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Study Committee B3

Substations & Electrical Installations

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Improved sealing of SF_6 gas insulated switchgear compartments

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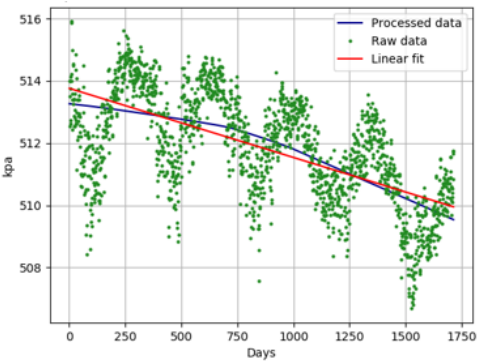
Motivation and summary

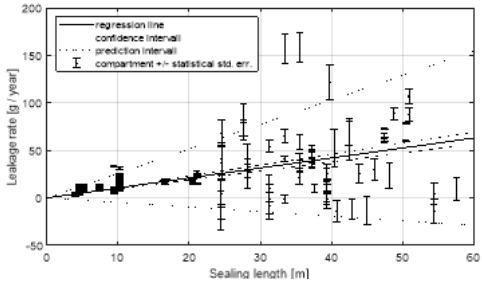
- To address high global warming potential of SF_6 in the atmosphere, efforts have been made to further reduce SF_6 loss to the environment based on customer requests and revised IEC 62271-203 standard for gas-insulated switchgear (GIS)
- Study of field data from substations located around the world shows that seal length plays key role in determining SF_6 loss from electrical equipment
- Laboratory studies under controlled conditions at 20 °C and 60 °C demonstrate that IIR O-rings lead to reduced SF_6 loss compared to EPDM O-rings

Field study

- Density measurements in several thousand EPDM O-ring equipped GIS compartments in the field
- Unlike pressure, gas density (and temperature) is not necessarily homogeneous in a gas compartment—ohmic losses heat inner conductor; solar radiations heats enclosure
- Sample measurement (before and after removal of seasonal variation and short-term fluctuations):



- Data show that SF_6 leakage rate increases with seal length, demonstrating that permeation plays a key role
- Larger compartments (typically located outdoors) exhibit larger fluctuations: weather has bigger impact, lower absolute leakage rates in large compartments
- Indoor: 1.35±0.04 g / year / m; outdoor: 1.09±0.23 g / year / m
- Presence of switching device: no impact on average leakage rate

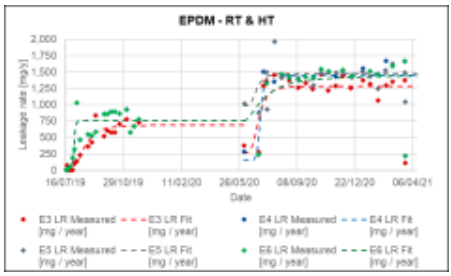


Factory measurement setup

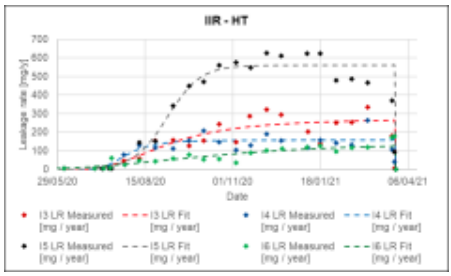
- Twelve identical factory modules were tested, six with IIR O-rings and six with EPDM O-rings
- DILO SF_6 tightness testing vacuum chamber + "bagging" tests
- **Test 1:** > 5 months at ambient temperature, biweekly measurements
- **Test 2:** 260 days at 78 °C ("exaggerated worst-case scenario")

Results of factory measurements

- Data for EPDM O-rings – step in July 2020 corresponds to start of Test 2 at higher temperature
- Steady-state at ambient temperature reached after about 1-2 months, corresponding to time needed for O-ring saturation

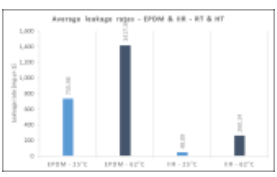


- Data for IIR O-rings – only for 78 °C tests, since no measurable SF_6 loss at ambient temperature
- Saturation only reached after 4-7 months; leakage dropped to almost undetectable levels after cooling to ambient temperature at end of test



Conclusion

- Field study: Permeation through O-rings is main systematic source of SF_6 loss from high voltage GIS
- Factory study: Use of IIR O-rings can substantially reduce already low SF_6 leakage rates of EPDM-equipped GIS by an order of magnitude



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