

Holec® Vacuum technology and Solid insulation

# Green Switching

A sustainable alternative for  
SF<sub>6</sub> gas-filled switchgear

**EATON**

*Powering Business Worldwide*

# Environmentally-friendly energy technology

## Vacuum technology and Solid insulation

In recent years, the environment has become a very important issue within society. Alarming reports on the greenhouse effect and climate change means that everyone is aware of the serious threat to life on earth. It is time for everyone to take responsibility for these developments.

Emissions of SF<sub>6</sub> gas from switchgear contribute significantly to the threat of the greenhouse effect and associated climate change. Production of SF<sub>6</sub> is still increasing worldwide, despite the fact that this greenhouse gas is listed in the Kyoto protocol as “undesirable” [1]. Eaton’s full range of SF<sub>6</sub>-free medium-voltage switchgear systems (see box) provide an opportunity to make an active contribution to reducing the worldwide emissions of SF<sub>6</sub>-gas.

### Alternatives for SF<sub>6</sub>

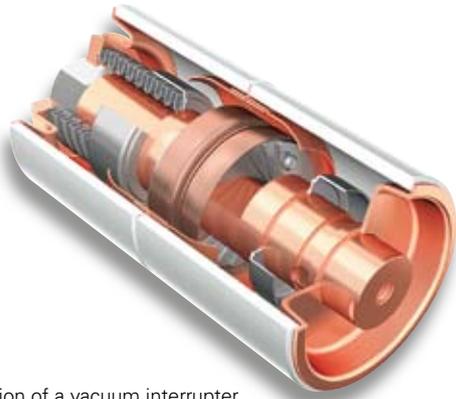
SF<sub>6</sub> gas is used as insulation and switching medium in switchgear since it has good switching properties and allows for relative compactness of gas insulated switchgear when compared to conventional air-insulated switchgear. But, while there is no economically viable alternative to SF<sub>6</sub> gas for high voltage (HV) switchgear (> 52 kV) in the transmission network, application of SF<sub>6</sub> is totally unnecessary for medium voltage (MV) switchgear (< 52 kV) in the distribution network.

Fully equivalent alternatives are commercially available on the market [2]. These alternatives may consist of the combination of vacuum technology for switching and high-quality materials for insulation purposes, resulting in minimised dimensions and at least the same degree of compactness as for SF<sub>6</sub> switchgear.

### A deliberate choice in favour of SF<sub>6</sub> free switchgear

In the 1980’s, the Holec group, as it was then, made a fundamental choice not to use SF<sub>6</sub> as a switching and insulation medium for medium voltage equipment. Holec had in the 1980’s SF<sub>6</sub> technology available in-house. The main reason for not using any SF<sub>6</sub> in medium voltage equipment was the complexity of the treatment required and the need for additional safety measures when used in public locations such as residential areas and shopping centres. There was also the possibility that SF<sub>6</sub> could be labelled an environmental risk, as was the case then with PCB’s and asbestos. Eaton’s Cutler-Hammer brand, which was the market leader in the United States with NEMA/ANSI medium voltage equipment, was also developing SF<sub>6</sub> free medium voltage switchgear for the same reasons.





Cross-section of a vacuum interrupter

### Features of vacuum technology

- Safe
- Compact
- Reliable
  - > 30,000 mechanical switching operations
  - > 100 switching operations of the short-circuit current ( $I_k$ )
- Maintenance free

### SF<sub>6</sub> gas – the facts

SF<sub>6</sub> is a synthetic compound consisting of one sulphur atom and six fluorine atoms and does not normally occur in nature. SF<sub>6</sub> is gaseous at room temperature and is heavier than air. Due to the strong bonds between the sulphur and fluorine atoms SF<sub>6</sub> is inert under normal circumstances. This gas has certain electrical properties that make it suitable as insulation and switching medium in switchgear for power distribution.

SF<sub>6</sub> breaks down into toxic substances on incineration, for example when an internal arc occurs in the switchgear. In the event of such an internal arc SF<sub>6</sub> gas and its toxic by-products are released into the atmosphere. These reactions also occur in normal use whenever an arc is suppressed. The toxic residues will then remain in the housing, as a result of which special precautions are required when dismantling and recycling the system at the end of its service life.

### Switchgear with SF<sub>6</sub> gas

There are three principal designs for SF<sub>6</sub> insulated switchgear. With the first two, known as *controlled pressure* systems and *closed pressure* systems, release of SF<sub>6</sub> is unavoidable in practice. This is because the systems require maintenance in the course of their service life, at which point leakage occurs. Furthermore, leakage occurs when the units are dismantled at the end of their service life.

The third principle design is the *hermetically sealed* system, which does not require maintenance in the course of its service life. Emissions of these systems due to leakage are claimed to be limited although these will never be zero, as in practice gaskets are a source for leakage. Leaks can also not be ruled out in the long term over the service life of the installation (> 30 years).

### Annual worldwide emission of SF<sub>6</sub> gas

As energy consumption increases the use of SF<sub>6</sub> increases in absolute terms as well. It is estimated that annual SF<sub>6</sub> gas production will reach around 8000 metric tonnes, 80% of which is used in electrical energy technology for switching operations, cooling and insulation [3].

The production of SF<sub>6</sub> is still increasing, despite the fact that the gas is included in the Kyoto protocol for its contribution to the greenhouse effect. Recent studies have shown that the annual percentage increase of SF<sub>6</sub> gas in the air is 8% +/- 0.7%, the highest figure of all greenhouse gases [4].

With the increase in the number of switchgear using SF<sub>6</sub> gas for switching and insulation purposes in electricity networks, emissions of SF<sub>6</sub> gas into the atmosphere will increase accordingly, a trend which will continue if policy remains unchanged.

### Use of SF<sub>6</sub> discouraged by the Kyoto protocol

Emissions of SF<sub>6</sub> gas from switchgear contribute significantly to the threat of the greenhouse effect and the associated climate change. SF<sub>6</sub> is on the list of greenhouse gases in the Kyoto protocol [1]. SF<sub>6</sub> is the most potent of the six main greenhouse gases with a Global Warming Potential (GWP) of 23,000 [5]. The United Nations institution that monitors this, the Intergovernmental Panel on Climate Change (IPCC), has since then added SF<sub>6</sub> gas to the list of extremely harmful greenhouse gases. The Kyoto Treaty (1992) stipulates that emissions of SF<sub>6</sub> gas must be reduced. Discouraging use is the best answer to this for the time being.

## Eaton's SF<sub>6</sub>-free switchgear for medium voltage

The medium voltage switchgear systems carrying Eaton's Holec brand are based on the use of vacuum switches combined with solid insulation material. This is an environmentally-friendly technology in comparison with the methods used by many other suppliers, which use SF<sub>6</sub> as an insulation gas.



**Magnefix 3,6 - 15 kV**

Epoxy resin insulated Ring Main Units for energy distribution.



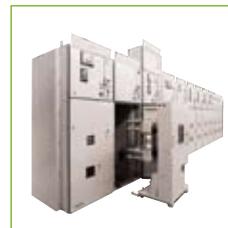
**Xiria 3,6 - 24 kV**

Metal-enclosed epoxy resin insulated Ring Main Units for energy distribution and industry.



**SVS 3,6 - 24 kV**

Metal-enclosed modular epoxy resin insulated switchgear system with vacuum interrupters.



**Unitole UP 3,6 - 17,5 kV**

Metal-enclosed air insulated motor control centre and single busbar main distribution system.



**MMS 3,6 - 24 kV**

Metal-enclosed modular double busbar switchgear for energy distribution and industry.

SF<sub>6</sub> FREE

## European F-gas regulation

As a consequence of the outcome of the IPCC studies and the fact that SF<sub>6</sub> is a greenhouse gas listed under the Kyoto-protocol of which emissions should be mitigated [1], the European Union passed legislation that bans SF<sub>6</sub> for almost all applications, except for electrical switchgear. The reasoning for this exception is that no viable alternative would be available. Under the F-gas regulation (2006) the use of SF<sub>6</sub> is now prohibited for most applications, like in sport shoes, car tyres, tennis balls and for double glazing [6].

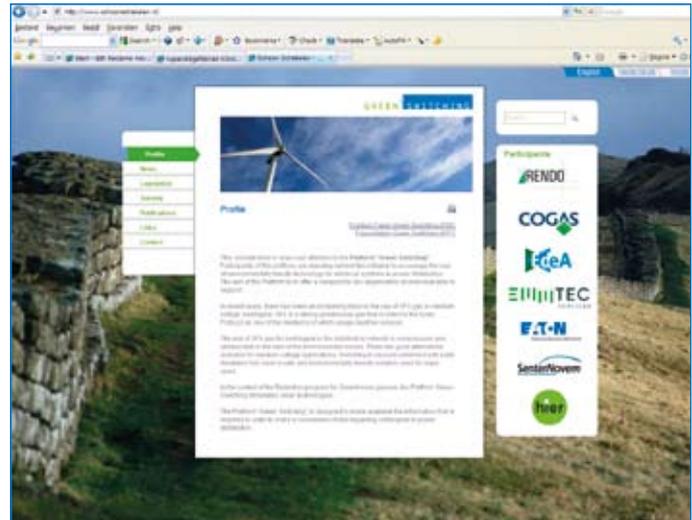
The F-gas regulation prescribes a lot of precautions to limit the emission in HV and MV switchgear applications. Utilities and switchgear manufacturers have to take special measures to limit the emission during the production, use, maintenance and end of life of equipment containing SF<sub>6</sub>. Technicians involved in regular inspections, maintenance, refilling and recycling of switchgear containing SF<sub>6</sub>, need to be trained and certified. There are three IEC standards that prescribe how to deal with SF<sub>6</sub> for HV and MV switchgear applications.

## Corporate Social Responsibility

Over the recent years we have seen a trend of increasing professionalism within the *asset managers* of the electricity network companies. This has led to a more balanced approach where the quality of the network, cost control, safety risks and sustainability have to be considered during the decision making process. Utilities are focusing more and more on *Total Cost of Ownership* (TCO) instead of the initial purchasing price.

Asset managers within the larger utilities take the use of SF<sub>6</sub> also into account from a financial point of view. They calculate a certain percentage as penalty to compensate the potential risks of SF<sub>6</sub> and its by-products over the lifetime, and also reward SF<sub>6</sub> free technology with a 5% to 10% benefit as a consequence of the potential savings during the life cycle. This has led to a more well balanced decision making process within the utilities, as not only the initial investment costs are taken into account

Recent independent evaluations show that SF<sub>6</sub>-free switchgear is not only technically equivalent, but also more cost-competitive over the full service life.



## Eaton supports the Green Switching initiative

Due to a growing concern about the impact of global warming, several utilities and Eaton are joined in the Green Switching initiative. Green Switching is a platform of users, manufacturers, Non Governmental Organisations and other participants who are concerned about the growing use of SF<sub>6</sub> for MV applications. The participants share the idea that the use of SF<sub>6</sub> should be prevented wherever there are alternatives available on the market. The Green Switching platform has published a position paper and several related publications. It also presents scientific and technical articles about SF<sub>6</sub> and its alternatives on a website. More information: [www.greenswitching.com](http://www.greenswitching.com)

As a result of this Green Switching initiative there is a growing consciousness in the energy distribution market about the use of SF<sub>6</sub>. Utility network companies, industrial users, owners of railway and underground infrastructure and public private investors in the healthcare sector are becoming more aware of the health & safety aspects of SF<sub>6</sub> and its toxic by-products as well as its impact on global warming. This has resulted in a growing concern about the use of SF<sub>6</sub> for MV applications.

## References:

1. United Nations Framework Convention on Climate Change. Kyoto protocol, Rio de Janeiro (Brasil) 1992.
2. Porte, W. and Schoonenberg G.C. "Green Switching - Opportunity to avoid SF<sub>6</sub> emission from electrical networks," Fifth International Symposium on Non-CO<sub>2</sub> Greenhouse Gases (NCGG-5), Wageningen, The Netherlands 2009
3. Smythe, K. "Trends in SF<sub>6</sub> and End-Use Applications: 1961-2003," Conference on SF<sub>6</sub> and the Environment. Scottsdale, Arizona, December 1-3, 2004.
4. Powell, A.H. "Environmental aspects of the use of Sulphur Hexafluoride. ERA Technology Ltd. 2002."
5. Intergovernmental Panel on Climate Change 2007. IPCC Fourth Assessment Report, Working Group I "The Physical Science Basis" Chapter 2.
6. European Union Regulation (EC) No 842/2006 of the European Parliament and of the Council.

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