

Possible harmonisation of C4-FN mixtures?

A3 / PS2

Q13: A variety of C4-FN based mixtures (with and without oxygen) and composition ratios (some even undisclosed) is reported. With every manufacturer having its “proprietary gas” could “inter-operability” be realized? Can specialist predict whether a “one-gas-fits-all” solution is waiting at the horizon or at what time horizon convergence of various technologies can be expected?

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C4-FN based mixtures / why different mixtures?

- Different ratios of C4-FN/O₂/CO₂ → additional degrees of freedom to further **optimize the design**
- It seems **too early to freeze ratios**:
 - HV retrofilling of existing SF₆ assets might require higher ratio (20%) of fluoronitrile^[1] than the ones usually implemented in new assets (3 to 6%).
 - MV load break switch^[2] application requiring 10 to 15% C4-FN
- Anyhow for new equipment **convergence** is starting for O₂ content:
 - **13% of O₂** was identified as the **optimum**^[3]

[1] L. Loizou et al., “Technical Viability of Retro-filling C3F7CN/CO2 Gas Mixtures in SF6-designed Gas Insulated Lines and Busbars at Transmission Voltages”, *IEEE TRANSACTIONS ON POWER DELIVERY*, VOL. 35, NO. 5, OCTOBER 2020

[2] A. Laso et al, “Design Considerations for Implementing SF₆ Alternatives for Distribution Switchgear Applications with Focus on Toxicity and Load Break Performance,” in *CIGRE Paper A3-10136*, Paris, 2022.

[3] J. Ozil et al, “Return of experience of the SF6-free solution by the use of Fluoronitrile gas mixture and progress on coverage of full range of transmission equipment,” in *CIGRE Paper A3-117R*, Paris, 2021.

C4-FN based mixtures / why different mixtures?

- Could the **mixtures** based on C4-FN be **jointly defined**?
 - A joint definition by several manufacturer will **remain difficult** as:
 - **Optimum** in design could **depend on the manufacturer**
 - **Changing ratio** of some compound for the ones who have already developed a solution could lead to **re-design** and **re-type-test**
 - **Co-development between OEM** would require sharing information between **competitors**
 - To limit the definition of new mixtures, newcomers in the field of alternatives could select already proposed mixture by other OEM

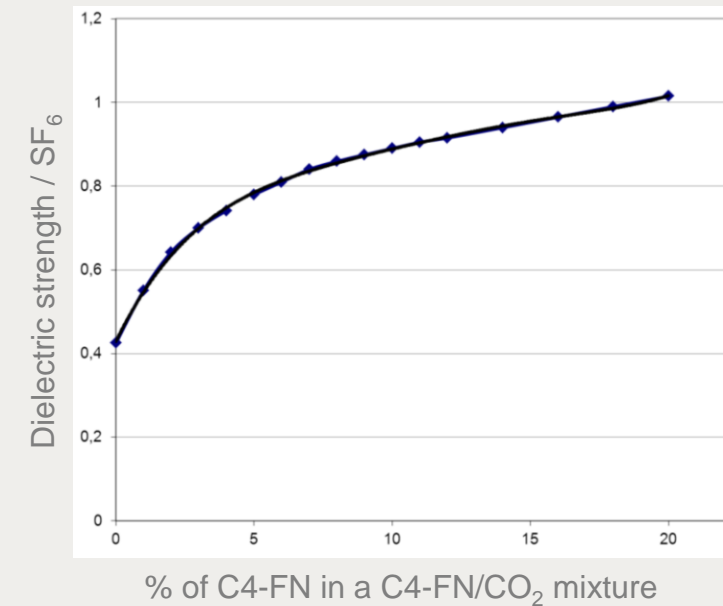
Inter-operability of gas mixtures?

- **C4-FN** being the main driver of **dielectric strength**
→ it is not likely that using any C4-FN mixtures could be used in any type of switchgear validated to be used with a specific amount of C4-FN

Anyhow:

- **all C4-FN mixtures** can be operated with the **same tools**
 - Gas carts
 - Gas analysers

Group Discussion Meeting



One-gas-fits-all? By when?

- **Step by step harmonisation** of C4-FN gas mixtures is coming for new developed equipment.
- Manufacturers having a 10+ yrs experience in C4-FN have been already through this process of **reducing the number of available mixtures**

but...

- As C4FN mixtures are extending their use to a **wider range of applications** to enable **SF6 phase-out**, **it is not likely that a single type of mixture will exist in the coming years.**
 - Recent **retrofit applications**^[4] with N₂ instead of CO₂ have demonstrated interesting capability for refilling existing SF₆ GIL without gasket change
 - Application in **MV voltage** is having specific needs
 - Application outside electrical switchgear (e-beam and others)

[4] L. Chen et al., "Application of SF₆ Alternatives for Retro-filling Existing Equipment", in CIGRE Paper A3-10103, Paris, 2022.

Group Discussion Meeting