



Gas Insulated Substation Installation

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This course provides practical information that has been collected from a number of different GIS projects. The GIS equipment installation is demanding and asks for a detailed plan and sequence of works. With great amount of involved parts in the assembly, a proper sequence plan is a basic requirement to allow an efficient work flow and a high quality installation. Course also discusses safety standards and useful assembly tips. Substantial planning is needed including complex engineering and design, preparation of construction documents, material gathering, identification of material storage locations, potential GIS extensions, other power utility interconnections at the remote ends, identification of necessary permits, energization schedules, testing and commissioning demands, documentation check etc.

The project planning process needs to consider initial site surveys, core borings, security evaluations, identification of environmentally sensitive locations, checking heavy equipment requirements for site grading, civil works, and managing material, formulating gas processing routines, and organising special test equipment deliveries, personnel requirements and their training and qualifications etc. Visual inspections, testing for control of cables, bus leakage and gas quality verifications, main circuit resistance checks, mechanical switching inspections, interlocking verifications, grounding measurements, and instrument transformer verifications are some of the necessary tests and they are presented in this course. The student will be presented with an overview of the requirements to plan and perform a successful and effective GIS installation.

Provided information can be used as reference to support the manufacturers' directions or to use in the case that GIS modifications are needed on older devices that may not be supported by the manufacturer. As presented in the next paragraphs, staff involved in the GIS installation needs to be properly trained, well aware of the high voltage electrical and mechanical risks, and the chemical handling aspects. Generally, it is a common practice to have a manufacturer's representative present during the installation to direct utility staff or contractors. As soon as GIS equipment is energized, the owner's or utility's operations and safety routines are applied.



These routines include minimum approach distances to equipment exposed live parts (e.g., bushing connections) and switching and tagging routines. In line with local or regulatory directives, the owner or utility may define gas handling procedures and SF6 use records (e.g., the gas amount in each compartment).

Safety Aspects and Assembly Suggestions

1. Just like for any other power equipment, there is a risk of electrical shock and lethal injury. GIS devices also bring the complexities of working with pressurized elements and gas manipulation. When installing new GIS equipment, especially additions or expansions to energized equipment, it is important to follow adequate lock-out tag-out routines and ensure that devices or hardware are adequately sectionalized, grounded, and depressurized before inspecting a GIS compartment.
2. If the installation includes a cable trench or vaults, basements, or confined spaces below floor level, the space needs to be tested for oxygen levels. SF6 is heavier than air and may cumulate in low or confined facility areas.
3. GIS devices have numerous mechanisms in small enclosures and can be controlled remotely. To prevent injury ensure that motor mechanisms and spring/pneumatic and hydraulic operators are discharged and de-energized before any work starts.
4. Use approved mechanical and electrical tools, including the correct size wrenches, handles, and other hardware. Some projects demand metric and English toolsets to work with locally provided materials and the GIS.
5. Current transformers may already be included in the GIS assembly. To prevent damage, the secondaries, if not used, should be shorted before energization.
6. Avoid unreasonable force during the assembly routines. Epoxy insulators can break with a substantial jolt or unusual lateral or axial tensions during alignment.

7. If GIS devices are equipped with view ports to check disconnect or ground switch status, do not directly observe while the device is switching. Electrical arcs may start and they can harm eyesight.

Overall Project Planning Procedure

An overall installation process, including considerations for future extension of GIS bays and equipment, is essential for an efficient and successful project. Typically, the preassembled devices and bus sections coupled with the manufacturer's directions will impact the assembly process and they need to follow a series of the following steps:

1. Preconstruction discussion between the end user and the manufacturer including the installation and assembly contractor.
2. Site initial works that include grading, drainage installation, foundations and equipment grounding, access roads, and auxiliary removal facilities.
3. Arrangement of construction equipment that will be needed for the installation.
4. Final alignment and foundations levelling for associated devices.
5. Collecting, unloading, and stacking away GIS devices
6. On-site GIS primary assembly
7. Leak tests
8. Protection relay, revenue metering, SCADA, communications, station service and the related control wiring installation.
9. Vacuum processing and gas filling with moisture and gas quality verifications.

10. Mechanical and operational tests on the switches, instrument transformers, and circuit breakers.
11. Primary bus high voltage dielectric and partial discharge checks. It is also crucial to discover the test connection point especially in the case of indoor devices where a temporary air to inspect bushing may be required.
12. Commissioning and start procedure
13. Construction snag list and site cleaning

Future GIS Expansion Aspects

The basic GIS design should include provisions for expansion and future requirements. For example, if system planning studies envisage two transmission lines in a breaker-and-a-half arrangement, and within the next ten to fifteen years load growth will demand additional bus connections, space should be provided for the future devices, especially if a new building is part of the project. In addition to space considerations, it may be a wise step to install isolation disconnects where the future sections are to be placed. When the future connection is done, SF6 gas is taken out from the disconnect zone and the existing bus on the opposite side is only decreased in pressure, not completely discharged. This step will prevent potential pollution and moisture infiltration in the bus.

Additional Planning and Initial Site Assessment

As part of the preliminary design, the different parties (contractor, manufacturer and end user) should collectively make a composite project plan for the overall project. The plan should be very detailed with crucial milestones well defined and analysed. Precise planning and project coordination is a crucial element for success. Important elements of a project schedule should include:

1. Design, engineering and regulatory approvals
 - a. Management and project organization data (milestone execution dates, major payments)
 - b. Document, study and drawing approval procedures
 - c. Single line and electrical schematic release sequences
 - d. Specification and coordinated release of construction drawings (structural, civil, electrical primary and GIS installation, wiring and controls etc.)
 - e. Assembly and building approvals
 - f. Regional or national electrical transmission authority approvals (security, safety, communications, protection systems)
2. Material procurement
 - a. Big long lead-time elements: GIS device/circuit breakers, bus, underground transmission cable and transformer bushing terminations, and other big interconnected devices – underground cables and power transformers
 - b. Typical electrical construction materials: fittings, conduit, cable tray, control and instrumentation cables
 - c. Structural and civil materials: anchor bolts, steel supports, rebar, concrete
3. Construction procedure
 - a. Site planning and organisation: yard grading, fence
 - b. Structural and civil works, foundations, basement and building construction



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