Transformer Components

311010
Transformer Components
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Introduction

This document will discuss the basic components of a power transformer, including their method of control and associated hazards. Power transformers are one of the most costly devices used within the transmission system. The Controller must understand the hazards associated with transformers to ensure the safety of the public and equipment as well as to maintain power quality. The document will focus on the knowledge necessary for a Controller to operate and isolate equipment in an interconnected power system.

Objectives

By completing a multiple-choice test, you will demonstrate your knowledge of the components of a step-down regulating transformer, including the basic parts, method of control and associated hazards. This will include all major types of step-down regulating transformer. You will have sufficient understanding to be able to apply your knowledge to the isolation of equipment.

Prerequisites

Have an understanding of basic electrical theory and transformer fundamentals. You must also be able to read and understand operating diagrams.

Module Outline

Controllers are required to operate transformers and provide isolations on equipment under their control.

This document will identify the components used on the power transformer and provide information regarding their purpose of each component, associated hazards and isolation required. Links or references to supporting instructions, training documents and reference material may be included.
What the Controller Needs to Know

Example:
Transformer Operation and Isolation
- What does the Underload tapchanger do? What is its method of control? What are the hazards associated with it? What isolation is required to protect the worker from these hazards?
- Etc.

Contents of this Training Document

- Hazards Associated with a Typical Transformer
  - Live oil filled equipment

- Components of a Transformer
  - List of Components with brief explanation of its purpose, method of control and associated hazards.

- Typical DESN Transformer Operating Diagram
  - Brief explanation of how it works and how to isolate a transformer.

Legend

Need to Know
Information the Controller needs to know about the protection.

Supplemental Information
Additional information on the protection

Controller Action
Response required by the Controller - contains link to operating instruction where the required action is documented.

Operating Note
Operating Notes - Helpful reminders
Transformers – Hazards, Components, Isolation

The components that make up a basic step-down regulating type transformer are discussed in this document. The type of components may vary depending on the type of transformer and its installation. This document details the purpose, method of control and hazards associated with the components found on a typical Step-down power transformer to help you understand how to operate and isolate a typical power transformer.

Hazards Associated with a Transformer

Live Apparatus
A transformer is connected to an electrical source and current flows through the transformer.

Hazards:
Electrical contact – resulting in electric shock, burns
- Equipment failure resulting explosions, fire and flying debris
- flashover due to insulation break down
- animal contact
- Internal component failure etc.

Mechanical failure – Components with moving gears and parts
- Tap changers, fans and pumps
Oil Leaks - Oil/Liquid filled transformers provide insulation and cooling.
- Loss of oil creates environmental concerns and equipment concerns
- If the oil level drops and exposes the windings, overheating and flashover damage may occur
- Environmental Hazards - oil leaks, large volume of oil in larger transformers using conservator tanks.
- Oil containment is necessary to ensure oil doesn’t contaminate the ground or enter the watershed system
- Working Hazards - Oil leaks can also cause slipping hazards

Auxiliary Supply Hazards
- Hazards AC and DC supplies associated with transformer components may also cause a hazard when working on them. Specific hazards requiring isolation are specified with the transformer component.

Elimination and/or Control of Hazards
To eliminate and control electrical hazards the transformer must be isolated and de-energized for work on or near it. In addition, work methods are used to control hazards.
Components of a Typical Power Transformer

The outline of a simplified transformer below illustrates the general location of the various components. The following pages give a brief description of each component.
**Tank**

The transformer tank or enclosure of a power transformer is fabricated of welded steel. The tank contains the transformer core and coil assembly. It is normally filled with mineral oil or a synthetic nonflammable insulating liquid that is used as an insulating and cooling medium.

**Acoustic Enclosure**

In residential locations, to reduce noise from the transformers an acoustic enclosure is built around the transformer tank. The bushings, conservator, explosion vent and cooling radiators and fans are exterior to the enclosure.
Hazard - Noise from transformer; enclosed area

**Access Cover**

Located on the top of the tank, it allows access to the inside of the tank for inspection and repairs.
Hazard - Oil filled tank, confined space - Follow work procedures for entering transformer

**Transformer Core and Coils**

The transformer core is built of iron or steel, and it provides the magnetic circuit to link the transformer windings.
The transformer coils or windings provide the electrical circuit for current flow in the transformer. The source winding is known as the primary winding and the winding delivering power is known as the secondary winding.

**Terminal or Headboard**

In order to meet the varying requirements of a certain load, or changes in the supply voltage to the transformer, it is necessary to adjust the turns ratio (i.e., voltage ratio). This may be accomplished by bringing taps from the windings up to a terminal board or headboard. These terminals may be connected together by links or straps to select the number of turns that give the desired ratio.

**Off Load Tapchanger (OLTC)**

To change the turns ratio on the source winding, a switch is operated by a handwheel on the exterior of the tank. The handwheel is used to operate a switch within the tank via an exterior operating rod and interior insulated operating rods. The switch takes the form of fixed terminals or contacts arranged in a circle. Turning the handwheel moves the contact or finger around the centre of the circle to complete the circuit and give the desired ratio. This is known as changing tap positions and is performed with the transformer off potential since these switches cannot open a circuit carrying current.
Hazards – Possible failure if operated on potential. Mechanical failure of moving devices.

**Underload Tapchanger (ULTC)**

To respond to changing voltage levels on the load side of the transformer is accomplished by adjusting the transformer's turns ratios. The underload tapchanger switch is designed to change the tapped windings while carrying load current. It is normally operated by a motor and can be operated by hand. The tapchanger can be located electrically in the low voltage winding or electrically in the neutral end of the high voltage winding. The motor and control cabinet for the tapchanger is located on the side of the transformer.

**Hazards** – Mechanism cabinet - AC motor operated requires isolation from motor AC supply for work on tapchanger.

**Bushings**

The electrical power circuits must be insulated where they enter the tank. A bushing provides an insulated oil-tight and weather-tight entrance for the conductor into the transformer. It is usually composed of an outer porcelain body, and at higher voltages, additional insulation in the form of oil and wound paper is used within the porcelain column.

**Conservator**

On larger transformers (over 500 KVA), a reservoir of oil is maintained in a tank at a level above the cover of the transformer which is connected to the transformer by a pipe. This is known as a conservator tank (expansion tank) and keeps the main tank completely full of oil at all times, permitting expansion and contraction. An oil level indicator with an alarm circuit is provided to indicate the oil level in the conservator tank.

**Note** – Small Transformers under 10 MVA may be constructed without conservator tanks. These units are known as sealed transformers. To allow for the expansion and contraction of the oil, the main tank is designed with a suitable gas space above the oil.

**Breather**

The conservator tank has a breather to the outside. In order to take care of the expansion and contraction of the cooling liquid with varying temperatures, smaller units have an air space above the oil, which is connected to atmosphere by a breather. This breather is arranged to prevent the entry of moisture, snow, etc, into the transformer.
Oil Gauge
Located on the side of the Conservator tank, it indicates the level of oil in the tank and will provide annunciation when level drops below the gauge limit. On transformers without a conservator tank, an oil level gauge is located on the side of the tank to indicate oil level in the tank.

Explosion Vent
When an electrical fault occurs under oil, very high pressures are possible. These pressures could readily burst the sheet steel tank if some means were not used to guard against this.
The explosion vent consists of a large diameter pipe (4 inches or larger) extending slightly above the conservator tank of the transformer and curved in the direction of the ground. A diaphragm is fitted at the end of the pipe; it will rupture at a relatively low pressure to release the forces from within the transformer to atmosphere. On some transformers, a second diaphragm is located at the bottom of the pipe where the explosion vents connects to the transformer tank. This prevents oil from entering the explosion vent except under fault pressure.

Qualitrol Valve
Newer transformers have been equipped with self-resetting pressure relief vents known as Qualitrol valves. The vent may be mounted on the top or side of the transformer. When the fault pressure in the transformer reaches a predetermined level, it forces open a seal that is under spring pressure. The pressure is then vented to atmosphere.
In some installations, these valves will also initiate tripping of the transformer zone.

Gas Relay
The gas relay is located at the top of the transformer and is used to detect gas or air in the transformer. An electrical arc or fault can result in a pressure wave in the liquid, which the gas relay will detect and initiate removal of the transformer from service.

Gradual overheating of any part, such as a hot joint, while not causing a pressure wave, can ultimately result in failure of the transformer. This local overheating will decompose the oil, forming gases that rise to the top of the tank and accumulate in the gas relay. The gas accumulation will be displayed on the relay and annunciate the condition to the Controller. A sampling line is attached to the gas relay and brought near ground level for the convenience of the personnel when taking samples from or bleeding the gas relay.
Gas Relays are discussed in detail in the Transformer Protections document.

Hazards – DC supplies to gas relay – requires maintenance gas relay blocking switch in mechanism box open when working on gas relay.
**Vacuum Valve**

All transformers are capable of withstanding a vacuum and have a vacuum valve located on the top of the transformer. Transformers are filled with oil under vacuum to remove moisture and air in the tank; this improves the insulation value of both the solid and liquid insulation.

**Oil Drain and Sample Valve**

In order to conveniently add or remove liquid from the tank, a valve is fitted at the bottom of the tank. It is usually connected to a sump to ensure that all liquid will be removed. Adjacent to this is 1/2 in. needle valve, also leading to the sump, which is used for drawing off a sample of liquid for test purposes. By taking liquid from the lowest point in the tank, any free water should appear in the sample and give warning of contamination of the liquid.

**Transformer Cooling**

In smaller size, liquid-filled types of transformers, natural convection carries the heat of the insulating medium to the walls of the tank. As the size of the transformer increases so does the heat generated, additional means of cooling the transformer are required - Radiator, Fans and Pumps.

*Transformer Cooling is discussed in detail in Transformer- Limitations and Cooling Document.*

**Radiators**

Radiators are fitted to the tank so that a larger surface is reached by the liquid flowing into the top, down the tubes of the radiators and back into the bottom of the transformer.

**Cooling Fans**

Fans blow air across the radiators to increase the cooling of the oil.

**Cooling Pumps**

Pumps are used to pump the oil through the radiators.

**Water Cooled**

In some installations, water may be used to cool the transformer. This is done by installing water-cooling coils inside the main tank or by leading the oil from the main tank to a separate water-cooled heat exchanger.

**Water Spray Cooling**

Some installations use a water spray on the transformer and cooling radiators to provide additional cooling.
**Temperature Indicators**

Various temperature sensing devices are used to indicate the operating temperature of the transformer. The number and use of the devices varies with the size and application of the transformer.

On small transformers that require no fans or pumps, the indicating device may be in the form of a liquid-filled thermometer mounted at the top of the tank.

Larger transformers with fans and pumps can have up to three temperature sensing devices:
- liquid temperature gauge
- winding temperature gauge
- thermocouples

**Liquid Temperature Gauge (Top Oil)**

The liquid temperature indicator is usually the gas-filled type, with the sensing bulb fitted into a well cover near the top of the tank, and the indicator at the bottom of the tank, at eye level. Contacts are provided to annunciate an alarm and, in some cases, start fans and pumps.

**Winding Temperature Gauge (Hot Spot)**

A winding temperature indicator is generally the same design as the liquid temperature indicator. The purpose of this indicator is to simulate the hottest point in the transformer.

**Thermocouples**

There are generally two thermocouples in a large transformer and they are located adjacent to each other in an oil-filled well in the top oil. These devices are be used to provide remote indication and annunciation.

**Hazards** – DC supply for temperature indication

**Fire Detectors**

On larger transformers, Heat Activated Devices (HADs) are located around the top of the tank. The HAD contains a thermocouple to detect excessive heat that would be produced should the transformer catch fire. The HAD is used to initiate a Transformer Fire annunciation to the Controller.

*This is discussed in detail in the Transformer Fire Protection document.*

**Hazards** – DC supply to HADs - when work on them required.
**Deluge Fire Protection**

Large Transformers located at indoor transformer stations have a water deluge fire protection system to extinguish a fire. (This is discussed in detail in the Transformer Fire Protection document)

**Hazards** - pressurized water - requires Deluge isolated when working on the transformer.

**Oil Containment**

Large transformers a filled with large volumes of oil, containment pits are built under these transformers to contain the oil should a spill occur. Sumps associated with these pits will fill with water. A sump pump is used to pump out the water and will initiate an alarm to alert the controller that the sump requires pumping. The sump oil in water detector will block the operation of the pump if the water in the sump contains oil.

**Hazards** - sump pump supply, environmental spills

**Equipment Associated with the Transformer Operation and Isolation**

- LV Breakers and/or disconnects to provide isolation on the LV side.
- HV Disconnect or Circuit Switcher to provide isolation on the HV side.
- Tertiary winding s – connected equipment – Station Service, Reactors etc.
- Connected Auxiliary transformers – Potential (PT) or Voltage Transformers (VT), Current Transformers (CT), Capacitor Voltage Transformers (CVT).

See next section for example of a typical step-down transformer application.
**Typical DESN Step Down Transformer Isolation**

In the Operating Diagram below, it shows a typical DESN step-down transformer station. There are two separate 115kV supply lines (C7BM,W6MC), two 115/44kV step-down transformers (T1,T2) and two 44kV Busses with bus tie breaker (BJ). Power flows through the transformers into busses and out the feeders (M1, M2) to Distribution Stations and Customers.

**Transformer Isolation for Maintenance and Repairs**

To complete maintenance or repairs to a transformer (T2) it must be isolated from the power system sources – 115kV Supply line (C7BM) and 44kV Bus (J Bus)

**To take T2 out of service**

1. Open T2J – unloads T2 – power now flowing through T1/T1B into “J” Bus via BJ breaker
2. Open T2-C7BM – takes T2 off potential (open air break switch provides visible isolation from 115kV source)
**TRANSFORMER-COMPONENTS**

**Typical Isolation**
1. Check Open the HV transformer disconnect - T2-C7BM, Open DC supply to disconnect motor and lock switch inoperative.
2. Manually open T2J-J air break switch to provide visible isolation from 44kV sources.
3. In addition to this power system isolation there is also isolation required from auxiliary sources such as Station Service, potential transformers, current transformers, CVTs etc.
4. Also there are hazards associated with components of a transformer that may require isolation
   - Open Transformer AC Supply Switch(s) to isolate supply to tapchanger motor, fans and pumps.
   - Open Gas Relay Blocking Switch(s) for equipment protection - prevent erroneous trips
   - Require additional protection from auxiliaries when working on them.

**Summary**

This document discussed the various components of a basic transformer, including method of control and hazards associated with the transformer. The basic isolation requirements for a typical step-down transformer were discussed. Due to diversity of equipment used in Hydro One the isolation and components will vary with the installation. The Controller should be aware of the equipment under their control. This information will assist you in understanding the operation and isolation of a basic transformer.
## RELATED REFERENCE DOCUMENTS

Listed here are other documents that relate to the process.

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<tr>
<th>DOCUMENT No.</th>
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