SIEMENS
GOVERNMENT TECHNOLOGIES

ISOLATED-PHASE, MEDIUM-VOLTAGE

Gas-insulated **switchgear**

For energy resilience and safety to the **Department of Defense**

Index

Introduction

Given the Department of Defense's inherent need to have energy resilient power to support its mission critical electrical loads, there is an undeniable and clear need to deploy medium-voltage switchgear that is both inherently reliable and safe. Isolated-phase, medium-voltage, gas-insulated switchgear (GIS) is the state-of-the-industry technology that provides both energy resilience and equipment to meet this need.

Isolated-phase GIS segregates each phase of the switch, circuit breaker, and bus section into three separate housings (phases A, B, and C). This design prevents the possibility of a phase-to-phase fault. The polyphase design (non-isolated) either in air-insulated switchgear (AIS) or GIS contains all three phases in one housing that could allow a phase-phase fault. This technology mitigates environmental and electrical arc-flash risks to avoid costly shutdowns of the entire system while also allowing personnel to safely operate this equipment without extensive arc-flash Personal Protective Equipment (PPE).

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Energy **resilience**

As defined in 10 U.S.C. § 101 (e)(6), energy resilience means the ability to avoid, prepare for, minimize, adapt to, and recover from anticipated and unanticipated energy disruptions in order to ensure energy availability and reliability sufficient to provide for mission assurance and readiness, including mission essential operations related to readiness, and to execute or rapidly reestablish mission essential requirements.

Isolated-phase GIS provides energy resilience by separately encapsulating each of the three energized phases of electricity in a sealed, gaseous, insulating medium that reduces the risk and severity of any potential arc fault inside the switchgear. It is well-understood and documented that, in air-insulated switchgear (AIS) and electrical distribution equipment, a single-phase arc fault that is not interrupted will rapidly propagate to become a three-phase arc fault and likely lead to a catastrophic failure of equipment, which endangers lives, compromises the support to the mission critical loads, and creates large scale property damage. Additionally, AIS high-energy faults can also pose a significant risk to damaging additional equipment in the same circuit .

However, the design characteristic of isolated-phase GIS equipment is that lower level arcs (phase-to-ground faults) inside the enclosure are typically self-extinguishing due to the dielectric characteristics of the insulating gaseous medium. Additionally, if the system is resistance grounded, the ground current is significantly limited (usually to 400 A or less) and thus a single-phase arcing event to ground would likely be self-extinguishing. **The design's ability to limit faults to low-level, single-phase-to-ground arcs results in much less, if any, equipment damage.**

Due to the isolated and sealed design of the isolated-phase GIS, the risk of harsh environmental factors and foreign contaminates is also removed. The positive gas pressure eliminates contaminants and humidity from entering the GIS. In fact, an estimated 50% of the root cause failures listed in IEEE 493 Gold Book are not applicable to isolated-phase GIS and are thus completely mitigated as risks. The sealed, gas-pressure system also removes any need to derate the equipment for altitude making it an ideal choice for remote facilities subject to harsh environmental conditions where energy resilience is critical.

Additionally, the lack of internal maintenance required until 10,000 operating cycles of the Siemens' circuit breaker, which often represents the entire life cycle of the equipment, means that isolated-phase GIS provides maximum equipment availability as there is no need for downtime for maintenance compared to competitors' AIS, which requires regular maintenance cycles to inspect and grease mechanical components. **By greatly reducing the need for routine maintenance (i.e., every 10 years), isolated-phase GIS also provides energy resilience** by reducing the need for conventional spare parts (i.e., space heaters) replacement due to wear-and-tear compared to AIS.

Medium-voltage, air-insulated switchgear failure cause	Share	Not applicable to medium-voltage, gas-insulated switchgear
Exposure to moisture	**30%**	**Not applicable**
Malfunction of protective device	10%	
Exposure to dust or other contaminants	**10%**	**Not applicable**
Normal deterioration from age	10%	
Thermocycling	7%	
Mechanical damage from foreign source	**7%**	**Not applicable**
Exposure to non-electrical fire	7%	
Others	4%	
Mechanical structure failure	3%	
Shorting by snakes, birds, rodents, etc.	**3%**	**Not applicable**
Above normal ambient	3%	
Exposure to chemicals or solvents	**3%**	**Not applicable**
Severe weather condition	3%	

Source: IEEE 493 Gold Book, Annex E, table XVIII, page 479

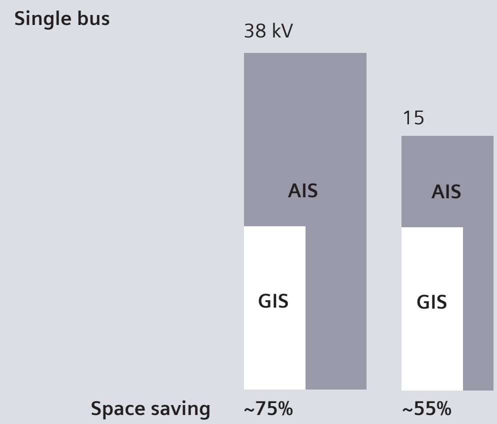
Estimated 50% of failure causes not applicable with MV GIS

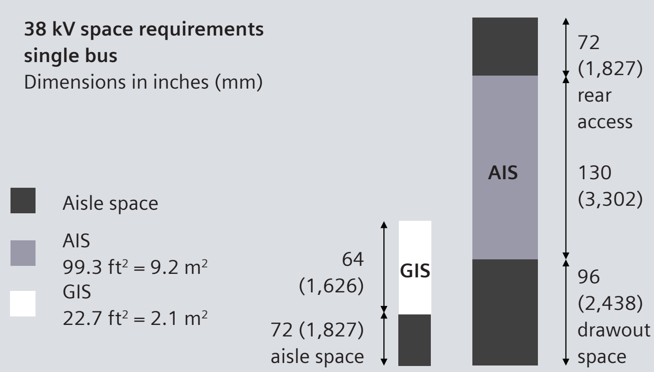
In the unlikely event of an arc flash with isolated-phase GIS, a factory-trained technician can remove the damaged phase components and replace them with the identical components (from Siemens or a spare cubicle or spare parts inventory) and return the cubicle to service in a short amount of time. **In most cases, this work can be completed with the remainder of the switchgear lineup still in service.**

In contrast, in polyphase, non-isolated GIS, if an arc flash occurs, the entire gas-insulated compartment will be impacted and most likely require replacement. The design requires that any repairs on the switch, circuit breaker, or bus components must be completely de-energized and possibly be refurbished within the factory so that the tank can be properly sealed after the repair. Multi-phase GIS will be unable to provide any level of support to the mission critical loads while these repairs are undertaken. Polyphase GIS in the event of a gas leak requires to trip and lockout the circuit breaker or trip the circuit breaker until the correct gas pressure is restored resulting in lower reliability.

It is also extremely important to note that isolated-phase GIS has a reduced footprint compared to AIS (up to a 75% reduction at 38 kV), which may facilitate its installation in elevated, underground, or concealed locations to further provide energy resilience by reducing site-specific risks, such as flooding, wind, hail, hurricane, or physical security threats.

Footprint comparison





*No rear access required, eliminating need for rear aisle

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Safety

As noted above, the design of an isolated-phase GIS segregates each phase of the switch, circuit breaker, and bus section prevents a single-phase, arc-flash event from propagating to a three-phase event. The risk of a single-phase, arc-flash event is also minimized due to the design of isolated-phase GIS individually encapsulating each live bus phase within a gaseous insulating and arc-quenching medium.

Siemens' isolated-phase GIS has been tested to ANSI/IEEE C37.20.7-2017/IEC 62271-200 type 2B requirements meaning that Personal Protective Equipment (PPE) requirements are met through a long sleeve shirt and pants, face shield, gloves, hardhat, and boots with minimum arc rating of 8 cal/cm^2.

The PPE of a 40 cal "beekeeper" suit and head covering, which is often needed for AIS locations in electrical systems, can increase the difficulty for personnel to see and operate equipment. However, there is no requirement for this level of PPE with isolated-phase GIS for safe operation.

Additionally, the absence of internal maintenance required until 10,000 operating cycles of Siemens circuit breakers, which often represents the entire life cycle of the equipment, eliminates the need for a technician to work on any of the equipment internals and expose themselves to arc-flash risks as opposed to competitors AIS, which requires regular maintenance cycles to inspect and lubricate mechanical components.

Due to the isolated-phase GIS design not requiring a drawout circuit breaker, potential transformer trays, or rear doors, there is no access to medium voltage therefore reducing human error that can cause outages and increasing safety. Grounding operations can be performed remotely.

Examples of personal protective equipment

8 cal

https://enesproppe.com/products/8-cal-enespro-arc-flash-kit

40 cal

https://www.mitchellinstrument.com/salisbury-light-weight-sk40plt-c-40-cal-arc-flash-pro-air-hood-system-full-body-protection-kit.html

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Conclusion

With the threat risks to the Department of Defense continuing to grow, energy resilience and safety are key requirements to ensure that mission critical functions are supported by continued and reliable power to the mission critical electric loads while maintaining the safety of those who work on or around those loads and equipment. Isolated-phase, medium-voltage, arc-resistant, gas-insulated switchgear provides both the energy resilience, safety, and reduced maintenance which is required to meet the mission.

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