

Gas management with SF₆-free gas mixtures

Question Q12: In different projects, different practices of mixing gas components are reported. Authors of 10102 prefer off-site mixing, whereas authors of 10656 describe on-site mixing as “most beneficial”. Can specialist (e.g., authors of 10799, 10966) report on experiences in other projects?

To reduce their greenhouse gas emissions, both utilities and manufacturers are committed to reduce the quantity of SF₆ installed on the network and to migrate to SF₆-free solutions.

About five years ago, the first SF₆-free solutions based on fluoronitrile C4-FN gas mixtures were installed onto the European network. Based on these first and positive experiences, manufacturers of HV equipment are now developing solutions to replace SF₆ products on the complete range of HV equipment.

C4-FN is the gas candidate offering on short term scale the optimum solution to interrupt 63 kA for the classic 420 kV voltage level as commonly used on European network. Other gas candidates exist for lower performances and/or lower voltage levels and this leads to the installation on the network of solutions with multiple gas.

The move from one gas like SF₆ to multiple gases brings some new requirements in terms of gas management during installation and maintenance. In addition to the technical solution for the product itself, manufacturers have developed solutions to manage the gas in laboratory, in production and on site.

In this contribution, we concentrate on filling on site.

Methods of filling gas into HV equipment depends on different factors:

- Type of gas used
- Quantity of gas to be used
- Facility to manipulate the various gases on site

These factors are not new as they were already existing for SF₆ based gas mixture. CIGRE brochure 163 published in 2000 is already comparing the various solutions with premixed deliveries or solutions with mixing on site.

For example, for long GIL with SF₆ based gas mixture (like a mix of SF₆ and N₂), gas mixing on site was widely used. For short GIL connections (typically used for low temperature for instance) pre-mixed gas is used and the ratio between SF₆ and N₂ is depending on the minimum temperature that needs to be achieved. These lead already to some multiple gas management for some utilities.

SF₆-free solutions are commonly based on gas mixtures and therefore, filling HV equipment with gas mixtures will increase significantly in the coming years. Today, more than 25 utilities have already adopted gas mixtures based on fluoronitrile solutions and first 420 kV GIL and 145 kV GIS references have been filled with pre-mixed gases. Manufacturers must facilitate the use of gas mixtures during the life of the equipment

User's expectations were defined in paper A3-10102 and key points are highlighted below:

- Unique identification of mixtures and no use of manufactures' brand or trade names
- Explicit labelling with details of the gas or gas mixture used (type, ratio)
- Mandating types of filling point
- Always possible to obtain pre-mixed bottles for maintenance / top-up activities

For the filling point, one of the user, after consultation with switchgear and gas handling equipment manufacturers, has defined the requirements for SF₆-free solutions. Result is shown in below table. This requirement has been included into its specifications for all applicable equipment.

This table is now used as a basis of discussion within IEC TC 17 committee to look for possible standardization.

Gas / Gas Mixture	Colour	RAL	Connection
N ₂ / O ₂ mixtures	Light Blue	5012	DN20 with M50 thread
Mixtures containing C4-FN (C ₄ F ₇ N)	Yellow Green	6018	DN8 with M28 thread or DN20 with M48 thread
Mixtures containing C5-FK (C ₅ F ₁₀ N)	Telemagenta	4010	DN8 with M24 thread or DN20 with M43 thread
CO ₂ / O ₂ mixtures	Dusty Grey	7037	Malmquist valve with M32 thread

Manufacturer solutions were also defined in paper A3-10102. For instance, for C4-FN solution, a unique type of filling valve has been adopted, with different color and thread compared to SF₆. Collaboration with manufacturers of gas cart has been performed to simplify the process of mixing:

- From manual control of filling → move to full automatic control
- Solutions also for top-up which are different to initial filling

Development is also in progress with manufacturers of gas cart for implementing specific QR code and labelling to facilitate site operations, as shown on following graph.

