# Overall Testing Of GIS Control Panel

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***Abstract-*** *To achieve the reliability over power supply, the power system equipment's must need to be improved to the best quality and to achieve this one must need to test the equipment's with the foremost accuracy and determination. The control panel is the most important and irrevocable part of power system and it consist mainly circuit breaker, disconnector switch, C.T., P.T. which provides the indication and alarm for various faults occurring on the line. The control panel must need to be tested with due care so that no margin of error will be there for any kind of faults during the abnormal conditions. Here in we will discuss the total testing procedurecarried out to test control panel and the major arrears occurring during this process.*

***Keywords***- PPM- Part Per Million, SLD- Single Line Diagram, DS- Disconnector Switch, IR- Insulation Resistance, SF6 – Sulphur Fluro oxide.

## I. INTRODUCTION

The control panel is assembly of number of electrical equipment's mounted together for protection and measurement of lines and it is generally employedat the substation.To get the protection against the various faults and also to monitor every single condition of line control panel is mostly preferred. The control panel can be defined as the Assembly of various electrical equipment's such as disconnector switch, Circuit Breaker, current transformer, potential transformer and other electrical measuring and protection equipment's such as Ammeter, Voltmeter,Frequencymeter, Tri-vector meter and various types of indicators for displaying the condition of the line. The testing of control panel is taken out at various stages during manufacturing and installation of the control panel and these tests are necessary to check the Quality of the control panel. If one of the tests gives unsatisfactory results during manufacturing orinstallationprocessthen it can produce harm during operation on the site. The Testing of GIS Control panel mainly includes following testing processes:

1. Mechanical testing
2. Gas leak testing
3. Visual testing
4. Electrical testing

## II. MECHANICAL TESTING

Mechanical testing of Hollow (GIS) Gas Insulated Switchgear tank is done to check the quality of tank before filling the insulating (arc quenching) media (SF6 Gas). The tank of Control panel is built by welding the sheets of steel material and it is so that any kind of leakage of insulating gas will not be possible through it. The SF6gasis mostly preferred for arc quenching in (GIS)Gas insulated switchgears because theSF6 gas has remarkable arc quenching properties and it is very safe to use.The SF6 gas is filled in the container where the contacts of the disconnector switch move in direction (ON-OFF-EARTH)and the contacts of circuit breaker move in a direction such that (TRIP-CLOSE) this action closes or opens the circuitand hence whenever the arc struck between the two contacts during opening and closing, the SF6 gas predominantly extinguish the arc by its own presence.

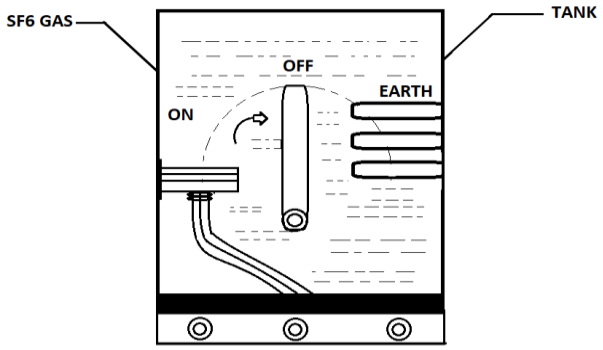


Figure 1: Disconnector Switch Tank

The following are the major errors which can be observed during mechanical testing of the control panel.

A) Unwanted Welding Burrs

The tank of the GIS control panel is made with required dimensions and as per the various voltage levels the tank size of control panel may increase. The tank is made by welding the sheets of Steel material with good thickness.During precise welding process there may be

chances of welding Burrs and this Welding burrs are nothing but unwanted extra welding done on the sheets of the tank due to some errors and they need to be clearedas early as possible. During the assembly of various fixtures and fascia thewelding burrs may produce sag in between fascia and the tank, which may lead to improper mounting of fascia and fixtures and to avoid this welding burrs should be removed immediately after welding.

B) Loose Mechanical Mounting

The mechanical mounting of the control panel should be strong and good enough to withstand the load and severe atmospheric conditions.Loose mechanical mounting becomes a common problem with the carelessness of the workers which affects the quality of the control panel. It mainly includes the following

i) Loose Nuts and Bolts
ii) Loose fittings of fixtures
iii) Loose mounting of bushings
iv) Loose mounting of C.T. and P.T. terminals
v) Loose mounting of Earth-Bar Rod
vi) Loose fitting of Pressure Gauge etc.

These errorsare unacceptable and became a serious issue during the installation and operating of the control panel and need to be regulated as early as possible.The loose mechanical mounting and loose connections provide very high value of leakage current (IL) which may flow throughout the body of the control paneland if the operator came in contact with the equipment there is a chance of electric shock also this may lead to chances of extreme accidents as well therefore the mechanical mounting of every equipment should tighten with due care.

C) Bursting Disc Check

The burstingdisc is the primary protection for troubleshooting of the SF6 gas and also for the problems associated with control panel tank. The bursting disc is generally mounted on the rear side of the tank which is made by a very thin sheet. If a stress more than a certain value is applied on the bursting disc sheet then the at the rear side of tank will break providing a way for SF6 gas to release in the outer atmosphere. Without bursting disc there will be chances of severe accidents. In GIS tank the SF6 gas is filled which provides arc quenching feature but Whenever the gas in the control panel exceeds its required level then the bursting discmay break and should provide area to release the gas in the atmosphere and this prevents the overall damage of circuit breaker and disconnector switch.

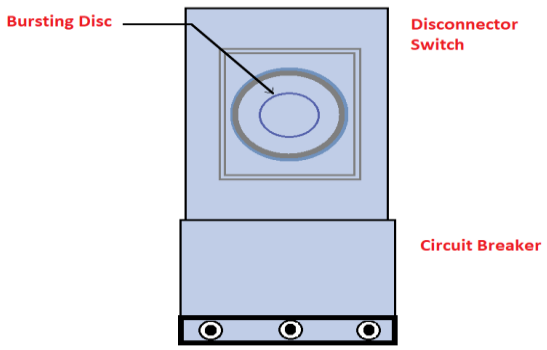

Figure 2. Bursting Disc on rear side of Tank

D) Leak Check of Control Panel

The SF6 gas provides best characteristics for quenching of arc and due to its remarkablecharacteristic, such as

- Inflammable Gas
- Do not take part in any reaction
- Safe to use
- Arc can be extinguished within seconds

The Sulphur fluor oxide (SF6) is mostly preferred for GIS Switchgear. The SF6 gas iscostlier compared to other gases and if the leakage through the tank continues then it will create danger condition and no arc quenching will take place so it becomes very first priority of manufacturing companies to avoid any kind of leakage through any small crack. To prevent any kind of leakage seal, gel is used on the areas of control panel where the chances of leakage are more. Manufacturing companies employ various methods to prevent any kind of leakage through the tank such as the following

a) Helium Leak Check
b) Leak check by Using IR Technology

a) Helium Leak Check

After filling the SF6 gas in a closedtank it is kept under observation by quality inspector for a period of time in Helium Leak check machine. As we know the Helium is lighter in weight so, it makes us easy to find any leakage area of the tank. Helium leak check machine makes it easy to find the cracks on the tank.

b) Leak check by using IR Technology

In this method infrared technology is used to detect the leakage of SF6 gas through the tank of control panel.If the gas leakage through the tank is greater than 1 PPM

concentration in air, then the IR sensor will sense the gas and it will provide a signal of gas leak. The machine consists of gun on the front end of this gun a sensor which sucks the gas present in environmentand check whether the concentration of SF6 gas is present in environment.

## III. VISUAL TESTING

A visual check is carried at various phases of manufacturing of control panel. The visual test provides data which is to be collected by taking due care. This is done to get the best quality product which provides good look to the control panel and maintains the aesthetic values of it. More often visual check is done to check whether the requirements are fulfilled by the manufacturing company or not. Visual corrections are cleared by the workers working on the line quickly so as to improve the basic quality features of it. It mainly includes a sheet of data over which number of points are covered the quality inspector needs to verify every single point and provide the points which are to be revised.

Table1: Data Sheet for Visual Testing

| VISUAL CHECK | POINTS IF ANY | REMARKS |
|---|---|---|
| 1) Earth Bar | Not Aligned properly | ---------- |
| 2) Mimic Diagram | √ | Ok |
| 3) Upper Fascia | Not mounted properly | ---------- |
| 4) Lower Fascia | √ | Ok |
| 5) Paint Shade | √ | Ok |
| 6) Dimensions of Tank | √ | Ok |

The visual check includes all the following points such as paint shade, Paint thickness, Alignment of various elements, Dimensions of the tank, Dimensions of the busbar, Single line diagrams, mimic diagrams,fascia and fixtures of control panel.

A) Mimic and Single Line Diagrams (SLD's)

The single line diagrams and other symbols must need to be stuck carefully with the respective circuit elements. One can understand the operation only when he understood the mimic diagrams and SLD's. The quality inspector must need to check the single line diagrams with reference to the individual panels elements and suggest remarks over it.

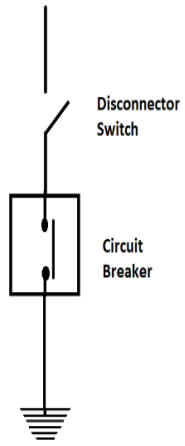


Figure 3: Single Line Diagram

The above figure shows the generalized SLD of control panel.

B) The paint Shade and Thickness

The paint of the control panel plays a very important role and the layer of paint should be thick enough to resist the rusting of fascia and fixtures in the outer atmospheric conditions. The control panel may be subjected to outdoor operations and hence it should be ready to sustain the sunlight, rain and all the other atmospheric conditions. The paint should have high insulating capacity and the thickness ranging greater than 0.5 microns which can resist the rusting of the control panel.

B) Stickers and Danger labels

Stickers are used to denote various conditions on the control panel such as ON-OFF-EARTH of Disconnector switch and TRIP-CLOSE of Circuit Breaker.They are also used for indication of respective phasesI.e., R, Y, Bover the bushings of control panel.

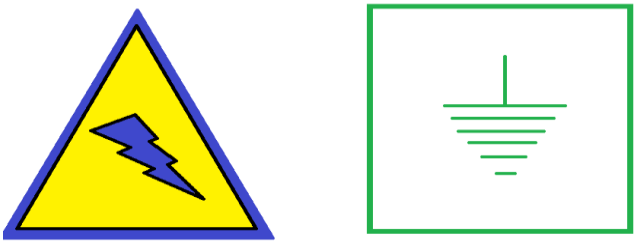

Figure 4: Various Stickers Used in control panel

The earthingStickers are stuck near the earthing rod. The danger label sticker is provided on every front end and

back end of the control panel which indicates the high voltage and also helps to prevent the chances of accidents.

## IV. ELECTRICAL TESTING

The electrical testing of the control panel is taken with due care during manufacturing the control panel. The electrical testing plays very important role because it satisfies all the norms of operation and provides all the information about the control panel such as leakage current, breaking capacity of circuit breaker, tripping time of circuit breaker, Insulation resistance of control panel, sequence of operation of various equipment's and the actual values that CT and PT receive from one end. The electrical testing primarily includes:

A) Insulation Resistance Test
B) High Voltage Test
C) Trip time of Circuit Breaker
D) Current Injection method
E) Wiring testing of Control panel

### A) Insulation Resistance testing

The insulation resistance test is carried out by using megger.In this method the terminals of megger are connected with R, Y, B phases individually and their insulation resistance is calculated on the megger.

Table 2: Insulation Resistance after Testing

| Sr. No. | Phase (R) | Phase(Y) | Phase(B) |
|---|---|---|---|
| 1) 5000 V | 10 Terra Ω | 10 Terra Ω | 10 Terra Ω |

The megger is used to check the continuity of line by applying a high voltage and circulating large current through the element. The insulation resistance value should be greater than10 terra ohms.If the value on megger is less than 10 Terra Ohm then the insulation resistance test is said to be failed and the control panel is again taken to quality revision.The below are the various readings obtained by connecting each phase by using Megger.The above are the various readings obtained from each phase by using Megger during insulation resistance testing of control panel.

### B) High Voltage Test

The High Voltage Test is carried out in a restricted area where a current transformer of high rating is available.The high voltage test is very important to determine whether the control panel sustains the high voltage.

$$\text{Applied (H.V.) Voltage} = 2*\text{RatedVoltage}$$

The control panel must go through the H.V. test before operating on the actual field or the site where it is to be installed.The high voltage test is carried out at various stages of manufacturing to check the potential withstand capability of the control panel in which it is provided with high voltage of two times the rated voltage.for example, if 33KV control panel is taken for under the high voltage testing, then the supply of 66KV should be provided and at the initial condition the supply is slowly increased from 0 V to 66 KV by using a step-upcurrent transformer and the time duration for High Voltage test is considered for 1 minute. if the spark occurs at one of the bushings during High Voltage testing, then the high voltage test is said to be fail, if the voltage quietly increases from 0 to 66 KV without any interruption, sparking or any trip more than 1 minute then the test is said to be ok. By using High Voltage test we can get the value of leakage current and if the circuit breaker sustains the magnitude of voltage for more than 1 minute then the high voltage test is said to be successfully done and the control panel is then further processed for the next quality check.

### C) Trip Time of Circuit Breaker

Trip time of the circuit breaker is very important during clearing of the faults on the line and when extreme high fault currents flow through the system. This test is carried out to check whether the circuit breaker operates in the predetermined time or not.Trip time of circuit breaker should be as small as possible to clear the fault quickly and hence trip time is tested by usingtime testing machine.The machine consists various terminals which are connected with the control panel bushings namely R, Y, B phases and neutral is connected to the earth bar rod of the control panel.The time testing machine has a unique feature that it providessignal pulses to the motorof the circuit breaker which helps to trip and close operations and it alsocalculates the time required for the circuit breaker to move from open position to close position. Initially when the circuit breaker is in closed position, the signal is provided through the time testing machine and hence the circuit breaker operates and it tripsthe circuit and provide isolation to one part of the circuit.

The time duration for various operation is recorded and the receipt of various operations can be printed by the same machine.In the above action the time taken by the circuit breaker to move from close position to the trip position is calculated with this machine and we can also find the time required by the circuit breaker from off position to close position.

**D) Primary Current Testing of C.T**

In primary current testing the cable is inserted through the CT and current is made to flow through the cable by using current injection trolley. The current transformer senses the current flowing through the cable and it provides signal to relay. The relay is specified with predetermined value of trip currents and hence itprovides the signal only when predetermined current exceeds the limit.The CT is nothing but measuring transformer (instrument transformer) which provides magnitude of current through the cable.The primary current testing is taken by specifying different values of currents in the relay and the current is provided by current injection trolley for tripping of circuit breaker for different phases.

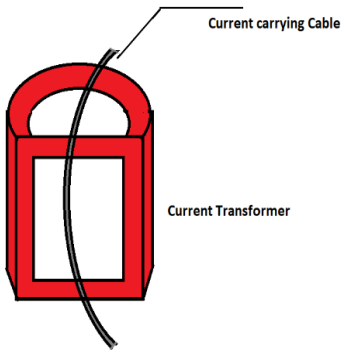


Figure 4. Primary Current Injection Method

Table 3: Primary Current Injection

| Sr. No. | CT Ratio | Current in Relay | Current Applied | Tripping current |
|---|---|---|---|---|
| 1) | 100-50/1 | 1 A | 100 A | 0.96 A |
| 2) | 100-50/1 | 2 A | 50 A | 0.98A |

The above table shows the values of different currents at which the tripping of circuit breaker take place. The relay is provided with values of current at which we want to trip the circuit breaker and when the current in the cable reaches the predetermined value of current then the relay provide signal to the circuit breaker similarly, the current injection of fault passage indicators (FPI) can be done.Relay can provide the trip time in seconds whenever the currents exceeds the predetermined value and Trip time for different current values can also be measured by using this method. This method is generally used in industries to check whether the CT provide right readings of the current provided and also to check whether the CT terminals are shorted or ok.

## V. FINAL QUALITY CHECK

After going through all testing and supervision methods. The final Quality testing is done over the control panel in this final quality check every equipment is operated twice to get the satisfaction over the equipment and the Performance of every equipment is taken into observations. The control panel is provided with the rated supply and all the equipment's such as Relay, C.B., Ammeter,Voltmeteretc. are made to operate. After charging the control panel few operations should be taken and the value on every electrical instrument is observed very carefully.For example, if we have to check the Gas pressure low condition then we will have to only remove the gas sensing wires for temporary purpose and then the circuit breaker gas pressure low signal is tested over which the alarm and annunciator operates. Final quality check is done by using the drawing and layouts only and the connections in the control panel board are testedwhile primary between bus coupler and bus riser is done by taking operations of both. The incomer and outgoing feeders are tested and they are simply provided with release which are Programmable.The final quality check plays a very important role because in this quality check the control panel is in fully live condition and total supply monitoring can be done thought and also, we can get to know how thathow control panel will work on the site.If one of the results of final quality check are not satisfactory then the control panel is again taken fortesting.

## VI. CONCLUSION

From this project, we came to the conclusion that the Testing of control panel isvery much important to determine whether the control panel is in good condition or not and after finding the issues we can resolve them by the following methods by only testing the control panel.

- The testing of control panel makes it reliable to use.
- The overall accuracy of the control panel can be increased by just solving the tiny problems.
- The testing of control panel can reduce the various arrears that are unacceptable in the power system.
- The testing can help in both production and during the maintenance of controlpanel.
- During testing we can find various arrears and we can make the various provisions according to the arrears.
- During maintenance one should know the total testing procedure and the overall cost of the control panel is very high so the maintenance should be done with due care.
- The overall testing of the control panel needs to be done at regular instances to avoid the maintenance of the control panel.

- The overall quality check makes the control panel reliable to handle the load in any severe condition and the overall accuracy of the control panel increases.

## VII. APPENDIX

Testing of control panel is a practical approach in which the quality engineer tests the control panel using various methods to get the reliability over the control panel. The Gas Insulated Switchgear is very much helpful in power system to trip on the occurrence of fault.The Gas Insulated Switchgear is very much helpful in power system to trip on the occurrence of fault. The testing of this switchgear helps to control the various faults. The testing helps to gain the accuracy over the measuring transformers i.e. CT and PT and all the other electrical equipment's.

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