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Comparison of breakdown voltage of N2, CO2, SF6, N2-SF6 and CO2-SF6 mixtures: Seeking substitutes for SF6 for high voltage apparatus

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Due to excellent and outstanding properties in both electrical insulation and current interruption performances, sulfur hexafluoride gas, SF6, is the most used gas in high voltage power equipment such as circuit breakers (GCB), switchgears (GIS), and transmission lines (GIL) since 1960s. ; SF6 is one of the best insulators gas known to date. However, by its excessive size and life span (several centuries or even thousands of years), the SF6 molecule is an agent aggravating the greenhouse effect; its global warming potential (GWP) is 23900 times that of CO2. In 1997, the Kyoto Protocol (COP 3) labeled SF6 as one of the global warming gases and began to control its use and emission into the atmosphere. Thus, the international recommendations tend to heavily restrict or even prohibit in the future, its use for preserving the environment. Since then, important researches have been undertaken to find substitutes for SF6 that have less impact on the environment, and compatible dielectric and current interrupting capabilities. Various gases have been considered. Unfortunately all these gases present a high liquefaction temperature as well as a high price. To increase the liquefaction temperature, these gases can be mixed with N2 and CO2. Among these gases, c-C4F8 has a dielectric strength 1.25 to 1.31 times higher than that of SF6 and its global warming potentia1 (GWP) is 36 %1ower than that of SF6. However its liquefaction temperature is too high. The breakdown voltage of c-C4F8-N2 mixture increases with pressure reaching an asymptote. Other mixtures that have been investigated include c-C4F8-CO2, C3F8-CO2, C3F8-N2, C2F6-CO2 and C2F6-N2. Of the mixtures, 20 %C3F8 - 80 %N2 shows the best performance. This mixture enables the GWP to be reduced and its dielectric properties are close to those of 20 %SF6 - 80 %N2 at 0.79 MPa. It clearly appears that it will be difficult to find a suitable substitute for high voltage power equipment even if the last years, some new gas mixtures that are under study seem interesting. In this paper, we present a comparison study of breakdown voltage of CO2, N2 and SF6, and CO2-SF6 and N2–SF6 gas/mixtures under different types of voltage namely AC, DC and lightning impulse voltage in a sphere –sphere electrodes arrangement. The influence of percentage of SF6 in CO2 and N2 and pressure are investigated. The equivalencies between breakdown voltage SF6 and those of mixtures versus pressure are discussed. The economic and safety aspects are also analyzed.

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