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Question: Report 10103 states retro-fill can be realized with C4-FN/CO2 without exchange of sealing material. This seems to in contrast with the findings of authors of 10656 who recommend replacement of the EPDM (SF_6) gaskets with buthyl type for CO_2 carrier gas and the use of N_2 carrier in retro-fill? Can specialist share experiences on the optimum gas mixture and material compatibility?

Sealing Materials for Retrofill

The carrier gas of C4-FN based gas mixtures has a major influence on a variety of properties of the switchgear. Two main carrier-gases are in use: N_2 and CO_2. Those carrier gases, usually with a concentration of >80 mol% in total (in the gas mixture) and thus play a major role in definition of sealing material.

CO2-based mixtures
Gas mixtures of C4-FN/CO_2 and C4-FN/CO_2/O_2 are a commonly used as SF_6 alternative for newly developed equipment: report 11118: 1000 kV GIL, report 10659: 145 kV LPIT, report 10126: various switchgear and GIL, report 10136: 17.5…38 kV load break switches, report 10656: 420 kV GIS + various switchgear, report 10658: 145 k V GIS CB, report 10799: 170 kV GIS, report 10966: 170 kV GIS, report 10317: 245 kV CB, report 10848: 245 kV/420 kV GIS CB, report 10102: 420 kV GIS.
Furthermore, it is used to retrofill existing, installed SF_6 equipment: 10103 (420 kV GIL)

N2-based mixtures
In one report C4-FN/N_2/O_2 is used to retrofill existing SF_6 equipment in the installed base: report 10656 (420 kV GIL)

Selection of carrier gas
CO_2 is the dominant carrier gas for new SF_6 alternative equipment for a wide variety of HV equipment and the only choice for HV gas circuit breakers. On the other hand, N_2 can be interesting carrier gas for Retrofill application for compartments other than gas circuit breakers, due to its permeation properties, see Figure 1.

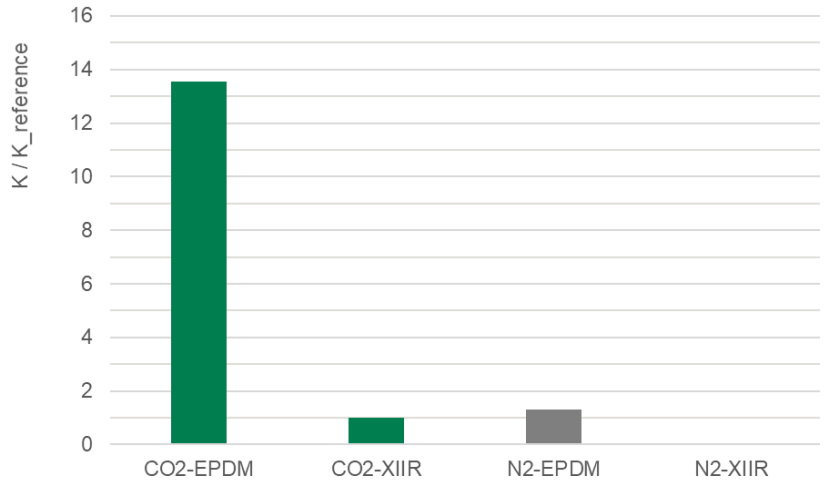

Figure 1. Relative permeation coefficients of CO_2 and N_2 for two different elastomer sealing materials at 20°C

Permeation rate

The permeation rate is strongly dependent on temperature, gas and sealing material.
CO_2 based gas mixtures with EPDM are expected to exhibit an increased permeation by more than a factor of ~10, compared to N_2 based mixtures. Comparing N_2 with EPDM and CO_2 with XIIR sealings shows the permeation rate is in the same order of magnitude. Retrofill as presented 10656 uses N_2 based background gas and therefore a change of sealing material is not required.

Generally, retrofilling of existing SF_6 equipment with an SF_6 alternative also requires type testing of the existing design with the SF_6 alternative, as well as qualification of the existing materials for the SF_6 alternative, see also 10656 and B3 GDM contribution PS2 Q2 (Freddy von Arx).

To conclude on the posed question regarding selection of sealing materials for retrofill: the choice of gas mixture influences the choice of sealing material:

C4-FN/CO_2 and C4-FN/CO_2/O_2

If CO_2 is used as a carrier gas, the sealing material should be changed to XIIR, in case EPDM is installed. This causes significant onsite work for exchanging the flange sealings and other sealings.

C4-FN/N_2/O_2

Using N2 as a carrier gas allows the continued use of EPDM sealings and therefore allows a much leaner on-site work scope, faster exchange and overall lower outage time.

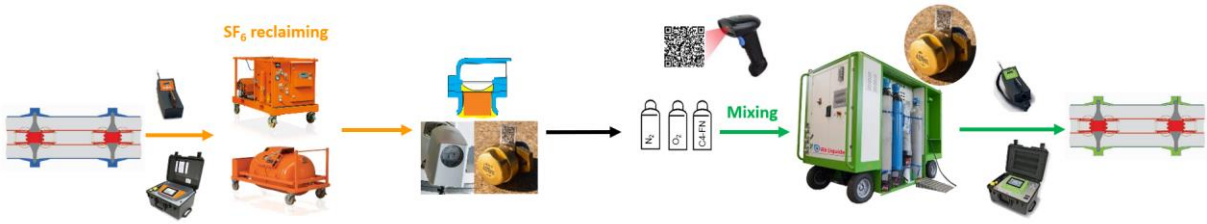

Figure 2: Retrofill of SF_6 equipment with C4-FN/N_2/O_2 onsite work procedure: Check SF_6 gas quality and tightness; reclaim SF_6; replace density monitors, filling ports and desiccant; fill in C4-FN/N_2/O_2; check C4-FN/N_2/O_2 gas quality and tightness