



Operation and Maintenance of a Gas Insulated Substation

Course Number: EE-06-944

PDH: 6

Approved for: AK, AL, AR, DC, DE, FL, GA, IA, ID, IL, IN, KS, KY, LA, MD, ME, MI, MN, MO, MS, MT, NC, ND, NH, NJ, NM, NV, NY, OH, OK, OR, PA, SC, SD, TN, TX, UT, VA, VT, WI, WV, and WY

State Board Approvals

Florida Provider # 0009553 License #868

Indiana Continuing Education Provider #CE21800088

Maryland Approved Provider of Continuing Professional Competency

New Jersey Professional Competency Approval #24GP00025600

North Carolina Approved Sponsor #S-0695

NYSED Sponsor #274

Course Author: Velmir Lackovic

How Our Written Courses Work

This document is the course text. You may review this material at your leisure before or after you purchase the course.

After the course has been purchased, review the technical material and then complete the quiz at your convenience.

A Certificate of Completion is available once you pass the exam (70% or greater).

If a passing grade is not obtained, you may take the quiz as many times as necessary until a passing grade is obtained).

If you have any questions or technical difficulties, please call (508) 298-4787 or email us at admin@PDH Pro.com.



Operation and Maintenance of a Gas Insulated Substation

A major difference between conventional air insulated substations (AIS) and the gas insulated substations (GIS) is that the SF₆ gas insulated electrical components are placed within an earthed, pressurized metallic container. This is a significant change in operating the switchgear with circuit breakers, disconnectors, and earth switches because there is no direct observation or visual contact of the open or closed disconnect switch gap or the open or closed earthing switch status.

Besides this difference, other special operating characteristics are related to view ports, cameras, endoscopes, induced currents in the metallic containers, alarms, local control cubicles, remote control, mimic schemes, gas zone, unmanned substations, etc.

The maintenance paragraphs give real life experiences from existing GIS technology that has been in service for a number of years. It describes the nature and sources of defects including their repair and sophisticated planning. Usual maintenance methodologies on measures to determine the quality of the SF₆ insulating gas, visual and optical verifications, gas handling records, and leak detection routines are presented. Special practices on interlocks, gas zones, spare parts, and special equipment are discussed. Experiences and lessons learned on gas zone identification, secondary interface, wiring methods are combined and presented. Preconstruction staff training that involves continuous monitoring, GIS retrofit and bus leak maintenance topics are also discussed.

This course presents the GIS repair process. Information is presented on the types of anticipated defects, which demand repair of a GIS installation, how much time needs to be expected, and how service continuity is related to the design.

In addition, this course describes how a GIS installation can be extended after it has been installed and used for a number of years. This course provides details about the definition of the interface between two GIS installations of different dimensions. It also presents the work that has to be completed when extension is not expected from the initial design stage, how service continuously during extension work can be given, and how the new interface can be verified after extension. In addition, this course explains retrofit for GIS installation upgrade. Here the challenges of old switchgear installations are discussed and details are provided to retrofit or upgrade a substation. A specific view is taken on replacement of circuit breakers in GIS installation to increase switching capacity. The situation of overloading GIS equipment is also described. The principle of the GIS installation for continuous rating current is presented under the thermal and dielectric conditions given in a substation design. The determination of the thermal limits based on IEEE and IEC standards are also included. The maximum continuous load current and the short-time overload capacity are discussed and equations for overload calculations are shown.

Gas Insulated Substation Operation

Both AIS and GIS installations use circuit breakers, disconnect switches (isolators), and earthing switches, and have different means of showing their status, either opened or closed. Operation of a GIS substation involves the same principles as operating an air insulated substation (AIS) even though the different active elements are physically arranged differently. The first obvious difference is that the blades of the disconnect switches and the earthing switches installed in a GIS substation are surrounded by earthed metallic enclosures. This enclosure prevents the blades from being easily visible to discover their fully opened or fully closed status. The second apparent difference relates to the bus conductors being installed inside earthed metallic enclosures. These enclosures prevent the bus from being earthed with portable personnel grounds except at very discrete locations, such as air-to-gas bushing terminations at transmission lines and transformer banks.

Typically, a GIS installation demands more extensive electrical interlocking between the circuit breakers, disconnect switches (isolators), and earthing switches. The specific detailed procedure of operating and interlocking is typically determined by the GIS end user.

Circuit Breaker

Since one of the main circuit breaker functions is to automatically and quickly de-energize faulted transmission lines, transformer banks, and buses, an opening operation is started by protective relays, which are commonly installed remotely in a relay and control room. This operation may also involve automatically reclosing of the circuit breaker for several times.

The opening or closing of a circuit breaker can also be started by human intervention from different locations, including manually from the circuit breaker mechanism, electrically from the LCC, from the relay and control panels remote from the circuit breaker, or from supervisory controls remote from the substation.

Typically, a circuit breaker is not stopped from opening and/or closing by the status of either a disconnect switch or earthing switch. Nevertheless, a circuit breaker is stopped from operating or is automatically demanded to operate by parameters that impact its successful function, such as low interrupting and insulating gas density, low mechanism pressure, pole disagreement tripping (in the case of circuit breakers with separate pole operation), or monitoring of the proper circuit breaker status before starting an operation. For instance, a circuit breaker has to be in the totally closed position before an open operation can be started and, conversely, a circuit breaker has to be in the completely open position before a close operation can be started.

The indication of the circuit breaker status can be monitored at the circuit breaker mechanism cabinet via mechanically operated semaphores, at the LCC, at the relay and control panels remote from the circuit breaker, or from supervisory controls remote from the substation with statuses showing red and green lights or semaphores.

Disconnect Switches

Disconnect switches in a GIS installation are used for the same function as those in an air insulated substation (AIS). They are applied to isolate different elements of the substation, such as circuit breakers, transmission lines, transformer banks, buses, and voltage transformers. Typically, they do not have big interrupting capability except for small quantities of charging current associated with short pieces of bus. Charging currents are in the range of 0.5 A to 2.0 A.

Disconnect switch operating systems involve:

- Only manual hand crank operation
- Motor operated with manual hand crank override
- Single-phase operation or three-phase group service

The disconnect switch status, open or closed, may be discovered by one or more of the following:

- An indicating element, such as red and green lights or semaphores, in the LCC
- A mechanical semaphore in the switch operating mechanism cabinet
- The physical status of the linkages that drive the switch blade

Direct/camera view of the status of the switch blade through a viewport in the earthed metallic enclosure. Where motorized disconnect or earthing switches are installed, some utilities and end users, demand a knife switch to make sure the motor mechanism is de-energized during maintenance. In addition, the motor mechanism may demand decoupling from disconnect operating arm. This has to be considered in the initial design stages.

Commonly, during the initial design stages, a utility or new GIS end user will meet with the GIS manufacturer to review their operating routines and functions.



Non-fault-Initiating Earthing Switches

Non-fault-initiating earthing switches in a GIS installation are used for the same staff protection purpose as those in an air insulated substation (AIS) similar to a portable personnel earthing connection made with a hook stick. They are used to earth different de-energized substation elements, such as circuit breakers and voltage transformers. Typically, these earthing switches do not have fault-closing or induced current-interrupting ability, but are capable of conducting fault current when in the closed position and a small quantity of continuous current for the purpose of testing circuit breakers and current transformers that are out of service.

Usually, non-fault-initiating earthing switches have the same type of operating mechanisms and method of discovering switch status as disconnect switches. External, removable links in the earthing switches are required to disconnect an earthing switch blade from the external ground. In the closed position, the removable links allow electrical access to the center conductor and allow timing tests on circuit breakers, conductivity tests, and current transformer measurements. To help with operator identification the outer housing of earthing switches may be painted a green, red or similar color to distinguish from the gray or aluminum color of the GIS elements.

High Speed Earthing Switches

High speed earthing switches are unique to GIS design as they are not normally used in air insulated substations. Their primary function is the same as earthing switches in air insulated substations and non-fault-initiating earthing switches in GIS installations. They also complete the same function as portable personnel earth connections made with hook sticks.

High speed earthing switches have an extra capability of closing an energized conductor, creating a short circuit without experiencing major damage to the switch or the enclosure. High speed earthing switches are used to earth different active substation elements, such as transmission lines, transformer banks, and main buses. In some GIS installations high speed earth switches are used to start protective relay functions. Commonly, they are not used to earth circuit breakers or voltage transformers.



Purchase this course to
see the remainder of
the technical materials.