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GROUP REF. : A3
PREF. SUBJECT :PS2
QUESTION N° : Q9

The special reporter claims that there are conflicting reports on the temperature rise performance of SF_6 alternatives. This contribution highlights the factors that influence temperature rise performance, adds findings from the working group A3.36, and addresses the claimed conflict in the aforementioned reports.

Temperature rise is a balance between heat generation and heat dissipation, which are discussed in detail in TB 830 from WG A3.36. Heat generation is mainly driven by current flow and the related power losses. Heat dissipation or cooling depends strongly on the design of the particular switchgear in question. In order to understand the heat dissipating conditions a brief overview of the heat transfer for a metal-enclosed switchgear is shown in Figure 1.

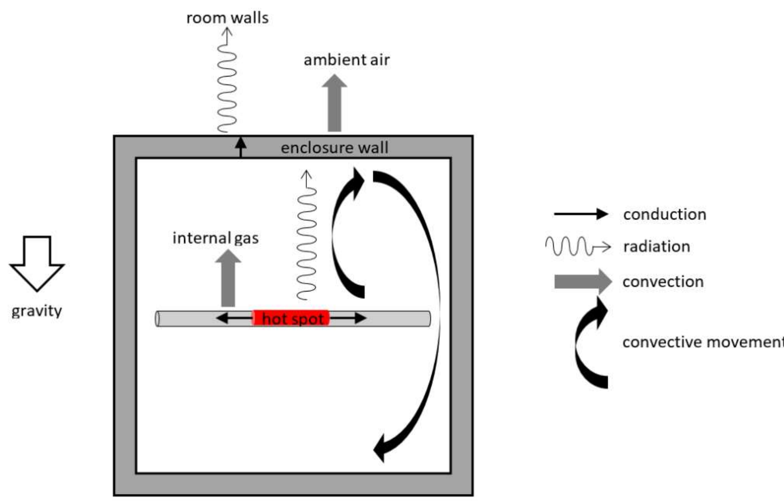

Figure 1: Heat transfer inside and outside a sealed switchgear enclosure.

First, the heat transfer inside the enclosure is considered. Heat is transferred by conduction from the hot spots (e.g., contacts) to cooler parts of the current path. The gas inside the switchgear is heated due to convective heat exchange with the current path. Buoyancy causes convective movement of the internal gas, which transfers heat to the inner walls of the enclosure. In addition, all parts inside the enclosure with an over-temperature will transfer energy to the inner walls of the enclosure by radiation.

Second, the heat transfer from the enclosure to the ambient air has to be considered. The heat is transported by conduction across the enclosure walls. If the enclosure is hermetically sealed, cooling of the enclosure can only be achieved by heat transfer from the outer walls to the surroundings by radiation and convection.

It can be concluded that convection inside the equipment is the only part of the heat transfer mechanism that depend on the gas or gas mixture. All other heat generation effects and heat dissipation effects strongly depend on the design of the equipment. Comparing temperature rise results for different gases therefore requires excluding any impact of differences in design.

WG A3.36 developed test devices to conduct a benchmark study on multi-physics simulation tools to calculate temperature rise. The WG concluded that the performance prediction of a temperature rise simulation can be done when the simulation model is calibrated with previous resistance and temperature measurements.

As part of the benchmark study temperature rise tests were done with different filling pressure, test current and insulation gases. For example, the difference in temperature rise between synthetic air and SF_6 at a filling pressure of 4 bar and a continuous current of 2000 A was measured to be 7 K. The design was kept the same for the different tests.

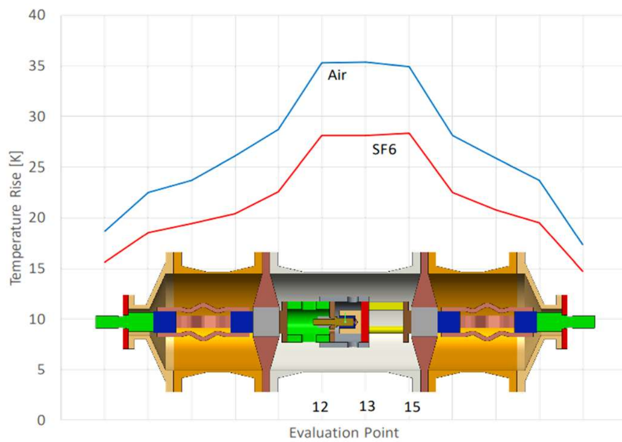

Figure 2: Tests at 4 bar filling pressure and with a test current of 2000 A, gas: synthetic air and SF_6

Tests with different filling pressure (1.5 bar, 4 bar and 5 bar) showed a lower pressure rise for both gases with increased filling pressure.

One of the reports the special reporter claims conflicts with others, 10658, finds that a specific C4-FN / CO_2 / O_2 mixture has a lower convective performance compared to SF_6. This is partly compensated by a higher filling pressure. Direct experimental and numerical comparison of the convective performance (performed in the same setup without design changes) revealed that the C4-FN gas mixture resulted in, on average, a 12 % higher temperature rise of the circuit breaker. The report further mentions that small design changes to the equipment would be sufficient to compensate for this remaining difference.

The other report, 10657, that the special reporter claims is in conflict describes temperature rise tests in a so-called pressurized air insulated cable. The temperature rise measurements presented are done only with air at a filling pressure of 11bar. A discussion on the impact of different gases or the impact of the design is not possible. The test result cannot be compared against the other reports.

The third report, 10126, mentioned by the special reporter notes that SF_6 has a lower temperature rise compared to its alternatives. However, as the operating pressures of SF_6-alternative-based equipment are generally higher, part of that difference is compensated. The report further states that for the same pressure and test object, a slightly higher temperature increase is observed with technical air or a CO_2 / O_2 mixture compared to C4-FN / CO_2 / O_2 and that small design adaptations permit the nominal current capability to be maintained while achieving the same footprint for the C4-FN / CO_2 / O_2 gas mixture based equipment as for SF_6 equipment.

As discussed above there is no conflict between the different reports. It can be concluded that specific C4-FN gas mixtures have a higher temperature rise than SF_6. However, this difference can be partly compensated by a higher filling pressure. Small design changes to the equipment are sufficient to achieve the same performance with the C4-FN gas mixture as with SF_6.