BACK

IN DEPTH

g^3 heralds a new technological era in the T&D field

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GIS G³ INSTRUMENT TRANSFORMERS SF6-FREE SOLUTIONS SF_6

A more environmentally friendly alternative to SF_6 in power equipment is a breakthrough. But developing products incorporating such a brand new technology is another matter – one that requires considerable effort and exhaustive testing. That is now showing results, with two g^3-compatible products to date: current transformers and gas-insulated busbars.

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When the g^3 gas mixture was announced last August during the CIGRE 2014 session as an alternative to SF_6, it was a major step in an effort to dramatically reduce the SF_6-engendered part of the carbon footprint of high voltage equipment. The next step is to make products available using the new gas mixture. This is what GE Renewable Energy's Grid Solutions business is now doing.

Although SF_6 has undeniable qualities – its arc quenching and dielectric insulation capabilities – its global warming potential (GWP) is 23,500 times that of CO_2, with a lifetime in the atmosphere of over 3,000 years. Hence the urge to replace it in HV equipment. Two candidates were chosen as “pioneers” in which to replace their SF_6 insulation by the g^3 gas mixture: a 245 kV current transformer (CT) and a 420 kV gas-insulated busbar (GIB). Both were selected because customers were keen to validate their feasibility with a view to installing them, and some customers are participating in pilot projects.

1 __Current transformer: g^3 for application down to -30 °C

Zoltan Roman, R&D Director for Conventional Instrument Transformers, confirms that approach. “Initially the current transformer was chosen because a German customer was interested in a pilot project, and we were convinced that we could make a g^3 version available rapidly. The 245 kV CT, originally designed for SF_6 insulation, was selected as this system voltage is in the mid-range of high voltage transmission voltages and therefore highly representative of the technology.

245 kV g^3-insulated current transformer

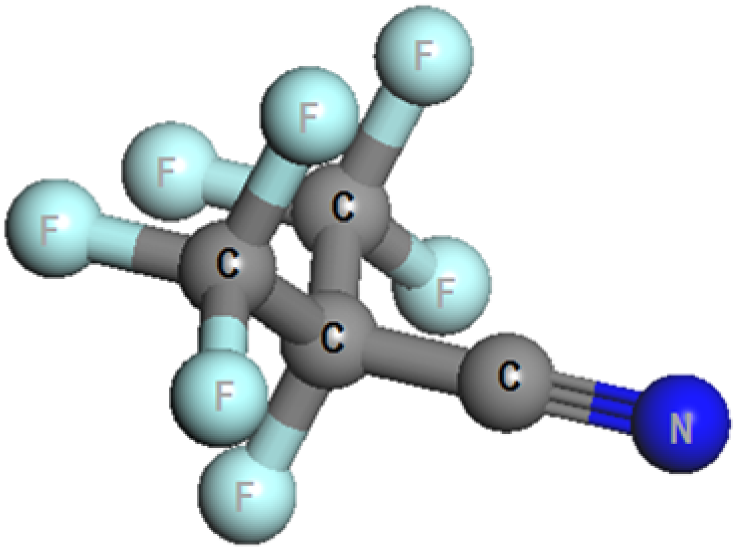
The gas-insulated high voltage CT, which is used to measure the current and to relay the data, underwent a whole battery of tests successfully – routine, type and special tests as specified by the IEC 61869 standard. “The tests were carried out in independent and certified laboratories to demonstrate the electrical and thermal behaviour of the g^3 gas mixture,” adds Roman.

The range of dielectric tests that were performed at p2 pressure (the second alarm pressure, which is the lowest operating pressure of the equipment) included:

- Applied Power Frequency Withstand Voltage (PFWV). This is the highest voltage to which the equipment will ever be subjected, and then only during testing. This test is performed at 50 and 60 Hz, and the test time is one minute. It is designed to ensure that at extreme overvoltages the equipment is still operational. The PFWV is usually 2.5 to 4 times the normal operating voltage. For 245 kV equipment the PFWV is 460 kV, while the maximum operating voltage is 170 kV.
- Wet PFWV.
- Basic Impulse Level (BIL). This is a fast rising and falling, impulse-like signal designed to simulate lightning stress to which the equipment may be subjected during operation. For a 245 kV system, the BIL is at a peak of 1,050 kV.
- Partial discharge (PD) up to 460 kV.
- Capacitance and dielectric factor measurement at 10% and 100% of the nominal line-to-ground voltage.
- Withstand test at -33 °C ambient temperature after thermal equilibrium has been reached, at 1.2 times the nominal line-to-ground voltage for 15 minutes.

Roman adds: “The current transformer passed all these tests successfully and proved that the g^3 gas mixture is electrically equivalent to SF_6 in our designs of high voltage current transformers, without modification in the design of most of the parts."

Ageing tests were also conducted with g^3. "Here, the sealing material was subject to particular attention," Roman explains. "g^3 is a composition of a new 3M Novec™ molecule and CO_2, the latter being the dominant gas in the mixture. Therefore, a larger leakage rate could have been expected with the pre-existing seals. So we opted for a different material for sealing. A new seal was rapidly developed and proven for service, and a new density meter is also being used because of the increased pressure in the g^3 CT."



Novec™ 4710: A new compound developed specifically by 3M™ for dielectric applications, fluorinated nitrile

After the success of the tests on the 245 kV CT, the g^3 gas will be tested on ultra-high voltage instrument transformers – first a 420 kV CT, followed by a combined 420 kV current and voltage transformer.

2__g^3 in gas-insulated busbars for application down to -25 °C

Grid Solutions' 420 kV GIB is also a g^3 pioneer. As Elodie Laruelle, Grid Solutions Eco-Design Engineer, proudly points out, “It will be the first g^3 product to be energised and that will happen in the UK."

Here again, a customer demand was a key driver. UK’s National Grid wanted to undertake a pilot project with the 420 kV GIB for its new Sellindge substation, which is an important element in National Grid’s expansion programme. Mark Waldron of National Grid says: “We have established targets to reduce greenhouse gases and made clear to Grid Solutions that we would be interested in trialling their g^3 solution for the outgoing busbars at the Sellindge site. What is exciting for us is that g^3 is the first commercially viable SF_6 alternative, opening the way for reducing or eliminating SF_6, and that is really important for National Grid.”

The g^3 GIB has been fully type-tested according to IEC standard 62271-203. “The equipment successfully passed the dielectric type-tests performed on an arrangement with composite bushing and busbar elements, i.e. lightning impulse, switching impulse and power frequency test voltages, as well as temperature rise tests to meet the same performance levels as GIS with SF_6,” Laruelle points out.

Dielectric test on a 420 kV busbar

There are two different g^3 mixtures for busbar applications. The first GIB version is filled with g^3 containing a lower proportion of Novec™ 4710 but with a moderate overpressure of CO_2, which requires the equipment to be adapted slightly. This solution can achieve a lower operating temperature limit down to -25 °C. The second version has a higher Novec™ 4710 content for a lower operating temperature limit of -5 °C, but without the need for any design adaptations as the slight overpressure is compatible with the existing design.

Because of its different chemical properties, SF_6 cannot simply be replaced “as is” by g^3 in the GIB. Laruelle explains: “We developed a certain number of innovative technical upgrades for the product such as sealings, absorbers, monitoring devices and filling valves, as well as for manufacturing and on-site tools.”

This part of the development also included various tests to check long-term behaviour of the gas and material compatibility. For instance, new sealing materials were tested and validated for both g^3 and SF_6 gases. Tests showed that the gasket size and groove design required no modification and are compatible with existing gas-insulated busbar designs. Other tests were carried out to assess the behaviour of the equipment under abnormal conditions such as PD behaviour in the presence of particles or internal fault test.

Also, a new gas filling device was a focus of development efforts to ensure that the GIB is correctly filled and that the homogeneity and precise gas ratio are respected. The standard SF_6 device cannot be used but alternatives exist, and Grid Solutions continues to work closely with gas equipment suppliers to develop dedicated g^3 filling equipment, including valves and gas checking equipment.

3 __Coming soon...

These new g^3 products represent a major advance in replacing SF_6 as an insulation medium in high voltage equipment. The next step is to replace SF_6 in switching equipment. The testing required for this is well under way.

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