

ALTERNATIVE GAS TO SF₆ FOR USE IN HIGH VOLTAGE SWITCHGEARS: g³

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ABSTRACT

The modern transmission and distribution network relies on SF₆ technology because of its remarkable arc quenching properties and dielectric insulation (approximately 3 times greater than air). However, even if SF₆ Switchgears are safe for the environment, the SF₆ insulating gas has potential significant environmental impacts if it leaks into the atmosphere. Indeed SF₆ is one of the six gases listed in the Kyoto Protocol, with a global warming potential that is 23500 times greater than CO₂. Alternative solutions to SF₆ have been researched for a long time. Up to now, no significant success has been achieved in solutions for the transmission network. This paper presents the research conducted with fluorinated compounds to qualify a new gas to be used into high voltage equipment as SF₆ alternatives with properties significantly improved with respect to typical SF₆/N₂ mixtures or others already in use. Potential applications of SF₆-free gas mixture, called g³ and based on 3MTM NovecTM 4710 Dielectric Fluid for dielectric insulation and arc switching into high voltage apparatuses are reported with the aim to be low in toxicity and to reduce the global warming potential of the new mixture by more than 98% by respect to SF₆ with no or minor design modification by respect to typical SF₆ design. Research in progress on arc interrupting capability of this new gas mixture has shown promising results. We expect this new gas mixture to allow a major move towards a new generation of environmentally friendly switchgears.

INTRODUCTION

The gas used most often in High Voltage Switchgear is sulfur hexafluoride (SF₆). This gas has relatively high dielectric strength, good thermal conductivity, is non-flammable and is chemically inert and nontoxic for humans and animals. After being dissociated by an electric arc, it recombines quickly and almost completely.

Nevertheless, SF₆ has the major drawback of presenting a global warming potential (GWP) of 23500 (relative to CO₂ over 100 years), and it has a lifetime in the atmosphere of 3200 years, thus placing it amongst the gases presenting the most potent greenhouse effect [1]. Therefore, 1kg of SF₆ released into the atmosphere has therefore the equivalent global warming impact as 23.5 tons of CO₂.

SF₆ was thus included by the Kyoto Protocol (1997) in the list of gases for which emissions need to be limited and the best way of limiting emissions of SF₆ consists in limiting the use of said gas, which has led industry to seek alternatives for SF₆.

EXISTING ALTERNATIVE

Research was done in past decades on substitutes to SF₆, covering different candidates including common gases (Nitrogen, air, CO₂), perfluorocarbons, and vacuum. All these technologies present advantages and drawbacks.

Available or recently developed technologies:

Traditional gases such as dry air, Nitrogen, CO₂ or their mixtures have the advantage of low global warming potential but very limited dielectric strength up to approximately 40% or less compared to SF₆. Use of such a gas as insulating or current interrupting medium would lead to drastic changes in term of high voltage product design – i.e. either filling pressure or apparatus dimension would be increased by a factor of at least 2.5. Increasing the pressure too much would impact vessels and enclosure design and safety. Increasing the size would directly impact the dimensional footprint and cost of the product making it unsuitable as a replacement product in existing substation. In circuit breaker applications, CO₂ has a higher thermal interruption capability relative to N₂ or Air.

CF₃I – trifluoroiodomethane - presents the advantage to combine high dielectric strength and current interruption capability with a low global warming potential (below 10 relative to CO₂) but is classified CMR category 3 [2, 3]. This means it is suspected to be mutagenic and therefore not suitable for large application in industrial equipment in contact with the public [4].

Vacuum is widely used in the medium voltage domain as current interruption medium. The technology is now well established and has proven to be reliable. Application in high voltage domain at 72.5 kV is now state of the art with pilot application at 145 kV. But due to the intrinsic insulating characteristics of vacuum, its insulation capability being not directly proportional to the insulating gap as it can be for pressurized gas, there is a saturation of the insulation capability for large gaps in vacuum making unlikely to use vacuum interrupters for higher voltage [5]. As a result, the application of vacuum at UHV does not appear to be economically competitive.

Therefore, none of these technologies is economically

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