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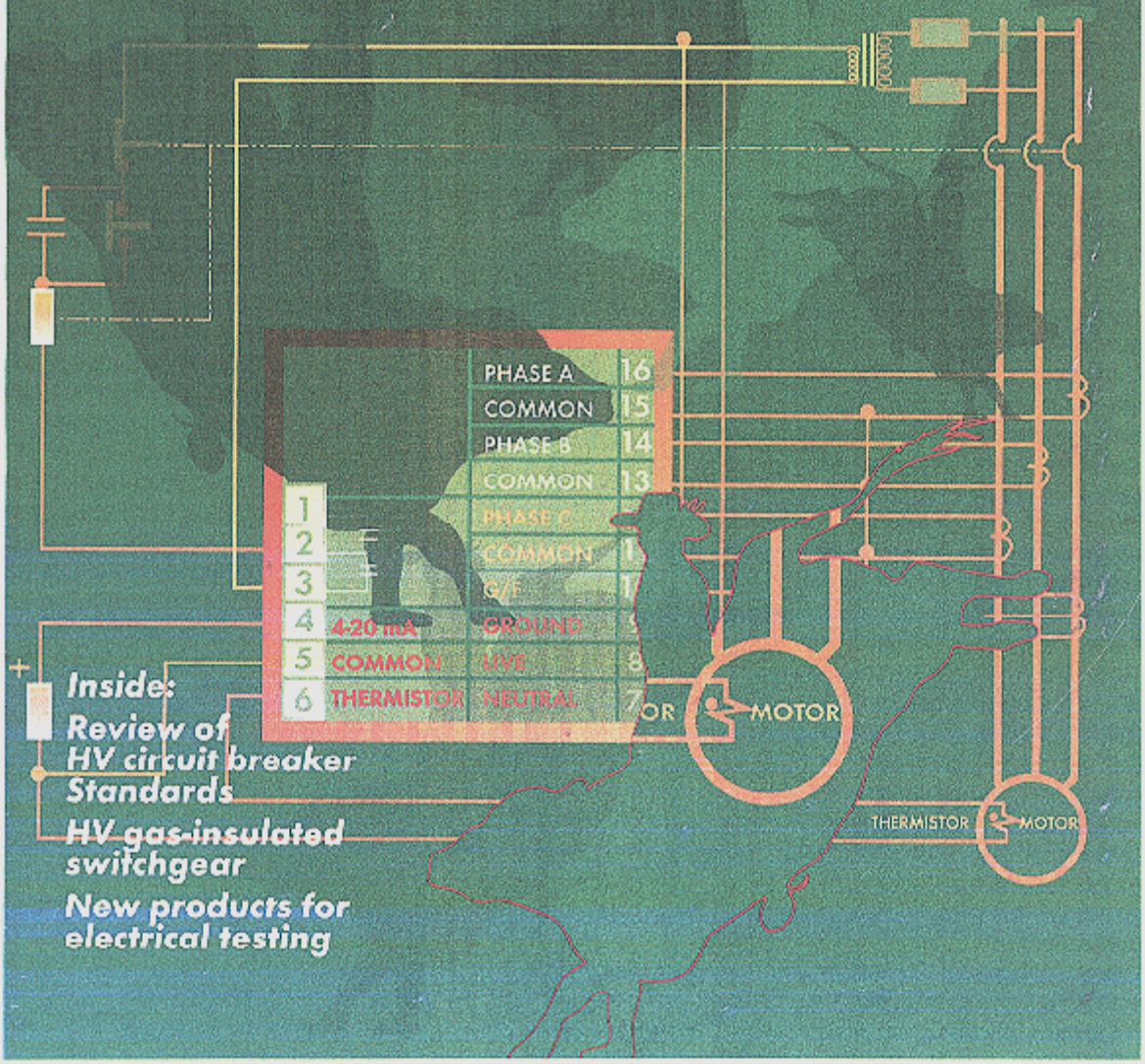

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High-Voltage, Gas-Insulated Switchgear

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Gas-insulated switchgear (GIS) products provide unique advantages over conventional air-insulated substation equipment. This article explores the features and applications of GIS and why the equipment is widely-used in high-voltage system design.

What is GIS?

GIS consists of a hermetically-sealed, metallic enclosure which is filled with sulfur hexafluoride (SF_6) gas. All live components such as circuit breakers, disconnect and grounding switches, bus bars, current transformers, lightning arresters, and potential transformers are safely contained within the grounded metallic structure (Figure 1). Typically, GIS is used in 69 kV to 500 kV applications, but more recently, the technology is being applied to medium-voltage systems as well.

The sealed design of GIS provides maximum operating personnel safety and protects the internal components from severe environmental conditions as can be seen in Figure 2. The equipment is extremely reliable and requires minimal maintenance which results in low operating costs. Perhaps the greatest advantage of GIS is the space-saving design which significantly reduces real estate requirements. Compared to air-insulated substation designs, GIS installations can represent up to a 90 percent space reduction. Other advantages include lightweight, modular design which reduces delivery and installation cost and also offers aesthetic appeal, as it blends well with surroundings. Additionally, electric fields

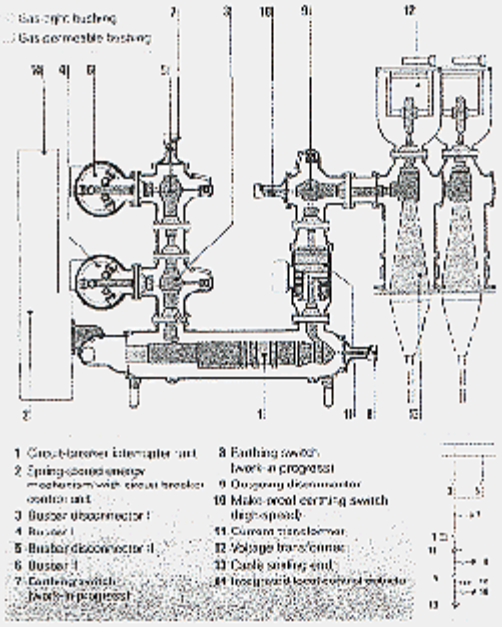

Figure 1

are confined within the enclosure, and magnetic fields are significantly reduced in comparison with air-insulated equipment which results in less exposure to operating personnel and the general public.

SF_6

Pure sulfur hexafluoride is a colorless, odorless, nonflammable, and nontoxic gas which possesses unique insulating and arc-quenching characteristics that make it useful in high-voltage electrical equipment applications.

Toxic and corrosive decomposition products can be created by heavy arc interruption in SF_6 which will leave behind a fine gray powder inside the switchgear. Service personnel should follow manufacturer's established safety practices for servicing GIS and handling SF_6.

The dielectric withstand properties of the gas when maintained under pressure is ten times greater than that of air. The strong electronegative molecular structure of the gas causes absorption of free electrons which build heavy, slow moving, negative ions, thus impairing electron avalanches which could lead to flashovers. Electrical arcs are controlled effectively because the gas possesses excellent cooling properties at extremely high temperature.

SF_6 does not deplete the ozone layer, but it has been identified as a greenhouse gas. Greenhouse gases cause heat to remain trapped in the earth's atmosphere which leads to global warming. Although the SF_6's greenhouse effect is less than 0.1 percent of the total greenhouse effect, as compared with carbon dioxide (CO_2) at 60 percent (Figure 3), it should be handled carefully to avoid escape in the atmosphere. Efficient gas handling is accomplished with special, commercially available, portable gas recovery units.

Maintenance

A recent utility survey indicated that gas leaks cause seven percent of major failures and forty percent of minor problems. If SF_6 pressure levels should drop to atmospheric pressure, dielectric withstand properties would drop by a factor of four, which would likely lead to insulation failure. It is, therefore, essential to monitor gas pressure and alarm systems. Additionally, gas should be sampled and tested for percent SF_6, percent air, moisture, dielectric breakdown, arc by-products, and contaminates at intervals recommended by the manufacturer.

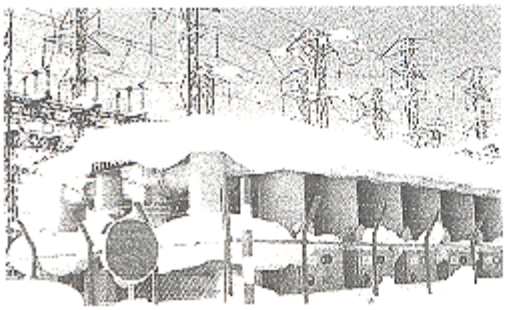

Figure 2

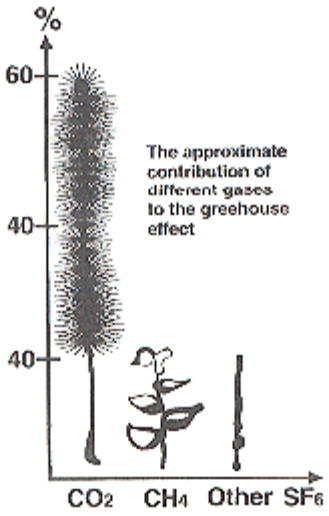

Figure 3

Many other system checks and inspections should be performed in accordance with manufacturer's recommendations. GIS assemblies are typically equipped with breaker condition monitoring systems. These systems provide status of critical components such as contacts and interrupters, close and trip coils, and compressor motors. Operating parameters such as breaker timing and presence of partial discharges are also often provided on GIS equipment. An example of the useful information that can be obtained from these monitoring systems can be seen in Figure 4. This system receives inputs from the breaker's current transformers, trip and close coils, and auxiliary contacts to determine breaker timing and operation condition. When these parameters are combined with fault current data, contact and interrupter wear can be predicted. This information allows maintenance intervals to be determined by equipment condition which increases maintenance personnel efficiency. Breaker monitoring systems should be inspected as necessary. If all systems operate correctly, major equipment maintenance may not be necessary for 25 years.

Applications

The versatility of GIS has lead to many creative applications, including vertical substations placed in buildings located in urban areas, offshore oil-rig structures, and containerized stations for moveable geothermal power plants.

The design of the electrical system at the Venetian Hotel is a good example of applying the space saving and reliability features of GIS to realize immediate financial benefits.

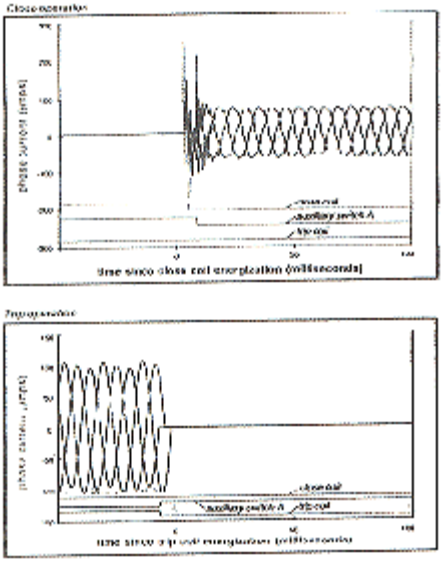

Figure 4

Upon completion of phase II construction, the Venetian (Figure 5) will be the world's largest hotel with over 6,000 rooms. The facility is located on the "strip" in Las Vegas, Nevada, where real estate is among the highest priced in the world. When complete, the total construction costs will exceed two billion dollars.

Two 138 kV GE-Hitachi gas-insulated switchgear assemblies protect the facility's two 50 MVA transformers. The transformers step down the voltage to 25 kV for distribution across the resort's 63-acre complex. Redundancy has been designed throughout the electrical system, and an additional 10 MW of generation is available for emergency power and to ensure that service to the 5,000 electronic gaming machines is not interrupted.

Summary

The unique features of GIS offer many advantages over conventional air-insulated equipment. Numerous successful applications have proven the reliability of this equipment. Operation and maintenance guidelines set forth by the manufacturer should be followed to ensure long reliable service.

Figure 5