

# ALTERNATIVE GAS TO SF<sub>6</sub> FOR USE IN HIGH VOLTAGE SWITCHGEARS: g<sup>3</sup>

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## ABSTRACT

*The modern transmission and distribution network relies on SF<sub>6</sub> technology because of its remarkable arc quenching properties and dielectric insulation (approximately 3 times greater than air). However, even if SF<sub>6</sub> Switchgears are safe for the environment, the SF<sub>6</sub> insulating gas has potential significant environmental impacts if it leaks into the atmosphere. Indeed SF<sub>6</sub> is one of the six gases listed in the Kyoto Protocol, with a global warming potential that is 23500 times greater than CO<sub>2</sub>. Alternative solutions to SF<sub>6</sub> 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 SF<sub>6</sub> alternatives with properties significantly improved with respect to typical SF<sub>6</sub>/N<sub>2</sub> mixtures or others already in use. Potential applications of SF<sub>6</sub>-free gas mixture, called g<sup>3</sup> and based on 3M™ Novec™ 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 SF<sub>6</sub> with no or minor design modification by respect to typical SF<sub>6</sub> 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 (SF<sub>6</sub>). 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, SF<sub>6</sub> has the major drawback of presenting a global warming potential (GWP) of 23500 (relative to CO<sub>2</sub> 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 SF<sub>6</sub> released into the atmosphere has therefore the equivalent global warming impact as 23.5 tons of CO<sub>2</sub>.

SF<sub>6</sub> 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 SF<sub>6</sub> consists in limiting the use of said gas, which has led industry to seek alternatives for SF<sub>6</sub>.

## EXISTING ALTERNATIVE

Research was done in past decades on substitutes to SF<sub>6</sub>, covering different candidates including common gases (Nitrogen, air, CO<sub>2</sub>), perfluorocarbons, and vacuum. All these technologies present advantages and drawbacks.

Available or recently developed technologies:

Traditional gases such as dry air, Nitrogen, CO<sub>2</sub> or their mixtures have the advantage of low global warming potential but very limited dielectric strength up to approximately 40% or less compared to SF<sub>6</sub>. 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, CO<sub>2</sub> has a higher thermal interruption capability relative to N<sub>2</sub> or Air.

CF<sub>3</sub>I – trifluoroiodomethane - presents the advantage to combine high dielectric strength and current interruption capability with a low global warming potential (below 10 relative to CO<sub>2</sub>) 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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**O García**

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mixtures e.g. pure N<sub>2</sub>, low concentrations of SF<sub>6</sub> in N<sub>2</sub> and SF<sub>6</sub>/He mixtures for which a smaller yet significant amount of data are available  
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