

Epoxy-based Hermetic Feedthroughs Boost Switchgear Reliability

Hermetic sealing technology keeps switchgear up and running by safeguarding power distribution equipment against environmental ingress.

As the backbone of modern society, power transmission and distribution networks must keep pace with technology advancements as well as changing standards and environmental considerations. Chief among today's concerns are issues related to greenhouse gases and climate change. With regard to power distribution, attention remains focused on finding alternatives to the use of sulfur hexafluoride (SF6) in gas-insulated electrical switchgear. SF6 is widely used in both high-voltage and medium-voltage switchgear due to its exceptional performance as an electrical insulator, enabling more compact equipment designs compared to oil or vacuum insulated switchgear.

Despite its usefulness, SF6 is one of the most potent greenhouse gases with a global warming potential of 23,000 times that of CO₂ according to the Intergovernmental Panel on Climate Change. Due to its extreme potency and lifespan, the Kyoto Protocol has listed SF6 among the major substances whose use and emissions should be minimized. In addition, SF6 is banned in Europe in practically all applications except high-voltage switchgear, and this is only allowed because alternative technologies are not yet economically viable.

With medium-voltage switchgear, greater progress is being made with regard to finding SF6 alternatives. Designs that incorporate dry air or a mixture of fluoroketone, nitrogen and oxygen as the insulating gas are being explored to minimize environmental impact. Oil, vacuum and CO₂ are other common alternatives to SF6. CO₂ seems the most promising future material with claims that it will eliminate 10 tons of greenhouse gases over the switchgear's lifecycle. Regardless of the type of gas used, it is important that all individual



Switchgear feedthrough assembly

components used within the switchgear assembly are compatible. Further, they must be robust and reliable enough to withstand harsh environments, temperature extremes and regular submersion in water.

RELIABLE FEEDTHROUGHS FOR SWITCHGEAR

One of the most important parts of the overall switchgear assembly is the feedthrough used to carry conductor wires in and out of the gas-insulated cavity. Hermetically sealed feedthroughs ensure that water and moisture stay outside of the switchgear while insulating greenhouse gases stay inside, even if the switchgear were to be fully submerged in water. This is especially critical for switchgear installed underground, but above ground equipment also has to be storm hardened for submersion in flood prone areas.

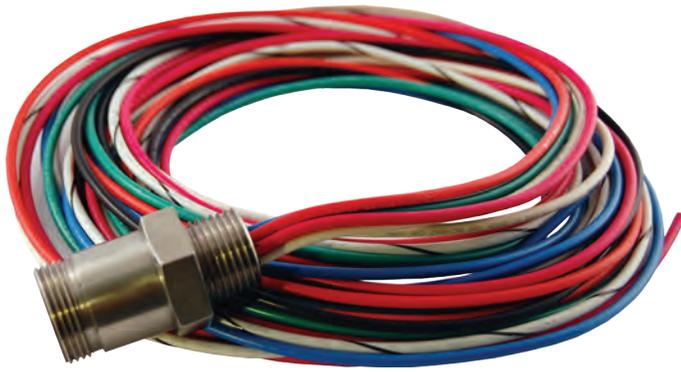
Epoxy-based hermetic feedthroughs are the dominant choice for switchgear applications for a few reasons. For one, epoxy is chemically inert, making it compatible with the different gases used as switchgear insulation. For another, epoxy offers both robust mechanical properties and resistance to temperature extremes. Less capable materials often cannot maintain long-lasting hermetic seals around wires and connectors when exposed to switchgear operating environments.



Integrated waterproof connector and wire harness

LEAKAGE RATE COMPARISON

Helium	Nitrogen	Water Vapor	Air		SF6		CO ²	
cm ³ /sec	cm ³ /sec	cm ³ /sec	cm ³ /sec	grams/yr	cm ³ /sec	grams/yr	cm ³ /sec	grams/yr
5.0E+00	5.6E+00	1.0E+01	5.4E+00	840,000	6.4E+00	1,207,546	6.7E+00	380,681
1.0E+00	1.1E+00	2.1E+00	1.1E+00	168,000	1.3E+00	241,509	1.3E+00	76,136
5.0E-01	5.6E-01	1.0E+00	5.4E-01	84,000	6.4E-01	120,755	6.7E-01	38,068
1.0E-01	1.1E-01	2.1E-01	1.1E-01	16,800	1.3E-01	24,151	1.3E-01	7,614
5.0E-02	5.6E-02	1.0E-01	5.4E-02	8,400	6.4E-02	12,075	6.7E-02	3,807
1.0E-02	1.1E-02	2.1E-02	1.1E-02	1,680	1.3E-02	2,415	1.3E-02	761
5.0E-03	5.6E-03	1.0E-02	5.4E-03	840	6.4E-03	1,208	6.7E-03	381
1.0E-03	1.1E-03	2.1E-03	1.1E-03	168	1.3E-03	242	1.3E-03	76
5.0E-04	5.6E-04	1.0E-03	5.4E-04	84	6.4E-04	121	6.7E-04	38
1.0E-04	1.1E-04	2.1E-04	1.1E-04	17	1.3E-04	24	1.3E-04	8
5.0E-05	1.9E-05	2.3E-05	1.9E-05	3	1.9E-05	4	2.0E-05	1
1.0E-05	3.7E-06	4.7E-06	3.7E-06	5.8E-01	3.9E-06	7.3E-01	4.0E-06	2.2E-01
5.0E-06	1.9E-06	2.3E-06	1.9E-06	2.9E-01	1.9E-06	3.6E-01	2.0E-06	1.1E-01
1.0E-06	3.7E-07	4.7E-07	3.7E-07	5.8E-02	3.9E-07	7.3E-02	4.0E-07	2.2E-02
5.0E-07	1.9E-07	2.3E-07	1.9E-07	2.9E-02	1.9E-07	3.6E-02	2.0E-07	1.1E-02
1.0E-07	3.7E-08	4.7E-08	3.7E-08	5.8E-03	3.9E-08	7.3E-03	4.0E-08	2.2E-03
5.0E-08	1.9E-08	2.3E-08	1.9E-08	2.9E-03	1.9E-08	3.6E-03	2.0E-08	1.1E-03
1.0E-08	3.7E-09	4.7E-09	3.7E-09	5.8E-04	3.9E-09	7.3E-04	4.0E-09	2.2E-04
5.0E-09	1.9E-09	2.3E-09	1.9E-09	2.9E-04	1.9E-09	3.6E-04	2.0E-09	1.1E-04
1.0E-09	3.7E-10	4.7E-10	3.7E-10	5.8E-05	3.9E-10	7.3E-05	4.0E-10	2.2E-05



Water proof pin connector and hermetic feedthrough

In fact, epoxy-based feedthroughs and connectors meet a range of stringent performance requirements to serve successfully in switchgear applications. These include:

- Truly hermetic with leakage rates less than **1 x 10⁻⁹ cc-He/sec** per MIL-STD-883 testing
- Vacuum to 1 x 10⁸ Torr
- Pressure to 15,000 psi
- Temperatures from -100° to 350°F
- Wire gauges from 38 AWG to 500 MCM
- Conductor counts from one wire to 3200 in a single feedthrough
- Cable lengths to 2000 m.
- High-voltage solutions available, greater than 30kV

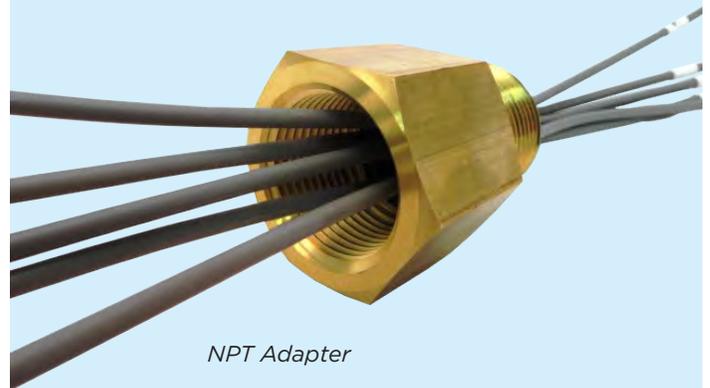
These hermetically sealed feedthroughs and connectors are widely specified in demanding applications such as medium- and high-voltage electric switchgear used for power distribution, switchgear used in communication networks and military equipment requiring 100% uptime in the most demanding environments.

For more information on specific applications involving hermetic feedthroughs for medium- and high-voltage switchgear, contact the engineering team at Douglas Electrical or visit www.douglaselectrical.com.

FEEDTHROUGHS FOR POWER DISTRIBUTION

Power generation and distribution equipment requires reliable cable seals to guarantee the integrity of today's complex electrical grid. Epoxy-based hermetic feedthrough technology ensures that environmental factors are kept out of sensitive equipment, while insulating gases and oils remain intact. Following are a few applications where hermetic feedthroughs are frequently used:

- Medium- and high-voltage switchgear
- Transformers
- Network protectors
- Magnetic bearing flywheels used in smart energy storage
- Alternative energy sources including: High power fuel cells, sterling engines and lithium batteries
- Performance monitoring for power generators



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