Green switching
A Green Switching Platform publication

Introduction

This publication by the 'Green Switching' Platform is a position paper with a compilation of information about the consequences of the use of the greenhouse gas SF_6 in electrical switchgear. According to the Intergovernmental Panel on Climate Change (IPCC), SF_6 is the most potent of the six main greenhouse gases with a global warming potential (GWP) of 23,000 times that of CO_2. The lifetime of SF_6 in the atmosphere is over 1000 years. For this reason SF_6 has been put on the Kyoto list of substances of which the use and emission should be minimized.

Emissions of SF_6 gas from switchgear contribute significantly to the threat of the greenhouse effect and the associated climate change. It is the aim of this publication to contribute to the provision of clear information in order to support policy makers within the government, the power utilities and industrial companies to make responsible decisions in selecting green switchgear for their distribution networks.

The power network and distribution switchgear

Power plants generate electrical power, which is transmitted to consumers through a network of overhead lines and cables. Switchgear provides safe control and distribution of the electricity at nodal points in the distribution network. Applications for these systems can be found in power utilities, process and general industry, infrastructural projects, hospitals, commercial buildings and shopping centres. In the event of a fault, circuit breakers are required to shut off the power to an electrical circuit.

In the power transmission and distribution different voltage levels are used to dimension the network on the most economic way and to minimize the energy losses. High voltage (>50 kV) is used for long distance transmission and medium voltage (1-50 kV) is used for distribution via overhead lines or underground cables close to the end users. At the end user level medium voltage is again transformed to low voltage which is used for all kind of applications.

SF_6-free alternatives are available

SF_6 has become popular as insulation- and switching medium in switchgear, due to good switching properties and the relatively compactness of this type of switchgear compared to conventional air-insulated switchgear. But, while there is no economically viable alternative to SF_6 gas for HV switchgear in the transmission network, application of SF_6 is totally unnecessary for MV switchgear in the distribution network.

Fully equivalent alternatives are commercially available on the market. These alternatives may consist of the combination of vacuum technology for switching and solids for insulation purpose, resulting minimized dimensions and the same degree of compactness as for SF_6 switchgear.

SF_6 gas emissions

There are three principal designs for SF_6 containing switchgear. With the first two, known as 'controlled pressure' systems and 'closed pressure' systems, release of SF_6 is unavoidable in practice. This is because the systems require maintenance in the course of their service life, at which point leakage occurs. And finally 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. Due to this fact 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.

SF_6 gas – the facts

SF_6 is a synthetic compound consisting of one sulphur atom and six fluorine atoms and does not normally occur in nature. SF_6 is gaseous at room temperature and is heavier than air. Due to the strong bonds between the sulphur and fluorine atoms SF_6 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_6 has also certain disadvantages. SF_6 breaks down into toxic substances like HF, SOF_2, SF_4 and S_2F_{10} on incineration or when an internal arc in the switchgear occurs. In the event of such an internal arc SF_6 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 the system at the end of its service life. Approximately 8,000 metric tons of SF_6 are produced annually, of which about 80 percent is used by the electrical power industry for arc interruption, cooling, and insulating. Production of SF_6 is still increasing worldwide, although this greenhouse gas is listed in the Kyoto protocol.

As energy consumption increases the use of SF_6 increases in absolute terms as well. It is estimated that SF_6 gas production will reach around 10,000 metric tonnes in 2010. With the increase in the number of switchgear using SF_6 gas for switching and insulation purposes in electricity networks, emissions of SF_6 gas into the atmosphere will increase accordingly, a trend which will continue if policy remains unchanged. There is growing concern about this development, because it is so closely associated with the rise in the earth's temperature and the climate change related to it. As figures of SF_6 emissions are not publicly available in detail not a great deal is known about the extent of this leakage. Emissions ranging between 6% and 13% are nevertheless reached in practice.

In many countries where SF_6 gas is used in switchgear, measures are now taken to limit the emission of SF_6. Examples are the voluntary program of the Environmental Protection Agency (EPA) in the USA and the F-gas regulation in Europe. In the new European F-gas regulation (2007) it is mandatory that all larger systems containing SF_6 gas should be inspected on a regular basis and emissions should be prevented as much as possible during maintenance, refilling and dismantling. Although there is currently an exception for hermetically sealed switchgear containing less than 6 kg SF_6 it is expected that there will be additional measures in the future for this kind of applications due to an increasing pressure from non-governmental organizations (NGO's) and political parties to limit the emissions of non-carbon greenhouse gasses.

Concerns about SF_6 gas

Climate Change

The largest concerns about SF_6 gas relate to the environment. This applies predominantly to the contribution of SF_6 to the greenhouse effect. This has only been realised relatively recently when more knowledge became available. SF_6 gas is a recognised greenhouse gas. The United Nations institution that monitors this, the Intergovernmental Panel on Climate Change (IPCC), has since then added SF_6 gas to the list of extremely harmful greenhouse gases. The Kyoto Treaty (1992) stipulates that emissions of SF_6 gas must be reduced. Discouraging use is the best answer to this for the time being.

Greenhouse danger

The increase in gases in the atmosphere that retain heat also reinforces the greenhouse effect. The consequences of this are hard to predict. However, according to a report by the IPCC, a panel of scientists that operates under auspices of the UN organisations for meteorology (WMO) and the environment (UNEP), the average temperature on earth could rise by 6.4 degrees Celsius during the twenty-first century.

The IPCC points to the increase in carbon dioxide (CO_2) in the atmosphere, as a result of human activity, as the most significant cause of this. CO_2 in fact has a strong insulating effect, preventing the earth's heat from escaping into space. In addition to this there are a number of other gases that also contribute largely to the greenhouse effect. Although emissions of these gasses are much lower than that of CO_2, the insulating effect per kg is much larger. SF_6 is very prominent in this category of non-carbon greenhouse gasses.

A unit of calculation has been established in order to be able to assess the contribution of greenhouse gasses such as SF_6 to the greenhouse effect. Known as 'Global Warming Potential' (GWP), it is a measure of the degree to which a gas contributes to the greenhouse effect per unit of its weight. This measure is derived from CO_2 and is therefore expressed as CO_2 equivalent. Thus, the GWP of SF_6 gas is 23,000. Hence SF_6 gas is 23,000 times "more powerful" per kg than CO_2.

Ozone Layer

A further concern is the discovery by researchers from Germany, the US and Britain of a new, highly active greenhouse gas that attacks the ozone layer. This gas is SF_5CF_3, of which the concentration has been increased by a factor of one hundred over the past 50 years. Scientists have concluded that this gas is a by-product of the breakdown of sulphur hexafluoride (SF_6).

Health & Safety Risks

SF_6 gas, and especially its derivates that inevitably are formed during switching or internal faults, poses risks to the health of operators and maintenance technicians and to the health of anyone in the immediate surroundings. Although these by-products may regenerate over time, this does not detract from the fact that there are concentrations of toxic by-products in this type of switchgear. Maintenance technicians are also exposed to increased risk once switchgear needs to be decommissioned at the end of its service life. The concern primarily relates to the handling of the toxic by-products, especially formed as a result of switching in SF_6 gas, during normal use.

Although there are IEC standards and guidelines available, risks for the health and safety of the maintenance personnel can never be excluded. Another aspect is that SF_6 containing switchgear – normally handled as chemical waste - is exported as normal waste to third world countries where it has the risk to be dismantled by uncertified personnel causing all kinds of damage to the people and environment.

And finally, there is the risk of an open arc causing heavy contamination of the surroundings. In case of an internal failure leading to an open arc there will be an explosion which will spread the toxic by-products of SF_6 over the whole area. Although switchgear may be tested according to international standards, in respect of internal arcs, the dangers of SF_6-by-products are never taken into consideration from a safety point of view. As especially MV switchgear is widely used in public buildings, shopping malls and hospitals this might have a huge impact on the health and safety of the public that is in the proximity.

International regulations

It was agreed in the Kyoto Treaty that industrial countries must reduce their emissions during the period 2008–2012 by an average of 5.2% based on 1990 emission levels. This includes the greenhouse gasses carbon dioxide, methane, nitrous oxide and a number of fluorine compounds of which SF_6 is one. Given the hitherto essential role of SF_6 gas in high voltage networks, international agreements have not aimed for a ban on SF_6. To limit the damage, targets are being set for the use, recovery and recycling of SF_6 gas in switchgear.

However, now it is clear that SF_6-free alternatives for MV switchgear are available on the market, there should be a split between HV and MV switchgear in policy making and additional measures should be taken to limit the use of SF_6 for MV switchgear. This should lead to a legal ban of SF_6 on all applications where alternatives are available. The development and use of SF_6-free technologies should be stimulated by government policy as well.

Corporate Social Responsibility

Over the recent years we have seen a trend of increasing professionalism within the asset management departments 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. Recent independent evaluations show that SF_6-free switchgear is not only technically equivalent, but also cost-competitive over the complete Life Cycle.

As a consequence of their Corporate Social Responsibility programs there are already several leading utilities and industrial companies that have chosen for SF_6-free switchgear in their MV-networks. This is also stimulated by the insight that companies need to base their vision, mission and strategy on more dimensions than only shareholders value. SF_6-free switchgear is really a must in respect to this Corporate Social Responsibility and with the growing trend to sustainability in our society.

Green Switching Platform Oosteinde 237, 2271 EG Voorburg, Postbus 123, 1234 AA Voorburg, The Netherlands
Tel. +31 (0)70 354 9000, Fax +31 (0)70 350 3145, Email: info@schoonschakelen.nl, www.greenswitching.com