

NAME : Peter Gronbach, Sylvio Kosse
 COUNTRY : Germany
 REGISTRATION NUMBER : 5390

GROUP REF. : A3
 PREF. SUBJECT : PS2
 QUESTION N° : Q 7

SC A3 – Transmission and Distribution (T&D) Equipment
 PS 2 – Decarbonisation of T&D equipment, SF₆ Alternatives
 Q7 – The filling pressure of equipment with natural-origin gases is often above 1 MPa. Is there any experience or an estimate on the long-term leakage or other lifetime limiting mechanisms, including mechanical damage, deformation of internal parts, e.g., vacuum interrupters at 0 MPa?

Title: Design Experience with Clean Air insulation for switchgear and equipment

As an example, for long term experience with high pressures of synthetic air > 1 MPa the BISEP GIS 170 kV/ 50 kA with air-blast CB & air-insulation - commissioned with 88 bays in the Netherlands starting from 1970s (see figure 1) can be considered. The filling pressure is 1,8 MPa and most of the bays are still in service. A retrofit program was carried out 2004...2016 with focus on CB. The GIS is designed as a controlled pressure system where no humidity filters are applied. The MTBF of the installed bays is 830 bay-years considered for 1970 – 2022. Compared to the literature figures¹ for GIS built before 1979, which figure is a MTBF of app. 50 bay-years. Failure as in the IEC definition of major failure.

1. Up to now no negative effects in the air insulation or damages of parts due to the high pressure
2. Air is a long-term stable insulation medium and proven for GIS
3. Safe operation guaranteed for the user

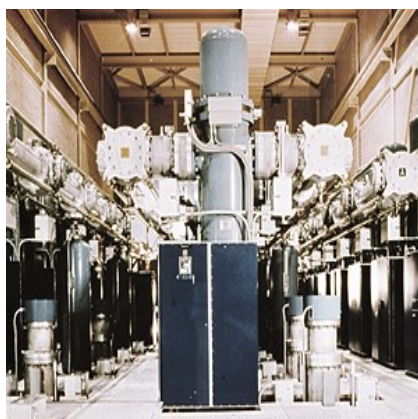


Figure 1: First HV First HV GIS with air-insulation (170 kV, Alblasterdam)

As an example, for the experience of the tightness of vacuum interrupters, vacuum level measurements were performed after operations in service.

- 72,5 kV vacuum CBs were investigated after 4 – 8 years in service and up to 4624 switching operations
 - Vacuum interrupters are hermetically sealed
 - In operation the vacuum level is constant
- No leakage of HV vacuum interrupters were detected

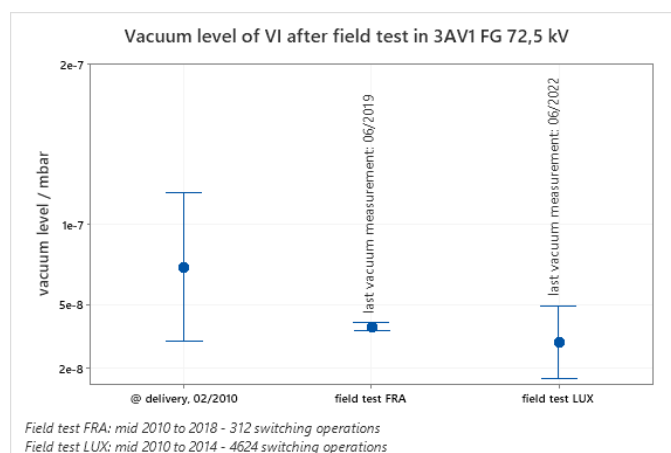


Figure 2: Measurement of vacuum level of VI after operation

Further experience is gained by the recent developments of high voltage equipment with air-insulation.

- For GIS < 420 kV and live-tank circuit breakers filling pressure comparable to SF₆ equipment
- For gas-insulated switchgear and gas-insulated busducts ≥ 420 kV slightly higher filling pressures are considered and covered by switchgear design.
- 420 kV VT, CT and Combi IT were introduced with filling pressures of 1,25 MPa to ensure the same footprint and tech. parameters as SF₆ design by reinforced housing design (see figure 3).
- Explosion proof VT design with highest protection class II and protection stage 2 according to IEC 61869. Internal arc test with an arc current of 80 kA, 0,3s succeeded.
- For circuit breaker application with vacuum interrupter (VI) technology the capability of the VI to withstand the pressure is proven and a key design factor for the CB.

→ For all CA applications tightness measurements as part of type tests, accord. IEC (after mech. Endurance type tests, high and low temp. test, temp. rise test) prove leakage rates similar to SF₆ equipment.



Figure 3: Comparison of Clean Air (blue) and SF₆ (green) 420 kV VT

References:

[1] CIGRE Technical Brochure 513, Final Report of the 2004 - 2007 International Enquiry on Reliability of High Voltage Equipment Part 5 - Gas Insulated Switchgear (GIS), page 64.