

Study Committee B3

Substations and Electrical Installations

10894 ID_2022

420kV GIL retrofit guidelines with fluoronitrile-based gas mix

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To support electrical consumption growth (that is expected to increase 50% between 2012 and 2040) there is a demand to develop grid network and build new GIS substations. Climate change is a reality and an alternative to the insulating medium SF₆ (a F-gas with an extremely high Global Warming Potential) is necessary and urgent.

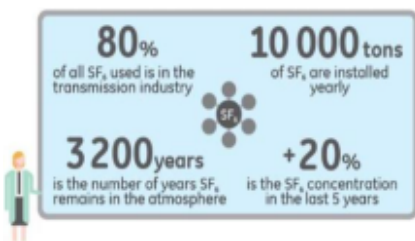
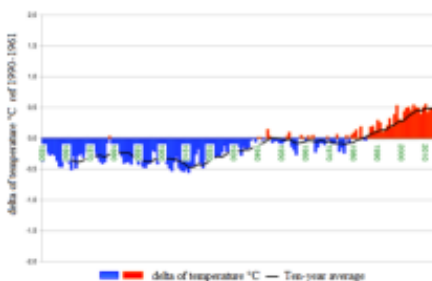


Fig.1 - Overview of SF₆ application in electric transmission industry.



source : Meteo France

Fig.2- Global warming, temperature increase.

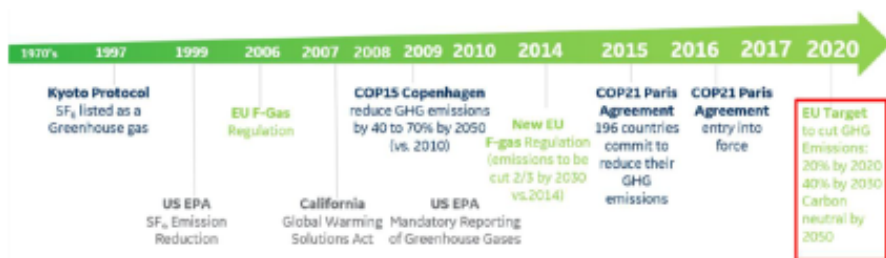


Fig.3- Regulation and restrictions of using F-Gas over the past decades:

Supported and encouraged by authorities, also reinforcement by regulation against F-Gas, manufacturers propose more and more new SF₆-free products.

To adapt these new regulations to existing equipment, what would be the pathway?

Proposing a pathway to retrofit existing GIL, by replacing SF₆:

- Selection of a SF₆ alternative;
- Technical Validation process for retrofitting existing installation;
- Certification program.
- Environmental impact study

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A. SF₆ alternative

continued

SF₆ has incredible technical properties but an enormous impact if released to atmosphere. Specification to replace has a lot of requirements, which can be grouped in different categories:

- Environmental impact;
- Safety for users;
- Technical Performances;
- Cost & Certification.

A mix of fluoronitrile and CO₂ has been selected to provide an alternative to SF₆.

It is necessary a higher pressure than SF₆ to reach similar insulation properties, leading to a technical validation of associated enclosures.

B. Technical Validation Process

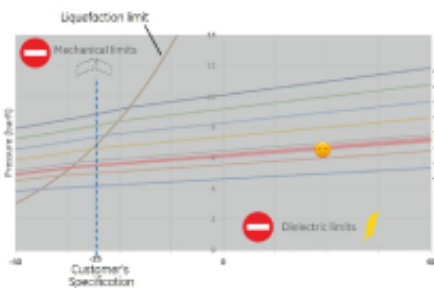
1) Selection of compartment to be retrofitted:

Since there are different properties between Fluoronitrile and CO₂, only passive compartments may be selected to project scope.

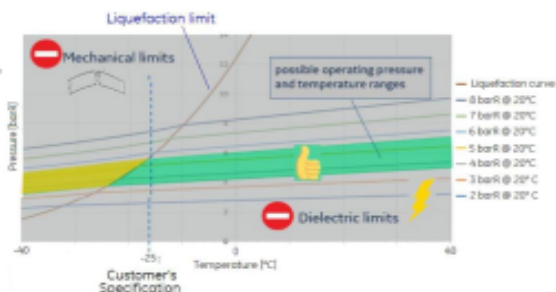


2) Validation of technical properties for existing GIL:

- Stress withstand:
 - Dielectric withstand;
 - Pressure/mechanical withstand.
- Behavior in the range of use:
 - Lack of liquefaction;
 - Heating behavior.



Technical feasibility not ok: out of possible working area. Required pressure to withstand dielectric stress is too high for existing enclosure design.



Technical feasibility ok: under working area.

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C. Certification program:

IEC 62271-203 stated a series of types-test to ensure both safety and technical performances. Here is an example of validation procedure for 400 kV and 550 kV GIL, considering a retrofit for passive compartments:

Type of test	Values checked	
	420kV	550kV
Lightning impulse	± 1425kV	± 1550kV
Switching impulse	± 1050kV	± 1175kV
Power frequency	650kV	710kV
Partial Discharges	<5 pC ar 291kVp/v2	<5 pC ar 381kVp/v2



For temperature rise test, a theoretical calculation can be conducted, if a reference model is available.

SF6-Free mix	Filling Pressure	Bar ø100mm	
		Enclosure Th. 5mm	Enclosure Th. 7mm
C ₄ F ₇ N + CO ₂	4.7 Bar R	64	62
	5.5 Bar R	62	59
C ₂ F ₇ N + O ₂ + CO ₂	4.7 Bar R	67	66
	5.5 Bar R	65	63

Temperature rise (in K°) for fluoronitrile-based gas mix.

D. Environmental impact study for a reference GIL (100m of 420kV)

- Low raw material consumption, manufacturing and shipping lead times are drastically reduced
- For 100m of 420kV GIL, example of potential savings are :
 - Reduction of CO₂ equivalent footprint of 16240 tons;
 - Reduction of leakage impact of 630tons. (leakage rate of 0.5% during 40years)



*Evaluation to be performed project per project for accurate figures

Conclusion

- Retrofitting a SF₆ GIL with C₄-FN mix is submitted to various conditions, but when possible, it allows end-users to modernize installed base.
- It is a cost effective solution as most parts are reused and SF₆ volume is reduced
- Environmental impact is reduced and has immediate effect
- Lifespan SF₆ assets is extended when it could be condemned and dismantled when SF₆ ban rules will be applied