Electrical Testing Instruments Used In Various Electrical Equipment – Power System Testing, Commissioning & Maintenance

by:

Engr. Rodolfo R. Penalosa, PEE, PECE, APEC Engr., Asean Chartered Professional Engineer Registered;

Former Chairman, Board of Electrical Engineering, PRC

WHY DO WE NEED TO TEST?

- **Personnel safety – arc flash protection assumes**
- **equipment will interrupt precisely as intended**
- **Fire safety**
- **Insurance company required**
- **Regulatory**
- **Aging infrastructure**
- **Equipment manufactured to precise specifications**
- **Increase life cycle and defer the need for capital**
- **investment**

Test Sets for Substation Apparatus Testing

- Low Resistance Ohmmeter (Ductor)
- Insulation Resistance Tester
- Dielectric Withstand (Hi-Pot)
- Transformer Turns Ratio (TTR)
- Power Factor (Doble)
- Transformer Ohmmeter – Winding Resistance
- Vacuum Bottle Integrity Tester

- **Ground Resistance Tester**
- **High Current Injection**
- **Circuit Breaker Analyzer**
- **Relay Test Set**
- **Oil Dielectric Test Set**
- **Sweep Frequency Response Analyser**
- **Insulation Resistance Monitoring Tester**

Electrical Testing
High, Medium and Low Voltage Electrical Systems:

- **The use of electrical test instruments is to test, low, medium and high voltage electrical systems.**
- **These instruments may be used for testing and commissioning for new installations, third party acceptance and for maintenance activities.**
- **These tests is to ascertain that all electrical equipment, such as; power transformers, bushings, PT, CT, surge arresters, power circuit breaker, grounding grid, MVSG, LVSG, power cables, motor control center, main panels, sub-panels, etc. are safe to operate.**

Purposes of T&C Tests & Kinds of Test Instruments to Use:

- **To ensure that all components and systems are in a satisfactory and safe condition before start up.**
- **Preliminary adjustment and setting of equipment at this stage shall also be carried out at the same time to pave way for the coming functional performance tests.**
- **Before carrying out any test, the Contractor shall ensure that the installation complies with all relevant statutory requirements and regulations.**

Purposes of T&C Tests & Kinds of Test Instruments to Use:

- **The T&C works shall comply with all site safety regulatory requirements currently in force, including but not limited to:**
  - **RA 7920 Electrical Engineering Law**
  - **National Building Code (NBC) & Fire Code**
  - **City Ordinances, separate from NBC rulings, if any**
  - **National Safey Code**
  - **Industry Practices not part of the code**
  - **Other International Codes**

Electrical Testing
High, Medium and Low Voltage Electrical Systems:

What are the **objectives** of electrical testing?

- **To verify proper functioning of the equipment/system after installation;**
- **To verify that the performance of the installed equipment/systems meet with the specified design intent or statutory requirements through a series of tests, measurements and adjustments; and**
- **To capture and record performance data of the whole installation as the baseline for future operation and maintenance.**

For Electrical Construction Works: Testing & Commissioning

Before carrying out T&C, the EE Contractor shall take the following steps:-

- **Submit draft T&C procedures to the Construction Managers, T&C team for approval.**
- **The draft T&C procedures shall include essential procedures mentioned in this T&C Procedure plus additional T&C procedures required for specific installations as well as manufacturer's recommendation;**
- **Obtain design drawings and specifications and to be thoroughly acquainted with the design intent;**
- **Obtain copies of approved shop drawings and equipment schedules;**
- **Review approved shop drawings and equipment schedules;**

For Power Transformers:
DGA – Dissolve Gas Analysis Test

Dissolve Gas Analyser and Moisture Content Test Capabilities (DGA)

- Hydrogen
- Methane
- Ethane
- Ethylene
- Acetylene
- Carbon Monoxide
- Carbon Dioxide

Moisture Content

Relative Saturation

Oil Quality Tests

OIL DIELECTRIC TESTER

- Liquid dielectric breakdown testers
- Determines the dielectric strength of high voltage insulating liquids
- Measures voltage at breakdown
- Measures the insulating ability of a liquid t withstand electrical stress
- Different electrodes for different standards
- Gap is set with spacer
- Some standards call for stirring

Power Transformer Testing

POWER TRANSFORMER TEST SET
Automated Insulation Analyser

Automated Insulation Analyser Test Capabilities

- **Overall Insulation Power Factor Test**
- **Exciting Current Test**
- **Leakage Reactance/Short Circuit Impedance Test**
- **High Voltage Ratio Test**
- **Oil Insulation Power Factor Test**
- **Capacitance Test**
- **Watts Loss**

POWER TRANSFORMER TEST SET
Sweep Frequency Response Analyser

- **Test Capabilities**

a) **Sweep Frequency Response Analysis Testing**

POWER TRANSFORMER TEST SET
Insulation Resistance Tester

- **Test Procedures**

a) **Insulation Resistance Test**

b) **Polarization Index (P.I.)**

POWER TRANSFORMER TEST SET
Micro-Ohmeter Tester

- **Test Procedures**

a) **Low Winding Resistance Test**

POWER TRANSFORMER TEST SET
Dissolve Gas Analyser and Moisture in Oil

Low Resistance Ohmmeter

- **Ductor, Digital Low Resistance Ohmmeter (DLRO)**
- **or micro-ohmmeter**
- **Measure contact resistance, bus joints, etc.**
- **Applies DC Current**
- **Measures Voltage Drop**
- **Calculates (Low) Resistance in**
- **Utilizes Kelvin connections**

INSULATION RESISTANCE TESTER

- Megohmmeter
- Applied at or above rated voltage
- Affected by temperature, humidity, test voltage
- Should be normalized to 20°C
- Comparison test
- Used for Polarization Index
- Applies DC Voltage up to 10kV
- Measures Leakage Current
- Calculates (High) Resistance in MegaOhm

TRANSFORMER WINDING RESISTANCE TESTER

- **Apply a DC current and measure voltage drop**
- **Calculate resistance**
- **Need to saturate the core**
- **DC current magnetizes the core**
- **Demagnetize to avoid high inrush currents**

DIELECTRIC WITHSTAND TEST

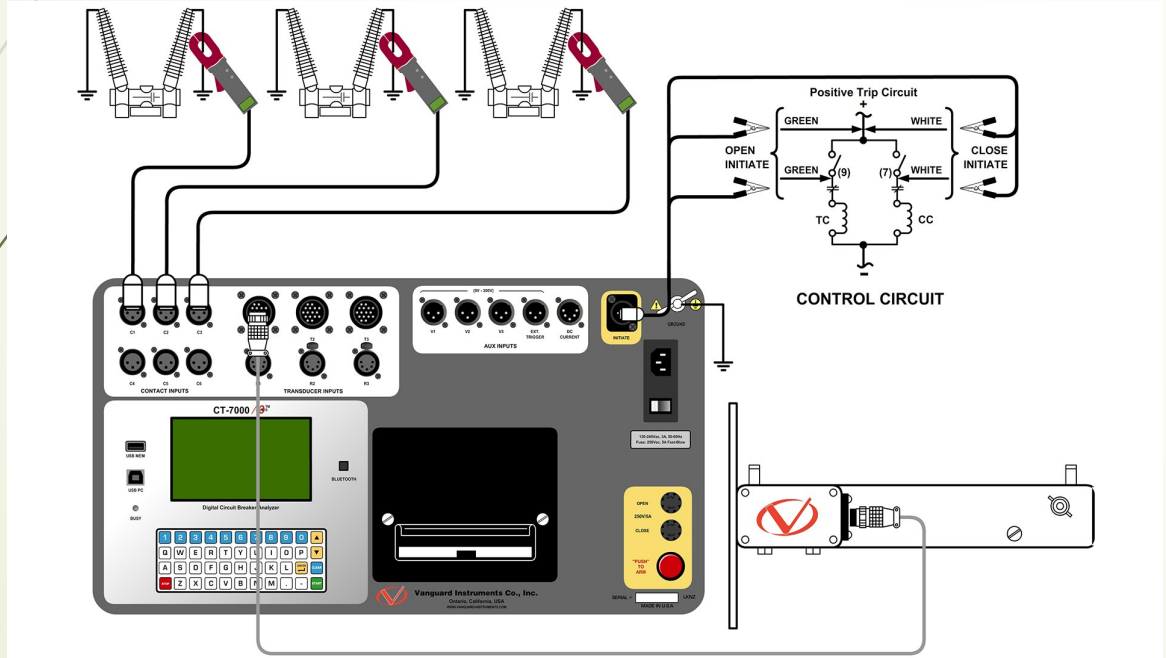
- High Potential, Hi-Pot
- DC test applied at 60Hz crest voltage 2 X RMS
- Overpotential – Go / No Go or Pass/Fail test
- Used for dielectric absorption
- Good insulation should show increase in resistance
- Because absorption current decreases
- Used for step-voltage test
- DC not recommended for old cables
- AC test applied at 60Hz
- Used for testing bucket trucks

TRANSFORMER TURNS RATIO

- **Determine ratio of transformers**
- **Applies voltage to one winding and measures the**
- **other and calculates the ratio**

Power Circuit Breaker Tests

POWER CIRCUIT BREAKER TEST SET
CIRCUIT BREAKER Analyser



HIGH CURRENT INJECTION

- Primary Injection through low voltage circui breakers
- Injects full current through circuit breaker
- Allows measurement of instantaneous, long time,
- short time and ground fault
- Provides complete check of breaker and protective circuit

CIRCUIT BREAKER ANALYSER

- TIME – TRAVEL

Measures:

- Closing & opening time
- Contact bounce
- Opening & closing synchronization
- Closing and opening velocity
- Trip operation
- Trip-free operation
- Close operation
- Trip-close operation

VACUUM INTEGRITY TESTER

- **Check integrity of vacuum**
- **AC Hi-Pot test**
- **DC Hi-Pot test**

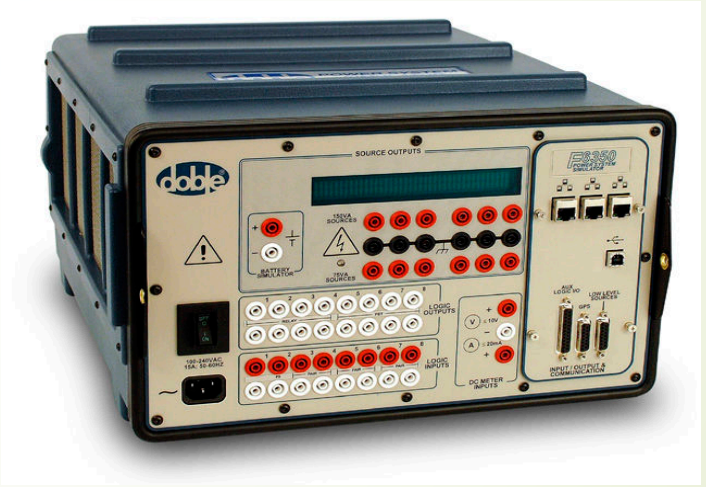
Power Circuit Breaker Test Procedures

- Travel/ Motion Testing
- Contact Timing Test
- Contact Resistance Test
- Overtravel
- Contact Bounce
- Medium and Low Voltage

Protective Relay Tests

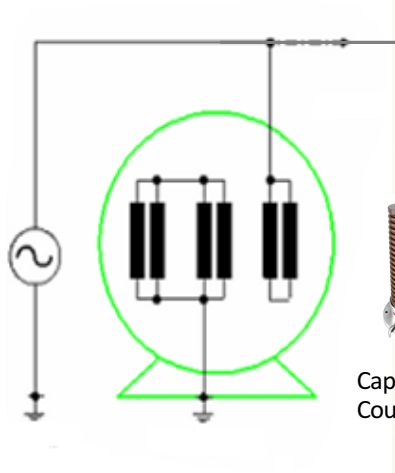
RELAY TEST SET

- High compliance voltage and high current output to
- test
- Test electromechanical, solid-state and microprocessor relay
- Timed outputs until relay trips
- End to end test with GPS
- IEC 61850 & GOOSE protocol




Generator Tests

GENERATOR TEST SET
Partial Discharge Analyser



Capacitive Coupler

Splitter

PD TESTER

Partial Discharge Analyser for Generators

- Partial Discharge Tester Can be used for
  - Electrical PD testing and diagnostics acc to IEC 60270
  - Non-conventional PD detection with indirect couplers
- Any HV apparatus may be tested
  - Rotating machines (motors and generators)
  - Switchgear
  - Cables (fault location) and Cable Terminations
  - Power transformers

Statutory Tests & Inspection
Functional & Performance Tests

- **Functional performance tests is to demonstrate that the equipment/installation can meet the functional and performance requirements as specified in the General/Particular Specifications.**
- **Functional performance test should proceed from the testing of individual components to the testing of different systems in the installation.**

Statutory Tests & Inspection
Functional & Performance Tests

- **The specific tests required and the order of tests will vary depending on the type and size of systems, number of systems, sequence of construction, interface with other installations, relationship with the building elements and other specific requirements as indicated in the General/Particular Specifications.**
- **The testing of systems may have to be carried out in stages depending on the progress of work or as proposed by the Contractor.**

THANK YOU!