



Property Risk Consulting Guidelines

A Publication of AXA XL Risk Consulting

PRC.5.9.4

TRANSFORMERS - SURROUNDINGS

INTRODUCTION

A transformer can be damaged by the environment in which it operates. It can be damaged if the environment is too hot, is corrosive or is otherwise contaminated.

Conversely, a transformer can affect the environment surrounding it and thereby expose nearby objects to damage. In the event of failure, the transformer can emit heat, flames and contaminants, including smoke, corrosive particles and fluids. Additionally, short circuit overcurrents and arcing can endanger electrically upstream equipment and equipment located nearby.

OVERVIEW describes what is included in a total management program for loss prevention and loss control. PRC.5.9.0.1 guides the evaluation of transformer importance. Transformers and dielectric fluid maintenance are discussed in PRC.5.4.5 and PRC.5.9.1. Placement, arrangement, fire exposure and fixed fire protection are discussed in PRC.5.4.5.1 and PRC.5.9.2. Electrical protection, instrumentation and controls for transformers are described in PRC.5.2.1, PRC.5.2.2, PRC.5.4.5.1 and PRC.5.9.3.

This Property Risk Consulting Guideline supplements those guidelines by describing special concerns that transformer environments can present. It applies to all units regardless of size if the consequences of loss are significant.

POSITION

Hazard Identification And Evaluation

Before installing a new or replacement transformer, examine the surroundings in which the unit will be placed. Evaluate exposure hazards, both to and from the unit. Look for combustible materials and materials susceptible to contamination or corrosion. Investigate buildings and other structures, stock and other storage, and equipment and other contents that expose or are exposed by the unit. Consider all transformer failure modes and consequences of failure, including environmental consequences. For indoor installations, pay particular attention to building susceptibility to loss upon transformer failure, and to the potential for spread of damage. Follow appropriate codes, regulations and standards. Follow manufacturers' guidelines. Take appropriate measures to prevent or limit damage from fire, smoke, escaping liquids and other hazards.

Maintain temperatures and ventilation around each transformer to prevent its full-load temperature rise from exceeding its rated rise. Additionally, maintain the temperature of any room, vault or area containing an air cooled transformer to satisfy the following features which are incorporated in the design of these units:

- A maximum ambient temperature at or below 40°C (104°F).

- A 24 h average ambient temperature at or below 30°C (86°F).

Dry Units

Protect open, vented and enclosed dry type transformers from environments which may damage them. Avoid the following in the air spaces surrounding these transformers:

- Airborne dusts or fibers of a size and density that may accumulate in or on the transformer to impair cooling, reduce the dielectric strength of the air insulation or ignite.
- Moisture or humidity of a magnitude and duration that can weaken the insulation.
- Oil mists or gases that could ignite.
- Vapors that could corrode wiring, connections or insulation.
- Steam, water and any vapor or liquid lines located where accidental breakage or leakage of a pipe or fitting could allow a spray, mist or flow to enter the transformer.

De-energize an open-type, vented or enclosed dry type transformer only in an environment having low humidity. Take precautions to keep moisture out of the windings, especially if the unit is to be allowed to approach ambient temperature. As an example, construct a temporary shelter with a controlled, dry environment.

Do not locate sulfur hexafluoride (SF₆) gas-filled transformers in areas where the construction or occupancy is highly susceptible to corrosion. Provide transformer rooms containing these units with their own, dedicated, induced (negative pressure) room ventilation systems that discharge directly to the outdoors. Locate the exhaust discharge away from air intakes to prevent any leakage of gas from being drawn into other building areas.

Liquid Insulated Units

Install indoor oil-insulated transformers in transformer vaults. Units rated at or below 75 kVA need not be installed in vaults if construction and protection features prevent the spread of damage from a transformer oil fire. See the *National Electrical Code*[®] (NEC). Automatic sprinkler protection, curbs and draft curtains may provide adequate protection for these smaller units.

Do not locate tetrachloroethylene fluid-insulated transformers in areas where the construction or occupancy is highly susceptible to corrosion.

Install indoor less-flammable liquid-insulated (LFLI) transformers in transformer vaults unless all of the following conditions are met:

- The area is protected by automatic sprinklers or both building construction and occupancy are noncombustible.
- There are no sources of ignition exceeding 400°C (752°F) within 15 ft (5 m) of the transformer.
- The area is enclosed by 4 in. (100 mm) or higher curb that will contain the maximum possible spill from the largest transformer within the curbed area.

An electrical fault in a liquid insulated transformer can result in tank failure, which can cause the insulating/cooling fluid to spray or spew into/onto nearby equipment. In any area containing a liquid insulated transformer, evaluate this hazard. Look at equipment enclosures, separation between equipment and the transformer, and the position of the openings. Where a discharge of transformer fluid can cause the significant extension of property damage to nearby equipment, or where it can significantly extend a power interruption, consider the following:

- Relocate the liquid insulated transformers or replace them with dry units.
- Replace exposed equipment with equipment designed to protect interior energized components from liquid entry, e.g., see PRC.5.13.1.
- Use partially enclosed equipment, and position it so that no opening or exposed component is in a fluid discharge path.

- Protect open equipment and equipment containing openings from damage by installing splash-shields, drip guards or similar protective barriers. These may be sheet metal, may be removable for maintenance, and need not be fire-rated. Position them where they will prevent fluid from reaching vents and exposed components.

DISCUSSION

Transformers are classified as either dry type or liquid insulated. Dry type units are further categorized based on construction. Liquid insulated units are categorized based on the dielectric fluid used.

Dry Transformers

There are four basic types of dry type transformers: vented or open, encapsulated or encapsulated-coil, enclosed and sealed. All designs are considered combustible because of the combustible insulation inside. All also contain a source of ignition, electricity.

The **vented** dry type transformer, which employs through-type ventilation, is the most common design. The coils and windings of a vented transformer are cooled by natural, forced, or a combination of natural and forced air circulation. These units are essentially open to the transformer environment since air circulation may bring contaminants into the air passageways and the windings. Some units are more **open** than vented. Open and vented units are highly susceptible to internal contamination. Contamination can lead to overheating, insulation breakdown, short circuiting, arcing and fire.

Another design is called an **encapsulated**, or an **encapsulated-coil** transformer. Its coils are encapsulated in an epoxy resin. Synthetic-resin-wound and cast-coil transformers are encapsulated-coil units. These units have low susceptibility to internal contamination.

Another design is the **enclosed**, nonventilated, self-cooled, dry type transformer. The transformer enclosure does not have vents, but neither is it tightly sealed. Air exchange may occur, although it would be incidental to the transformer's performance since air circulation was not made a requirement in the design calculations. This design is moderately susceptible to internal contamination.

The last type is a hermetically **sealed**, self-cooled, gas-filled transformer. The unit is pressurized with a gas of adequately high dielectric strength like sulfur hexafluoride or nitrogen. Because it is sealed, this design has low susceptibility to internal contamination. When an arcing fault takes place in sulfur hexafluoride, the high temperature of the arc may break down the dielectric to gases which can form corrosive acids upon combining with moisture in the air.

Usually, dry type transformers are lighter, have lower basic impulse insulation level (BIL) ratings, and operate at higher temperatures than liquid insulated transformers. Generally, dry units have a shorter service life and are more susceptible to failure from surges, than liquid insulated units.

Low voltage units rated up to 1000 kVA are available for specialty, general purpose and power applications. These units are listed by Underwriters Laboratories Inc. (UL®) in the Electrical Construction Equipment Directory. General precautions are identified in the NEC, Articles 450-21 and 450-22. Experience has shown that with good basic electrical precautions, dry transformers are not a significant fire problem.

Liquid Insulated Transformers

The NEC identifies liquid filled transformers as oil insulated, askarel-insulated, nonflammable fluid-insulated, and less-flammable liquid-insulated. The term "askarel" has become a generic term for certain fluids containing polychlorinated biphenyls (PCBs). PRC.5.4.5 and PRC.5.4.5.1 describe these dielectrics and the PCB hazard in more detail.

Oil insulated transformers can be likened to closed, pressurized containers holding mineral oil. The mineral oil is a dielectric, an insulating and cooling medium for the internal components of the

transformer. For most codes and standards, the term “oil insulated transformer” means the mineral oil is not PCB contaminated, and the transformer is rated and maintained as a “Non PCB transformer.” Where oil has been contaminated, the transformer is either a “PCB-contaminated transformer” or a “mineral oil PCB transformer.” Special installation and protection requirements apply. Basically, both oil and askarel protection guidelines should be followed. PRC.5.4.5.1 provides additional information.

Of all transformers, mineral oil insulated transformers are the greatest fire threat because of the severity of the fire that can occur upon electrical breakdown. But fire losses are reasonably controlled with good maintenance and design practices and fixed fire protection, including ventilation, drainage, vaults, protective devices and protection systems.

An **askarel-insulated transformer** is a “PCB transformer.” The use of askarels in transformers has resulted in building and environmental contamination which required extensive cleanup. An effective loss control program requires full information concerning the dielectric fluid and continual monitoring for compliance with laws, codes and guidelines. PRC.5.4.5.1 provides further information.

Because **nonflammable fluid-insulated transformers** are relatively new, field experience is limited. NEC Section 450-24 requires a transformer vault only where a unit rated over 35,000 V is located indoors. But because high temperature decomposition of tetrachloroethylene and similar products can lead to the development of corrosive acids, outdoor or vault placement may be necessary to effect loss control where the building or occupancy is susceptible to major damage from corrosion.

Article 450-23 of the NEC permits **less-flammable liquid-insulated (LFLI) transformers** up to 35,000 V to be installed indoors, without a vault and without an automatic fire extinguishing system, if located in noncombustible occupancy areas of noncombustible buildings provided:

- The liquid has a fire point of not less than 300°C (572°F);
- The liquid will be contained in the event of tank rupture or leak; and
- Its use complies with the restrictions provided in its listing.

LFLI transformer fluids are listed in the category “Dielectric Mediums [EOUV]” in the *UL Gas & Oil Equipment Directory*. These fluids are acceptable in either replacement or reclassification use, without a vault or special fire protection, when NEC requirements and Property Risk Consulting guidelines are followed.

Polydimethyl siloxane (silicone) and hydrocarbon fluids with a fire point of not less than 300°C (572°F) are more expensive than mineral oil and are typically used in LFLI transformers of up to 5000 kVA rating, indoors and outdoors. While generally self extinguishing in the small scale fire situation, “less-flammable liquids” will burn if sufficiently heated.

The Property Risk Consulting position on LFLI units applies only to “Non PCB transformers.” This fluid is not PCB contaminated. Although experience has been limited, we accept LFLI transformers indoors, without a vault, because of their generally excellent performance record.

Failure Mode For Liquid Insulated Units

In general, deterioration of a dielectric fluid or winding insulation can cause electrical breakdown in these units. This can lead to sudden increases in internal pressures which, in turn, can lead to containment failures. A pressurized release of fluid can result in a fluid stream or spray that can reach nearby equipment. By the time a fluid escapes, it may no longer have the characteristics of electrical insulation. Further, the fluid can pick up external contaminants along its path. Upon reaching energized equipment, contaminated fluids can cause additional equipment damage.

Oil sprays have traveled more than 20 ft (6 m) from transformer oil tanks. The hazards of oil insulated units and their potential to spread fire as oil flows or is sprayed are readily recognized. The hazards of dielectrics sprayed from other transformers are not as apparent, but pressurized flows of these materials can also be hazardous, particularly when contaminated.

When fluid insulated units must be located near other electrical equipment, the hazard arising from fluid sprayed into exposed equipment while energized must be evaluated, particularly if separate branch circuits are involved and coordination effectively separates or isolates these branches. In

general, oil insulated units should be isolated from other equipment to preclude this hazard. Damage caused by impingement of the less-flammable or nonflammable fluids on exposed equipment might be mitigated by using equipment constructed for outdoor use, or by increasing the distance separating the transformer and exposed equipment, or by providing equipment with shields or guards that can be readily removed if necessary for equipment maintenance. Knowledge of a transformer's design may help guide the installation of shielding to only limited, specific positions.

All Units

The NEC contains a limited discussion of transformer loss control and the methods of safeguarding against fire spread. It does not address transformer preventive maintenance, described in PRC.5.9.1 and PRC.5.4.5, nor does it address devices, instrumentation and controls that should be installed to prevent or control losses, as described in PRC.5.9.3.

The NEC does not address many of the loss control considerations needed to analyze safeguards against transformer damage from surrounding and nearby exposures. Hazardous exposures can include salt water spray, dust, corrosive atmospheres, contamination, moving objects, rupturing gas mains or pressure vessels, and earth movement. These concerns are particularly important where a potentially significant loss can be mitigated by cost-effective precautions. See PRC.5.9.2 for further discussion of exposures.