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Design of Substation Equipment Sizing, Testing and Commissioning

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Abstract - The objective of this project to design substation equipment by means of sizing of equipments like Lightning arrester, Wave trap, CVT, Current transformer, Isolator, Circuit breaker, Transformer etc. by means of different rating like 66kv, 132kv, 220kv, 400kv, 765kv. We also studied different tests which are carried out on each equipment such as Routine test, Type test and Acceptance test. We also studied commissioning of electrical equipments at the time of installation on site. In order to design a substation we needs to get its equipment sizing done in order to get appropriate rating of the equipments through any consultant agency or electrical engineer experts, so that it should give a proper operation. We also need to get that if the equipment passes through various tests, it should withstand any system abnormal conditions. Thus we have a variety of tests for each and every equipment. It is also important to take proper commissioning to check the delivered equipment is proper for continuous operation.

***Key Words*: Substation Equipment, Sizing Testing, Commissioning, IEC standards.**

1. INTRODUCTION

Power demand in India is increasing rapidly due to increase in industrial, commercial and agricultural consumers. It is required to have large blocks of power generation in country like India where transmission and distribution losses are 25 – 30 %. To meet consumer demand, more generating stations like Thermal, Gas, Hydro and Nuclear are needed which are far away from consumer. To transmit large amount of power up to long distance, extra high voltage lines are necessary to transmit huge blocks of power from the sources of power to the load centers, to interconnect two systems, to interconnect power stations for increased reliability of supply, greater system stability and lesser stand-by plant and hence cheaper electric energy. In between power stations and consumers, transformation and switching stations called as substations are necessary for the control of electrical power system.

Substation equipments are required to control and maintain power supply. Substation equipments design is very important from the point of view of reliability of system supply. In this Project, main objective is to sizing of 400/220/132 Kv substation equipments which has higher reliability & security.

It is the procedure to reveal particular equipment's capability by different types of procedures and suitable arrangements. The testing of machine reveals its quality, performance and reliability. Generally it is done before putting into widespread use or practice. The equipment goes through every possible hardened or worst condition by applying several stresses with help of electrical and mechanical parameters as well. It will insure equipments withstand ability during abnormal conditions like bad weather or faulty condition in power system.

Electrical commissioning is essential to start up of any electrical system for the first time regardless of size or industry. On equipment electrical testing solution will perform visual, mechanical and electrical tests to ensure trouble-free energizing of equipments.

2. SUBSTATION EQUIPMENT SIZING

In equipment sizing of substation here we have taken a case study of Sitamahri Substation located at mithila, Bihar. The substation is 400kv receiving substation. It is having three voltage rating i.e. 400kv, 220kv, 132kv. The substation has total thirty bays which include incoming bays, transformer bays, outgoing bays, P.T bays, Bus coupler bays and reactor bays. The overview of bay details including future plan expansion plan is given as under.

Table -1

Sr. No.	Parameter Description	Unit	Value
1	**Bay Details**		
	voltage level	kV	132
	Fault level at bus(Current)	kA	40
	Fault level at bus(MVA)	MVA	9145.2283
	Fault level at bus(Time)	Sec	1
	DC operation Voltage	V	220
	DC operation Voltage	V	48
	Line loading	MW	150
	Power Factor	-	0.85

Line loading	MVA	176.4705882

2Lightning Arrester

Type	-	Gapless Type and Station Class
Voltage Rating	kV	118.5553036
Current Rating	kA	10

3 Wave Trap

Rated inductance	mH	1

Capacitance Potential Transformer

Rated Primary core voltage	kV	132/√3
Rated Secondary Core 1		
Voltage	V	220/√3
Application	-	Metering
Class	-	0.2
Output Burden	VA	100
Rated Secondary Core 2		
Voltage	V	220/√3
Application	-	Protection
Class	-	3P
Output Burden	VA	100
Rated Secondary Core 3		
Voltage	V	220/√3
Application	-	Spare
Class	-	3P
Output Burden	VA	100
Capacitance (Minimum)	pF	4400

5 Isolator

Type	-	Double break Type
Voltage Rating	kV	146
Current Rating	Amp	1157.788

6 Current Transformer

Rated Primary Core Current	Amp	964.2366
Rated Secondary Core 1		
Current	Amp	1
Application	-	Metering
Class	-	0.2
Output Burden	VA	50
Rated Secondary Core 2		
Current	Amp	1
Application	-	Protection
Class	-	5P20
Output Burden	VA	50
Rated Secondary Core 3		
Current	Amp	1
Application	-	Protection
Class	-	5P20
Output Burden	VA	50
Rated Secondary Core 4		
Current	Amp	1
Application	-	Protection
Class	-	5P20
Output Burden	VA	50

7 Circuit Breaker

Type	-	SF6 Outdoor Type
Voltage Rating	kV	146
Current Rating	Amp	1157.788

3. TESTING

It is the procedure to reveal particular equipments capability by different types of procedures and suitable arrangements.

The testing of machine reveals its quality, performance and reliability. Generally it is done before putting into widespread use or practice.

The equipment goes through every possible hardened or worst condition by applying several stresses with help of electrical and mechanical parameters as well.

It will insure equipments withstand ability during abnormal conditions like bad weather or faulty condition in power system

Types of Testing:

There are three types of testing:

1. Type tests
2. Routine tests
3. Special tests

Tests done at site:

There are three types of tests done at site:

1. Pre-commissioning tests
2. Periodic monitoring tests
3. Emergency tests

Type Test:

To prove that the equipment meets customers specifications and design expectations, it has to go through different testing procedures in manufacturer premises. Some tests are carried out for confirming the basic design expectation of that equipment. These tests are done mainly in a prototype unit not in all manufactured units in a lot. Type test of confirms main and basic design criteria of a production lot.

Routine Tests:

A routine test of equipment is mainly for confirming operational performance of individual unit in a production lot. Routine tests are carried out on every unit manufactured.

Special Tests:

A special test of equipment is done as per customer requirement to obtain information useful to the user during operation or maintenance.

Pre Commissioning Test:

The equipment goes through some other tests, performed on it, before actual commissioning at site. The equipment testing performed before commissioning it is called pre-commissioning test. These tests are done to assess the condition of equipment after installation and compare the test results of all the low voltage tests with the factory test reports.

4. COMMISSIONING

Major steps of commissioning:

1. Fitment of Accessories
2. Drying out
3. Cleaning of porcelains of bushings with trichloroethylene and then by dry cloth.
4. Conductors and/or cables
5. Earthing of equipments
6. Connection of protection circuits and alarm circuits with CTs.
7. Setting of relays (in control room)
8.

Sweep Frequency Response Analysis:

Sweep Frequency Response Analysis (SFRA) is a powerful and sensitive method to evaluate the mechanical integrity of core, windings and clamping structures within power transformers by measuring their electrical transfer functions over a wide frequency range. SFRA is a proven method for frequency measurements.

The SFRA is a comparative method, meaning an evaluation of the transformer condition is done by comparing an actual set of SFRA results to reference results.

Methods of SFRA:

Three methods are commonly used to assess the measured traces:

1. Time-based: In this type of test current SFRA results will be compared to previous results of the same unit.

2. Type-based: In this type of test SFRA of one transformer will be compared to an equal type of transformer.

3. Phase comparison: In this type of test SFRA results of one phase will be compared to the results of the other phases of the same transformer.

Working:

Transformers consist of multiple complex networks of capacitances and resistors that can generate a unique signature when tested at discreet frequencies and plotted as a curve. The distance between conductors of the transformer forms a capacitance. Any movement of the conductors or windings will change this capacitance. This capacitance being a part of complex L (inductance), R (Resistance) and C (Capacitance) network, any change in this capacitance will be reflected in the curve or signature. An initial SFRA test is carried out to obtain the signature of the transformer frequency response by injecting various discreet frequencies. This reference is then used for future comparisons. A change in winding position, degradation in the insulation, etc. will result in change in capacitance or inductance thereby affecting the measured curves. Tests are carried out periodically or during major external events like short circuits and results compared against the initial signature to test for any problems.

Uses:

1. To obtain initial signature of healthy transformer for future comparisons
2. Periodic checks as part of regular maintenance
3. Immediately after a major external event like short circuit

4. Transportation or relocation of transformer
5. Earthquakes
6. Pre-commissioning check

5. CONCLUSION

By getting substation parameters we have to design the equipment by higher than its nominal voltage rating and also according to its total current carrying capacity. We can determine its operating current and voltage (in case of L.A) at normal condition.It is also seen that by testing we can determine reliability of the equipment. The commissioning process leads to inspecting and onsite testing to determine if equipment is ready to use or not and if is there any physical damage occurred or not.

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