GIS Testing

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Contents

International standards specify requirements and define ratings and tests for gas-insulated metalenclosed switchgear and its individual components. The applicable IEC standards are those defined in the table in ▶ Sect. 25.9. (Many of these standards are under revision. The reader is encouraged to use the most recent editions):

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T. Krieg, J. Finn (eds.), *Substations*, CIGRE Green Books,
https://doi.org/10.1007/978-3-319-49574-3_22

IEC 62271-203 states rules for the dimensioning of the enclosures, but also pressurized equipment regulations, existing in various countries, must be taken into account if they have the force of law. The standards define for gas-insulated switchgear three types of tests:

- Type tests
- Routine tests (to be performed, whenever practicable, at the manufacturer's works)
- Tests after installation on site (considered part of routine tests by IEC standards)

22.1 Type Tests

The type tests are for the purpose of proving the characteristics of switchgear and control gear, of their operating devices, and of their auxiliary equipment. They must be carried out on a given design, to prove compliance with a standard.

The manufacturer must be able to demonstrate, with test reports or test certificates, that all the type tests have been performed on subassemblies of the same design supplied to the customer. Type tests are not part of a quality assurance system applicable to each supply consignment and should be performed only once for a given design. Type tests involve at least:

- Dielectric tests
- Measurement of the resistance of the main circuits
- Temperature rise tests
- Short-time withstand currents and peak withstand current tests
- Verification of the degree of protection of the enclosure
- Tightness tests
- Electromagnetic compatibility (EMC) test
- Verification of making and breaking capacities
- Low and high temperature tests
- Proof tests for enclosures
- Pressure test on partitions
- Tests to prove performance under thermal cycling and gas tightness tests on insulators
- Circuit breaker design tests
- Fault-making capability of high speed earthing switch
- Switch operating mechanical life tests

22.2 Routine Tests

Routine tests are an integral part of the quality assurance process. They are carried out during manufacture on each item of equipment, with the purpose of revealing faults in material or construction. Acceptance tests, if requested by the customer, should be a part of routine tests. Since the acceptance tests are not defined by

standards, acceptance criteria with tolerances should be stated by the manufacturer prior to routine tests in order that they can be witnessed by the customer. Tests included in routine tests are:

- Dielectric tests
- Tests on auxiliary and control circuits
- Tightness tests
- Measurement of the resistance of the main circuits
- Pressure tests of enclosures
- Mechanical operation tests
- Tests on auxiliary circuits, equipment, and interlocks in the control mechanism
- Pressure tests on partitions

22.3 Tests After Installation On-Site

Tests after installation on-site are carried out in order to detect possible damage suffered during transportation, storage, exposure to the environment, or final assembly. Typically, a gas-insulated switchgear is mostly partially assembled in the factory. It is important to point out that on-site testing is a repetition neither of type tests nor of routine tests. The aim is to prove the integrity of the system before it is energized. It is the final step in the process of quality control and quality assurance.

Recommendations as well as technical and practical considerations of site testing are given in ► Chap. 20 and annex C of IEC 62271-203. Particular attention must be paid to dielectric tests. While all other tests can be performed quite easily and do not require expensive test equipment, dielectric tests may pose problems concerning:

- The optimal test procedure to be chosen
- The actual possibility of performing the tests
- The cost of the tests

Examples for different test setups are given in Figs. 22.1 and 22.2. Figure 22.1 shows a resonance test circuit where the voltage is applied to the GIS with an air bushing. Figure 22.2 shows a gas-insulated test transformer directly connected to the GIS with attached coupling capacity for conventional PD measurement. Today, IEC standards recommend mainly voltage tests (AC or impulse voltage tests). New methods, using partial discharge detection with nonconventional detecting systems (e.g., acoustical or UHF), have been developed. In this respect many users and manufacturers apply test procedures (which should be agreed in advance) based on their own experience.

22.4 Installation, On-Site Test, Commissioning, and Formal Acceptance

Special conditions apply during the installation of GIS. All civil works have to be completed before the start of the installation.

Fig. 22.1 Resonance test circuit connected to the GIS via SF_6/air bushing

Fig. 22.2 Gas-insulated test transformer and coupling capacitor for PD measurement directly connected to the GIS

The installation work requires special skills and should preferably be done by the manufacturer. The manufacturer should at least supervise the work and ensure that appropriate site qualities prevail.

22.5 Site Preparation

Regardless of indoor or outdoor installation, the GIS platform or building must be complete and all preparations in place prior to the start of installation. Project scheduling should ensure that inappropriate tasks (e.g., civil works modifications) are not planned for the same installation period. The keyword is "cleanliness." The long-term reliability of the final product depends greatly on the level of cleanliness maintained during the installation process. This can be achieved by the provision of a defined clean working area. Additional preparation measures to be taken include the following:

- The manufacturer should specify any local working condition limitations which should be imposed on the installation of the GIS to avoid contamination by particles, dust, water, or ice. Temporary measures in the form of shelters, barriers, or heaters may be necessary to achieve this condition, especially during outdoor installation.
- The party responsible for the on-site installation of the GIS must ensure the availability of the contractually agreed installation tools and accessories (e.g., lifting equipment, tools, and power supply) throughout the full installation period.
- The manufacturer should specify the number and qualifications of the personnel needed to complete the installation.
- The foundation (floor) should be cleared to allow for the layout of the GIS and the concrete sealing preventing unnecessary dust pollution.
- The unpacking and if necessary general cleaning of the components should be performed away from the final clean assembly area.

22.6 Work Crew Preparation

It is strongly recommended that GIS be installed under the supervision of the manufacturer. If the actual installation is performed by a third party, it is essential that this party possesses the basic knowledge regarding the assembly procedures and quality standards and has to hold every certificate to fulfill the manufacturing standard. This can be achieved by the following:

- Prior to the installation start, the installation crew is given adequate training in the quality standards applicable to the tasks to be performed. This training should be "refreshed" at regular intervals during the installation process.
- Clear instructions are given, especially if a second language is used.
- The relevant installation documentation should be available.

- The correct tools, accessories, and special clothing are available and their proper use is understood.
- All installation activities which require direct supervision are firmly established between all parties.

22.7 Installation of New GIS

The overall installation process for GIS may encompass many months, during which time other activities associated with the project must continue. Coordination of activities among all the project's responsible parties is a necessity, especially with regard to the interface with the HV transformer and HV cable connections.

Time spent in these coordination processes will help to ensure the minimum number of disruptions during the installation process. Disruptions will nevertheless occur and a certain degree of flexibility on the part of all parties is essential.

Specific installation procedures are tailored for each manufacturer's GIS requirements. However, a typical sequence for the installation of new GIS could be as follows:

- The anchoring/support system is installed and leveled to accommodate civil works tolerances.
- Complete bays and single- or three-phase bay components are erected on their respective supports.
- Inter-bay connecting elements are installed and busbars coupled.
- Installation of secondary control panels and interconnecting cables.
- Commencement of SF_6 gas vacuum-filling process.
- Voltage transformers and busducts, including SF_6 air bushings to outgoing transformers or line positions, are installed.
- Interface components are installed (e.g., GIS to HV cable or power transformers), but busbar links remain uncoupled.
- Site commissioning tests are completed, including local control.
- GIS is subjected to the high-voltage withstand tests (ref. Chap. 22).
- Ancillary GIS devices (e.g., surge arresters and monitoring/signaling equipment) are installed and busbar links to high-voltage cables and/or transformers coupled.

To accelerate the overall program, some tasks can be done in parallel if the overall standard of the assembly practices is not compromised.

22.8 Installation of GIS Extensions

The installation of an extension to an existing GIS substation imposes special conditions on both the manufacturer and plant operator that do not normally apply for the installation of new GIS. These special conditions or limitations can be related but not limited to:

- Provisions provided in the existing substation for future extensions like space availability (ref. ▶ Sect. 16.5)
- The need to keep in operation all or portions of the existing plant (ref. ▶ Sect. 24.3 ongoing)
- Safety concerns with operational equipment, both primary and secondary
- High-voltage withstand testing of the completed extension (ref. Chap. 22)

There is no standard installation sequence related to an extension of a GIS substation. Each case must be looked at separately by the manufacturer who can say what must be done, and the user will have to say how it can be achieved with minimum disruption of the existing operational plant. The following specific terms can apply (acc. to IEEE C37.122.6-2013 "Recommended practice for the interface of new gas-insulated equipment in existing gas-insulated substations rated above 52 kV"):

- Manufacturer A: The supplier of the existing or initial GIS
- Manufacturer B: The supplier of the new extension GIS
- User: Current owner of the existing or initial GIS and of the new extension GIS

It should be recognized that manufacturer B will be the same as manufacturer A in those situations where the extension is of the same make but of different design.

During the extension process, the end user and plant operator will have to play an active role in order to assure that the working practices of the installation contractor meet the minimum safety standards applicable to their operating practices.

22.9 Service Continuity

When performing an extension, prime consideration should be made to keep the max number of existing feeders in service. Some outages of feeders may be required to make the connection to the existing equipment and to perform the high-voltage tests. This is dependent on the bus configuration and on the layout of the GIS.

Therefore, it is important to anticipate this requirement during the early stages of GIS design, as it can impact the SLD arrangement, the layout, and the number of components to be supplied in the initial stage.

The outage implications can be different during installation of the extension equipment and during site testing. They should be assessed by the user and manufacturer B during the design of the extension and should cover both site installation and site testing. More additional guidance about service continuity is also given in IEEE C37.122.6 and in Annex F of the IEC 62271-203.

22.10 Commissioning

The commissioning of GIS, including the performance of all applicable tests, represents the final stage of the manufacturer's quality assurance program prior to the GIS being connected into the user's network. The procedures specified in this

stage are intended to be complementary to the manufacturer's overall quality assurance program and should not replace or duplicate controls which have been acted upon in prior stages.

22.10.1 Commissioning of Primary Equipment

The procedures and tests recommended by the manufacturer for primary components are intended to confirm that the interfaces between factory-assembled components have been assembled on-site without error or introduction of defects.

Special attention should be paid to the high-voltage AC dielectric test. Recommendations given in IEC 62271-203 should be used as a basis for discussions between the user and manufacturer for establishing the dielectric site test procedures to be applied to the completed GIS. For information concerning commissioning and on-site tests, see also Chap. 22.

22.10.2 Commissioning of Secondary Equipment

As the secondary control and protection equipment associated with a complete substation is normally only integrated into the GIS during the on-site assembly, it is necessary to confirm that:

- The interconnecting wiring and cabling between GIS and panels has been accurately and securely installed.
- All operational and annunciation functions in both remote and local mode are correct.
- The bay-by-bay control philosophy pretested in the manufacturer's works reflects the user's complete substation operation control and logic requirements.

22.10.3 Commissioning of the SF_6 Insulation Medium

In most cases the processing of the GIS gas compartment prior to the filling of SF_6 gas is performed after completion of the installation of the GIS. Exceptions to this rule may be factory-assembled gas compartments, which can be shipped in their entirety and require no additional intervention during the on-site assembly process (e.g., voltage transformers and circuit breakers). The controls and checks of this on-site processing should include:

- Confirmation of the tightness of each gas compartment during the vacuum cycle and after final SF_6 gas filling
- Confirming that the final moisture content of the SF_6 is within recommended limits (e.g., values can be found in the operation manual or IEC 60376)

22.11 Information to be Given by the Manufacturer and the User

22.11.1 Basic Users Input Data

- Access limitations to the local site
- Local working conditions and any restrictions that may apply (e.g., safety equipment, normal working hours, union requirements for supervisor, manufacturer's and local installation crew, etc.)
- Availability and capacity of lifting and handling equipment
- Availability, number, and experience of local personnel
- Specific pressure vessel rules and procedures that may apply during installation and commissioning tests
- Interface requirements for high-voltage cables and transformers
- In the case of extensions to existing GIS:
  - Provisions for the extension available within existing primary and secondary equipment
  - In-service conditions or operating restrictions that must be respected.
  - Safety regulations that must be adhered too

22.11.2 Basic Manufacturers Input Data

- Space necessary for installation and assembly
- Size and weight of GIS components and testing equipment
- Site conditions regarding cleanliness and temperature for clean installation and preparation area
- Number and experience of local personnel required for installation
- Time and activity schedules for installation and commissioning
- Electric power, lighting, water, and other needs for installation and commissioning
- Proposed training of installation and service personnel
- In case of extension to existing GIS:
  - Out-of-service requirements of existing components related to the installation schedule
- Safety precautions