
Switchgear - HV switchgear – there is a green alternative

High voltage switchgear is one of the few applications where the use of SF6 gas is still permitted under Greenhouse Gas Regulations. This is based on the premise that there is no viable alternative. However, in the range 1-52kV there is a perfectly viable option in the form of vacuum switchgear with solid dielectric insulation. Vacuum switchgear is similar in size and technically equivalent, if not superior, to SF6 switchgear. It is being used increasingly by utilities in Europe for medium voltage (1-52kV) applications explain W Porte and GC Schoonenberg from Eaton, in the first instalment of this two-part article



The notion there is no viable alternative to SF6 switchgear for high voltage applications, which is exploited by the producers of SF6 and manufacturers of SF6 switchgear, can be attributed in part to the different methods of classifying voltage levels. IEC terminology identifies two voltage bands - low voltage for applications up to 1,000V a.c. and high voltage for anything greater than 1,000V. However the term medium voltage is widely used for distribution voltages in the range 1kV-52kV. Thus it is perceived by some that SF6 is the only option for systems greater than 1kV when, in reality, vacuum switchgear is a 'green' option up to 52kV.

F-gas Regulations

The Fluorinated Greenhouse Gas Regulations 2009, which came into force in March, impose strict legal requirements upon personnel and companies in five industry sectors which use fluorinated greenhouse gases (F gases). These gases include the fluorocarbons (CFCs and HFCs) as well as sulphur hexafluoride (SF6). High voltage switchgear is one of the five industry sectors along with refrigeration and air conditioning, fire protection systems and certain types of solvent.

The Regulations and steps that can be taken to train personnel in the recovery of SF6 gas, or mixtures of the gas, during maintenance or at end of life were described by Gary Eastwood in the August issue of *Electrical Review*.

Concerned utilities are turning increasingly to vacuum technology for medium voltage applications. Northern Ireland Electricity became the first United Kingdom utility to order Eaton's Xiria vacuum ring main units in 2007, as part of its framework contract for secondary power distribution, and last year EDF Energy placed a three-year framework contract with Eaton to supply 11kV double-busbar switchgear incorporating its Innovac vacuum circuit-breakers. The first 60 units were supplied to EDF Energy for a major substation in Stratford, East London.

In the Netherlands, the government is supporting a Green Switching initiative involving four utilities, the SenterNovem (a Dutch agency of the Ministry of Economic Affairs for the promotion of sustainability and innovation) and Eaton. This group is working to increase awareness of the issues surrounding non-carbon greenhouse gases and to promote the development of alternative technologies. It believes that there should be tighter controls over the use of SF6 with a ban on its use up to 52kV. A position paper and other documentation are available on www.greenswitching.com.

In the USA, the Environmental Protection Agency (EPA) is promoting a voluntary SF6 emission reduction programme in which 80 utilities are participating. Between 2000 and 2006, emissions by these utilities fell from 15.1% to 6.5%. Meanwhile, the Leadership in Energy and Environmental Design (LEED) system for rating green buildings, developed by the US Green Building Council, is being adopted in many parts of the world as a way to quantify and compare sustainability. Use of vacuum switchgear with solid dielectric will help achieve the objectives of the LEED standards.

SF6 switchgear

Approximately 8,000 tonnes of SF6 are produced annually, of which 80% is used in electrical switchgear. It is used for two functions - circuit interruption and insulation.

For circuit interruption SF6 offers excellent arc quenching and heat transfer properties. It has a high chemical stability and a fast dielectric recovery time with self-healing properties under electrical discharge conditions. Under normal operating conditions it is non-flammable and non-explosive, making it an excellent alternative to oil-filled switchgear, which has largely disappeared as a technology over the last thirty years.

As an insulating medium, SF6 has an electrical breakdown strength approximately three times that of air at atmospheric pressure. This means by filling a circuit-breaker enclosure with SF6 gas the line-to-line and line-to-earth distances can be reduced, making for compact equipment. This is the principal reason why SF6 gas has been used so extensively as an insulation medium in gas insulated switchgear (GIS) even where vacuum technology is used for circuit interruption.

However, SF6 is one of the six most potent greenhouse gases identified by the Intergovernmental Panel on Climate Change (IPCC) and consequently included in the Kyoto list of substances whose use and emission should be minimised. Although far less common than carbon dioxide, it has a global warming potential (GWP) listed as 23,900. This means one tonne of SF6 has the same greenhouse effect as 23,900 tonnes of CO2. At present its contribution to global warming is only 0.01% but, unlike other greenhouse gases, it is largely immune to chemical and photolytic degradation so its effects are cumulative. Annual rate of increase in the atmosphere is said to be 8% and lifetime in the atmosphere is estimated as 3,200 years (CO2 is 50-200 years).

Under the F-gas Regulations of 2006, the use of SF6 was prohibited for most applications including sports shoes, tennis balls, car tyres and double glazing. However, its continued use for HV switchgear is permitted on the basis that there is no viable alternative. Nevertheless, the Regulations imposed strict requirements for the manufacture, use, maintenance and disposal of SF6 switchgear, including special requirements for the training and certification of personnel. These requirements were strengthened by the 2009 Regulations.

The extent of leakage of SF6 into the atmosphere is not known, but emissions of 6-13% per annum have been estimated. Under the F-gas Regulations all larger systems containing SF6 should be inspected regularly and emissions should be prevented as far as possible during maintenance. Some authorities insist on continuous monitoring of all gas-filled enclosures to detect leaks.

SF6 also poses a number of health risks. For example, although it is non-toxic and chemically and thermally stable under normal conditions, it can break down into highly toxic substances such as HF, SOF2, SF4 and S2F10 when exposed to arcing, partial discharges or incineration. Under normal operating conditions these are generally recombined after a discharge is cleared but some toxic residue may remain in the housing. If there is a catastrophic failure, these products could be released into the atmosphere, exposing the public to risk. Consequently, SF6 switchgear should not be used in residential areas, commercial buildings, shopping malls, railway stations, hospitals, educational campuses or underground installations.

Asphyxiation is another risk. SF6 is a colourless, odourless gas which is about five times the density of air. Consequently locations should be well-ventilated and gas analysing equipment may be needed to alert staff to any risk from leakage.

End-of-life disposal is an important consideration. Measures must be in place to recover the SF6 gas and personnel need to be protected against risks from harmful by-products. The presence of these by-products restricts the ability of the materials to be recycled. It should also be borne in mind while these products are manufactured under controlled conditions in industrialised countries, they are being sold worldwide, including countries where controls embodied in the F-Gas Regulations and similar legislation are not enforced. End-of-life disposal becomes even more uncertain in these countries. The risks are exacerbated when used equipment containing SF6 gas is exported as waste to third-world countries where it may be dismantled by unqualified personnel.

The second part of this feature will appear in the November issue of Electrical Review