Gas Insulated Substation Testing and Applications

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Gas Insulated Substation Testing and Applications

Velimir Lackovic, Electrical Engineer

A GIS must be tested to ensure the safety and functionality intended in the design has been achieved in the installation. The testing procedure is done to confirm the technical information as well as safe operation of the GIS installation over its life duration. The main tests are dielectric tests, short-circuit tests, mechanical tests, and temperature rise tests.

Two different test processes are used: type tests that are also known as design tests, and routine tests, that are known as factory or production tests. While type tests confirm the functionality of one GIS type after product development, routine tests check that each manufactured item functions according to the technical demands to which the GIS installation is supposed to adhere.

Type Tests

One of the crucial steps in the development of GIS equipment is type tests. They are done to check the performance of the GIS equipment. The ratings defined in the type tests will also be declared as default data when the GIS equipment is in the production cycle. Type tests at least include:

- Measurement of the resistance of the main circuits
- Tightness tests
- Temperature rise checks
- Short-time withstand current and peak withstand current tests
- Dielectric checks
- Electromagnetic compatibility (EMC) test

- Check of the degree of protection of the enclosure
- Switch operating mechanical life tests
- Check of making and breaking capacities
- Verifications to check performance under thermal cycling and gas tightness tests on insulators
- Proof tests for enclosures
- Low and high-temperature verifications
- Pressure test on partitions
- Fault-making capability of high-speed earthing switch
- Circuit breaker design tests

The following paragraphs present some of the tests.

Dielectric Tests

Dielectric tests are done to check the dielectric capability of the GIS installation under all foreseeable operating circumstances, including temporary and transient over-voltages, and hence involve power frequency verifications, lightning impulse checks, switching impulse checks, partial discharge verifications, and tests on auxiliary and control circuits. In Table 1, an overview of the various dielectric tests presented. The high voltage tests need a big size of test equipment to create the test voltages of some thousands or millions of volts.

Resistance Measurement of the Main Circuits

This test assesses the resistance of a set of conduction paths in a GIS installation. The test will show the conductivity of conductor material, conductor connections, and associated contacts. At a current of generally 100 A DC, the resistance or voltage drop of specified arrangements will be measured. The test results provide information about the conductor quality connections and contacts and also give a basis for a cross comparison between the three phases. The lower the resistance values, the lower the temperature rise would be when in operation. The temperature rise is a crucial factor for checking the continuous current capability of the product. The test results make a benchmark for the GIS test later during the manufacturing process.

Table 1: Dielectric tests

Dielectric tests				
Power frequency tests	Lighting impulse tests	Switching impulse tests	Partial discharge tests	Tests on aux. & control circuits
Simulating conditions under operating frequency	Assessing atmospheric overvoltage	Assessing over-voltages caused by switching operations	Testing to ensure that design and solid insulation is free of partial discharges	Checking that the insulation of aux. & control circuits withstands the dielectrical conditions
Primary equipment				Secondary equipment

Temperature Rise Tests

To determine at what maximum continuous current the GIS equipment can be operated, a temperature rise test is done. Thermocouples will be installed at different locations such as

conductors, connections, contacts, and insulators to assess the temperature rise at a defined continuous current the GIS equipment is made for. Other than this discrete measure technique, by using thermocouples, extra thermographic measures can be implemented to support the evaluation of the arrangement related to the temperature rise, particularly during development tests.

Short-Time Withstand Current and Peak Withstand Current Tests

This test is for verification that the main circuits of the GIS installation will be able to conduct the peak withstand current and the rated short-time withstand current. Elements of the main circuit, as well as support insulators, need to withstand the dynamical stress during the short-time withstand current and the peak withstands current that the GIS installation has to conduct in the closed position of the circuit breaker and disconnect switches. Common values of the short-circuit duration are 1 s or 3 s. With a time duration of 45 ms and for a frequency of 60 Hz the value of the peak withstand current is 2.6 times the rated short-time withstand current. The short-circuit verifications demand high currents, which are created in big, special generators. In some situations, the short-circuit current is taken from the electrical network, but as this might cause disturbances in the network, it is usually prohibited.

Tightness Verifications

Tightness tests verify that the SF6 leakage rate of the tested GIS equipment does not surpass a predetermined value of a permissible leakage rate. According to GIS IEEE and IEC standards, the leakage rate must not surpass 0.5% per year per gas compartment. Certain GIS manufacturers claim even leakage rates of 0.1% per year per gas compartment.

Low and High-Temperature Verifications

This verification is part of the mechanical and environmental tests. All GIS components must work under predetermined low and high-temperature conditions. The GIS or elements of the GIS will be installed in a climate chamber. At minimum and maximum temperatures, operation

verifications will be done. After the test cycles, the SF6 gas pressure and the SF6 leakage rate over a period of 24 hours will be checked.

Proof Verifications for GIS Enclosures

Proof verifications of the enclosures can be destructive or nondestructive. The graph in Figure 1 presents the type test pressure as the highest pressure before the burst and rupture pressure of the enclosure. Coordination of the design and test pressure levels for the GIS enclosures is presented in Figure 1.

Circuit Breaker Design Verifications

Apart from the tests already presented, such as the dielectrical verifications and temperature rise tests, circuit breakers have to be type-tested according to their adequate operation duties.

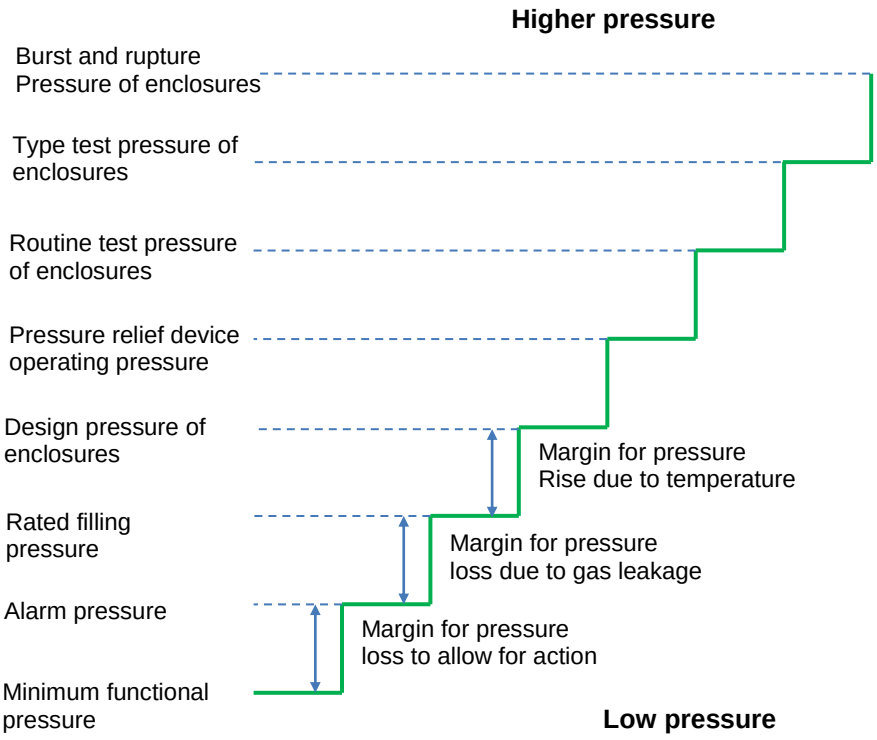

Figure 1: Pressure coordination of enclosures and pressure-relief elements

These tests involve but are not limited to, interrupting time verifications, transient recovery voltage (TRV) verifications, short-circuit current-interrupting verifications, load current checks, capacitor switching current checks, out-of-phase switching verifications, and mechanical endurance tests. These verifications are presented in the IEEE standard for test procedures for high voltage circuit breakers (IEEE Std. C37.09).

Switch Operating Mechanical Life Verifications

To check the mechanical durability of the GIS disconnect and earthing switches, these switches are operated with at least 1000 close/open operations according to IEEE C37.122 standard. The test has to show that the switch and the operating mechanism do not show significant wear and that they are in a good mechanical condition. This will be accomplished by an examination of the switch contacts and associated elements of the kinematic chain and of the mechanism as well. A contact resistance measurement will restate the contact capability to conduct the continuous current after being exposed to stress by the mechanical operations. To check that the mechanical operation test does not affect the SF6 tightness, SF6 gas tightness verification is done before and after the mechanical operation test.

Routine Tests

Routine tests typicall e to make sure that each GIS installation work routine verifications are done for each GIS ins lity gate before the GIS installation leaves the st results, which means that, within defined tol st parameters. Routine tests are defined in IEE

- Pressure checks c
- Measurement of t
- Pressure tests of en