# SPECIAL REPORT A3 PS2. QUESTION 9

# MV HEAT RISE FACTORS FOR C4-FN MIXTURES IN NORTH AMERICA

**Application and design**

MV gas insulated switchgear in North America is required frequently to fulfill some unique requirements, naming some of them:

- Compactness
- Customization
- Capable to be exposed to environment
- Design flexibility

From these requirements, the design variables that have an impact on the thermal performance regarding heat-rise are: heat dissipation, conductor size, material and shape, contact resistance and gas media. Gas media will be the focus of this analysis.

Regarding the material and limits of temperature, the IEEE C37.74-2014 (Table 5) list the maximum total temperature and the temperature rise at ambient when the device is exposed to solar radiation and when it is not.

With all this factors and understanding the variety of applications, design of switchgear can be performed. However, the design requires analytical and empirical methodology.

**Testing and simulation**

Two tests were performed. Test 1 focused on single and three busbar simple configurations. Butt bolted connections between straight conductor of 0.25”x1.25”section. The temperature was monitored by using thermocouples, with filling pressure of 1.7bar absolute at 22C for all gases. Three gas media were tested, three times each to account for changes in the contact resistance or any other variability: SF6, CO2 and C4-FN and CO2 mixture in a 15/85 mol ratio. The tests performed used 630A and 200A.

Test 2 took an existing SF6 rotary breaker and filled with SF6 and CO2. Thermocouples indicated the temperature rise at different points of the breaker for both gases at 1.7bar absolute at 22C for all gases. The test performed used 630A.

Both tests show an agreement between SF6 and CO2 performance of about 5 to 10% temperature increase with respect to each other. The CFD analysis for both gases showed an agreement with up to 10% error from the tested values. For 15/85 mixture, the temperature increase was lower than for CO2, being between 2 to 5% higher than for SF6.

**Conclusions**

CO2 shows the worst thermal performance, with 5 to 10% temperature increase higher than SF6. On the other hand, C4-FN mixed with CO2 at 15/85 mol ratio it’s a middle ground, showing a 2 to 5% increase with respect to SF6 for the same configuration.

For all tests, the temperatures recorded were lower than the temperature limit of the materials in SF6.

The simulations performed with the model tested show the estimated heat-rise temperatures for an increase/decrease of the contact resistance between 0 to 200%, and an increase of the current from 630A rms to 1000A rms for SF6 and CO2.

New SF6-free designs will require heat-rise analysis to confirm that they meet the heat-rise requirements per the standard applicable.