

LIQUID FILLED TRANSFORMER MAINTENANCE

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INTRODUCTION

Conventional power and distribution transformers are generally regarded as reliable devices having low electrical failure rates. However, the ageing of the sub-station infra-structure in all parts of the industrial world is causing increasing concerns with evidence of increasing losses.

It is predicted that sub-station transformer failures will rise by 500% within the next 10 years as many of the units installed in the 1960's and 1970's are exceeding their expected operational life cycle. Transformer failure rate calculations have shown that the reliability rapidly decreases after 35 to 40 years of use and at 60 years is almost at 100%.

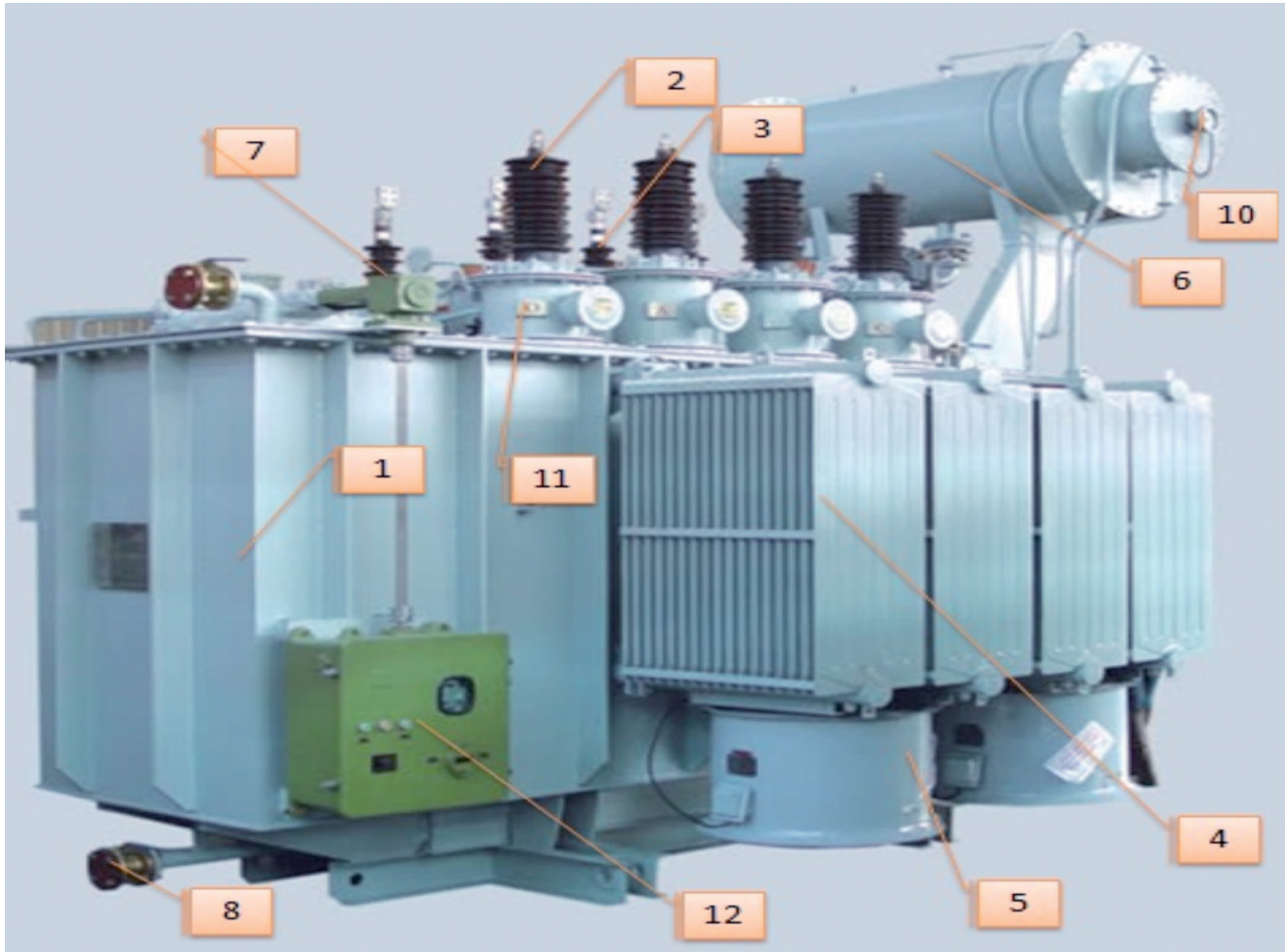
While the age of the equipment has an important bearing on failures, so does poor maintenance procedures. Fortunately, there are a number of practical and proven means to significantly reduce the risk of transformer failures.

DEFINITION

A transformer is a device that transfers electrical energy in an alternating current system from one voltage (distribution level voltage) to another (utilization level voltage). They can be dry or liquid filled (e.g., oil insulated), with dry transformers available in ratings up to 10 MVA although larger ratings tend to be liquid filled. Mineral insulating oil is commonly used. Also silicon oils, esters, etc., may be used, but these are more costly.

In liquid filled transformers, the windings and core are totally immersed in the liquid which functions as the cooling/heat transfer medium and the insulator to control stray currents. It is these types of transformers that are the subject of this technical note.

MAIN COMPONENT PARTS

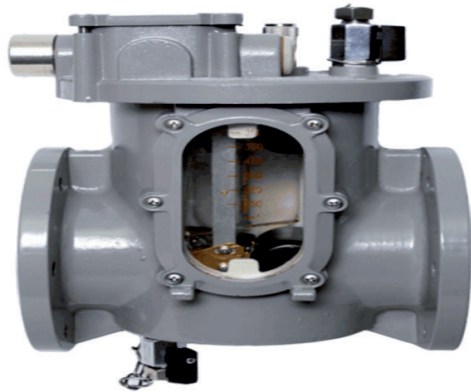


Typical Oil Filled Power Transformer

- 1. Transformer Tank:** Holds the transformer windings and its insulating medium (oil-filled).
- 2. High Voltage Bushing:** Terminals where the primary windings of the transformer terminate and serve as an insulator from the transformer tank.
- 3. Low Voltage Bushing:** Like the high voltage bushing, terminals where the secondary windings of the transformer terminate and serve as an insulator from the transformer tank.
- 4. Cooling Fins/Radiator:** In order for the transformer to dissipate the heat generated in its oil-insulation, cooling fins and radiators are usually attached to the transformer tanks.
- 5. Cooling Fans:** Can be usually found attached to the cooling fins.
- 6. Conservator Tank:** An oil preservation system in which the oil in the main tank is isolated from the atmosphere, over the temperature range specified, by means of an auxiliary tank partly filled with oil and connected to the completely filled main tank.
- 7. System Ground Terminal:** Usually present when a wye (Y) connection is used in the transformer windings.
- 8. Drain Valve:** Used to drain oil from the transformer.
- 9. Dehydrating Breather (not shown):** Prevents the normal moisture in the air from coming in contact with the oil in electrical equipment as the load or temperature changes. This reduces the degeneration of the oil and helps maintain its insulation capability.
- 10. Oil Temperature/Pressure Gauges:** Used for monitoring the internal characteristics of the transformer, especially its windings.
- 11. Bushing Current Transformers:** Located at the transformer terminals and used for metering and relaying purposes.
- 12. Control Panel:** Houses the transformer's monitoring device terminals and auxiliary devices.

Oil filled transformers with a conservator tank tend to be equipped with a gas accumulator relay (Buchholz relay). This is a gas and oil operated device installed in the pipework between the top of the transformer main tank and the conservator. The function of the relay is to detect an abnormal condition within the tank and send an alarm or trip signal. Under normal conditions the relay is completely full of oil. Operation occurs when floats are displaced by an accumulation of gas, or a flap is moved by a surge of oil.

Transformers without conservators are usually equipped with sudden pressure relays, which perform a similar function as the Buchholz relay.



Buchholz Relay

TRANSFORMER AGE

The life of a transformer depends largely on the life of the paper that is used to insulate the coil windings and various other components. The life of the paper is a function of the quality of the oil with which the transformer is filled, the quality of the paper itself, the operating temperature, the load and the surges to which the transformer is exposed.

The quality of the oil is a function of the duty of the transformer and the maintenance regime to which it is subject. Mean time to failure (MTF) of large transformers is around 50 years. All such data would seem to indicate that failures are relatively rare in the first 25 years but that the failure rate increases significantly after 40 years of use.

FAILURES

The leading cause of transformer failure is related to insulation (e.g., inadequate or defective, deterioration and short circuits). These can result from a number of different causes. Examples include:

- Vibration leading to insulation failure and short circuit.
- External shorts dislodging one or more coil turns.

Other reasons for failure that can be commonly encountered include moisture within the transformer, which can lead to short circuits. The moisture content of the oil should also be routinely monitored in operation. When the water content reaches a certain level, the oil must be dried if the transformer life is not to be drastically shortened.

On-line drying systems are available and silica gel breathers are routinely used to minimise the ingress of water in normal operation. Insulating liquid failure is another major cause of transformer failure. The purity and dryness of the oil will deteriorate as a result of moisture ingress, prolonged overloading, low oil level or the presence of conducting particles in suspension. The dielectric strength of the oil can be reduced to a dangerously low level at which breakdown or flash over could occur if not routinely monitored.

PREVENTIVE ACTION

While not all inclusive, the following basic preventive maintenance can greatly reduce the potential for liquid filled transformer failures and resulting business interruption:

1. Thermographic inspection of electrical systems. Inspections should be performed annually or more frequently (e.g., quarterly or semiannually) where warranted by loss experience, installation of new equipment, or changes in environmental, operational or load conditions.
2. Inspect transformer for general condition, including any leaks, at least monthly. Current, voltage, temperature, liquid level, and pressure/vacuum readings should be recorded to ensure they are within proper limits.
3. Test insulating liquid for dielectric breakdown, acidity, color, power factor, and interfacial tension at least annually. In addition, a gas in oil analysis (also known as dissolved gas analysis or DGA) should be performed annually or more frequently as warranted by the test results.
4. Older transformers are recommended to be additionally tested to determine levels of polychlorinated biphenyls (PCBs). Some government regulations may require service or replacement of the transformer tested, as PCB's are considered a toxic substance.

The actual level and frequency of maintenance will be determined by the criticality of the equipment to the site and the potential exposures as a result of a power outage due to failure.

If any of the above tests show that the insulating liquid is not in satisfactory condition, the liquid can be restored by reconditioning or reclaiming, or completely replaced.

REFERENCES

NFPA 70B, *Recommended Practice for Electrical Equipment Maintenance*

QUESTIONS OR COMMENTS?

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Reference 02/22/02

Tech Talk is a technical document developed by ARC to assist our clients in property loss prevention. ARC has an extensive global network of more than 100 property risk engineers that offers tailor made, customer focused risk engineering solutions.

Design: AGCS Graphic Design Centre

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