Testing Manual for Electrical Equipment

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Abstract

Quality Assurance (QA) refers to a program for the systematic monitoring and evaluation of the various aspects of a project, service, or facility to ensure that standards of quality are being met. The equipment should be suitable for the intended purpose (fit for purpose) and errors/omission should be eliminated before putting the equipment in service.The paper has been developed to capture various aspects/requirements of inspection and test thru Factory Acceptance Test (FAT), Site Acceptance Tests (SAT) and to ensure quality of the equipment/system.

Keywords: factory acceptance test,routine test, site acceptance test, type test.

Introduction

The purpose of this testing manual is to provide guidelines for inspection and testing of various Electrical Equipmentin compliance to relevant international standards/specifications.It provides information on procedures and testing of Major Electrical equipment's to be followed during testing by engineers and also furnish evidence that an electrical equipment/device is free of inherent flaws or faults.

The tests on equipment/system have been broadly categorized into two categories viz. Factory Acceptance Test (FAT) and Site Acceptance Tests (SAT). These tests have been tailored to ensure design, construction and performance requirements of each equipment.

This testingmanual includes High Voltage Switchboards, Low Voltage Switchboards, Transformer, Diesel Generator Sets, Induction Motors, Cables, Un-interrupted Power Supply (UPS), Ring Main Unit, Light Fittings, MOV Actuators, Isolator Switch and Earthing Systems etc. However in this Paper only highlights the high voltage cables and related test methods.

Benefits

- Most useful practical information regarding the Factory Acceptance Tests (FAT) & Site Acceptance Tests (SAT) activities
- Highlights the type of test and their desired result values. These values are derived from the International standards, manufacturer's guidelines and good practical experiences.
- It covers for all major Electrical Equipment.
- Simplifies procedures/integration

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- requirements are fulfilled.
- Improve the quality control of the project and simplify the procedures for engineers.
- Saving of material searching time.

Factory Acceptance Tests (FAT)

The Routine tests shall be made with each Electrical Equipment and, whenever practicable, at the manufacturer's works to ensure that the product is in accordance with the equipment on which the type tests have been carried out.

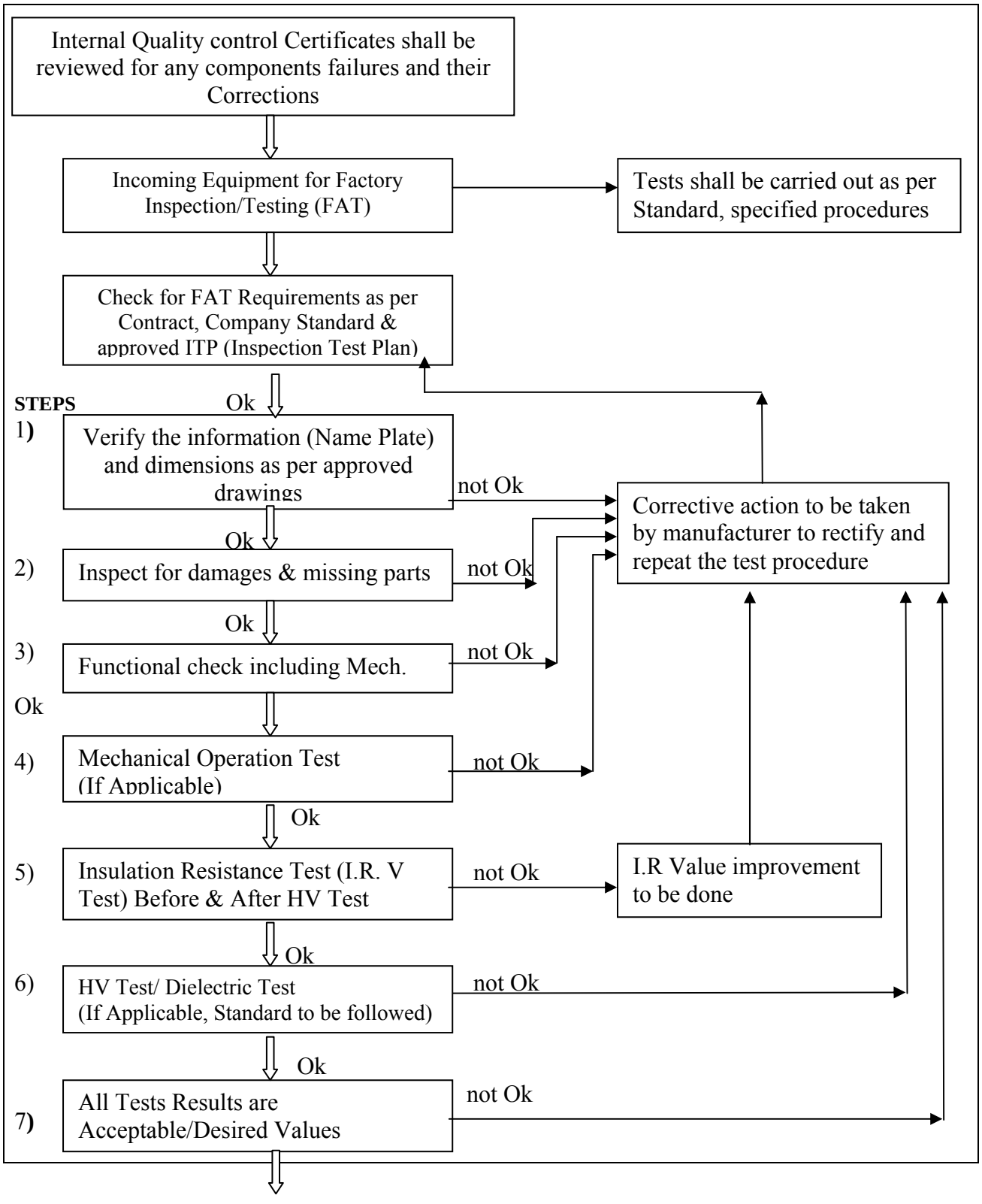
The factory acceptance tests consist of Routine, Type Tests and Special tests (project specific) as per company and International standards. Routine tests may comprise,

Functional tests - Mechanical Operation Test -Test on auxiliary equipment-Verification of correct wiring.

Dielectric Tests - It is presumed that every such equipment would also comply with the type test, since design is identical.

The factory inspection and testing are conducted according to Company/international standards. The Inspection/testing of Electrical Equipment at Factory are carried out as per the flowchart attached below,

Flow Chart for Factory Acceptance Test (FAT)



Yes

8) Test Passed Equipment- Dispatch clearance may be given

Test Methods and Desired Values

In this paper we have highlighted only the High Voltage Cables. Similar way it covers to all major Electrical equipment's.

Typical FAT Report- A typical Factory Acceptance Tests (FAT) formats for High Voltage Cables is as below;

Sr. No.	**Description**	**Procedure**	**Desired Values / Results**
All internal quality control certificates shall be reviewed for any component failures and their corrections.			
1.	Visual Inspection	Check the Conductor, General Construction and cable Identification etc.	Ok. (as per approved document)
2.	High Voltage Test	AC Voltage test shall be applied between the conductor and the metallic shield (for 11KV cables 23KV for 5 minutes) at ambient temperature.	No Breakdown
3.	Insulation Resistance Test	The measurement shall be made between conductor and the cores & metallic shield.	Value shall be Minimum 100 MΩ
4.	Partial Discharge Test	The test voltage shall be applied between each conductor and the metallic shield. The partial discharge is measured at 11KV.	No detectable discharge/puncture
5.	Voltage Test for 4 Hours.	The test voltage (25.5 KV AC for 11KV shall be applied between conductors and the metallic shield. (Applied voltage shall be 4Uo for 4 hrs. for XLPE cables sample)	No breakdown
6.	Conductor and screen Resistance test	The conductor resistance measured atambient temperature by Double bridge method.	As per IEC 60502-2 (approved document)
7.	Conductor/Armour wire examination	Sampling : Outside diameter of conductor shall be measured at 3 points by caliper and average value shall be calculated. And diameter of armour wire shall be measured on 10% of total armour wires.	As per IEC 60502-2(As per approved document)

8.	Measurement of thickness of insulation, bedding sheath and outer covering	Sampling : i) Thickness of insulation shall be measured at 6 points by projector. ii) Thickness of bedding sheath shall be measured at 6 points by vernier caliber iii) Thickness of outer-covering shall be measured at 6 points	As per IEC 60502-2(As per approved document)
9.	Measurement of overall diameter	Sampling : Cable overall diameter shall be measured by diameter tape.	As per IEC 60502-2(As per approved document)
10.	Hot set test for XLPE insulation	Sampling : The test pieces shall be suspended in the oven and weight (20N/cm2) attached to bottom. After 15Min. in the oven temp. The elongation calculated.	Elongation under load : Max 175% Permanent elongation after cooling : Max 15%
11.	Flame Retardant Test CAT A	The mounted sample shall be placed in the test chamber; the test flame shall be applied for 40min. after which it shall be extinguished. The charred portion shall be measured in meters from the bottom edge of burner to onset of char.	Max. length of charred portion should not exceed 2.5m

Test Results for FAT (Implementation):

The tests carried out at manufacturer's facility for the following type of new cable,

3 Core 300 mm2 Copper Conductor, XLPE Insulated, Copper tape screened, PVC innersheathed, Galvanized Steel Wire Armoured and black PVC outer sheath 11KV cable to IEC-60502-2 and Flame Retardant to IEC 60332-3 Cat.A Specification.

The test result values are tabulated below:

Sr. No.	**Description**	**Test Values/Results**	**Remarks**
All internal quality control certificates are reviewed for any component failures and their corrections.			
1.	Visual Inspection	Ok. (As per approved document). i.e. physical dimensions are verified	Ok.
2.	High Voltage Test	AC Voltage test applied between the conductor and the metallic shield (for 11KV cables 23KV for 5 minutes) at ambient temperature. No Breakdown.	Pass

3.	Insulation Resistance Test	The measurement shall be made between conductor and the cores & metallic shield. Before and after HV test carried out the values are more than 21.2 GΩ (Giga Ohm).	Pass
4.	Partial Discharge Test	The test voltage shall be applied between each conductor and the metallic shield. The partial discharge is measured at 11KV. No detectable discharge/puncture	Pass
5.	Voltage Test for 4 Hours.	The test voltage (25.4 KV AC for 11KV shall be applied between conductors and the metallic shield. (Applied voltage shall be 4Uo for 4 hrs. for XLPE cables sample). No breakdown	Pass
6.	Conductor and screen Resistance test	The conductor resistance measured atambient temperature by Double bridge method.(0.2437Ω/Km at 20 Deg.)	Pass
7.	Conductor/Armour wire examination	Sampling : Outside diameter of conductor measured at 3 points by caliper and average value calculated. And diameter of armour wire measured on 10% of total armour wires.	Pass
8.	Measurement of thickness of insulation, bedding sheath and outer covering	Sampling : a) Thickness of insulation measured at 6 points by projector. b) Thickness of bedding sheath measured at 6 points by vernier caliber c) Thickness of outer-covering measured at 6 points	Pass
9.	Measurement of overall diameter	Sampling : Cable overall diameter measured by diameter tape.	Pass
10.	Hot set test for XLPE insulation	Sampling : The test pieces suspended in the oven and weight (20N/cm2) attached to bottom. After 15Min. in the oven temp. The elongation calculated. (Elongation under load 75% & 0%)	Pass
11.	Flame Retardant Test CAT A	The mounted sample placed in the test chamber; the test flame applied for 40min. after which it	Pass

		extinguished. The charred portion measured in meters from the bottom edge of burner to onset of char. (1.0 m)	
All above test results from the witnessed inspection tests are found satisfactory.			

Site Acceptance Tests (SAT)

These tests, as defined in the Contract specification, are carried out by the vendor/contractor during commissioning at site and are witnessed by Company Engineer.

Typical SAT Report - A typical Site Acceptance Tests (SAT) formats for High Voltage Cables is as below;

	Site Acceptance Test (SAT)		
	TEST REPORT FORM NO.1		**PAGE 1 OF 1**
Unit No. :		Type . :	
Service :		Size :	
Voltage :			
Sr. No.	Check List	Desired Values/Results	Remarks.
1	Inspect both ends of cable for safety	Both side cable core separated	
2	Check that cable is disconnected	Ok	
3	Test Insulation resistance, mega ohms , R-Y Y-B B-R R-G Y-G B-G	11KV- 5000V Megger 3.3KV-2500V Megger For HV cable-100MΩ min	
4	Test high potential capability Apply different set of Test Voltage (KV) (DC) and corresponding leakage current is to be measured (Micro Amps).	For HV(11KV)- 23 KV For HV (3.3 KV)-6.9 KV for 5 Min. with stood ok	
5	Continuity Test	OK	
6	Ambient temperature	50^0 C (actual)	

Company Engineer : **Contractor's Engineer :** **Date :**

Test Results for SAT (Implementation):

The tests were carried out at Site facility for the following type of new cable,

3Core, 300 mm^2 Copper Conductor, XLPE Insulated, Copper tape screened, PVC innersheathed, Galvanized Steel Wire Armoured and black PVC outer sheath 11KV cable to IEC-60502-2 and Flame Retardant to IEC 60332-3 Cat.A Specification.

	Site Acceptance Test (SAT)	
	PAGE 1 OF 1 **TEST REPORT FORM NO.1**	
Unit No. : 1 Type : XLPE/LC/PVC/GSWA/PVC Service : Incoming Feeder Size : 3Core x 300 sqmm Copper Armoured Voltage : 11KV		

Sr. No.	Check List	Desired Values/Results	Remarks.

1	Inspect both ends of cable for safety	Both side cable core separated	
2	Check that cable is disconnected	Ok	
3	Test Insulation resistance, mega ohms ,	5000V Megger	
	R-Y : 20 G Ohm Y-B : 20 G Ohm B-R : 22 G Ohm R-G : 15 G Ohm Y-G : 16 G Ohm B-G : 15 G Ohm	Ok	
4	Test high potential capability		
	Apply different set of Test Voltage (23KV) (DC) and corresponding leakage current is measured (Micro Amps).	For HV(11KV)- 23 KV for 5 Min. with stood ok	
5	Continuity Test	OK	
6	Ambient temperature	40^0 C (actual)	

Conclusions

It may be observed that by way of implementing Testing Manual it can be very easily ensured that all critical parameters are checked&verified. Also, it enables us to ensure that the equipment is in compliance with desired specifications and standards, before they are actually put into service.

References

British Standard BS 5467: 1997. *Electric Cables- Thermosetting insulate, armoured cables For voltages of 600/1000 V and 1900/3300 V.*

International Standard, IEC 60332-1-2, edition 1.0., year 2004. *Tests on electric and optical fibre cables under fire conditions - Part 1-2: Test for vertical flame propagation for a single insulated wire or cable*.

International Standard, IEC60502-2, second edition 2005-03. *Power cables with extruded Insulation and their accessories for rated voltages from 1 kV up to 30 kV, Part 2: Cables for rated voltages from 6 kV up to 30 kV.*

International Standard, IEC 60885-1-2-3, edition 1.0, year 1987. *Electric Test Methods for Electric cables*.

Appendix-I

Factory acceptance test (FAT)- is carried out at Manufacturer's Factory premises.

Routine test - are intended to detect faults in materials and workmanship and ascertain proper functioning of the equipment. They shall be made on each individual piece of equipment.

Site acceptance test (SAT)- are carried out during commissioning/pre-commissioning at site.

Type test - are intended to verify compliance of the design of given equipment with this standard, where applicable, and the relevant product standard. They may comprise, as appropriate, the verification of, Constructional requirement, Temperature rise, Dielectric properties, Making and breaking capabilities, Operating Limits, Operational performance, Degree of protection of enclosed equipment. Type Tests are performed on single specified Electrical Equipment of one type and are intended to check the design characteristics. Type test usually relates to the first unit manufactured by a firm to given specification.