OsecoElfab

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Gas Insulated Switchgear (GIS)
An informal introduction

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EXECUTIVE SUMMARY

With an ever-growing need for greater capacity of our aging infrastructure, power consumption is on the rise. According to fortunebusinessinsghts.com, a UN report in 2018 states about 55% of the world's population lives in urban areas and is projected to increase to 68% by 2050. The US Energy Information Administration has the US total primary energy consumption about 17% of the total world consumption in 2018, with only about 4% of the world's population. As such, improvements in efficiency, space requirements, and safety become a larger consideration in designing and maintaining power systems.

One such solution is a Gas Insulated Switchgear (GIS). With its improved dielectric strength, smaller footprint, minimal annual maintenance, and a decreased likelihood of arc events, GIS command a much better proposition in a power system design. As with all power systems and electrical grids, safety is always a concern. Rupture discs provide the necessary requirements needed to mitigate any safety hazards during over pressurization of the units. With our mission to protect life, and provide solutions for a safer, cleaner world, OsecoElfab is a market leader in the manufacturing of rupture discs. With precision quality, our rupture discs can protect your capital equipment from catastrophic failure within milliseconds of an overpressure event.

Inside a GIS Switchgear

History

Gas Insulated Switchgear (GIS) units are major conducting structures within a sealed environment. They are insulated by a dielectric gas, Sulfur Hexafluoride (SF6). Air insulated Switchgear (AIS) units utilize atmospheric air as the gas medium, and are generally located in outside environments. In a GIS substation, the electrical components are enclosed in a metal structure with SF6 gas. During the 1920s, metal enclosed substations were utilized in high-voltage systems with oil as the insulating medium. Research began focusing on different gases, with a Freon-based GIS appearing in the 1930s.Over the next few decades, new developments in industrial processes, chemistry and physics led the industry to the use of SF6. Towards the end of the 20th century, SF6 gas became the main GIS insulator for arc extinguishing. With a higher dielectric strength than air, clearances between components (such as circuit breakers, busbars and isolators), are smaller, reducing the overall size of the complete sub-station. A GIS facility is roughly a tenth of the size of an AIS one.

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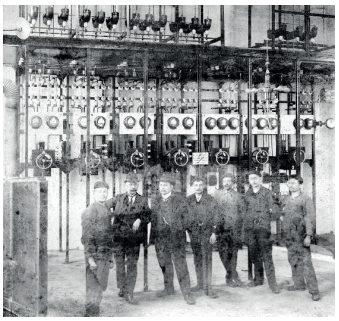

Early German switchgear from c. 1910 (Source: Ancestor, Public domain, via Wikimedia Commons)

Today

Since the introduction of SF6 to industry, GIS companies have installed thousands of indoor and outdoor GIS worldwide. Research and continuous development of the first system types paved the way to the current generation of GIS units. They are among the most compact and most reliably performing designs available, used internationally by such renowned companies as ABB, Siemens, Hitachi, and Mitsubishi. With a low weight, long operating life, low operating costs, and modular, space-saving design, GIS can be extremely economical.

Future Developments

GIS technology is constantly changing and evolving. There is an increasing effort to improve GIS design, manufacturing, testing, and operation technologies and best practices. According to Toshiba's website, they have been collaborating jointly with Meidensha to develop GIS using natural origin gases. The gas will not contain any SF6 gas due to the greater demand for a carbon neutral footprint. The two companies plan to confirm performance and testing by March 2022.

Toshiba is working on a GIS which will not contain any SF6 gas due to the greater demand for a carbon neutral footprint.

Another new technology solution developed over the last decade is that of non-conventional instrument transformers (NCIT). Special electronic units for preprocessing and merging of sampled values were developed to convert outputs for each NCIT technology. Once

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installed, NCIT will provide manufacturers and utility companies the ability to reduce SF6, simplify wiring, and enjoy greater manufacturing and engineering efficiencies.

As new technologies and advancements in electrical insulation become available, GIS will continue to change to meet the market demand. Pressure relief and rupture disc technology will continue to advance to keep pace with the market trends and GIS needs.

Governing Bodies

IEC and ANSI/IEEE

There are two governing bodies for GIS, the International Electrotechnical Commission (IEC), and the Institute of Electrical and Electronics Engineers (IEEE).

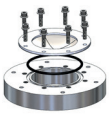
The IEC originated during the International Electrical Congress in St. Louis in 1904, during the World's Fair. The congress made a proposal to set up a permanent international commission to establish the terms and measurements for the ratings of electrical apparatuses and machinery. The IEC was founded in London and convened its initial meeting June 26th, 1906. Sixteen countries participated, represented by delegates designated by their respective governments. The IEC is the world's leading organization for the preparation and publication of international standards for all electrical, electronic, and related technologies.

IEC International Electrotechnical Commission

IEEE has roots going back to 1884 during the time of the telegraph, the major established electrical industry of the time. In 1884, a small group of electrical professionals met in New York and formed a new organization to apply innovation for the betterment of humanity: the American Institute of Electrical Engineers (AIEE). A decade later, a new industry arose with invention of the radio, and in 1912 the Institute of Radio Engineers was born. Memberships in both organizations grew, and in 1957, the two merged to become IEEE. IEEE is the world's largest technical professional organization dedicated to advancing technology for the benefit of humanity. Within the IEEE, there is the IEEE Standards Association, which develops and advances global technologies.

IEEE Advancing Technology for Humanity

Both organizations' standards are used globally, with the IEC's predominantly used in Europe. Many of IEEE's standards are jointly produced with ANSI and in general are a suggested guide, and not mandatory unless required by the project specification or by an authority having jurisdiction.



STRUCTURE OF A GIS SWITCHGEAR

Harmonization

Technology spans borders and thrives upon innovation. Reducing the amount of time to draft and publish international standards is paramount. As such, it becomes essential to prevent duplication of effort by individuals, organizations, and nations. Responding to this need, the IEC and IEEE Standards Association began to work together on the adoption, revision, and joint establishment of relevant standards. In October 2002, the two organizations signed a significant agreement, in which the logos of both organizations will appear on the standard.

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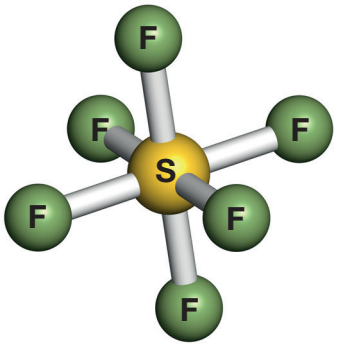
Structure of a GIS Switchgear

Enclosures

Today, enclosures are generally cast or welded aluminium. Steel is also sometimes used. Steel enclosures are painted both inside and out to prevent rusting. Aluminium enclosures do not require paint but, may be painted for easier cleaning and appearance.

SF6 Gas

Sulfur Hexafluoride (SF6) is a synthetic fluorinated compound. It is colourless, odourless, and non-flammable. Due to is dielectric properties, electrical utilities rely on SF6 for electrical insulation, current interruption, and arc quenching. It is also more efficient in heat transfer, being twice as efficient as air.



Circuit Breakers

A high-voltage circuit breaker is a mechanical switching device that can create, maintain, and break currents. Its main purpose is to interrupt fault currents and isolate faulted components. It will have great conductivity properties, be able to isolate components in the open position, and change from open to closed in 0.1 seconds. It will not cause voltage spikes during its operation.

Current/Voltage Transformers

Current and voltage transformers convert high transmission line currents and voltages to lower values that are standardized and easy to measure. They can be up to 6000 Amps and up to 800 kV. This allows for metering, protection, and regulation of the high voltage system.

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Ground Switches

A ground switch will have a moving contact that opens or closes a gap between a high voltage conductor and the enclosure. It can either be operated manually or by motor drive to close or open. When fully closed it will carry the rated short circuit load. Fast acting ground switches are commonly used in GIS as a connection point between the GIS and the rest of the power network. A fast-acting ground switch is more capable of handling the discharge of trapped charges and breaking the capacitive or inductive coupled currents on the connected line.

Interconnecting Bus (Busbar)

A busbar is a metal strip or bar within a switchgear, panel boards and busway enclosures to distribute local high currents. They will also connect high voltage equipment in electrical switchyards and low voltage components in battery banks. Generally, they are uninsulated and are structurally sound to be suspended in air by insulating pillars. This allows sufficient cooling of conductors and the ability to connect at various locations without new joints.

Surge Arrestors

A surge arrestor is designed to protect high voltage components in GIS against the effects of voltage spikes. Voltage spikes can be caused by lightning strikes, electromagnetic pulses, static discharge, or switching operations. Different surge arrestor types and materials will be used according to the application.

Local Control Cabinet (LCC)

A local control cabinet (LCC) is provided for each circuit breaker position to wire the GIS back to the substation control room. Control and power wires are shielded, multi-conductor cables used to operate the mechanisms, alarms, heaters, and auxiliary switches, that run between the GIS equipment modules and the LCC. The LCC will include a mimic diagram of the part of the GIS being controlled, along with all of the terminals for the GIS wiring.

ADVANTAGES AND DISADVANTAGES OF GIS

Advantages of Gas Insulated Switchgear

The Gas Insulated Switchgear has proven to show many advantages since its emergence in the late 20th century. With SF6 being incombustible, it has the advantage of both insulating and cooling without the need for fire-fighting equipment. The design of the pressure tank can withstand the pressure rise of an internal fault. A GIS substation requires substantially less real-estate, being about a 1/10 the size of an AIS. Because GIS is classified as electrical equipment, and due to the moderate pressures involved, it does not require code stamping. Finally, the expected service life for GIS substations is more than 30 years, with minimal to no inspection or maintenance.

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Disadvantages of Gas Insulated Switchgear

There are some disadvantages to GIS. They are inherently more expensive, requiring more upfront capital. Sulfur Hexafluoride is an extremely potent and persistent greenhouse gas. Repairing damage due to internal faults can be arduous, causing long outage periods. Cleanliness standards are very stringent, as dust and/or moisture can cause internal faults. Procurement of SF6 can be problematic, which requires an adequate stock to be maintained on-site. Maintenance on live parts can be difficult, making it hard to diagnose faults without gas reclamation and disassembly.

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RUPTURE DISCS AND GIS

Rupture Discs and GIS

A rupture disc is a non-reclosing, one-time use pressure relief device, with a specific set point for pressure and temperature at which it will activate. The part of the rupture disc that activates is the membrane, which can be a single layer of material or a combination of multiple layers and materials, depending on the application's needs. Depending on size, rupture discs provide a pressure relief response within micro- to milliseconds, and are designed to protect vessels and other capital equipment from dangerous and damaging overpressurisation. The rupture disc will burst open and safely relieve the overpressure condition when the line or vessel reaches a pre-determined pressure and temperature.

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Rupture discs can provide both primary and secondary relief, and are used in combination with pressure relief valves to prevent leakage. The disc will also protect the relief valve seats from potential exposure to corrosive and sticky substances. Its major advantages over other pressure relief solutions include leak tightness, lower costs, quick response time, a good range of sizes, and low maintenance.

Most rupture discs are manufactured from corrosion-resistant metals, using a design that is specified to meet the burst pressure and performance requirements of a given application. The user must specify the size, type, material, requested burst pressure and temperature. The discs will then be manufactured and manipulated with the appropriate material in different ways to meet the user's specifications. During the manufacturing process, destructive testing will be carried out to ensure that the manufactured lot meets customer requirements.

Rupture discs are used in Gas Insulated Switchgear, which is pressurized with SF6. Within GIS enclosures, internal faults may cause large amounts of energy to be released in the forms of heat and radiation. This release of energy can produce high pressures very quickly. If the internal pressure exceeds the MAWP of the switchgear, the housing may rupture unless given a relief outlet. Rupture discs provide this outlet. According to IEEE and IEC standards, gas zones should be equipped with gas density monitoring devices and a pressure relief device. Specifically in IEEE C37.122.2-2011, it states in section 4.2.1.3.2: "In the event of an internal arc fault, pressure builds up in the enclosure and gas with by-products will be relieved through a rupture disc/pressure relief device into the switchgear room."

CONCLUSION

Conclusion

Gas Insulated Switchgear or substations (GIS) have successfully been in use for over 50 years, with an increasing use worldwide. GIS offers a number of key growth factors for the power market, including safety, a small footprint, low maintenance and environmental compatibility. GIS is therefore gaining rapid preference. Continuous reliability and greater efficiencies have increased the share of GIS projects compared to Air Insulated Substations (AIS). As technology advances, GIS will accelerate to eventually replace all existing AIS near urban centers. According to MarketWatch.com, the global GIS market is projected to grow from USD 16.9 billion to USD 26.5 billion by 2025, at a CAGR of 9.5% from 2020 to 2025.

With over 70 years in the industry, we maintain the highest standards of safety and quality.

Due to this GIS market expansion, the need and utilization of rupture disc technology will continue to grow in the diverse market of power generation and storage. Rupture discs provide the reliability, low maintenance, and responsiveness required to mitigate the concerns of leaking and activation that can be challenges with other pressure relief solutions. Installed directly to the equipment between flanges, rupture discs provide the utmost safety for employees and the environment, while reducing installation time and the need for separate holders.

The global GIS market is projected to grow from USD 16.9 billion to USD 26.5 billion by 2025.

With our mission to protect life, and provide solutions for a safer, cleaner world, OsecoElfab can match your GIS needs to one of our GIS discs. With precision quality, our rupture discs protect your capital equipment from catastrophic failure within milliseconds of an overpressure event. We are committed to finding solutions to your needs.

We offer over 70 years' experience in the pressure management industry, and specialize in developing rupture discs specifically designed for the GIS market. We maintain the highest standards of safety and quality throughout our manufacturing process. Rigorous burst and leak tests are performed to give you complete confidence in our end products. Delivering exceptional pressure management, life safety and equipment protection solutions for our customers is underpinned by our Best Quality Approach. You can lean on our reliability with an emergency response team that is available 24/7/365.

We are industry certified, following a stringent and traceable line of processes before products are placed into use. With the best warranty on the market, you can be confident in the performance of our products and services.

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CITATIONS

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ABOUT OSECOELFAB

About OsecoElfab

OsecoElfab is a leading provider of pressure relief solutions, offering products and services related to all aspects of pressure management. Our purpose is ‘Protecting life. Solutions for a safer, cleaner world.’

Following this purpose, we manufacture rupture discs, explosion vents and associated burst detection systems to protect people, plant and the environment. Our services include highly specialized engineering and design consultation, product training seminars, site surveys and a stock consolidation program.

Serving a global customer base, we have two manufacturing facilities: one in Broken Arrow, Oklahoma (USA) and one in North Shields, UK. These are supported by six regional sales offices and over sixty approved representatives worldwide. Alongside the chemical process industry, key sectors include pharmaceutical and biopharmaceutical, power transmission and distribution, bulk handling, gas generation and handling, cryogenics, medical, aerospace and energy.

OsecoElfab is part of the Halma Group, a FTSE 100 company with over 50 subsidiaries worldwide.

OsecoElfab is a leading provider of pressure relief solutions, offering products and services related to all aspects of pressure management.

Protecting life. Solutions for a safer, cleaner world.

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