Risk information – Property

Maintenance of electrical power transformers

Introduction

If undetected, adverse conditions within a transformer can lead to a physical failure resulting in property loss, business interruption, personal injury and even loss of life.

This risk improvement guide provides information to assist in the identification of adverse operating conditions, allowing remedial action to be performed to prolong the life, maintain efficiency and increase the reliability of a transformer.

Note that there is no difference between transformers that are self-owned or the property of a power supply company. Your facility is dependent on the transformer (or a number of transformers) to continue efficient operation whatever the ownership.

Figure 1: Dry Type Transformer

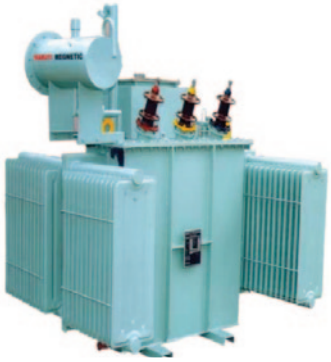

Figure 2: Liquid Immersed Transformer

Transformer types

Transformers can be classified by their method of cooling. Two major types of cooling are commonly available (each with a large number of sub-varieties). These are "Liquid Immersed" and "Dry Type". Of specific note, Liquid Immersed transformers typically use oil as an insulating medium for the transformer windings which makes them particularly susceptible to damage from overheating.

The risks

Over-heating is a major source of damage to transformers. Operating at a temperature of only 10°C above the transformer rating can reduce its life by up to 50%. Not to mention the impact upon operational efficiency and reliability.

Extended operation at elevated temperatures can also lead to a fire and/or explosion.

The consequences

A fire and/or explosion involving a transformer can have significant consequences including but not limited to:

- Damage to the transformer and surrounding property such as other transformers, buildings, plant & equipment.
- Business interruption as a result of the complete or partial failure of power supply.
- Most importantly, the potential for personal injury and or loss of life.

Maintenance

Power supply company owned and maintained transformers:
A site representative is encouraged to verify that adequate servicing is being provided to address the risk of a transformer failure. Utilise the maintenance schedules outlined in Tables 1 and 2 as a base of assessment. Formal advice from the power supply company is suggested and should be retained on file.

Your own transformers:
Recommended maintenance schedules for self-owned transformers are provided in Tables 1 and 2 and should form an integral part of any risk management programme. Note that maintenance schedules are different for Dry Type and Liquid Immersed transformers. (Source – FIST 3-30).

Figure 3: Oil Filled Transformer Fire (Source NRC Canada)

Life safety

All persons working on or near transformers should be specifically trained to undertake activities in accordance with regulatory endorsed "Standard Operating Procedures" (SOP's) specific to the task at hand. As a bare minimum these should encompass:

1. Utilisation of appropriate electrical system tools and other associated apparatus
2. Specific tag-out/lock-out procedures
3. Personal protective equipment.

Recommended maintenance schedules

(Routine inspections and periodic tests)

Table 1: Dry type transformers

Frequency	Task
Annually	**On-line** (a) Conduct an external "Infra-red" scan looking for hot spots (b) Check for rate of dust accumulation & moisture on visible surfaces (c) Check for audible sounds concentrating on characteristics as well as level.
	Perform an **Off-line** internal inspection, checking for: (a) Discoloured copper and insulation (b) Corroded and loose connections (c) Carbon tracking on insulation and insulators (d) Cracked, chipped and loose insulators (e) Dirt on windings (indicative of poor air filtration) (f) Cleanliness of fan blades (g) Fans, controls, alarms and enunciator points (h) Pressure gauge for Nitrogen filled transformers (pressure should not fall below 1 psi) (i) Tightness of all accessible hardware (j) Arcing or overheating of the core laminations.
	Repair all problems found in the above inspections.
	NOTE: If the transformer is de-energised long enough so that it can cool to ambient temperature, make sure the unit is kept dry. Remedial action may be warranted to dry internals prior to re-assembly.

Table 2: Liquid immersed transformers

Frequency	Task
Annually	(a) Perform an in-depth inspection of the transformer and cooling system, checking for leaks and proper operation. (b) Conduct an oil sample analysis (see below for further information). (c) Conduct an Infra-red scan of the transformer cooling system, bushings and all wiring. (d) Test all controls, relays, gauges, test alarms and enunciator points. (e) Inspect pressure relief for leaks and indication of acceptable operation. (f) Inspect the transformer bushings (use binoculars to check for cracks and chips), looking carefully for oil leaks. (g) Check oil levels. (h) Inspect pressure controls and pressure gauge (for Nitrogen over oil transformers).
Three to five years	(a) Conduct an in-depth inspection of bushings including cleaning and waxing if needed. (b) If the transformer has a conservator, check the diaphragm or bladder for leaks.

Oil sample analysis

Sampling and testing of transformer insulating oil is a particularly useful "condition monitoring" technique for Liquid Immersed transformers. It is particularly useful for determining trends and establishing the deterioration rate of the oil. In this regard sample testing should be conducted regularly, allowing comparison with past results. A number of tests can be conducted including:

(a) Dissolved Gas Analysis (DGA)

(b) Dielectric strength

(c) Interfacial tension

(d) Acid number and

(e) Test for oxygen inhibitor.

Frequency of testing will depend on a number of factors and thus it may be required more than annually.

Further details on the testing of insulating oils can be found in Australian Standard AS 1883-1992.

Other exposures

Polychlorinated biphenyl

Historically polychlorinated biphenyl (PCB) has been used as an insulator in Liquid Immersed transformers instead of oil. When exposed to elevated temperatures, PCBs will liberate highly toxic furanes and dioxins. As much as possible PCB is no longer used as an insulator, however it may still be present in older systems. Transformers containing PCBs should be flushed with fresh oil to ensure a contamination level of less than 50 ppm. As remnant PCBs can leach out from the transformer windings, tests should be conducted over three to five year intervals to verify that contamination levels are maintained to an acceptable level.

Copper corrosion and copper sulphide deposition

Recently there have been a number of transformer failures resulting from corrosion of the copper windings and deposition of sulphides on the insulating paper. These failures, which can occur with no warning, have been associated with the presence of corrosive sulphur compounds in the insulating oil. Specific brands of transformer oil contain these compounds and transformer owners/users should be aware if any of their facility may be affected. Vero have a separate Risk Improvement Guide available with further details on this issue.

Further information

1. Transformer Maintenance, FIST 3-30, Hydroelectric Research and Technical Services Group, US Department of the Interior, October 2000.
2. AS 1883-1992 Guide to maintenance and supervision of insulating oils in service, Standards Australia, 1992.
3. Transformers, FM Global Property Loss Prevention Data Sheet 5-4, May 2010.
4. Corrosive Sulphur in Transformer Insulating Oil, Risk Improvement Guide, Vero Global and Risk Managed, 2009.