Benchmarking the suitability of Novec™ 4710 for application in flux compression generators

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Current data indicates that C_4F_7N (3M, Novec™ 4710) may have many benefits over traditional insulating gases, such as SF_6. For example, data has shown that pure Novec™ surpasses SF_6 electrical insulating properties. However, the data available is primarily for DC or low frequency (i.e. 60 Hz) conditions and at static pressures. For applications such as flux compression generators (FCGs), the operating conditions are significantly different, and we have yet to see any data which is suggestive of Novec™ performance under dynamic stresses similar to those found in FCGs. Here we report a performance comparison of FCGs utilizing air, SF_6, or Novec™ 4710 as the insulating gas. Generators used for this study consist of a single stage, single-pitch helix having an inner diameter of 46 mm (1.8 in), and employing an armature with a diameter of 25 mm (1 in). Direct current seeding is applied to the FCG. In the initial testing, the stator wires are kept bare of insulation to simplify the performance assessment to focus on the different gases. In the experiments, seed current, and load inductance, are explicitly chosen to emphasize the performance differences between Novec™, air, and SF_6 while avoiding statistical variations in other potential flux loss sources that could mask the gas-specific results. The generator dI/dt is monitored using Rogowski coils and provides the primary indications of gas insulation failure, that being sudden deviations or partial collapses in the waveform during FCG operation. The voltage and electric field distributions within the generator during times of observed indications of breakdown are estimated from modeling and simulation. Other comparisons of FCG performance - namely current gain, energy gain, and output voltage - are provided as well. Future research will address the performance of Novec™ 4710 in more practical FCGs that typically have a stator fitted with solid dielectric insulation. Mixtures may be investigated in the future to evaluate what it would take to match SF_6 performance. In this context, we note that for low-frequency conditions, a mixture of 20% Novec™ 4710 with CO_2 already matches the insulating performance of SF_6.

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