Electricity Supply Association of Australia
Institution of Engineers, Australia
Railways of Australia Committee
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Australian Standard®

Recommendations for the handling of contaminated SF_6 gas, and associated arc decomposition products, in or from electrical equipment

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PREFACE

This Standard was prepared by the Standards Australia Committee on Power Switchgear. The Standard is a series of recommendations, to users of sulfur hexafluoride (SF_6) gas-filled equipment, for guidance in the preparation of instructions to their maintenance personnel. It does not attempt to replace any instructions provided by the manufacturer of SF_6 gas-filled equipment, rather it seeks to augment those instructions, where appropriate.

It consists of recommendations for the provision of appropriate protective clothing, safety equipment and facilities for the protection of personnel who handle, or come into contact with, contaminated SF_6 gas or materials that have been decomposed by electric arcs in an atmosphere of SF_6 gas. The recommendations cover safety procedures, personal hygiene, first aid treatment, cleansing of reusable protective clothing, and the treatment of contaminated waste materials.

In the preparation of this Standard, consideration was given to BSI document ZZ5621v, *Draft Code of Practice for the Maintenance of Electrical Switchgear for Voltages Above 36* kV, and acknowledgement is made of the assistance received from that source.

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FOREWORD

Sulfur hexafluoride (SF_6) gas is inert, colourless, tasteless, odourless non-flammable, non-toxic, heavier than air (relative density 5.11) and chemically stable in the normal conditions of use of electrical equipment.

At high temperatures (above 800°C) such as when exposed to an electric arc, some decomposition of SF_6 takes place producing contaminating SF compounds which may be toxic.

Special filters may be fitted in the gas compartments of some equipment to absorb certain SF_6 decomposition products.

The solid products resulting from the decomposition of metals subjected to electric arcs in the presence of SF_6 gas exist in the form of a whitish powder which hydrolizes in the presence of moisture to form a sticky grey deposit which is normally acidic. This material has an irritating action on the skin, eyes, and respiratory and mucous membranes.

Experience shows that in the rare event of any SF_6 decomposition products being present in the atmosphere, warning indications will be apparent at very low concentrations, in the form of a pungent and nauseous odour. This will be evident well before any toxic effects can take place.

STANDARDS AUSTRALIA

Australian Standard

Recommendations for the handling of contaminated SF_6 gas, and associated arc decomposition products in or from electrical equipment

1 SCOPE. This Standard is a series of recommendations for the guidance to users of sulfur hexafluoride (SF_6) filled equipment in the preparation of instructions to their maintenance personnel. The recommendations cover the provision of basic facilities and precautions that should be taken when handling (SF_6) gas which has been partially decomposed by electric arcing and also any solid decomposition products (generally metallic fluorides produced by the erosion of various materials by arcing in an atmosphere of SF_6 gas).

It covers different procedures and precautions that should be taken depending on whether the gas is contained in equipment—

(a) large enough for personnel to work bodily inside it for maintenance purposes;

(b) installed in the open air;

(c) installed in rooms and enclosed spaces;

(d) which the hand or arm only is required to enter for maintenance purposes; or

(e) not intended to be maintained.

This Standard does not cover requirements for electrical safety or apply to work carried out on equipment containing uncontaminated SF_6 gas or not containing arc decomposition products.

2 APPLICATION. This Standard applies to electrical equipment containing SF_6 gas used for insulating or arc extinguishing functions. Such equipment may include, but is not necessarily restricted to the following:

(a) Switchgear and controlgear.

(b) Disconnectors and earthing switches.

(c) Circuit-breakers.

(d) Fuse-switch combinations.

(e) Motor starters.

(f) Gas insulated metal-enclosed switchgear.

(g) Busbar systems.

(h) Instrument transformers.

3 REFERENCED DOCUMENTS. The following documents are referred to in this Standard.

AS

1319 Safety signs for the occupational environment

1716 Respiratory protective devices

3544 Industrial vacuum cleaners for particulates hazardous to health

4 CLASSIFICATION OF SF_6 EQUIPMENT WITH REGARD TO PROCEDURES. This Standard recognizes three basic classes of SF_6 equipment, installed indoors or outdoors, which require different considerations for the handling of contaminated SF_6 gas and arc decomposition products. These classes are as follows:

(a) *Class 1 equipment.* Class 1 equipment requires bodily entry (at least head and shoulders) to gas compartments in order to maintain equipment therein.

(b) *Class 2 equipment.* Class 2 equipment requires only the entry of a hand or arm to gas compartments in order to maintain equipment therein.

(c) *Class 3 equipment.* Class 3 equipment comprises gas-filled equipment forming the whole or part of a device, which is sealed for the duration of its working life and only its safe replacement or disposal is required.

5 RECOMMENDED FACILITIES FOR CLASS 1 AND CLASS 2 SF_6 EQUIPMENT. (See Clauses 4(a) and 4(b).)

5.1 General facilities. For Class 1 and Class 2 SF_6-filled equipment, it is recommended that the following facilities be provided:

(a) A clear space, for the period of work on the SF_6 gas-filled equipment, designated for the purpose of changing and storing protective clothing, having cold water supplies and containers for the storage of soiled protective clothing. The purpose of this space is to facilitate adequate hygiene by minimizing the spread of decomposition products and also to assist in obtaining the high standard of cleanliness required during maintenance of SF_6 equipment.

It is important that this space is not used for eating, drinking or smoking or for the storage of outdoor clothing or other materials not connected with the maintenance of contaminated SF_6 equipment. The size of the space and its facilities will be dependent on the size of the installation and the mass of gas involved.

(b) First-aid equipment in accordance with local industrial regulations, including equipment and materials detailed in Clause 9.

(c) Means of contacting emergency services.

(d) A separate suitable area, with cold water supply and drainage, for cleansing of clothing, any filter materials and disposable cleaning materials (see Clauses 10 and 11). This area may be at a different location to the designated space in Item (a) above.

5.2 Protective clothing. Suitable protective clothing should be available in quantities sufficient for maintenance and special operational requirements as follows:

(a) Pocketless, hooded, coated-polyester, or paper disposable, industrial grade overalls having elastic ankle and wrist grips, overlapping the footwear and gloves.

(b) Coated-polyester, or paper disposable, sleeves with wrist grips, overlapping the gloves.

(c) Protective rubber boots or suitable disposable overboots.

(d) Disposable plastic gloves or reusable industrial type rubber gloves (preferably nitrile or neoprene).

5.3 Safety and maintenance equipment. Suitable equipment should be available as follows:

(a) Full-face breathing apparatus, self-contained or supplied-air type, as appropriate (see AS 1716), for use in Class 1 equipment installations and in indoor Class 2 equipment installations where ventilation is restricted.

(b) Full-face respirator fitted with both acid dust filter and activated charcoal cartridges (see AS 1716).

(c) Industrial type mouth and nose mask fitted with acid-dust filter unit with attached eye protection or with separate chemical type industrial goggles (see AS 1716).

(d) Gas handling plant to drain SF_6 gas compartments.

(e) Gas servicing and storage trailers, where appropriate.

(f) Industrial vacuum cleaner with disposable filter bags or cartridges for removal of arc decomposition products down to a size of 0.3 μm during cleaning (see AS 3544).

(g) Disposable cleaning materials, as recommended by the manufacturer.

(h) A supply of double plastic bags, with means for sealing, for holding items such as contaminated clothing, cleaning materials and damaged components awaiting treatment or disposal or both.

(i) Fresh-air blower for Class 1 equipment.

(j) Forced ventilation equipment (fresh-air blower) for indoor equipment when natural ventilation is inadequate.

6 RECOMMENDED FACILITIES FOR CLASS 3 SF_6 EQUIPMENT. (See Clause 4(c).)

6.1 General facilities. For Class 3 equipment, it is recommended that the following general facilities be provided:

(a) A designated clear space or enclosure which, in the event of an arcing fault in equipment containing SF_6 gas, can be set aside for the purpose of changing and storing protective clothing. During an emergency it is important that the space is not used for normal purposes, including eating and smoking, until the area and its contents have been thoroughly cleaned. A supply of cold water needs to be available and means for the disposal of waste water.

NOTE: As Class 3 equipment is commonly used in distribution substations where space is restricted, and also in the open, a suitable arrangement is for a dedicated transportable unit (e.g. a caravan) to be provided for use as the designated space referred to above. The unit should hold all necessary equipment materials and protective clothing and be readily available at short notice.

(b) First aid equipment, in accordance with local industrial regulations, including equipment and materials detailed in Clause 9.

(c) Means of contacting emergency services.

6.2 Protective clothing. Arrangements need to be made whereby protective clothing as detailed in Clause 5.2 can be obtained.

6.3 Safety and maintenance equipment. Arrangements need to be made whereby the following equipment can be obtained:

(a) Full-face breathing apparatus for indoor locations only (see Clause 5.3(a)).

(b) Full-face respirator for indoor locations only (see Clause 5.3(b)).

(c) Forced ventilation equipment (fresh-air blower) when natural ventilation is inadequate.

(d) Disposable cleaning materials.

(e) A supply of double plastic bags, with means for sealing, for holding items such as contaminated clothing, cleaning materials and damaged components awaiting treatment or disposal or both.

7 PROCEDURES.

NOTE: The nature of the chemical hazard is described in the Foreword.

7.1 All classes of SF_6 equipment—procedure following rupture or burn-through of an SF_6 enclosure. In the unlikely event of internal flashover of SF_6 equipment gas enclosures, arcing will result in a rise in internal pressure which may cause rupture of any fitted pressure-relief devices and, with a reduced probability, may also result in burn-through of the enclosure. In these cases, SF_6 gas and its arc decomposition products are released to the surrounding air, and the following actions should be taken depending on the environment:

(a) *Within a room or enclosed space.* No entry to the room or enclosed space should be permitted without protective clothing and breathing apparatus until the decomposition products have been removed and it has been satisfactorily ventilated. The presence of the pungent odour of certain decomposition products will be immediately evident to anybody attempting to enter and will provide a warning that rupture of an enclosure may have occurred.

Personnel entering the room or enclosed space should proceed as follows:

(i) Don protective clothing as detailed in Clause 5.2 and the appropriate safety equipment as detailed in Clause 5.3.

(ii) Display prominent warning signs at all entrances having lettering in accordance with AS 1319 as shown below:

RESTRICTED ACCESS
ONLY PERSONS INSTRUCTED IN CONTAMINATED SF_6 PROCEDURES ALLOWED BEYOND THIS POINT.

(iii) Enter and locate the point(s) of burn-through or rupture of the enclosure.

(iv) Visually determine the location and extent of arc decomposition product deposits.

(v) Clean up the deposits, if still in powder form, using an industrial vacuum cleaner (see Clause 5.3(f)), otherwise use lint-free rags to wipe off deposits.

(vi) Following the removal of the deposits, force ventilate the room or enclosed space with a fresh-air blower.

(vii) Place contaminated protective clothing, contaminated cleaning rags, and, if used, the vacuum cleaner filter bags or cartridges in double plastic bags for subsequent treatment as detailed in Clauses 10 and 11.

(b) *Outdoors.* The SF_6 gas and its decomposition products will normally disperse together with much of the entrained solid arc decomposition product particles, but the area surrounding the release may be contaminated with solid arc decomposition products in the form of a whitish powder or an acidic sticky grey deposit.

Personnel entering this area to inspect the damage or to determine the location and extent of any remaining arc decomposition products should don protective clothing as detailed in Clause 5.2(c) and (d).

The following steps should be taken when evidence has been found of arc decomposition products:

(i) Don protective clothing as detailed in Clause 5.2(c) and (d).

(ii) Display warning signs at the approaches to the contaminated area as detailed in Item (a)(ii) above.

(iii) Wash the area down with fresh water.

7.2 Class 1 SF_6 equipment—procedures.

7.2.1 *Preparation of personnel.* Before opening any SF_6 compartment, personnel should don the protective clothing and equipment listed below as appropriate:

Overalls with hood (see Clause 5.2(a)).
Boots or overboots (see Clause 5.2(c)).
Gloves (see Clause 5.2(d)).
Breathing apparatus (see Clause 5.3(a)).
Respirator (see Clause 5.3(b)).
Mouth and nose mask and goggles (see Clause 5.3(c)).

7.2.2 *Preparation of SF_6 equipment.* The equipment should be prepared as follows:

(a) Use gas handling plant to drain gas compartments preferably down to 10 kPa absolute pressure. If this is not possible, follow the manufacturer's instructions.

NOTE: If it is expected that the gas compartments are heavily contaminated, the contamination may be considerably reduced by refilling with clean SF_6 and draining them again using the gas handling plant.

(b) Fill the gas compartments with dry air (dew point $\leq$10°C) at 0 kPa gauge pressure.

NOTE: Gas compartments are usually pressurized. The release of SF_6 to the atmosphere should be restricted. No gas should be released without adequate ventilation.

7.2.3 *Opening and cleaning compartments.* Following the preparation of personnel and the SF_6 equipment in accordance with Clauses 7.2.1 and 7.2.2 respectively, the procedure for entering and cleaning the gas compartments should be as follows:

NOTES:

1. The compartments must not be force ventilated until all the decomposition products have been cleaned out.
2. An observer, suitably clad and able to render any assistance required, should be in attendance while persons are inside compartments.

(a) Display appropriate signs at the worksite, in accordance with AS 1319, as detailed in Clause 7.1(a)(ii).

(b) Open the access cover and examine the inside of the compartments to determine the quantity of decomposition products and ensure that they have settled. If they have not settled, immediately close the compartments to exclude the entry of any further moist air and wait for them to settle.

(c) Immediately clean decomposition products from the internal surfaces using the industrial vacuum cleaner (see Clause 5.3(f)) with an open-ended nozzle. Carry out the vacuum cleaning as quickly as possible. Where the decomposition products cannot be removed with the cleaner use a clean, dry, lint free rag, to wipe off the remaining decomposition products, or as otherwise instructed by the manufacturer. On completion of cleaning, place the contaminated cleaning rags and vacuum cleaner filter bag or cartridge in a double plastic bag for subsequent treatment and disposal.

(d) Remove any filters from the gas compartments, in accordance with the manufacturer's instructions, and place them in a double plastic bag for subsequent treatment as detailed in Clause 11.

(e) Remove protective clothing, place disposable items in double plastic bags for treatment and disposal and place re-usable items in separate double plastic bags for laundering (see Clauses 10 and 11). Cleanse boots, gloves, tools and reusable items of equipment in accordance with Clause 10.

(f) Dispose of any non-reusable equipment that has been exposed to arcing in SF_6 gas, in accordance wth Clause 12.

(g) Following the removal of the decomposition products, force ventilate the compartments using a fresh-air blower and maintain ventilation while work is in progress therein.

Once it has been established that no further arc decomposition products are present, work may proceed with personnel wearing normal protective clothing and gloves (see Clause 5.2(d)) in accordance with the manufacturer's instructions.

7.3 Class 2 SF_6 equipment—Procedures.

7.3.1 *Preparation of SF_6 equipment.* Clause 7.2.2 applies.

7.3.2 *Preparation of personnel.* Before opening and working on the gas compartments, personnel should wear gloves (see Clause 5.2(d)) and coated-polyester, or paper disposable protective sleeves with wrist grips overlapping the gloves to protect the hands and arms (see Clause 5.2(b)), or overalls (see Clause 5.2(a)) without using the hood, and a respirator (see Clause 5.3(b).

Following visual inspection of the gas chambers, depending on the situation, only gloves may be necessary and if there is no persistent odour the respirator may be removed.

7.3.3 *Opening and cleaning compartments.* Following the preparation of the SF_6 equipment and personnel in accordance with Clauses 7.3.1 and 7.3.2 respectively, work should proceed in accordance with Clause 7.2.3, Steps (a) to (f).

7.4 Class 3 SF_6 equipment—procedures. The procedures set out in Clause 7.1 are applicable to Class 3 equipment. Refer also to Clauses 6 and 12.

8 PERSONAL HYGIENE. Personnel need to observe the following in the operational area:

(a) A high standard of personal hygiene.

(b) No eating, drinking or smoking.

(c) No wiping of nose, eyes or face other than with clean paper tissues.

(d) Before leaving the operational area, wipe down their clothing, where appropriate, and their equipment using disposable materials.

(e) Removal of protective clothing in the designated clear space (see Clauses 5.1 (a) and 6.1(a)) and thorough washing as soon as possible after leaving the working area. The requirements of (a), (b) and (c) above also need to be observed in the designated clear space.

If the supply of clean fresh water on site is limited, the preparation of a weak solution of sodium bicarbonate in water (5 g to 10 g per L) is recommended. It should be kept available to rinse any areas of the skin that may be contaminated by arc decomposition products.

NOTE: A fresh sodium bicarbonate solution should be prepared each day as it deteriorates on exposure to the air.

9 FIRST AID. First aid treatment should be as follows:

(a) *Eye irritation.* Wash the eye with a liberal quantity of clean water or recommended medication. This may best be done by using an eye-wash basin or an eye irrigation device, or by holding the eye open and dipping the head into a basin of water. Seek medical attention following this treatment.

(b) *Skin irritation.* Either wash the affected area of skin with soap and water to neutralize and remove the contamination, or where the supply of clean fresh water is limited, rinse the affected area of the skin with the weak sodium bicarbonate solution. (See Clause 8(e)).

(c) *Breathing difficulties.* If breathing is affected by lack of oxygen due to excessive concentration of SF_6 or by SF_6 decomposition products—

(i) move the person to fresh air immediately and remove any contaminated clothing;

(ii) if breathing has stopped, give artificial respiration;

(iii) keep warm by covering with a blanket; and

(iv) call an ambulance, or seek urgent medical attention.

10 CLEANSING OF REUSABLE PROTECTIVE CLOTHING, TOOLS AND EQUIPMENT. Items of re-usable protective clothing may be laundered in the usual manner.

If it is considered that the clothing is appreciably contaminated a small quantity of sodium carbonate (ordinary washing soda) should be added to the wash water to ensure it is alkaline and so assist in the neutralization of the arc decomposition products.

Boots, rubber gloves, tools, and reusable items of equipment not suitable for laundering, should be wiped free of visible contamination using rags or clean paper tissues and then wiped over with a soft cloth moistened with sodium bicarbonate solution (see Clause 8(e)) to neutralize any remaining contamination. The contaminated rags and tissues should be placed in the double plastic bags for treatment and disposal in accordance with Clause 11.

11 TREATMENT AND DISPOSAL OF CONTAMINATED WASTE MATERIAL AND NON-REUSABLE PROTECTIVE CLOTHING.

WARNING: Under no circumstances should treated or untreated filters or contaminanated waste material be burnt, as it may cause the emission of toxic gases. Gloves should be worn for Steps (a) to (f) below.

The following procedure should be adopted for the disposal of contaminated waste material and non-reusable items of protective clothing:

(a) Prepare a solution of sodium carbonate (ordinary washing soda) in clean water, 1 kg per 10 L, by dissolving it in a suitable container, e.g. bare steel or plastics, and stirring to ensure that all crystals are dissolved.

(b) Place disposable vacuum cleaner filter bags or cartridges and all contaminated disposable materials, other than filter units or their contents taken from SF_6 gas-filled compartments, into the solution.

(c) When filter units or their contents have been taken from SF_6 gas-filled compartments for disposal, unless otherwise instructed by the manufacturer, prepare a second container of solution as in Step (a) above and place them in it.

(d) Stir the solution(s) and contents of the container(s) for sufficient time to neutralize the arc decomposition products (approximately 15 min) checking that the solution remains alkaline (pH > 7).

If the solution is not alkaline, add more sodium carbonate and continue the above neutralization procedure.

(e) Pour the bulk of the solution from the waste material in the container(s) into a foul water drain or sewer and flush it down with water.

(f) Remove the remaining solid materials from the containers (Steps (b) and (c) above) and dispose of them in the normal manner. Dispose of any remaining solution with entrained particles as in Step (e) above.

12 DISPOSAL OF EQUIPMENT WHICH HAS BEEN SUBJECTED TO ARCING IN SF_6. The following procedure should be adopted to treat and safely dispose of any equipment that may contain contaminated SF_6 gas and arc decomposition products:

(a) Don the protective clothing and a respirator as detailed in Clauses 5.2 and 5.3 respectively, as appropriate.

(b) If indoors, ensure that the working area is well ventilated. Drain gas compartments as detailed in Clause 7.2.2(a), ignoring the Note. Take care to avoid personal contact with any escaping gas.

NOTE: The release of SF_6 to the atmosphere should be restricted.

(c) Dismantle the equipment in accordance with the manufacturer's instructions.

(d) Either treat the components as waste materials in accordance with Clause 11, ensuring that the sodium carbonate solution fills any confined space therein, or wipe all external surfaces of the components with rags to remove any decomposition products and fill all internal spaces therein with sodium carbonate solution prepared in accordance with Clause 11(a). Dispose of contaminated cleaning rags in accordance with Clause 11.

(e) Empty the liquid into a foul water drain or sewer and flush it down with water.

(f) Dispose of the components and any neutralized solid material from them in the normal manner.

The protective clothing and respirator may be removed after Step (d) above and if contaminated, should be placed in double plastic bags for treatment in accordance with Clause 10 or Clause 11 as appropriate.