



Novec™

Brand

Demonstrated Uses of 3M™ Novec™ Insulating Gases as Alternatives to SF₆ in the Power Sector

Use of 3M™ Novec™ Insulating Gases in Electrical Power Equipment

For decades, SF₆ has been a dielectric medium commonly used in electrical power applications. The end uses include both high-voltage equipment for electricity transmission and medium-voltage equipment used for distribution. However, SF₆ has long been recognized as a potent greenhouse gas and governments have sought to reduce emissions from gas-insulated equipment. While emission rates have been reduced the identification of suitable chemical alternatives to SF₆ in electrical power applications has been needed to further abate emissions from this industry.

3M™ Novec™ Insulating Gases have displayed the necessary performance and safety properties required in many electrical power applications. These attributes, combined with excellent environmental properties, make them a sustainable alternative to SF₆, capable of substantially reducing greenhouse gas emissions from gas-insulated equipment. Several equipment manufacturers evaluated Novec insulating gases and have designed equipment for their use.

Medium Voltage

A large volume of results have been published on the use of 3M™ Novec™ 5110 Insulating Gas in medium-voltage (MV) applications. Gas-insulated switchgear (GIS) containing gas mixtures with Novec 5110 gas have been designed, tested and commercialized. These gas mixtures contain up to 14 volume % Novec 5110 gas diluted with dry air and, in some cases, include oxygen as a minor component. GIS with IEC ratings up to 36 kV, 2000 A @ 50 Hz, 31.5 kA have been commercialized in central and northern Europe. MV primary GIS are designed for temperatures down to -15°C. The MV secondary GIS (ring main units) use a lower concentration of Novec 5110 gas and are rated for -25°C. The circuit breaker and load-break switch in these designs are currently based on vacuum technology with a gas mixture containing Novec™ 5110 gas providing the insulating medium. It has also been demonstrated that low current interruption in a MV GIS with a Novec 5110 gas mixture is feasible for currents up to 660 A and voltages of 24 kV.

Table 1: Commercially Available MV Equipment

The full voltage range of MV equipment can be met with the low temperature thresholds as indicated in Table 1.

Equipment Category	Voltage (kV)	Minimum Operating Temperature (°C)	Space Considerations
Primary distribution equipment	up to 36	-15	Same as SF ₆
Secondary – ring main units	up to 36	-25	Same as SF ₆

High Voltage

Gas mixtures containing 3M™ Novec™ 4710 Insulating Gas and CO₂, or a blend of CO₂ and O₂, have been developed for high-voltage applications. These gas mixtures have been evaluated in a wide range of high-voltage applications including circuit breakers (CB), current transformers (CT), voltage transformers (VT) and gas-insulated lines (GIL). Gas-filled equipment containing 4 to 10 volume percent Novec 4710 gas has been designed, type tested and operated in pilot facilities within each of these application categories. GIL are designed for rated voltage up to 420 kV. The GIS and CT/VT are currently rated up to 145 kV and 245 kV, respectively, and are commercially available in Europe with temperature ratings down to -30°C.

Although work has demonstrated likely efficacy at higher voltages, data to date would support an SF₆ phase out for new equipment at the voltages and low-temperature thresholds specified in Table 2.

Table 2: Commercially Available HV Equipment

Equipment Category	Voltage (kV)	Minimum Operating Temperature (°C)	Space Considerations
GIS including circuit breaker	145	-25	Same as SF ₆
Current and voltage transformers	245	-30	Same as SF ₆
Gas-Insulated Line (GIL)	420	-25	Same as SF ₆

Continued on the next page.

Summary

Table 3 summarizes the types of equipment currently in operation using a 3M™ Novec™ Insulating Gas and the length of experience for each type of equipment. As of May 2018, there were approximately 100 pieces of Novec gas-insulated equipment in operation. All the installations, including the examples in Table 3, continue to run successfully.

New equipment is also being designed with backward compatibility. That is, the gas-filled equipment can, with modifications, be used with SF₆. This feature helps to minimize any perceived risk by the utilities as they move forward with alternative gases.

Equipment Category	Voltage (kV)	Insulating Gas	Longest Date in Service on Grid
Ring Main Units	20	Containing Novec 5110 gas and dry air	November 2015
MV GIS	22	Containing Novec 5110 gas and dry air	May 2015
HV GIS	150	Containing Novec 5110 gas and dry air	May 2015
HV GIS including circuit breaker	110	Containing Novec 4710 gas and CO ₂	October 2017
Current Transformer	245	Containing Novec 4710 gas and CO ₂	April 2017
Gas Insulated Line	420	Containing Novec 4710 gas and CO ₂	April 2017

While some limitations such as the full voltage range currently exist, OEMs continue to expand their equipment designs to span the voltage ratings employing SF₆. Based on the current rate of progress, as the technology matures, Novec insulating gases will be viable alternatives to SF₆ for the majority of electrical power equipment applications.

References:

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Kieffel, Y. and Biquez, F., “SF6 alternative development for high-voltage switchgears,” in Electrical Insulation Conference (EIC), 2015 IEEE, 2015.

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For additional information

For information on additional 3M™ Novec™ Insulating Gases visit our web site at: 3M.com/novec

Smart. Safe. Sustainable.

The 3M™ Novec™ Brand Family

The Novec brand is the hallmark for a variety of proprietary 3M products. Although each has its own unique formula and performance properties, all Novec products are designed in common to address the need for smart, safe and sustainable solutions in industry-specific applications. These include precision and electronics cleaning, heat transfer, fire protection, protective coatings, immersion cooling, advanced insulation media replacement solutions and several specialty chemical applications.

3M™ Novec™ Engineered Fluids ■ 3M™ Novec™ Aerosol Cleaners ■ 3M™ Novec™ 1230 Fire Protection Fluid ■ 3M™ Novec™ Electronic Grade Coatings ■ 3M™ Novec™ Electronic Surfactants ■ 3M™ Novec™ Insulating Gases

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