SF_6 Recycling Guide

Reuse of SF_6 Gas in Electrical Power Equipment and Final Disposal

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CIGRE: International Council on Large Electrical Systems

Non-governmental voluntary organization to study technical topics by 3,700 members in 80 countries led by 15 study committees whose members are appointed by the national committees

Subcommittees and task forces of peer-recognized experts are set up for specific topics of special and current interest

SF_6 work mainly done in the Gas Insulated Switchgear (GIS) Subcommittee of the **Substations Study Committee,** Task Force on SF_6

Participants included:

Users: National Grid Company, Ontario Hydro, Scottish Power, ESB, etc.

Manufacturers: ABB, Siemens, Mitsubishi Electric, Toshiba, Alstom, Merlin Gerin, etc.

Others: universities, DILO, Solvay

In the 1980's, concern with handling SF_6 in general and especially with regard to personnel safety led to the publication of:

"Handling of SF_6 and its decomposition products in gas insulated switchgear"

ELECTRA, No. 136 and 137 (1991)

This document was the basis for:

"IEC Standard 1634: High voltage switchgear and control gear - Use and handling of sulphur hexafluoride in high voltage switchgear and control gear," 1995

Concern with SF_6 emissions led to a CIGRE position paper:

“SF_6 and the global atmosphere”

ELECTRA No. 164 (1996)

Although 80% of the use of SF_6 was by electric power industry, the total contribution of SF_6 to anthropogenic global warming was less than 0.1%, and even at present high release rates, would be less than 0.2% through 2100

Conclusions

SF_6 does not contribute to ozone depletion

Emissions of SF_6 associated with electrical power equipment can be minimized

Recycling equipment is available and widely used, but standards for the purity of SF_6 to be reused need to be established

SF_6 is indispensable in electric power equipment and advantageous on a total life cycle environmental impact analysis

Recommendations

SF_6 should not be deliberately released to the atmosphere

SF_6 should be recycled

SF_6 losses from electrical equipment should be further minimized by improved electrical equipment design and handling procedures

Standards for recycling procedures and purity of SF_6 should be established

Contamination of SF_6 in Electrical Power Equipment

Gas handling
Leakage
Desorption from surfaces, bulk materials
Decomposition by electrical discharges
Secondary reactions
Mechanical generation of dust particles

Effects of Contamination

Health risk
Corrosion
Insulation performance of gas gaps
Insulation performance of insulator surfaces
Switching capability
Heat transfer

Air and CF_4

From handling and switching arcs

Deteriorates switching capability and gas insulation

Tolerable at 3% by volume

Impurity limit for reuse: 2%

Field detectable at 1%

Not filterable, purification by distillation is not efficient; in small concentrations, can be reduced by dilution with new SF_6 gas

Humidity

From desorption from surfaces and polymers

Deteriorate surface insulation by liquid condensation

Tolerable level (dew point) is a function of the pressure at which the gas is to be stored and used:

At 2 MPa: 200 ppmv
At 500 kPa: 800 ppmv
At 100 kPa: 4000 ppmv

Corresponding impurity limits: 120, 320, and 1600 ppmv

Field detectable level is 25 ppmv; absorbants in gas handling equipment control the level to below 100 ppmv

Gaseous Decomposition Products: SF_4, WF_6, SOF_4, SOF_2, SO_2, HF, SO_2F_2

From arcing, partial discharges, and secondary reactions

Deteriorate surface insulation and are toxic

Tolerable level is 100 ppmv

Impurity limit is 50 ppmv

Field detectable at 10 ppmv using SO_2 plus SOF_2 as indicator gases with chemical color changing sensors

Limit is easily achieved with absorbants used in gas handling equipment

Solid Decomposition Products: CuF_2, WO_3, WO_2F_2, WOF_4, AlF_3

From contact erosion and internal arcing

Concern is toxicity

Not practical to quantify or to define field detection levels

Gas handling equipment having dust filters of 1 micrometer pore size will remove from gas

Proper cleaning procedures must be followed when opening equipment

Carbon and Metal Dust/Particles

From polymer carbonization and mechanical wear

Deteriorate surface insulation and gas insulation

Tolerable levels are low, but not easily quantified

Similarly, quantitative field detection is not practical

Control by 1 micrometer pore size filters in gas handling equipment

Oil

From pumps and lubrication

Deteriorates surface insulation

Tolerable level is low

Field detection is not practical

Easily avoided by proper procedures

Reclaiming and Reuse of SF_6 in Field

1) Electrical power equipment designed to allow reuse of SF_6

2) Reclaiming equipment

3) Purity standard for gas to be reused

4) Quality checks

5) Gas handling procedures and trained personnel

Electrical Power Equipment Designed for Reuse of SF_6

Minimize leakage rate

Present standard of less than 1% per year will be reduced to 0.5%, and the objective is less than 0.1%

Gas monitoring

Reduce threshold from present levels of an alarm after 5% to 10% of the gas is lost to more sensitive monitors that can measure leakage rate

Reclaiming Equipment

Commercial SF_6 reclaimers have been available since the 1950's

Consist of:

Vacuum pump to remove air from equipment to be filled

SF_6 compressor and vacuum pump to remove SF_6 from equipment and put into storage containers

Filters for particles, humidity, and gas decomposition products

Cost ranges from $1,000's for small systems up to around $100,000 for large, high-speed systems

Purity Standard for Reuse of SF_6 in Electrical Power Equipment

Currently use Table 1 of CIGRE SF_6 Recycling Guide

Accepted as meeting warranty requirements by electrical power equipment manufactures

IEC 480 is being revised to provide an international standard for purity levels

In general will follow the CIGRE purity limits

Quality Checks

Air and CF_4: speed of sound or thermal conductivity

Humidity: electronic hygrometers or dew point instruments

Decomposition Products: chemical reaction tubes with visual indication

Gas Handling Procedures

Establish a policy regarding reuse and reduction of emissions

Document procedures suited for your situation

Inventory reports to allow determination of losses
(upper level of emissions)

Train personnel

Provide equipment for reclaiming and leak checking

Eliminate leakage

Storage and Transport

Use standard SF_6 containers as are used for new gas

These will meet applicable national regulations

Special containers used in gas handling systems may or may not meet transport regulations

Labeling should clearly indicate status:

New gas
Used gas suitable for reuse
Used gas of unknown purity--possibly toxic

Final Disposal

Use a thermal process followed by a calcium hydroxide scrubber to form solid sulphates and fluorides:

$CaSO_4$

CaF_2

These are naturally minerals used in construction and toothpaste

Conclusions:

SF_6 is easily recyled for reuse in electrical power equipment

Standards for purity of SF_6 gas to be reused in electrical power equipment have been established

Purity of SF_6 to be reused in electrical power equipment can be easily checked in the field using commercially available equipment

SF_6 gas handling equipment is readily available and affordable for both small and large quantities of SF_6 gas