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**Project Title:** Editing technical regulation for commissioning and preventive maintenance of the Gas Insulated Switchgear's equipment.

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### Project Necessity:

Nowadays, due to the increasing consumption of electricity, the need to build more substations in different parts of the power network is increasing. Depending on the type of insulation used, electrical substations can be classified into two categories: gas insulated and air insulated substations. The advantages of gas-insulated substations, which are the result of the distinctive insulating properties of sulfur hexafluoride gas, have led to a great tendency in recent

years to construct gas-insulated substations. In this regard, actions such as preventive maintenance of these substations, which ensure their safe and economical operation, are among the issues that will significantly improve the efficiency of the network. Hence, in many references and instructions of GIS equipment manufacturers, maintenance and commissioning measures and related topics have been thoroughly reviewed. Also, in order to organize this set of proposed measures, different countries have developed practical instructions in this field so that users can guide and use these manuals posts during commissioning and operation time of the substation. Given the increasing rate of GIS substations in the country and the lack of comprehensive guidelines in this area, it seems necessary to develop similar guidelines in this regard.

### **Project Goals:**

The purpose of this project is to develop technical criteria for commissioning and maintenance of gas insulated switchgear. In this way, by thoroughly reviewing the existing standards and instructions, the inspections and tests that are performed on the equipment during commissioning and maintenance are provided. Regarding the tests, the importance of the test, the test procedure and the criteria or reference value for their approval are explained. Ultimately, the goal is to compile these inspections and tests comprehensively.

### **Abstract:**

Energy demand has increased in recent years due to rapid advances in industrial technology and population growth. Environmental conditions and system reliability are the main reasons for introducing of gas insulated switchgear. GIS, which is filled with high pressure sulfur hexafluoride (SF<sub>6</sub>) gas as the electrical insulation, has been widely used in electrical power systems in recent decades due to its advantages such as small occupied space, no pollution penetration, long time periods for maintenance and high reliability. The reason for the development of these switchgears is that the high voltage parts that are energized are protected by the compartments, so the disturbance caused by the external magnetic fields is almost prevented. If the relevant technical measures are performed correctly during commissioning and in the maintenance periods, GIS would obtain higher reliability and longer life time. This can be seen by examining the operation history of the switchgears. These measures include tests and inspections related to the commissioning and preventive maintenance of the gas-insulated switchgears, and play an important role in improving the operation of the substations. Thus, in this project, tests and inspections related to GIS equipment that should be performed at different stages including commissioning and maintenance are presented. Inspections and tests are provided separately for each of the equipment available in the GIS.

The commissioning measures of the GIS includes tests and inspections. The proposed tests in the commissioning phase include general switchgear tests and operational tests related to equipment with moving parts (dynamic) in GIS (e.g. circuit breaker, disconnecter, voltage transformer and current transformer). These tests include main circuit and contacts resistance measurement, insulation resistance measurement test (also known as the Megger test), pressure test of the compartments, gas leakage and gas tightness test, humidity and purity test, functional tests, electrical conductivity of the ground's test, dielectric test set and electrical partial discharge (PD) test.

When commissioning a GIS, some equipment needs to be inspected to ensure proper assembly and operation. These inspections are performed separately for each equipment. Commissioning inspections are performed on the whole switchgear, circuit breakers (which according to the operating mechanism of the circuit breakers are categorized into four parts including inspections that are common for all operating mechanism, spring type mechanism, pneumatic type mechanism and hydraulic type mechanism), disconnectors and switches, current transformers, voltage transformers and the local control cabin.

Actions related to tests and inspections of the GIS equipment in maintenance periods are based on three general categories of short-term, periodic and overhaul maintenance for GIS equipment. Short-term actions are recommended to be done daily or several times a year, often a visual inspection of all GIS equipment should be performed without the need of de-energizing the equipment. The purpose of this inspection is to verify the health and absence of unexpected erosion and corrosion of equipment, and is usually performed by substation's operators. These daily inspections are performed separately for each equipment including circuit breakers (common for all operating mechanisms, spring type mechanisms, hydraulic type mechanisms and pneumatic type mechanisms), disconnectors and switches, cable terminals, voltage and current transformers and surge arresters. The required inspections are also performed on general parts in GIS. Periodic maintenance, which is in fact the same as preventive maintenance, according to the action, is performed annually (if necessary every 3 or 5 years). The actions of this section are classified into two sections: inspections and tests. It is recommended that all actions mentioned in short-term inspections be repeated in periodic inspections. The time interval of periodic actions is considered as annual and in cases of inspections where more time is suggested, the proposed time is mentioned. Periodic inspections, actions, tests and measurements are done for each equipment in GIS including circuit breakers (common for all operating mechanisms, spring type mechanisms, hydraulic type mechanisms and pneumatic type mechanisms), disconnectors and switches, cable terminal, current and voltage transformers, surge arresters and other equipment. Also, during performing of the preventive maintenance, humidity and purity test, pressure and gas leakage test, partial discharge test, main circuit and contact resistance measurement test sets and insulation resistance measurement test are performed. The time for long-term maintenance or overhauls is once every 15 years or after each overhaul. Nevertheless, equipment performance criteria and equipment conditions are the determining factor when to perform these actions. All commissioning tests in this section must be repeated. It is important to note that long-term inspections of dynamic equipment are of great importance, so this stage of inspections is recommended for circuit breakers and switches. Long-term maintenance or overhaul are performed on the all circuit breakers common for all operating mechanisms and disconnectors and switches.

### **Steps and Methodologies:**

This project is defined in four stages. In stages one and two, internal and external references and instructions have been studied and a list of tests and inspections has been compiled. In each case, the items related to the operation and maintenance of the gas insulation switchgears were extracted from the relevant manufacturer's instructions or standard and were classified. In the third stage, entitled "Development and editing the methods of performing commission and maintenance tests for gas insulation switchgears", after reviewing internal and external references and documents, in order to determine the list of related commissioning and maintenance tests, existing methods of conducting proposed tests based on references and relevant standards have been studied. Also in this stage, the acceptance criteria of each of the proposed tests is presented. The last step, the fourth, entitled "Draft instructions for commissioning and maintenance of gas insulated switchgear equipment" includes tests and inspections related to GIS substation equipment in the commissioning and maintenance stages. Finally, checklists for performing these tests and inspections, both at commissioning and during maintenance intervals, are provided.

### **Main Results (technical outputs, patents, papers, books, reports, etc.):**

- Carrying out preliminary studies and reviewing references and documents related to the project and documenting the existing procedures in the commissioning and maintenance of gas insulation switchgear's equipment.
- Editing of a list of commissioning tests and maintenance actions for gas insulation switchgear's equipment.

- Editing and codification of methods for performing commissioning and maintenance tests for gas insulation switchgears.
- Draft instructions for commissioning and maintenance of gas insulation switchgear's equipment.
- Paper entitled "Increasing the Productivity of Gas-Insulated Switchgears (GIS) Using Preventive Maintenance Measures" published in the 15th National Conference on Quality and Productivity.