# LOSS PREVENTION BULLETIN

## ELECTRICAL TRANSFORMER


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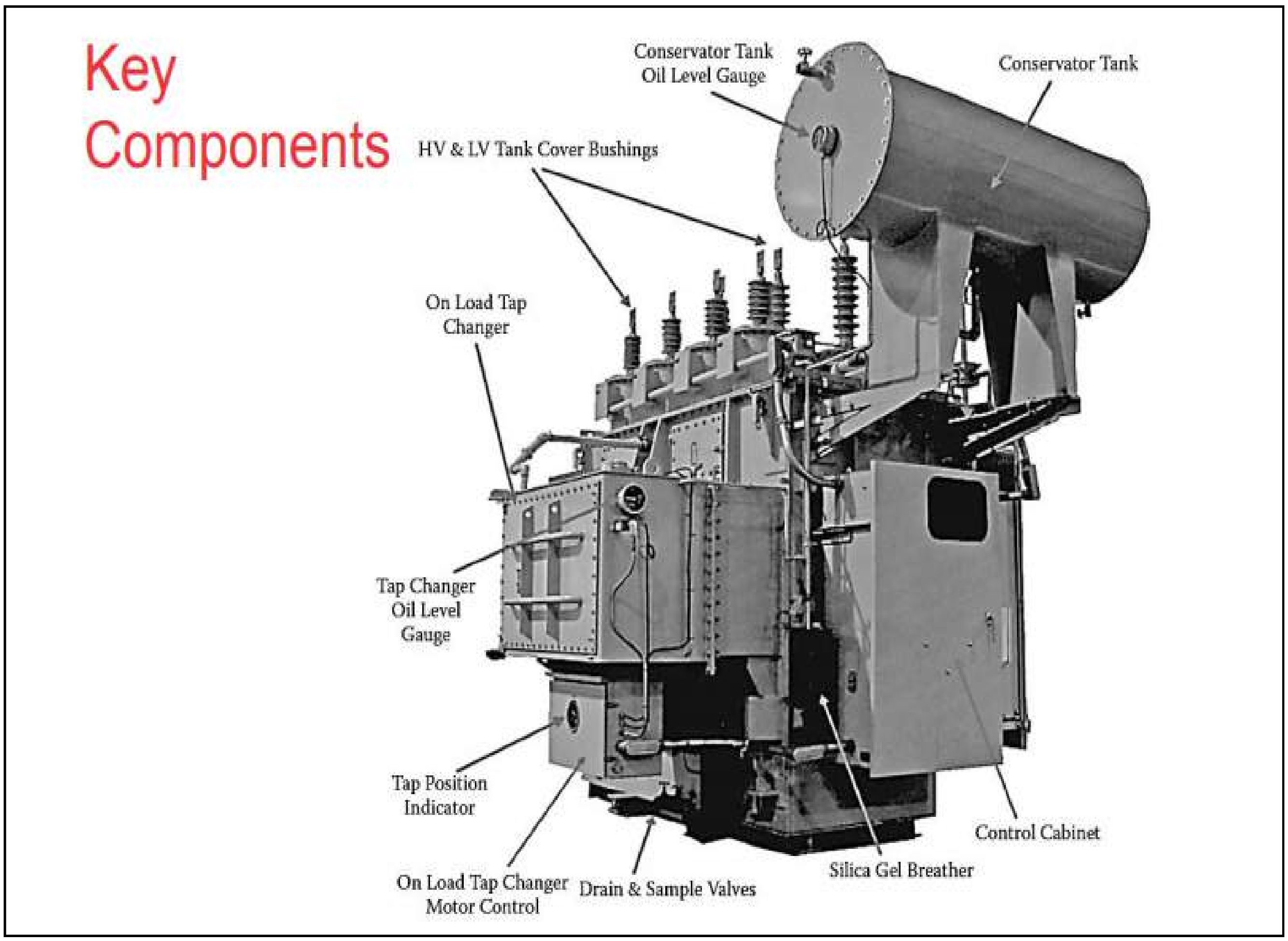
- Transformer is costliest equipment of power system and proper functioning is vital to system continuation. Any fault in transformer can cause failure and result in significant property damage and serious interruption to a business.
- A fault in a Transmission / Distribution transformer can cause power supply interruption in a large area. A power transformer failure can surely cause some serious damages on assets as well as human health and lives.
- Preventing transformer from explosions, leakage and other damages is not always possible. Factors like a proper installation and operation, oil test/BDV test and thorough maintenance can help decrease failures.
- A fault can also be very dangerous as the transformers contain a large quantity of oil in direct contact with high voltage components. This increases the risk of fire and explosions.
- Presenting useful and effective note about the major Transformer failure causes, fire prevention measures which can be applied on the transformers.



# Causes for Fire / Failure / Breakdown in Transformer

Below are the major factors for the fire/failure can be happened in the Power Transformer:

1) Winging failure
2) Bushing failure
3) Cooling system failure
4) Breakdown in oil/Tank failure
5) Tap changer failure
6) Core failure
7) Failure due to overload

## 1) Winding failure

- Winding are the major part of the transformer on which the Voltage ratio & Winding turns ratio depends. A too high current through the transformer leads, terminals and windings can cause localised or even wide spread overheating within the transformer.
- Transformer windings may be failed due to moisture, overheating, Di-electric stress / Mechanical stress, Breakdown of thermal insulation, Vibration & voltage surges etc.

- The windings are usually of copper. Due to the copper line resistance, Thermal losses occur & thermal losses make hotspots in the winding due to poor or lack of maintenance. This causes wear & tear and the decrease of the physical strength up to the point of breaking of the winding.
- Mechanical faults like twisting loosen or displacements of the windings are due to improper / poor maintenance, Corrosion, vibration and mechanical movement within the transformer.

## 2) Bushing Failure

- Bushing is an electrical insulator that allows an electrical conductor to pass safely through the transformer without making electrical contact with it.

- Transformer vibrations, overheating, partial discharges or Di electric losses due to seal break of bushings are the major causes of fire in the bushings. Insulation in bushings is highly stressed and there are inherent fire risks in their design.
- If an arcing failure occurs within an OIP (oil impregnated) bushing, it frequently results in failure and Damage of the upper or the lower porcelain, which will results in total loss of both porcelains.

### 3) Cooling system failure

- The heat generated in transformer due to the Copper losses ($I^2R$) as well as Hysteresis & Eddy current losses, so for that proper cooling system has to be fitted on the transformer.
- Mainly oil/Air/Water used as heat exchanging medium in the transformer. According to that various types of cooling methods has be made for the transformer.
- The failure in the cooling system causes the heat to build up in the transformer which affects the transformer in many ways. It causes more pressure to be built inside, which may cause the transformer to burst and also speeds up the degradation of insulating material like oil, paper and pressboard.

### 4) Oil Tank failure

- Transformer oil's primary function is to insulate and cooling of transformer. The oil has high dielectric strength, thermal conductivity and chemical stability. The fault in the tank occurs due to environmental stress, corrosion, high humidity and sun radiation resulting in a leakage or cracks in the tank walls.
- An internal arcing in an oil immersed transformer will cause a high temperature in the arcing gases and the surrounding oil, but it will not cause a fire inside the tank without access to oxygen.

- The oxygen dissolved in the oil is not accessible to start a fire. If the current feeding a high energy arc is not disconnected rapidly, then the tank may rupture and high temperature gases and oil then gets access to oxygen and will combust if the temperature is high enough for auto ignition, or if it is exposed to an arc or makes contact with metal with sufficiently high temperature to cause ignition.

### 5) Failure in Tap changer (OLTC)

- The purpose of a tap changer is to regulate the output voltage of a transformer. This is done by altering the number of turns in one winding by changing the turns ratio of the transformer.
- The Tap Changer failure is one of the most common failures that occur in a transformer, according to the classification of the detection failures.

- Tap changer failure due to Lack of maintenance (Moisture comes in contacts of Tap Changer), Old capacitors or burnt capacitor in the motor that causes the tap changer to fail to control its direction movement and breakdown of the motor in the tap changer because of over voltage.

## 6) Core Failure

- The function of the core is to conduct and concentrate the magnetic flux. Fault in the core can directly affect the transformer efficiency.

- The breakdown of the smallest part of the lamination results in increase of heat (due to increase of eddy currents), that can cause all kind of damages on the Transformer.
- Core insulation failure, shorted laminations & core over heating are the major cause of fire can be consider for the core failure.

## 7) Failure due to overload

- Overload is when a transformer is subjected to voltages and/or currents that exceed its design specifications. During overloading conditions, excess amount of heat will cause the insulation to break down which will results in decreased life expectancy of the transformer.
- When over current flow in the circuit / primary side of the transformer then excessive amount of heat generated due to increase of losses (Eddy current + hysteresis loss + $I^2R$ Losses) in the circuit and this will further damaged the winding as well as decreased the life span of transformer.
- Over current protection devices such as fuses, Relay's & Circuit breakers, limit the current to the proper rate and disconnect the circuits. The type of over current protection system used and the maximum current passing through the circuit components determine the size of the over current protection system.

# Transformer Fault types & Protection/Detection method

| No. | Fault Type | Protection used |
|---|---|---|
| 1. | Primary winding Phase-Phase fault | Differential; Overcurrent |
| 2. | Primary winding Phase-Earth fault | Differential; Overcurrent |
| 3. | Secondary winding Phase-Phase fault | Differential |
| 4. | Secondary winding Phase-Earth fault | Differential; Restricted Earth Fault (REF) |
| 5. | Interturn Fault | Differential; Buchholz |
| 6. | Core Fault | Differential; Buchholz |
| 7. | Oil tank Fault | Differential; Buchholz; Tank Earth |
| 8. | Overfluxing | Overfluxing |
| 9. | Overheating | Thermal |

- <u>Differential protection</u> schemes are mainly for the protection against phase-to-phase fault and phase to earth faults. The differential protection used for power transformers is based on Merz - Prize circulating current principle.

- <u>Over current protection</u> devices (Fuses, Relay's, CB's etc.) are meant to protect against the potentially dangerous effects of over currents (overload current or a short-circuit current) which creates a fault current. Equipment damage, personal injury, and even death can result from the improper application of a device's voltage rating, current rating, or interrupting rating.

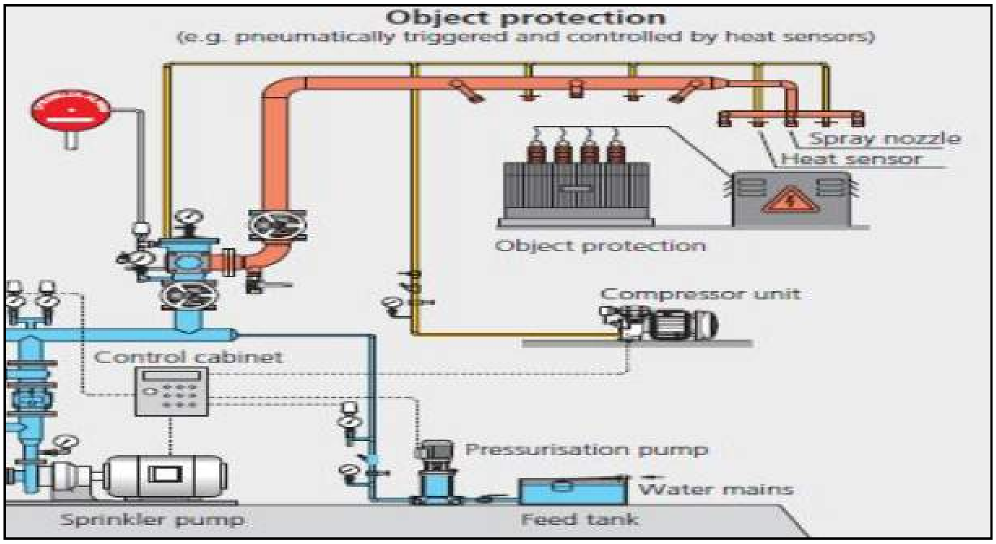
- <u>The Buchholz relay protection</u> is a mechanical fault detector for electrical faults in oil-immersed transformers. The Buchholz relay is placed in the piping between the transformer main tank and the oil conservator. It works independent of the number of transformer windings, tap changer position and instrument transformers.

# Fire Protection Systems for Transformers

The major risks to the environment is primarily from spill of oil or other forms of insulating fluid, water contaminated by oil, foam & other fire fighting chemicals.

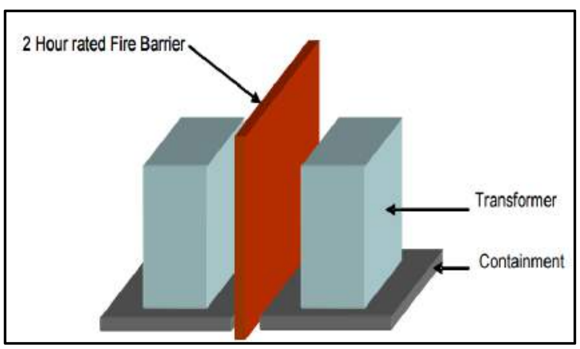
### 1) Deluge Systems

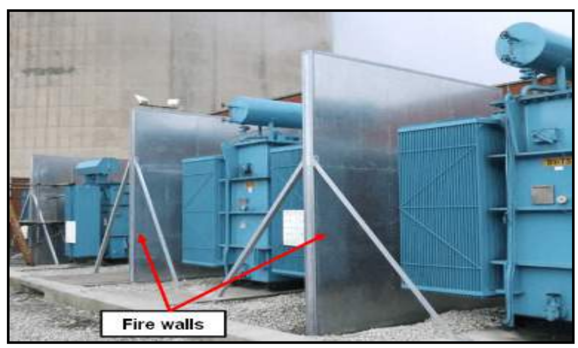
- This system uses open spray heads attached to a piping system connected to a water supply through a valve that is opened by means of a detection system installed in the same area as the spray heads. When the valve opens, water flows into the piping system and discharges through all spray heads attached to the system.
- Deluge systems are typically used where quick application of large quantities of water is required to control a fire and protect high value adjacent assets, such as on generator and unit transformers in power stations, bulks supply transformers at industrial plant and major transmission or substation transformer in city locations.
- In other words when the fire does take place, the detector ring detects this and gives the signal to the deluge valve / the entire sprinkler surrounding the transformer to start all at once.




## 2) Fire wall / Fire barriers protection

- Fire rated barriers are typically constructed from reinforced concrete or masonry supported by reinforced concrete piers. But they can also be constructed by from metal protected by a fire and heat resistant material to give at least a 2 hours' fire rating. The fire wall should extend at least 600 mm horizontally and 300 mm vertically beyond any transformer component.
- Fire wall should extend at least 1 ft above the top of the transformer casing and oil conservator tank and at least 2 ft beyond the width of the transformer and cooling radiators or to the edge of the containment area, whichever is greater.




## 3) Oil Containments

- Transformer oil containment system is an effective and reliable passive oil leak & spill management system that provides continuous protection against oil spills & leaks associated with transformers and other oil-filled equipment.
- The aim of the test is to contain spilled oil for avoiding pool fire spreading to adjacent plant and buildings. If the oil is kept surrounding to the transformer, then it is common practice to it store it within/below the surface of rock ballast or other form of oil containment medium where the oil is out of reach of the fire.

## 4) Water Mist System

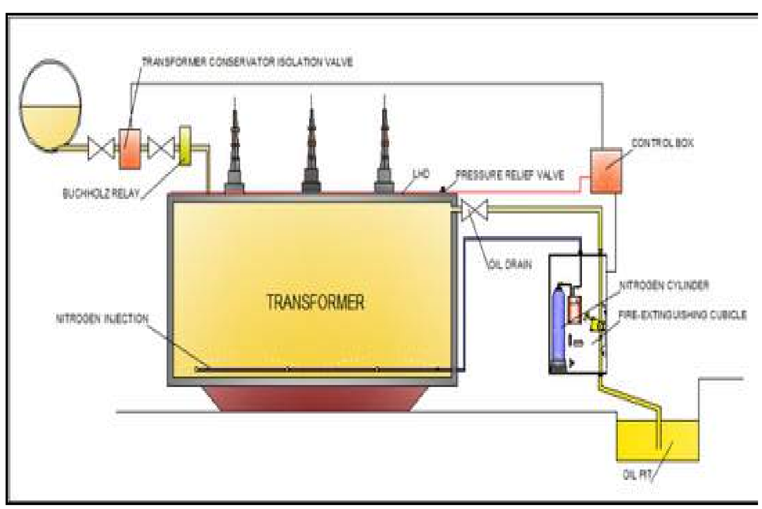
- Water Mist is also an efficient fire-fighting medium. The difference between Water Mist and a traditional water based fire fighting systems is that the Water Mist systems require much less water as they use have smaller water droplet (typically only 0.025 to 0.25mm dia. for high pressure water mist systems).
- Water mist is available in both as low and high pressure systems. However, for fire protection on transformers the high pressure system should be used as this is considered suitable for protection of machine containing Class B flammable liquid.

## 5) Water Curtain system

- Water curtain fire protection system for transformer is a high volume water spray system where water is also sprayed in a narrow line between closely spaced objects as well as onto the object on fire.
- A critical part of the design of Water Curtain protection is that there must be sufficient water available to maintain the required flow rate.

## 6) Nitrogen Injection fire protection system

- Nitrogen Injection Fire Protection System (NIFPS) prevents oil tank explosion/rapture & possible oil fire in event of arcing due to internal faults or external faults (failure of bushing or any other source) in Transformer.
- In case of rise in Temperature inside Transformer due to various reasons, PLC based NIFPS system receives internal inherent Faults / Feedback / Trip Signals from Transformer Panel.
- In case of fire NIFPS system activates electrically operated Transformer Conservator Isolation Valve / Oil Drain Valve / Nitrogen Injection Valve etc. which isolate the Oil Conservator Tank



from main Tank, drains out oil from Transformer into the Oil Pit and Nitrogen gas is injected which creates a layer for rest of the oil to avoid any contact with Atmospheric Oxygen.

## Case study on Transformer Failure

- Name of insured: Paper mill - Gujarat
- Cause of loss: Due to heavy spike/impulse, the bushing was overheated, Transformer oil leaked & OCB Tripped.
- Loss Amount**:** 4.5 Lacs (approx.)
- Incident brief: Insured has taken shutdown of the plant for the mechanical maintenance & after completing maintenance schedule; insured has tried to start the power supply but found that OCB was tripped & there was some oil leakage in the due to overheating of bushing.
- Business Interruption: Due to failure in transformer, insured also undergone for business interruption losses.

## Distances between Outdoor transformer and Buildings as per IEEE Standard

- As per the Indian Electricity Act, all buildings should maintain a 2.5 metre vertical clearance and 1.5 metre horizontal clearance from 11 kilovolt (kV) lines.

**Transformer Clearance from Building (IEEE Stand):**

| Transformer | Distance from Building (min) |
| --- | --- |
| Up to 75 KVA | 3.0 Meter |
| 75 KVA to 333 KVA | 6.0 Meter |
| More than 333 KVA | 9.0 Meter |

- Below are the some of the examples of Transformer clearance specifications:
    1) Clearance in front of transformer: 03 meter
    2) Between two transformers – 02 to 03 meters
    3) Between transformers & Trees/shrubs/vegetation – 03 meter
    4) Clearance from Transformer to boundary of the building – 03 meter

## Below are the few fire & safety standards for Electrical system

- IEE 979 – Guide for substation fire protection
- IEEE – 980 – Guide for containment & control of oil spills in substations
- IS 732 – 1989 : Standard for electrical wiring installation
- IS 4648 – 1968 : Guide for electrical layout in electrical buildings
- NFPA 70 – National electrical code
- NFPA 850 – Practice for fire protection in electrical system
- NFPA 70B – Electrical system maintenance
- NFPA 70E – Electrical safety in workplace
- NFPA 110 – Standard for standby power & emergency

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**Incorporation:** January 31, 2005

**Main objective:** Act as composite insurance broker (Life, Non-life & Reinsurance)

Our presence: Vadodara, Ahmedabad, Ankleshwar, Surat, Rajkot, Delhi, Mumbai, Jaipur, Indore, Gift City (Gandhinagar) and expanding in northern and southern regions.

Beacon insurance has a team of qualified MBA'S, Engineer's & Professionals certified from the Insurance Institute of India. The organization is set up to develop core competency in insurance sector. We started our operations in the year 2005. Since then, beacon is effectively managing insurance portfolio of numbers of individuals, small, medium and large corporate.

Professionals with 20 - 30 years' experience in private and public sector blended with young vibrant team have come up together to emerge beacon as a one of the fastest growing insurance broking company.

We also have team of around 35 engineers from the various fields like Mechanical, Electrical, Electronics & Communication, Civil, Computer engineering & Information and Technology, that added advantage to utilize the technical knowledge.

We have our networks all over India and have in house expertise in all aspects of property, human, liability and other insurance domains. We have strong infrastructure which takes care of all needs of clients for general and life insurance.

Beacon is committed to bring changes in the mindset of Indian corporate about effectiveness of implementing insurance as Risk management tool.