

# Tips for selecting between air-insulated and gas-insulated switchgear

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## Aligning equipment with application considerations

Switchgear provides essential functions: control, protection, and isolation of electric equipment and circuits. Power distribution systems across every application and market use switchgear to support power reliability and enhance safety. Typically, switchgear is installed and expected to work for 25 years or longer.

Despite switchgear's longevity and critical function, equipment selected for a specific job site can be based on past experiences. This method may not always align with current application or job-site requirements.

In medium-voltage applications, selecting between air-insulated switchgear (AIS) and gas-insulated switchgear (GIS) can be driven objectively by understanding the differences between the equipment. Today, the bulk of installed equipment is air-insulated switchgear. Yet gas-insulated equipment can provide advantages in certain applications. As we'll see on the next page, one main advantage of GIS is footprint. In order to determine the right equipment to apply, it is best to understand how the equipment is designed, operated, and maintained.

This paper identifies key considerations for the selection of the type of medium-voltage switchgear used in industrial, oil & gas, utility, data center, and other commercial applications.



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## What's the difference between AIS and GIS equipment?

AIS uses air as the main insulating medium. AIS is further classified as metal-clad or metal-enclosed. Metal-clad switchgear has extensive barriers, shutters, primary bussing covered with insulation, and uses drawout vacuum circuit breakers to interrupt faults.

Metal-clad switchgear is designed, manufactured, and tested to applicable American National Standards Institute (ANSI), Institute of Electrical and Electronics Engineers (IEEE®) and National Electrical Manufacturers Association (NEMA®) standards.

GIS has sealed enclosures filled with insulating gas (sulfur hexafluoride (SF<sub>6</sub>) or mixture of SF<sub>6</sub> and other insulating gases that have been recently released to the market) for insulation and uses fixed-mounted circuit breakers with three-position disconnect switches. GIS switchgear is designed, manufactured, and tested to International Electrotechnical Commission (IEC) performance standards. IEEE standards for metal-enclosed GIS is expected to be released in the near future.

The equipment selection is based on application requirements of customers' power system and operational preferences. Application requirements include: service voltage, continuous current, and interrupting capabilities.

In general, voltage, continuous current, and interrupting ratings are similar between GIS and metal-clad switchgear. Continuous current and interrupting ratings for metal-clad switchgear can reach 4000 A and 63 kA respectively, whereas GIS is typically limited to 3000 A and 40 kA.

## Operational flexibility

Metal-clad switchgear provides more operational flexibility compared to GIS. If application needs changed, modifications to primary circuits and future expansion can be easily made with metal-clad equipment. Primary circuit modifications/future expansion may not be easily made or may not be possible with GIS equipment. Future application needs must be taken into consideration when selecting between metal-clad and GIS.

## Equipment space, size, and location considerations

Due to differences in insulating mediums used in metal-clad switchgear and GIS, there are major differences between the metal-clad and GIS equipment sizes. At 27 and 38 kV, GIS offers a much smaller footprint than metal-clad switchgear. Utilizing GIS at those voltages can reduce the footprint by up to 60 percent, which can save building costs and free up space for other use. At 5 and 15 kV, lineups of metal-clad switchgear and GIS have similar footprints. The footprint savings at 27 and 38 kV are attractive and is one of the main reasons the majority of GIS is applied for 27 and 38 kV applications.

Metal-clad switchgear is widely available for indoor or outdoor applications. Outdoor applications may use outdoor aisle-less or sheltered-aisle type enclosures designed in accordance with IEEE C37.20.2 or may use custom designed electrocenter (e-house). Metal-enclosed GIS is generally used indoors. It requires custom electrocenter for its outdoor applications.

Metal-clad equipment can be installed on a standard leveled foundation and equipment sections can be joined easily using standard tools. GIS equipment requires a precisely leveled foundation for proper alignment of equipment and generally requires a cable vault.

Space for controls and relays is generally limited in the GIS equipment. Simple protection, control, and transfer schemes can be easily incorporated in GIS lineups. Complex control schemes for GIS are best applied using external control cabinets. Metal-clad switchgear offers design flexibility to accommodate complex control schemes to suit any application.

### Application tips:

- For 27 and 38 kV applications, GIS may provide substantial space saving—up to 60 percent compared to metal-clad.
- When equipment is placed outdoors, metal-clad switchgear may be more practical and cost-effective.



## Maintenance and environmental considerations

Metal-clad equipment with withdrawable circuit breakers and auxiliary components, such as VTs and CPTs, are easy to install, operate, test, and maintain. Performance and dielectric integrity of metal-clad equipment is negatively affected by environmental contaminants and humidity. Therefore, depending on the application location and surrounding environment, more elaborate and frequent maintenance may be required. In the case of GIS, primary circuits and components are contained within a sealed tank or covered with solid encapsulated insulation and therefore are not subject to destructive effects of the surrounding environment, thus requiring minimal or no maintenance for long periods. A well-designed GIS offers trouble-free operation without need for frequent maintenance. It is very rare for a primary component within the gas tank to fail, however, if such failure were to occur, extensive shut-down is required to perform repair and replacement of the failed component.



**Metal-clad switchgear offer ease of access and maintenance, however, it may require more frequent maintenance depending on the environment in which it is installed. GIS is not impacted by the environment and may require minimal or no maintenance for long periods.**

## Safety

Metal-clad equipment, by virtue of its defined characteristics and design requirements, uses more total parts compared to equivalent GIS equipment. Therefore, in general, GIS is considered more reliable compared to metal-clad. GIS is considered inherently arc resistant because it is impervious to environmental contaminants and foreign intrusion (intrusion by rodents, for example). GIS offers clear advantage over metal-clad as there is no possibility of internal arcing taking place within the insulating gas. A passive arc-resistant protection can be provided by using arc-resistant metal-clad designs tested to IEEE C37.20.7, however, such designs are complex, may require a large footprint, and special exhausts from electrical room. Arc-resistant GIS designs tested to IEC standards can also be applied for even higher reliability and safety, without large increase in equipment footprint.

**GIS offers powerful advantage:**

**GIS is inherently arc resistant by its design when compared to metal-clad design.**

## Total cost considerations

As the voltage decreases, metal-clad switchgear is more cost-effective, as the cost of metal-clad switchgear is less at lower voltages, while the cost for GIS remains similar across voltage ratings. For equipment at 5/15 kV voltage classes, cost of GIS can be upward of two or even two-and-a-half times as much as metal-clad equipment.

**At 27 and 38 kV applications, there is typically a premium associated with GIS compared to metal-clad switchgear, but those premiums can be offset when considering the savings from reduced maintenance and building costs.**



### Conclusion

Equipment, AIS or GIS, must be selected based on the equipment's ratings and capabilities to satisfy actual application requirements. GIS equipment offers a smaller footprint and space savings but may have higher initial cost. However, GIS requires minimal or no maintenance over long periods compared to regular or more frequent maintenance for metal-clad, hence in the long run, GIS may offer a cost advantage over metal-clad. Also GIS is not impacted by environmental influences and therefore it is expected to provide more reliable performance and safety over metal-clad. Where future expansion/changes are expected, metal-clad should be considered as it provides more operational and expansion/modification flexibility. Presently, the majority of switchgear applications at 5 and 15 kV uses metal-clad as it is less costly than GIS and offers choice of ratings to suit most applications. Experience with installation, operation, and maintenance of metal-clad switchgear also can make it more attractive compared to GIS.



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