

## Course Description

This Hands-On course will teach you how to prioritize your transformer maintenance strategy, stretch your maintenance budget and at the same time maximize the life and condition of your electrical transformer.

As an owner of transformers you are faced with the challenge of how to minimize downtime and maximize life expectancy of your valuable asset. With budget restraints, knowing how to prioritize your transformer testing and maintenance expenditures is crucial. This transformer testing and maintenance course will review what traditional and new maintenance testing procedures should be utilized by transformer owners. We will also look at the latest developments in transformer design, construction, testing, diagnostics, oil sampling techniques, interpretation of results and transformer asset planning.



Today's capital spending on new and replacement transformers is at its lowest level in decades. To make matters worse, the load on each transformer (or its utilization) continues to grow. Increased equipment utilization, deferred capital expenditures and reduced maintenance expenses are all challenges facing today's transformer owner.

Many electric utilities and large industrial, commercial and institutional owners of medium and large power transformers are beginning to develop their own "Life Cycle Transformer Management" programs.

Our transformer testing and maintenance course will deal with many of the technical and economic issues dealing with a) The Screening Process to prioritize the transformer fleet b) Transformer Condition Assessment of individual transformers, and c) Life Cycle Decisions retire, refurbish, replace, relocate.

Students will learn safe and proper maintenance and testing procedures on power transformers. The course covers transformers used in commercial and industrial power distribution systems, including oil and dry-type units. Larger power transformers used in utility applications are also covered.

## Students Will Learn

- **1. Understand the basics of transformer asset management.**
- **2. Understand transformer life cycle and maintenance planning**
- **3. Learn sulphur in transformer oil solutions**
- **4. Learn how to resolve moisture in transformer oil**

- 5. Understand turns ratios and calculate terminal voltage and current.
- 6. Learn about proposed Federal and State transformer regulations
- 7. Understand transformer operation, aging and failure
- 8. Understand transformer standards
- 9. Understand transformer factory testing and quality assurance
- 10. Understand the electrical testing methods performed on transformers such as insulation resistance testing, excitation and power factor testing.
- 11. Understand transformer on-line monitoring techniques
- 12. Understand the various tests performed on insulating oil.

## Target Audience

Anyone working with, supporting, maintaining, and testing Electrical Transformers.

## Prerequisites

A Basic understanding of Electricity and Electrical Transformers and components.

## Course Outline

### Module I. Transformer Design and Construction

Students will be introduced to the different types of single- and three-phase transformer construction, various types of core material, windings layout, connection, tap changers, voltage classifications and transformer applications, with an emphasis on explaining recent innovations in transformer design.

#### Transformer Core

- Transformer core
- Core form and shell form
- Core loss
- Exciting current
- Noise level
- Structure

#### Transformer Windings

- Winding conductors - ASTA
- Load loss
- Impedance and voltage drop
- Winding insulation
- Cooling structure
- Short circuit withstand capability

- Core and coil assembly

### **Transformer Insulation**

- Oil paper insulation system
- Two functions of insulation fluid
- Various insulation fluids
- Factors affecting quality
- Factors accelerating degradation
- Paper and pressboard insulation
- Two functions of solid insulation
- Factors affecting quality
- Factors accelerating aging
- Aging cycle

### **Transformer Tank**

- Main tank
- Main tank components
- Seals, gaskets and valves, bushings

### **Oil Preservation Systems**

- Air cell systems
- Breathing systems
- Auto-recharging dehydrating breather
- Oil cooling systems

### **Transformer Bushings**

- Voltage class
- Current ratings
- Top and bottom terminal connections
- Mounting flange
- Test and voltage taps
- Air side dimensions
- Oil side dimensions
- CT pocket length
- Oil reservoir
- Many styles and types in use

### **Tap Changers**

- LTC
- DETC (OCTC)
- ULTC
- Headboard links

### **Components and Accessories**

- Top oil temperature monitoring
- Devices/Indicators
- Winding temperature monitoring
- Liquid level Gauges/Indicators
- Pressure and vacuum Gauges/Indicators
- Pressure relief device
- Gas Detection Relays

- Alarm and trip functions are equipped and preset

## **Module II. Transformer Operation and Application**

### **Transformer Applications and Types**

- Dry type
- Liquid filled
- Industrial vs public distribution
- Potential transformers (PTs)
- Current transformers (CTs)
- Control and power supply transformers
- Auto transformers

### **Transformer Operation and Theory**

- Load vs no load
- Transformer losses
- Hysteresis losses
- Eddy current losses
- Copper losses
- Stray losses
- Relationship between primary and secondary values
- Transformer polarity
- Single phase transformer connections
- Transformer impedance
- Transformer ratings
- Optimum transformer rating

### **Transformer Cooling**

- Transformer cooling techniques and devices

### **Three-Phase Theory/Transformer Types**

- Transformer configuration
- Three phase transformer connections
- Delta connection
- Wye 'star' (Y) connection
- Voltage and current in various combinations
- Transformer terminal markings and identifications

### **Resistive Loads**

- Inductive loads
- Capacitive loads

### **Three-Phase Ratio's**

- Parallel operation of 3 phase transformers
- Phase angle shift
- Phase rotation
- Grounding transformers
- Auto transformers
- Regulators

- Phase shifters
- Three-phase ratios

#### **Transformer De-Rating**

- Harmonics
- K-factor

#### **Transformer Failures**

- Misapplication
- Vibration
- High operating temperature
- Lightning or line surges
- Overloading
- Care of control equipment
- Lack of cleanliness
- Care of idle or spare equipment
- Improper lubrication
- Careless or negligent operation

### **Module III. Transformer Field Diagnostic Testing and Maintenance Techniques**

#### **WINDING RESISTANCE**

- Testing techniques
- Voltmeter Ammeter method
- Bridge technique
- Micro ohmmeter

#### **TRANSFORMER RATIO/POLARITY**

- Testing Techniques
- Inductive kick (DC method) polarity
- Alternative voltage (AC method) polarity
- Turn ratio test set
- Double voltage meters

#### **EXCITATION CURRENT MEASUREMENT**

- Hysteresis
- Eddy currents
- Copper losses

#### **SHORT CIRCUIT IMPEDANCE MEASUREMENT**

- Testing techniques
- Voltmeter Ammeter method

#### **SWEEP FREQUENCY RESPONSE ANALYSIS**

- Testing techniques
- Problems detected
- Shifted winding/core
- Deformed windings
- Loose windings

## **INSULATION RESISTANCE**

- Testing techniques
- Megger
- Polarization index test (PI)
  - Can detect the following problems Insulation dryness Insulation contamination Sensitive to temperature

## **INSULATION CAPACITANCE AND POWER FACTOR**

- Testing techniques
- Capacitance bridge method DF
- AC Dielectric loss method - PF

## **PARTIAL DISCHARGE MEASUREMENT**

- Can detect the following problems Insulation defects Insulation contamination Air bubbles trapped in insulation Localized high electrical stress PD is the "cancer" of insulation system PD detector RIV

## **TRANSFORMER CORE TESTING**

- Problems
- Insulation resistance
- More grounding points
- Megger
- Separate external core ground lead from 250 resistor
- Measure core

## **INSULATING OIL**

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- **Sulphur in transformer oil solutions**
- **Resolving moisture in transformer oil**
- **Proposed federal PCB transformer regulations**
- **Transformer on-line oil monitoring techniques**
- **Various tests performed on insulating oil**
- **Properties and parameters of insulating**
- **Why oil sample?**
- **Dielectric breakdown**
- **Water content**
- **Power factor**
- **DGA "key" fault gasses**
- **Benchmarks**
- **Rating system**

## **BUSHING VISUAL CHECK**

- **Oil Level**
- **Leaking**
- **Chipped porcelain**
- **Fractured flange**
- **Poor gaskets**
- **Peeled painting**
- **Terminal connection**
- **Corrosion**

## **TAP CHANGERS**

- **DETC**
- **Contact resistance increase**
- **Loose contact pressure**
- **Misalignment**
- **Electrical and mechanical centers**
- **LTC**
- **Contact continuity**
- **Arcing switch and tap selector**
- **Drive mechanism operation**
- **Motor**
- **Timing**
- **Oil compartment**
- **Protection and control**

## **TRANSFORMER TANK**

- **Visual check**
- **Oil leaking**
- **Poor gaskets**
- **Peeled painting**
- **Rust/corrosion**
- **Temperature hot spot**

## **COMPONENTS AND ACCESSORIES**

- **Visual check and function test**
- **Cooling system radiators, fans or pumps**
- **Gauges and indicators oil level, pressure and temperature**
- **Pressure relief device**
- **Gas relay**
- **Air breather**
- **Inert air system**
- **Oil filters**

## **INFRARED TEMPERATURE MEASUREMENT**

### **Delivery Method**

Instructor-Led with numerous Hands-On Labs and Exercises.

### **Equipment Requirements**

(This apply's to our hands-on courses only)

BTS always provides equipment to have a very successful Hands-On course. BTS also encourages all attendees to bring

their own equipment to the course. This will provide attendees the opportunity to incorporate their own gear into the labs and gain valuable training using their specific equipment.

### **Course Length**

2 Days