Paris Session 2022

Importance of oxygen in C4-FN, CO_2, O_2 gas mixtures for circuit breakers

A3 - High Voltage Equipment

PS2 + Q13

A variety of C4-FN based mixtures (with and without oxygen) exist…

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Oxygen is an important constituent of C4-FN-based mixtures used in high-voltage circuit breakers

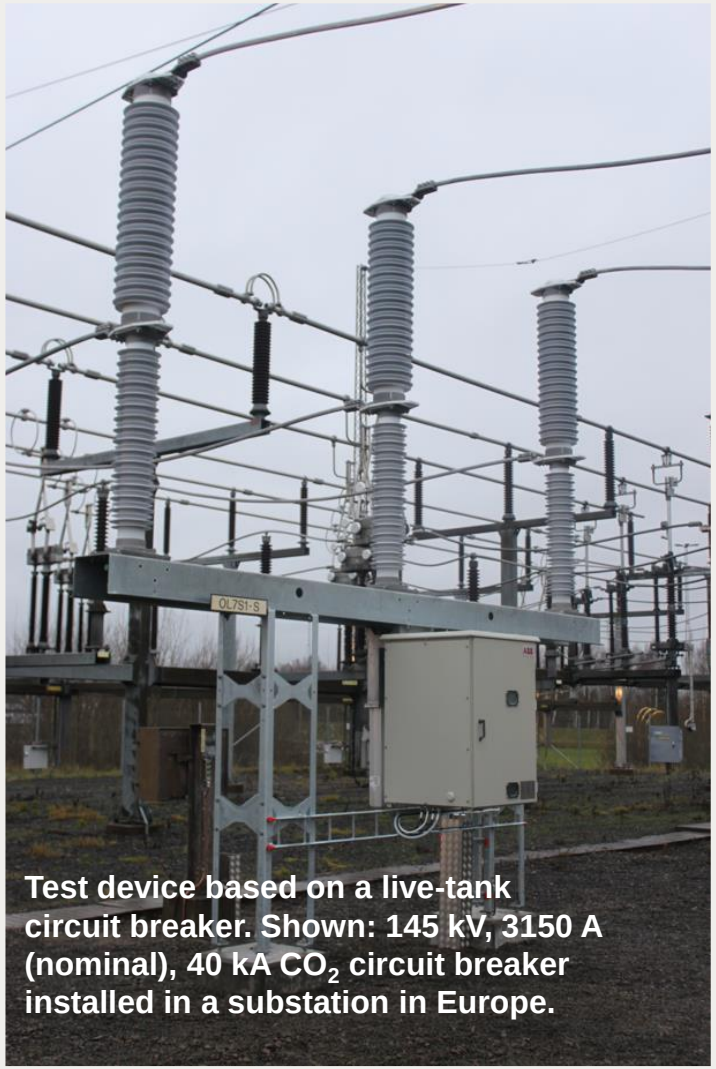
- Some C4-FN is decomposed in arc zone during short-circuit current interruption events, which can result in formation of solid, conductive carbon (graphite)

→ **Adding oxygen can prevent the formation of solid carbon**[1]

- Presence of conductive carbon on insulators can result in reduced dielectric strength, initiation of partial discharge, and even flashover in electrical equipment
- Extensive laboratory tests confirm that exothermic reaction of C4-FN with oxygen does not result in any practical problems for gas mixtures used in electrical equipment, even when considering severe conditions such as internal arc faults
- Oxidation that results from presence of oxygen does not have a negative impact on high voltage electrical equipment if appropriate materials are used

[1]E. André-Maouhoub et al., “Production of Graphite During the Extinguishing Arc with New SF6 Alternative Gases.” *Plasma Chemistry and Plasma Processing.* **40**, 795-808 (2020).

Controlled laboratory tests on a circuit breaker



Test device based on a live-tank circuit breaker. Shown: 145 kV, 3150 A (nominal), 40 kA CO_2 circuit breaker installed in a substation in Europe.

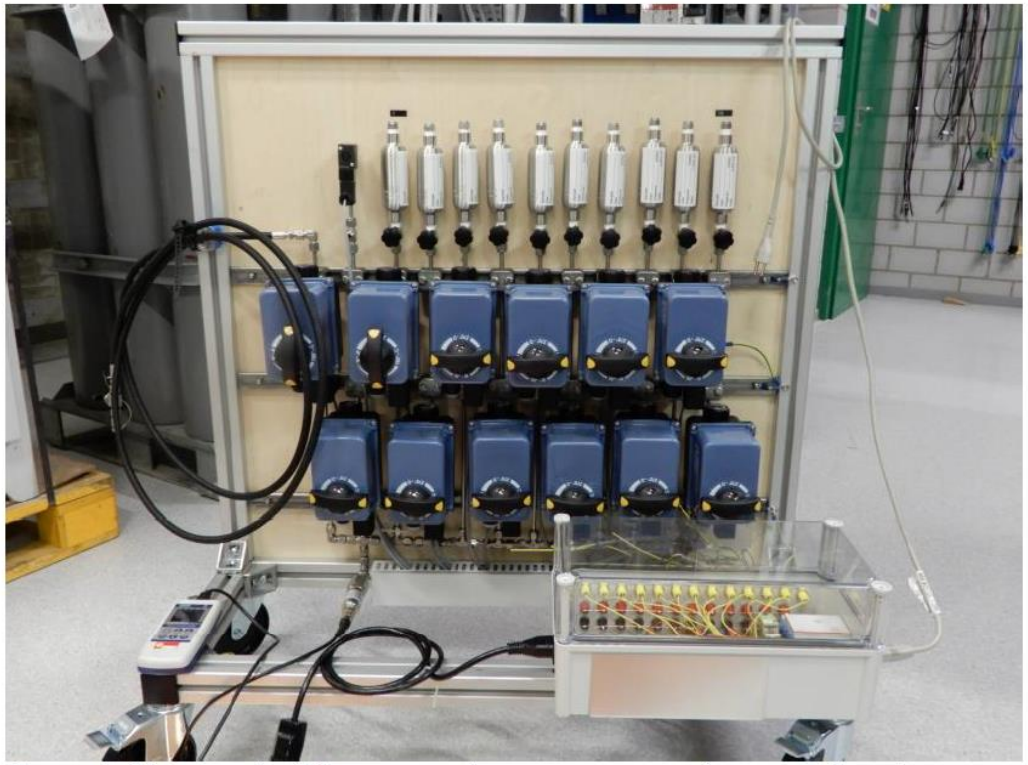


Figure 3. Photograph of the gas-sampling equipment used to remotely and automatically acquire gas samples during the short circuit current arc tests.

Gas sampling equipment

Practical example – influence of oxygen concentration on circuit breaker switching dust

- Tests in a circuit-breaker test device in the laboratory show that there is a clearly visible difference in the switching dust generated (CO_2 / O_2 gas mixture).
- In the absence of oxygen the switching dust has a different color and consistency and a higher electric conductivity.
- Qualitative assessment: much more switching dust is generated in the absence of oxygen.