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Medium-Voltage GIS Application Note

Medium-voltage (5 to 38 kV) gas insulated switchgear (GIS) differs greatly from the medium-voltage air insulated switchgear commonly used in North America. Instead of using air and solid insulation materials, GIS switchgear has the vacuum interrupter and bare bus conductors in a sealed housing filled with an insulating gas. The differences and associated concerns are highlighted below and illustrated on the last page of this document.

What You Should Know About GIS

Environmental Concerns - The insulating gas used in MV GIS switchgear, sulfur hexafluoride (SF6), is a highly potent greenhouse gas with a global warming potential 23,900 times greater than CO2. SF6 also has an atmospheric life of 3,200 years, so it will contribute to global warming for a very long time. One pound of SF6 has the global warming equivalent of 11 tons of CO2. (Source: EPA website www.epa.gov/electricpower-sf6)

Safety Concerns - In its normal state, SF6 gas is colorless, odorless, non-flammable, and non-toxic to humans. However, under high temperature conditions (> 350 degrees F), SF6 decomposes into products that are toxic and corrosive. Decomposition by-products can occur when SF6 is exposed to spark discharges, partial discharges, switching arcs and failure arcing. These by-products, in the form of gases or powders, can cause the following conditions in humans: irritation to the eyes, nose, and throat, pulmonary edema and other lung damage, skin and eye burns, nasal congestion, bronchitis; powders may cause rashes. (Source: EPA website www.epa.gov/electricpower-sf6)

ANSI certification results in equipment that meets rigorous U.S. operating requirements. GIS equipment is not tested to these standards, and definitely is not tested to IEEE guide for testing metal-enclosed switchgear for internal arcing faults. IEC 62271-200 - metal enclosed MV switchgear, accepts internal arc tests to be performed with air instead of SF6, for environmental reasons. However, it should be noted that the test results may differ if the tests were done with SF6. When a dielectric failure occurs in a GIS, the arc generally will not be extinguished by the SF6, and could lead to internal pressure build up and cause holes in metal walls due to concentrated burning of the arc. GIS manufacturers just state that the GIS equipment is "inherently" arc resistant, but in reality an arc can very well live within the GIS. Also it is well known that all SF6 containments leak, therefore, the chances of having an issue with GIS is more prevalent than ever having an arc issue within non arc resistant switchgear. Utilizing other solutions, such as designs that use complete single pole solid insulation, partial discharge sensors for insulation diagnostics, and remote racking for safety, the non arc resistant solution easily exceeds the safety of GIS.

Special Handling Procedures - Due to the safety concerns, special handling procedures are recommended for heavily arced SF6 including the use of personal protective equipment (PPE - i.e., respiratory device, protective clothing such as rubber gloves, footwear, goggles) for removal/handling of solid SF6 byproducts. Contaminated SF6 gas must either be filtered on-site using special mobile equipment or removed for off-site filtering or destruction using trained personnel. (Source: EPA website www.epa.gov/electricpower-sf6)

Installation Concerns - The most significant installation issues involves the need for proper alignment. The foundation must be level and in a single plane to allow for proper assembly of the shipping sections. The foundation height can only vary by 1 mm per meter, with a maximum deviation of 2 mm over the full length of the assembly. After installation of the GIS shipping groups, equipment must be sealed and SF6 is filled at site. To maintain dielectric withstand levels, special cable termination is required in GIS. The design also limits number of cables/phase that can be installed in a given circuit. Another issue is power cable connections are not accessible without disassembling the switchgear. (Source: IEEE Transaction on Industry Applications, Vol. 40, No. 5, September / October 2004 and Eaton experience.)

Operation & Maintenance Concerns - Because SF6 gas provides insulation of internal components, draw out circuit breaker designs are not possible. Most local codes require that the design of equipment incorporate a means to visually verify the isolating function of disconnect devices. In the GIS switchgear, this requires a means to visually verify the position of the three-position switch. To meet this requirement, some manufacturers install miniature video cameras, and associated lighting, both mounted external to the SF6 gas enclosure. The video leads are brought to the front panel of the switchgear, and a monitoring device is provided to view the position of the switch. (Source: IEEE Transaction on Industry Applications, Vol. 40, No. 5, September / October 2004)

End of Life / Recycling Concerns - Used SF6 gas must be recovered by trained professionals, then stored and transported in US Department of Transportation (DOT) approved cylinders for the final recycle process. DOT regulations require equipment containing SF6 gas at pressures greater than 25 psig at 68° F to be certified to transport compressed gas. DOT regulations require cylinders of SF6 gas with a gross weight greater than 220 lbs. to include a shipping paper. Recyclers equipped to handle metals exposed to SF6 gas should process the remaining metal parts of the switchgear. (Source: EPRI Guidelines for Safe Handling of SF6, DOT CFR 49 Chapter 1 Subchapter C)

Conclusion

Due to the environmental concerns, installing medium-voltage GIS switchgear is not consistent with the Sustainability Principles and Greenhouse Gas reduction goals of many leading edge corporations and institutions. The safety and special handling concerns could raise issues with internal Environmental Health & Safety policies. Finally, the installation, operation & maintenance and end of life / recycling concerns associated with medium-voltage GIS switchgear can raise the total cost of ownership and may not be the best value solution.

With a global product portfolio, Eaton has a variety of MV switchgear solutions that utilize environmentally responsible and safety conscious medium-voltage insulation materials. These alternative solutions include air insulated and solid insulated switchgear designs that avoid the use of SF6 gas and can offer a lower total cost of ownership over the complete life cycle of your medium-voltage equipment.

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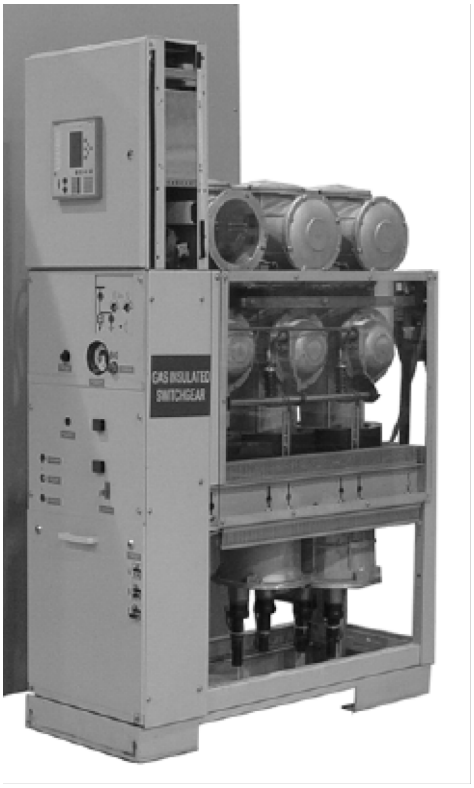
Addition Information

To make a more informed and responsible decision regarding the installation of medium voltage GIS switchgear, consult the following additional material on the Eaton Sustainability web site.

- SF6 PowerPoint Presentation
- SF6 Position Paper
- Technical White Papers
- Downloads and links to other sources of information
  - United States Environmental Protection Agency (EPA)
  - United States Department of Transportation (DOT)
  - Intergovernmental Panel on Climate Change (IPCC)
  - IEEE
  - EPRI

IEEE Transactions on Industry Applications. Vol. 40. No. 5, September/October 2004



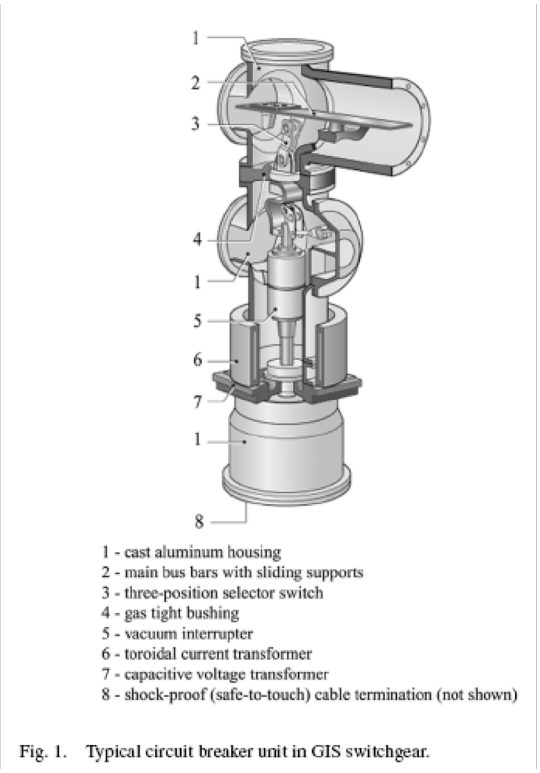


Fig. 1. Typical circuit breaker unit in GIS switchgear.

GIS differs greatly from traditional MV Metal Clad switchgear widely used in North America. A view of one pole of a typical unit of GIS switchgear is shown in Fig. 1. As in air insulated Metal Clad switchgear, vacuum circuit breakers are used for interruption. MV GIS switchgear differs from high-voltage GIS switchgear in that the SF6 gas is used for its insulating properties, not for interruption. Conventional MC switchgear relies on a combination of air and solid insulating materials, but GIS switchgear uses bare bus conductors on insulating supports, immersed in insulating gas.

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