IMPACT OF HUMIDITY ON THE EXTERNAL DIELECTRIC STRENGTH OF VACUUM INTERRUPTERS IN SYNTHETIC AIR INSULATION SYSTEMS

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ABSTRACT

Due to the high global warming potential (GWP) of sulfur hexafluoride (SF_6), its application in electrical equipment is increasingly restricted by international legislation, such as the current EU's Regulation on fluorinated greenhouse gases. Consequently, natural origin gases (NOGs) are gaining significant importance as climate-friendly alternatives for gas-insulated systems (GIS) as they offer a very low GWP and ease of handling.

In modern medium-voltage (MV) applications, these gases (and synthetic air in particular) are typically utilized in combination with vacuum interrupters. While SF_6 has been researched for decades, there is limited knowledge regarding the dielectric properties of NOGs under pressurized conditions, particularly concerning the external dielectric strength of vacuum switches. A critical challenge is the influence of humidity, which can enter the system via surface adsorption during assembly or post-assembly through leakages driven by partial pressure gradients [1].

In contrast to SF_6 insulation, where humidity is primarily a concern if condensation occurs on surfaces, oxygen-containing NOGs exhibit a higher sensitivity to moisture within the gas phase. Humidity leads to the formation of $O_2(H_2O)_n^-$ clusters [2], which increase negative ion density and have been shown to influence the partial discharge inception voltage (PDIV) [3].

This work investigates the dielectric behavior of synthetic air using a strongly inhomogeneous electrode configuration (needle-plane arrangement) within a pressure range of 0.15 to 0.5 MPa, and a systematic variation of humidity content from 5 to 5300 ppmv. To characterize the PD inception behavior and determine the breakdown voltage (BDV), various diagnostic methods are utilized, including IEC 60270, UHF, and HFCT sensors. The results provide vital insights for the insulation design of vacuum-based switching equipment and evaluate the reliability of existing PD diagnostic systems under varying environmental conditions.

References

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