

Dielectric Fluids

NEC® Requirement Guidelines 2008 Code Options for the Installation of Listed Less-Flammable Liquid-Filled Transformers

Reference Information

R900-20-13

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These guidelines represent Cooper Power Systems, Dielectric Fluids Products' understanding and interpretation of the National Electrical Code®, UL® Classification of Envirotemp® FR3® Fluid and FM Global Property Loss Prevention Data Sheets 5-4 - Transformers, and IEEE standards in effect at the time of this publication. It does not necessarily represent the position of Cooper Power Systems on the protection and installation of less-flammable transformers.

GENERAL REQUIREMENTS

NEC (NFPA 70) Recognition: These guidelines focus on the requirements of Section 450.23 of the 2008 National Electrical Code (NEC) for the installation of Less-Flammable Liquid-Insulated Transformers. Less-flammable liquids are used in transformers where an extra margin of fire safety is important. Typical applications include installations indoors, on rooftops, near buildings, bush and forest fire prone areas and in pedestrian traffic areas.

Less-flammable liquids, also known as high fire point liquids, are transformer dielectric coolants that have a minimum fire point of 300 °C. Commonly used fire resistant coolants include high molecular weight hydrocarbons (HMWH), dimethylsiloxane, synthetic esters (Envirotemp 200 fluid), and natural esters (Envirotemp FR3 fluid). Two Nationally Recognized Testing Laboratories (NRTL)*; Underwriters Laboratories (UL) and FM Global (FM) currently list less-flammable liquids. They also list less-flammable liquid-filled transformers.

Less-flammable liquid-filled transformers were formally recognized by the NEC for indoor installations in 1978. In 1990, the NEC integrated specific less-flammable transformer requirements for outdoor installations into Section 450.23, in effect recognizing less-flammable transformers as inherently safer than conventional oil-filled transformers. Less-flammable transformers, long recognized as an additional safeguard for indoor installations, are becoming increasingly recognized for outdoor installations as well.

NESC (ANSI C2) Recognition: Utility-owned transformer installations are typically subject to the requirements of the National Electrical Safety Code (NESC), ANSI C2, in lieu of the NEC. Since 1993, the NESC has also recognized the use of less-flammable transformer fluid as an optional fire safeguard for indoor and outdoor transformer installations in Section 152. Other optional fire safeguard methods that may be applied, depending on the degree of fire hazard present in the installation, are separation from combustible materials or structures, liquid confinement, fire resistant barriers or enclosures, or extinguishing systems

General NEC Transformer Installation Requirements:

The requirements and options for the different types of indoor and outdoor transformer installations are outlined in Tables 1 and 2. These guidelines also summarize the UL Classification and FM Global Approved installation requirements for less-flammable fluids referred to as "listing" requirements in NEC 450.23.

NEC Section 450.28, Modification of Transformers, requires that when modifications are made to transformers in existing installations that change the transformer type, the transformers must be marked to show the type of insulating liquid installed and the installations must comply with current requirements of the NEC. Examples of changes include replacing a complete transformer (retrofitting) or replacement of the fluid only (retrofilling). Askarel (PCB) and conventional mineral oil-filled transformers can be retrofitted or retrofilled using some types of less-flammable fluids like natural esters. Section 110.34 sets minimum clear work space dimensions around transformers.

* Refer to Occupational Safety & Health Administration (OSHA) for complete listing of NRTLs.

TABLE 1
NEC Section 450.23 Requirements - Indoor Installations

| | | |
|--|---|--|
| <p>INSTALLATION TYPE Transformer rated \leq 35 kV, installed in a non-combustible building with no combustible materials stored in area</p> <p>NEC OPTIONS*</p> <ul style="list-style-type: none"> ■ Both liquid confinement, and either of the following listing requirements <ul style="list-style-type: none"> A. Underwriters Laboratories B. FM Global <p>OR</p> <ul style="list-style-type: none"> ■ Both liquid confinement and auto extinguishment <p>OR</p> <ul style="list-style-type: none"> ■ Vault per NEC 450, Part III | <p>INSTALLATION TYPE Transformer rated \leq 35 kV, installed in a combustible building or in a building with combustible materials stored in area</p> <p>NEC OPTIONS*</p> <ul style="list-style-type: none"> ■ Both liquid confinement and auto-extinguishment <p>OR</p> <ul style="list-style-type: none"> ■ Vault per NEC 450, Part III | <p>INSTALLATION TYPE Transformer rated $>$ 35 kV</p> <p>NEC REQUIREMENT*</p> <ul style="list-style-type: none"> ■ Vault per NEC 450, Part III |
|--|---|--|

* No additional safeguards are required if one or more of Exceptions 1-6 of Section 450.26, Oil-Insulated Transformers Installed Indoors apply.

TABLE 2
NEC Section 450.23 Requirements - Outdoor Installations

| | |
|--|--|
| <p>INSTALLATION TYPE Non-combustible building* and no combustible materials stored in area</p> <p>NEC REQUIREMENT</p> <ul style="list-style-type: none"> ■ Either of the following listing requirements** <ul style="list-style-type: none"> A. Underwriters Laboratories B. FM Global | <p>INSTALLATION TYPE Combustible building* or combustible materials stored in area</p> <p>NEC REQUIREMENT</p> <ul style="list-style-type: none"> ■ In accordance with NEC Section 450.27, Oil Insulated Transformers Installed Outdoors i.e. space separation, fire barriers or water spray systems |
|--|--|

* Refer to NFPA 220 for definition of non-combustible Type I and II building construction.

** Fine Print Note, Section 450.23, (B)(1) states: "Installations adjacent to combustible material, fire escapes, or door and window openings may require additional safeguards such as those listed in Section 450.27."

INDOOR INSTALLATION OPTIONS

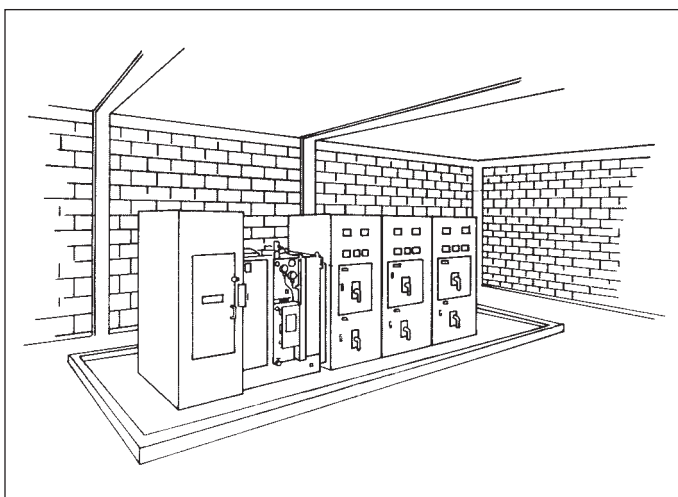
(Refer to Appendices 1 and 2)

Indoor installations using less-flammable liquid-insulated transformers must comply with NEC Section 450.23, which defines the requirements for three types of indoor transformer installations as detailed in Table 1:

- Non-combustible building* with no combustible materials stored in area
- Combustible building or combustibles stored in area
- Rating > 35 kV.

INDOOR INSTALLATIONS RATED \leq 35 kV

Without a Vault in Type I or II Buildings in Areas Where No Combustible Materials are Stored



INSTALLATION TYPE

Transformer rated \leq 35 kV, installed in a non-combustible building with no combustible materials stored in area.

NEC OPTIONS**

- Both liquid confinement, and either of the following listing requirements:
 - A. Underwriters Laboratories
 - B. FM Global;**OR**
- Both liquid confinement and auto-extinguishment; **OR**
- Vault per NEC 450, Part III.

The installation of less-flammable liquid-insulated transformers indoors without a vault in a Type I or II non-combustible building* where no combustible materials are stored requires that:

- A liquid confinement area be provided. Liquid confinement may include:
 - Containment pan
 - Curbing
 - Room containment (e.g. door sill)**AND**
- The transformer be filled with a listed less-flammable insulating liquid with a minimum 300 °C fire point **AND**
- The installation complies with all restrictions provided for in the listing of the liquid.

If the installation cannot meet the liquid listing requirements

- It must be provided with an automatic fire extinguishing system and a liquid containment area **OR**
- It must be installed in a vault complying with NEC 450 Part III, Transformer Vaults.

Section 450.26 may be followed in lieu of any requirements listed in Section 450.23. Exceptions to vault requirements listed in Section 450.26 are also valid for less-flammable fluid-filled installations. Construction requirements for vaults are detailed in Part III of Article 450.

Section 450.42 in Part III, Transformer Vaults, allows an exception to the 3-hour vault requirement permitting a 1-hour rated fire resistant rated room if equipped with an automatic extinguishing system.

* Refer to NFPA 220 for definition of non-combustible Type I and II building construction.

**No additional safeguards are required if one or more of Exceptions 1-6 of Section 450.26, Oil-Insulated Transformers Installed Indoors apply.

**LISTING OPTION – A
Underwriters Laboratories Requirements***


The UL Classification of less-flammable liquids per the NEC Section 450.23 for 3-Phase 45-10,000 kVA transformers requires:

- Transformers be equipped with tanks capable of withstanding 12 psig without rupture.
- Transformers be equipped with pressure relief devices with minimum pressure relief capacity per the UL Classification Marking.
- Transformer primaries be protected with overcurrent protection options per the UL Classification Marking.

Overcurrent Protection Option I, available exclusively with Envirotemp FR3 Fluid’s UL Classification, allows internal expulsion fuses (e.g. bay-o-net fuses) only if in series with current limiting fuses. Overcurrent Protection Option II allows stand-alone expulsion fuses, but they must be located outside the transformer tank.

To specify a UL Classified Envirotemp FR3 fluid-filled transformer for a specific kVA rating, refer to the UL Classification Marking for the fluid shown in Table 3.

Table 3: UL Classification Marking for Envirotemp FR3 Fluid (EOVK.MH10678)



Envirotemp FR3. Classed 4 to 5 less hazardous than paraffin oil in respect to fire hazard. Fire point 358 C (676 F). Ignition temperature 428 C (802 F).

Also Classified as a “less-flammable liquid” as specified in the National Electric Code® when used in 3-phase transformers, 45 through 10,000 kVA with the following “use restrictions”:

- A. For use only in 3-phase transformers having tanks capable of withstanding an internal pressure of 12 psig without rupture.
- B. Required use of pressure relief devices on transformer tank in accordance with the following tabulation to limit internal pressure buildup and prevent tank rupture due to gas generation under low current arcing faults, and
- C. Required use of current limiting fusing in the transformer primary having I²t characteristics not exceeding the values in the following tabulation. Under-fluid expulsion fuses may be used in series with the current-limiting fuses, in accordance with the manufacturer’s protection scheme, or
- D. Required use of overcurrent protection in the transformer primary having I²t characteristics not exceeding the values in the following tabulation. If the fuse is designed to vent during operation (such as an expulsion fuse), it shall be located external to the transformer tank.

| TRANSFORMER | REQUIRED PROTECTION | | REQUIRED PRC |
|--------------------------------|--|--|--|
| 3-Phase Transformer Rating kVA | Required Current Limiting Fusing (+) Maximum I ² t (A ² s) | OR Required Overcurrent Protection (+) Maximum I ² t (A ² s) | Minimum Required Pressure Relief Capacity, (++) SCFM at 15 psi |
| 45 | 500,000 | 700,000 | 35 |
| 75 | 500,000 | 800,000 | 35 |
| 112.5 | 550,000 | 900,000 | 35 |
| 150 | 600,000 | 1,000,000 | 50 |
| 225 | 650,000 | 1,200,000 | 100 |
| 300 | 750,000 | 1,400,000 | 100 |
| 500 | 900,000 | 1,900,000 | 350 |
| 750 | 1,100,000 | 2,200,000 | 350 |
| 1,000 | 1,250,000 | 3,400,000 | 350 |
| 1,500 | 1,500,000 | 4,500,000 | 700 |
| 2,000 | 1,750,000 | 6,000,000 | 700 |
| 2,500 | 2,000,000 | 7,500,000 | 5,000 |
| 3,000 | 2,250,000 | 9,000,000 | 5,000 |
| 3,750 | 2,500,000 | 11,000,000 | 5,000 |
| 5,000 | 3,000,000 | 14,000,000 | 5,000 |
| 7,500 | 3,000,000 | 14,000,000 | 5,000 |
| 10,000 | 3,000,000 | 14,000,000 | 5,000 |

(+) This is an additional requirement to the overcurrent protection required in accordance with Section 450.3 of the current National Electrical Code®.
 (++) Opening pressure, 10 psig maximum.

* UL EOVK - Transformer Fluids

LISTING OPTION - B

FM Global Requirements

The FM indoor installation requirements for all transformer and fluid types are given in FM Global Property Loss Prevention Data Sheets 5-4 - Transformers (LPD). Specific requirements for less-flammable liquid-insulated transformers are included. Refer to Section 2.2.1.2 of FM LPD for special installation requirements for network transformers.

General transformer requirements are as follows:

- Minimum 3 ft. clear from building walls, **AND**
- Liquid containment provisions, **AND**
- Room fire resistance rating based on fluid and transformer type, **AND**
- Room ventilation, if necessary, to prevent non-thermal damage, **AND**
- Smoke detection with alarm in the electrical room.

Less-flammable liquid-filled transformers must comply with one of the following:

- Be FM Approved or equivalent,
OR
- Be located in a room with a one hour fire resistance rating,
OR
- Have automatic sprinklers above the transformer and 20 ft. beyond with a discharge density of 0.20 gpm/sq. ft.

FM Approved Transformer:

Less-flammable liquid-filled transformers rated 5 through 10,000 kVA must be equipped with specific design and protection features to be FM Approved or equivalent. Key characteristics of this protection system are fire properties of the liquid, the ability to mechanically withstand pressure generated by a low level electrical fault and the ability of electrical protection to clear a fault before tank rupture.

According to FM Global Standard 3990, the key protection features are as listed below. Refer to the FM standard for **complete requirements**:

- The transformer tank rupture strength shall be a minimum of 15 psig for rectangular and 20 psig for cylindrical tanks. All transformer tanks shall be designed to withstand a pressure of 7 psig without permanent distortion, **AND**
- The transformer tank shall be provided with a pressure relief device to vent internal over-pressures. The device must be capable of venting a minimum specified flow rate, based on the kVA as noted in Table 4 and Section 2.3.3 of the FM Global Standard 3990. Proper pressure venting coordinated with proper tank pressure withstand rating has proven highly effective in preventing tank rupture from overpressure due to internal fault currents below the trip rating of primary circuit current limiting fuses, **AND**
- The unit is filled with an FM Global Less-Flammable fluid* to reduce the probability of ignition of the liquid. Less-Flammable fluids, also known as high fire point or fire resistant liquids, are dielectric coolants that have a minimum fire point of 300 °C per the ASTM D92 Cleveland Open Cup Test Method, **AND**
- The primary circuit shall have over-current protection which limits the let-through current (I^2t) to a specified maximum value as listed in Table 5 and in Section 2.3.5 of the FM Global Standard 3990. Current-limiting fusing and its functional equivalents are designed to interrupt a high current internal fault before the tank withstand pressure level is reached. If protection is designed to vent gas during operation, such as with expulsion fuses, this protection shall be located outside the transformer tank. Exception: Envirotemp FR3 fluid-immersed expulsion fusing (e.g. bay-o-net) may be mounted in the transformer tank if in series and properly coordinated with current limiting fusing, **AND**
- The transformer shall have an additional nameplate with the FM Global mark with the following data: tank pressure rating, fuse part number, pressure relief device part number, and requirements particular to the type of installation.

* For a listing of FM Global Less-Flammable fluids, refer to the Less Flammable Fluids section of the FM Global Approval Guide - Electrical Equipment.

LISTING OPTION - B
FM Global Requirements (continued)

- For grounded wye secondary windings of 150 volts or more and rated at 1,000 or more nominal amperes, a notification tag shall be provided by the manufacturer, secured to the low voltage neutral bushing, advising that the transformer installation requires ground fault relay protection prior to energization (if not installed at time of manufacturing), **AND**
- Indoor units greater than 500 kVA with alarm contacts only and outdoor units greater than 2,500 kVA shall be equipped with alarm contacts on the pressure relief device and a rapid-rise relay, **AND**
- Three-phase pad-mounted and substation transformers shall be equipped with an oil level gauge. Additionally, all transformers rated 750 kVA or higher shall be equipped with a liquid temperature indicator and pressure-vacuum gauge, **AND**
- Transformers shall be capable of passing Basic Lightning Impulse Insulation Level (BIL) testing at a minimum tilt of 1.5° from vertical.

Table 4: FM Pressure Relief Device Required Ratings

| kVA Rating 3-Phase (1-Phase) | Flow Rate SCFM @ 15psi (103 pKa) |
|---------------------------------|-------------------------------------|
| 112.5 (37.5) | 35 |
| 150 (50) | 50 |
| 300 (100) | 100 |
| 1,000 (333) | 350 |
| 2,000 (667) | 700 |
| 10,000 (3,333) | 5,000 |

Note: For kVA ratings not listed use next **highest** rating in table.

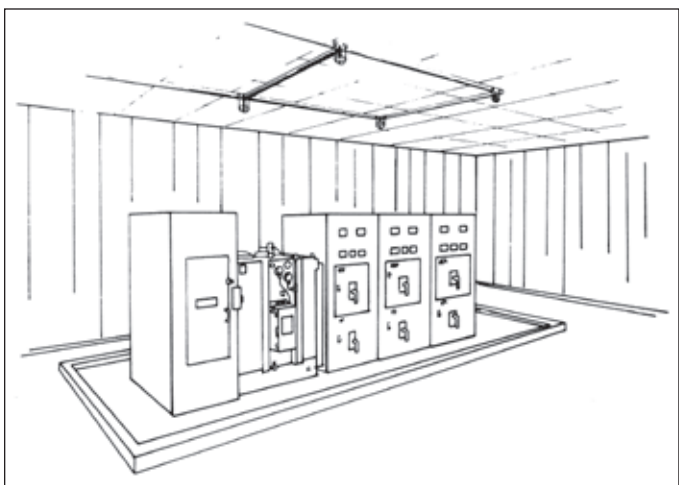
Table 5: FM Maximum I²t Let Through Required Ratings

| kVA Rating 3-Phase (1-Phase) | Current Limiting Fusing | Other Protection |
|---------------------------------|----------------------------|------------------|
| 45 (15) | 500,000 | 700,000 |
| 75 (25) | 500,000 | 800,000 |
| 112.5 (37.5) | 550,000 | 900,000 |
| 150 (50) | 600,000 | 1,000,000 |
| 225 (75) | 650,000 | 1,200,000 |
| 300 (100) | 750,000 | 1,400,000 |
| 500 (167) | 900,000 | 1,900,000 |
| 750 (250) | 1,100,000 | 2,200,000 |
| 1,000 (333) | 1,250,000 | 3,400,000 |
| 1,500 (500) | 1,500,000 | 4,500,000 |
| 2,000 (667) | 1,750,000 | 6,000,000 |
| 2,500 (833) | 2,000,000 | 7,500,000 |
| 3,000 (1,000) | 2,250,000 | 9,000,000 |
| 3,750 (1,250) | 2,500,000 | 11,000,000 |
| 5,000 (1,667) | 3,000,000 | 14,000,000 |
| 7,500 (2,500) | 3,000,000 | 14,000,000 |
| 10,000 (3,333) | 3,000,000 | 14,000,000 |

Note: For kVA ratings not listed use next **lowest** rating in table.

INDOOR INSTALLATIONS RATED \leq 35 kV

Without a Vault in Buildings Other Than Type I or II or
in Areas Where Combustible Materials are Stored



INSTALLATION TYPE

Transformer rated \leq 35 kV, installed in a combustible building or in a building with combustible materials stored in area.

NEC OPTIONS**

- Both liquid containment and auto extinguishment
OR
- Vault per NEC 450, Part III.

The installation of less-flammable liquid-insulated transformers indoors without a vault in Type I or II non-combustible building* where no combustible materials are stored required that:

- A liquid containment area be provided, **AND**
- The transformer be filled with a listed less-flammable insulating liquid with a minimum 300 °C fire point, **AND**
- The installation comply with the listing requirements of the liquid in the transformer.

If the installation cannot meet the liquid listing requirements or one or more of the exceptions listed in 450.26, the installation must **either** be provided with an automatic fire extinguishing system and a liquid confinement area **or** the transformer must be installed in a vault, per Section 450, Part III.

Section 450.42 in Part III, Transformer Vaults, allows an exception to the three-hour vault requirement permitting a one-hour rated fire resistant rated room if equipped with an automatic spray extinguishing system.

INDOOR INSTALLATIONS RATED > 35 kV INSTALLATION TYPE

Transformer rated > 35 kV

NEC REQUIREMENT**

- Vault per NEC 450, Part III.

If the installation does not comply with one or more of the exceptions listed in 450.26, the transformer must be installed in a vault complying with NEC 450, Part III Transformer Vaults. Section 450.26 may be followed in lieu of any requirements listed in Section 450.23. Exceptions to vault requirements listed in Section 450.26 would also be valid for less-flammable fluid-filled transformer installations. Construction requirements for vaults are detailed in Part III of Article 450.

Section 450.42 in Part III, Transformer Vaults, allows an exception to the three-hour vault requirement permitting a one-hour rated fire resistant rated room if equipped with an automatic extinguishing system.

*Refer to NFPA 220 for definition of non-combustible Type I and II building construction.

**No additional safeguards are required if one or more of Exceptions 1-6 of Section 450-26, Oil-Insulated Transformers Installed Indoors apply.

OUTDOOR INSTALLATION OPTIONS

(Refer to Appendices 3 and 4)

Outdoor installations attached to, adjacent to, or on the roof of buildings using less-flammable liquid-insulated transformers must comply with NEC Section 450.23. This Code Section defines the requirements for outdoor less-flammable transformer installations according to the building fire resistance rating.*

- On or adjacent or attached to Type I or II building*
- On or adjacent to a combustible building**

In addition to indoor installations, less-flammable liquid-insulated transformers are increasingly recognized as an additional safeguard by insurance underwriters and specifiers for outdoor applications. The degree of fire safety will be significantly increased when a transformer is filled with less-flammable fluid instead of conventional mineral oil. Transformers installed according to the listing requirements of less-flammable liquids will provide an even greater margin of safety.

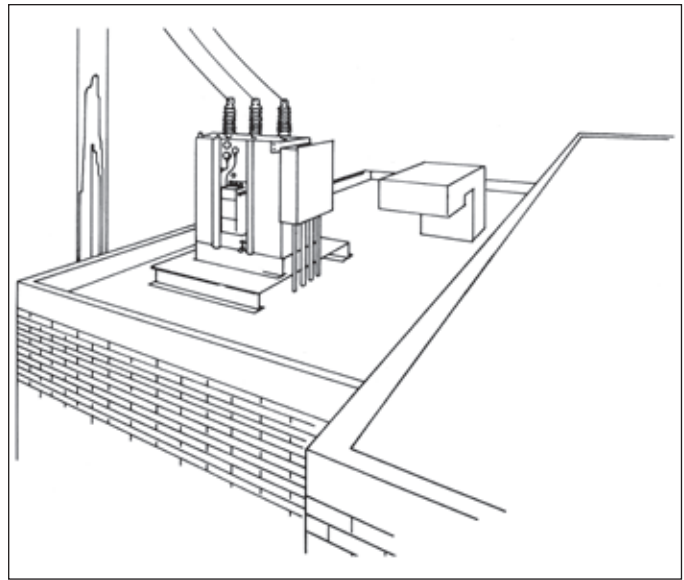
Note on Outdoor Installations Using Conventional Mineral Oil per IEEE:

IEEE Std 979™ standard, Guide For Substation Fire Protection recommends that transformers containing conventional mineral insulating oil be located not less than the distances listed in Table 6 from buildings. Where a transformer is located less than the specified minimum distance, fire-resistant wall construction should be used.

Table 6: Clearance Requirements From Buildings For Conventional Mineral Oil-Filled Transformers (per IEEE Std 979™ standard)

| Transformer Rating | Recommended Minimum Distance from Building |
|--------------------|--|
| 75 kVA or less | 10 ft. |
| 76-333 kVA | 20 ft. |
| More than 333 kVA | 30 ft. |

OUTDOORS ON OR ADJACENT TO TYPE I AND TYPE II BUILDINGS



INSTALLATION TYPE

Non-combustible building* and no combustible materials stored in area.

NEC REQUIREMENT

- Either of the following fluid listing requirements:
 - A. Underwriters Laboratories
 - B. FM Global

Less-flammable liquid-insulated transformers are permitted to be installed outdoors, attached to, on, or adjacent to non-combustible* buildings. The installation must comply with the requirements of a recognized listing of the fluid.

A fine print note states that combustible material**, combustible buildings, fire escapes and door and window openings may require additional safeguarding, as described in Section 450.27. Fine Print Notes (FPN) are defined in Section 90.5 as informational only and are not enforceable as code requirements.

* Refer to NFPA 220 for definition of non-combustible Type I and II building construction.

** Per NFPA 220, the definition of combustible material refers to material not classified as non-combustible or limited-combustible.

LISTING OPTION - A

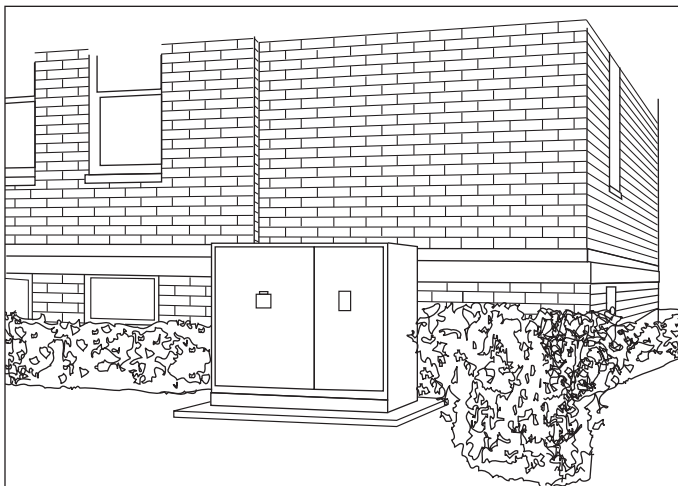
Underwriters Laboratories Requirements

The same UL Classification of less-flammable liquids per the NEC Section 450.23 for 3-Phase 45-10,000 kVA transformers applies to both indoor and outdoor applications and requires:

- Transformers be equipped with tanks capable of withstanding 12 psig without rupture, **AND**
- Transformers be equipped with pressure relief devices with minimum pressure relief capacity per the UL Classification Marking, **AND**
- Transformer primaries be protected with overcurrent protection options per the UL Classification Marking.

Overcurrent Protection Option I, available exclusively with Envirotemp FR3 Fluid's UL Classification, allows internal expulsion fuses (e.g. bay-o-net fuses) in series with current limiting fuses. Overcurrent Protection Option II allows stand-alone expulsion fuses, but they must be located outside the transformer tank.

To specify a UL Classified Envirotemp FR3 fluid-filled transformer for a specific kVA rating, refer to the UL Classification Marking for the fluid shown in Table 3.



LISTING OPTION - B

FM Global Requirements

The outdoor installation requirements according to FM Global Property Loss Prevention Data Sheets 5-4 - Transformers consist of requirements for transformer and fluid types. Specific requirements for less-flammable liquid-insulated transformers are included.

FM outdoor installation requirements are based on the FM Approval Status of the transformer and both the volume and FM Approval Status of the fluid. If transformers filled with conventional mineral oil or non-approved fluids would expose buildings and equipment to a release of oil, the transformer must comply with FM LPD requirements. This may include containment, separation distances, fire barriers, or water spray systems. Installation of FM Approved transformers or transformers with FM Approved less-flammable fluids must comply with FM LPD requirements for containment and separation distances. The FM LPD provides detailed requirements for fire barriers in Section 2.3.1.1.2 and water spray exposure protection in Section 2.3.2.1.

Fluid containment requirements as detailed in Section 2.3.1.2 of the FM LPD are:

- A release of mineral oil would expose buildings
OR
- More than 500 gal (1.9 m³) of mineral oil could be released
OR
- More than 1320 gal (5 m³) of FM Approved less-flammable fluid could be released
OR
- More than 2,640 gal (10 m³) of biodegradable FM Approved less flammable fluid could be released. For this purpose: 1) the fluid must be certified as a biodegradable fluid by the government environmental protection agency, 2) a release of the fluid must not expose navigable waterways (see Appendix A for definition) and 3) the transformer must be properly labeled.

LISTING OPTION - B
FM Global Requirements (continued)

Separation Distance: Separation distance requirements are based on whether the transformer is FM Approved or equivalent, or the volume of fluid, and if the fluid is FM Approved. For FM Listed less-flammable fluids, horizontal distance is measured from transformer; for non-listed fluids, horizontal distance is measured from inside of the outer edge of containment. (See Figure 1.)

TABLE 7. FM Required Separation Distance Between Outdoor Liquid Insulated Transformers and Buildings.*

| Liquid | FM Approved Transformer or Equivalent | Liquid Volume gal/(m ³) | Horizontal Distance** | | | Vertical Distance ft/(m) |
|---------------------------|---------------------------------------|-------------------------------------|-----------------------|------------------------|--------------------|--------------------------|
| | | | Fire Resistant ft/(m) | Non-Combustible ft/(m) | Combustible ft/(m) | |
| Less-Flammable (Approved) | Yes | N/A | 3 (0.9) | 3 (0.9) | 3 (0.9) | 5 (1.5) |
| | No | ≤10,000 (38) | 5 (1.5) | 5 (1.5) | 25 (7.6) | 25 (7.6) |
| | | >10,000 (38) | 15 (4.6) | 15 (4.6) | 50 (15.2) | 50 (15.2) |
| Mineral Oil | N/A | <500 (1.9) | 5 (1.5) | 15 (4.6) | 25 (7.6) | 25 (7.6) |
| | | 500-5,000 (1.9-19) | 15 (4.6) | 25 (7.6) | 50 (15.2) | 50 (15.2) |
| | | >5,000 (19) | 25 (7.6) | 50 (15.2) | 100 (30.5) | 100 (30.5) |

* FM Global Loss Prevention Data Sheet 5-4, Table 2a

** All transformer components must be accessible for inspection and maintenance.

TABLE 8. FM Outdoor Fluid Insulated Transformers Equipment Separation Distance.*

| Liquid | FM Approved Transformer or Equivalent | Fluid Volume gal/(m ³) | Distance** ft/(m) |
|---------------------------|---------------------------------------|------------------------------------|-------------------|
| Less-Flammable (Approved) | Yes | N/A | 3 (0.9) |
| | No | ≤10,000 (38) | 5 (1.5) |
| | | >10,000 (38) | 25 (7.6) |
| Mineral Oil | N/A | <500 (1.9) | 6 (1.5) |
| | | 500-5,000 (1.9-19) | 25 (7.6) |
| | | >5,000 (19) | 50 (15.2) |

* FM Global Loss Prevention Data Sheet 5-4, Table 2b

** All transformer components must be accessible for inspection and maintenance.

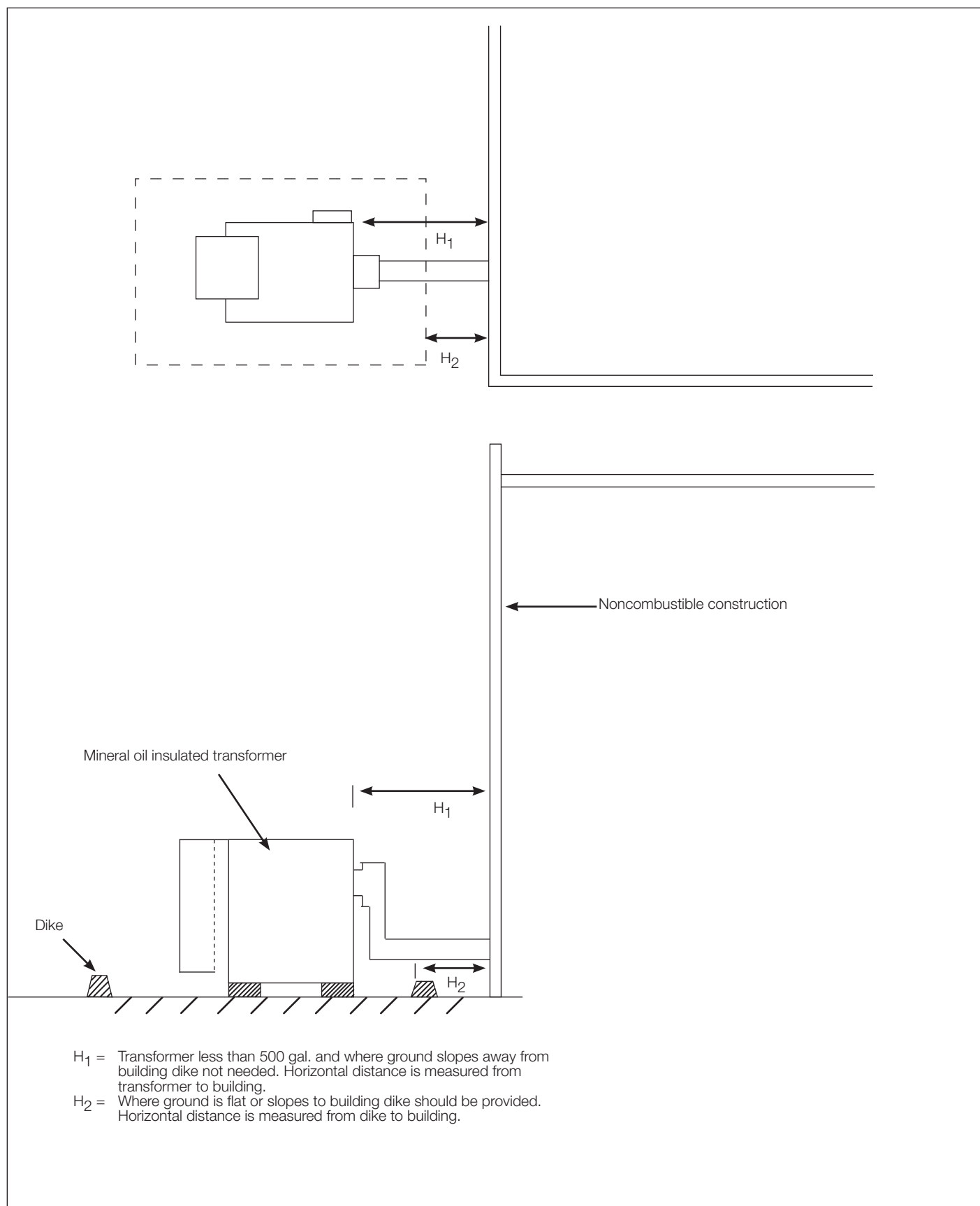


Figure 1. Separation between liquid insulated transformer and building. (Drawing excerpted from FM Global Loss Prevention Data Sheet 5-4.)

OUTDOORS ON OR ADJACENT TO COMBUSTIBLE BUILDINGS OR COMBUSTIBLE MATERIALS

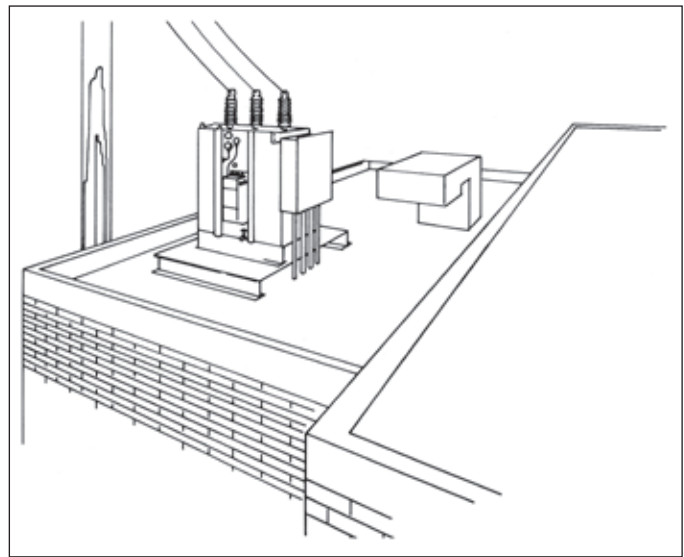
INSTALLATION TYPE

For installations other than Type I and Type II* buildings or for installations that do not comply with all the restrictions provided for in the listing of the liquid.

NEC REQUIREMENT

- Per NEC Section 450.27, Oil-Insulated Transformers Installed Outdoors.

Section 450.23 refers to Section 450.27, Oil Insulated Transformers Outdoors, for installation requirements when less-flammable liquid-filled transformers are installed on or adjacent to combustible buildings or near combustible materials. As for conventional oil-filled transformers, it requires the safeguarding of combustible material, combustible buildings, fire escapes and door and window openings. Recognized safeguards include space separation, fire barriers, spray extinguishing systems and confinement areas for spilled fluid. The NEC requires that one or more of the above safeguards be applied according to the degree of fire hazard present in cases where the installation presents a fire hazard. Obviously, less-flammable fluid-filled transformers significantly reduce the possibility that the installation presents a fire hazard compared to conventional mineral oil.

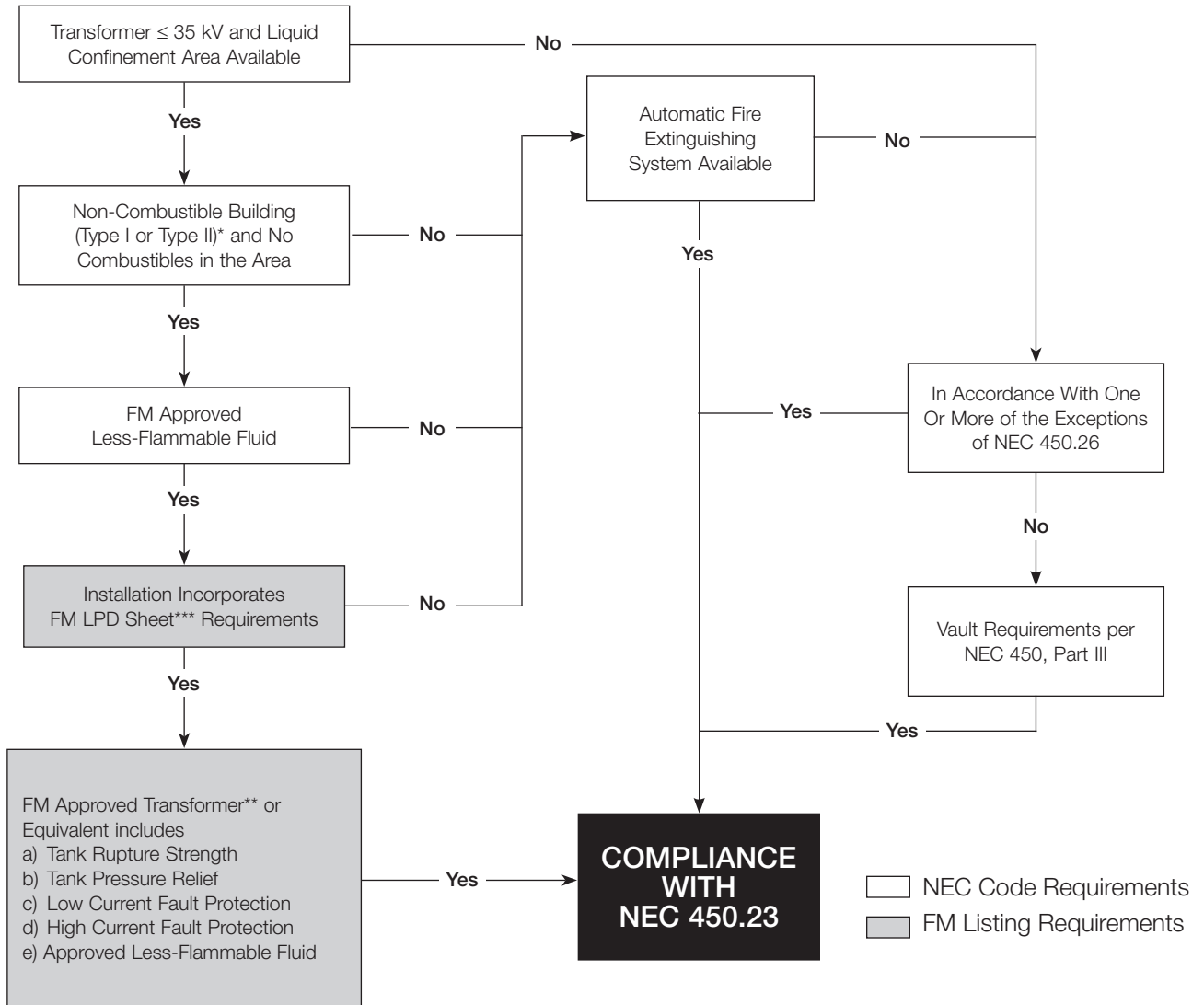


* Refer to NFPA 220, Section 2.1 for the definition of combustible building construction.

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Less-Flammable Liquid-Insulated Transformers Compliance to NEC 2008 Section 450.23 per FM Listing

Requirement Highlights for Indoor Installations



FM Approved Fluids include: **

- Envirotemp FR3 Fluid (natural ester)
- ABB BIOTEMP® (natural ester)
- M&I Materials MIDEL® 7131 (synthetic ester)
- Shell Diala® HFX (fire resistant hydrocarbon)
- Dow Chemical L-305, Y-7582 (silicone)
- DSI Alpha-1™, Beta® (hydrocarbon)
- Dow Corning® 561 (silicone)

FM Approved Transformers include: **

- Cooper Power Systems
- ABB
- Siemens
- Eaton Cutler-Hammer

* Refer to NFPA 220 for definition of non-combustible Type I and II building construction

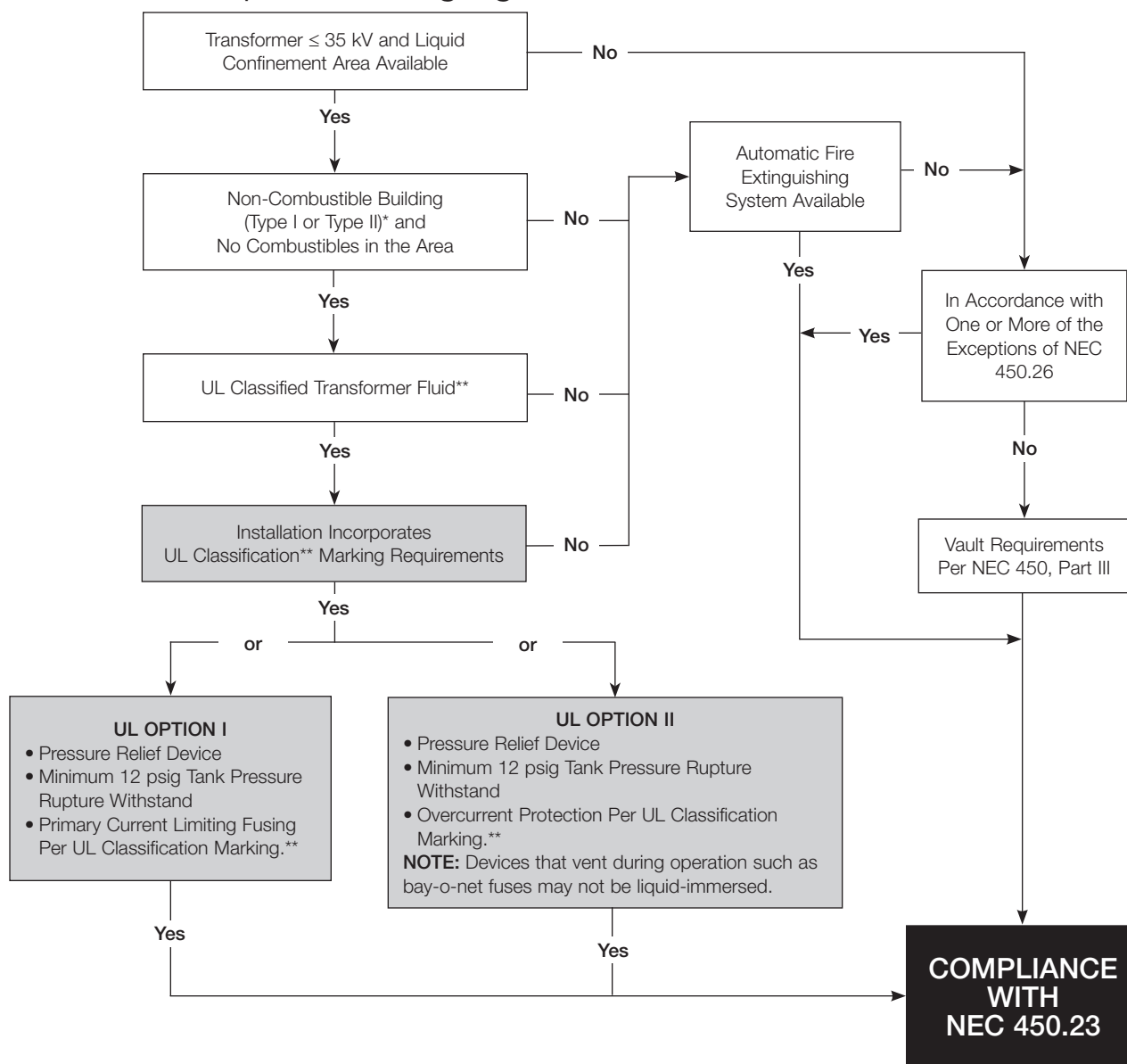
** FM Global Approval Guide

*** FM Global Property Loss Prevention Data Sheets 5-4 — Transformers

Appendix 1

Less-Flammable Liquid-Insulated Transformers Compliance to NEC 2008 Section 450.23 per UL Listing

Requirement Highlights for Indoor Installations



□ NEC Code Requirements

■ UL Listing Requirements

UL Classified Transformer Fluids:**

Envirotemp FR3 Fluid (natural ester), Option I or Option II
Dow Corning® 561 (silicone), Option II only

* Refer to NFPA 220 for definition of non-combustible Type I and II building construction

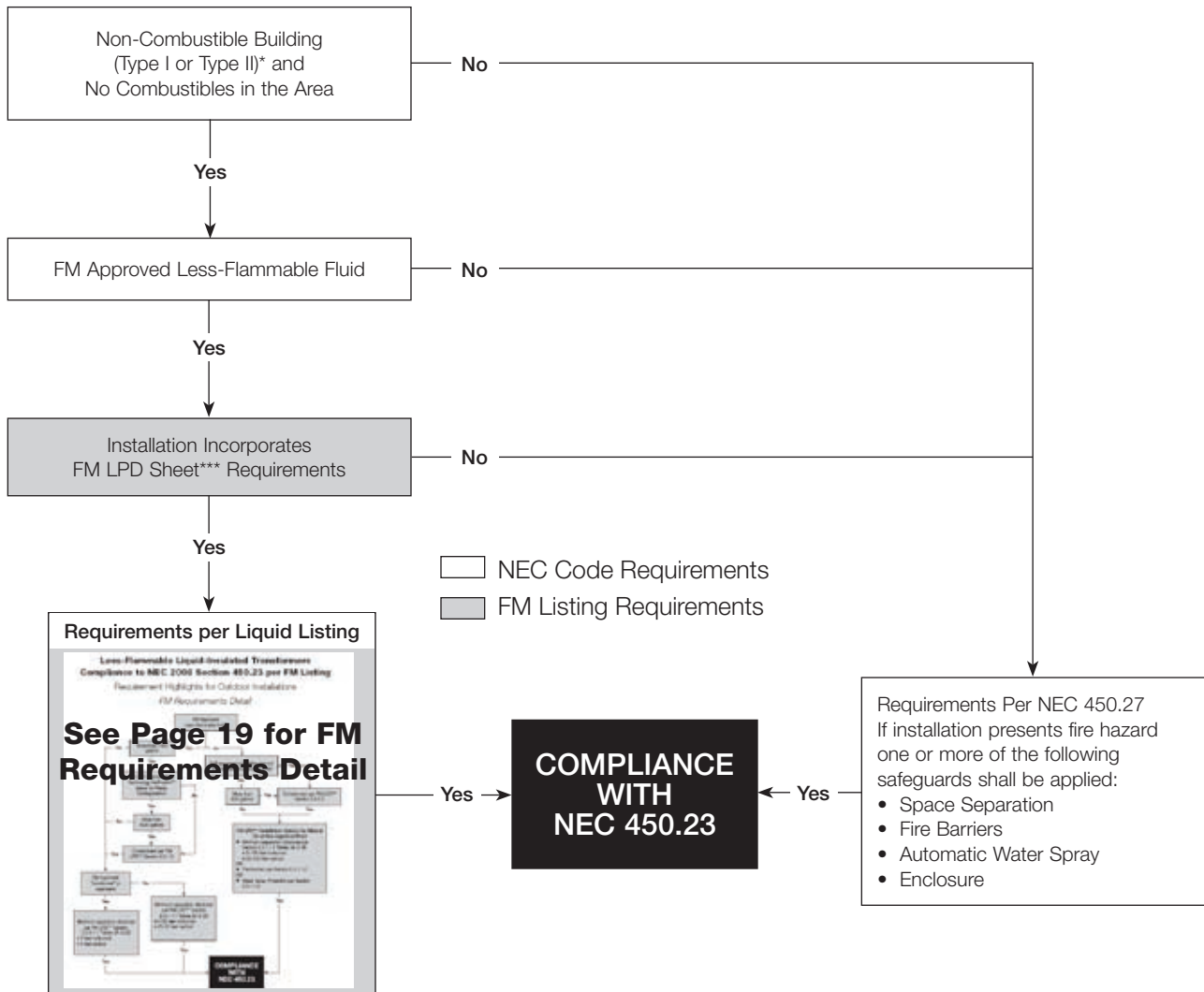
** Transformer Fluids (EOVK), Underwriters Laboratories Certifications Directory

NOTE: UL Classification Dielectric Mediums (EOUV) states that "Liquids intended for use as dielectric and cooling mediums in electrical transformers are covered under Transformer Fluids (EOVK).

Appendix 2

Less-Flammable Liquid-Insulated Transformers Compliance to NEC 2008 Section 450.23 per FM*** Listing

Requirement Highlights for Outdoor Installations



FM Approved Fluids: **

- Envirotemp FR3 Fluid (natural ester)
- ABB BIOTEMP® (natural ester), ETV status
- M&I Materials Ltd. MIDEL® 7131 (synthetic ester)
- Shell Diala® Oil HFX (fire resistant hydrocarbon)
- Dow Chemical L-305, Y-7582 (silicone)
- DSI Alpha-1™, Beta® (hydrocarbon)
- Dow Corning® 561 (silicone)

FM Approved Transformers: **

- Cooper Power Systems
- ABB
- Siemens
- Eaton Cutler-Hammer

* Refer to NFPA 220 for definition of non-combustible Type I and II building construction

** FM Global Approval Guide

*** FM Global Property Loss Prevention Data Sheets 5-4 — Transformers

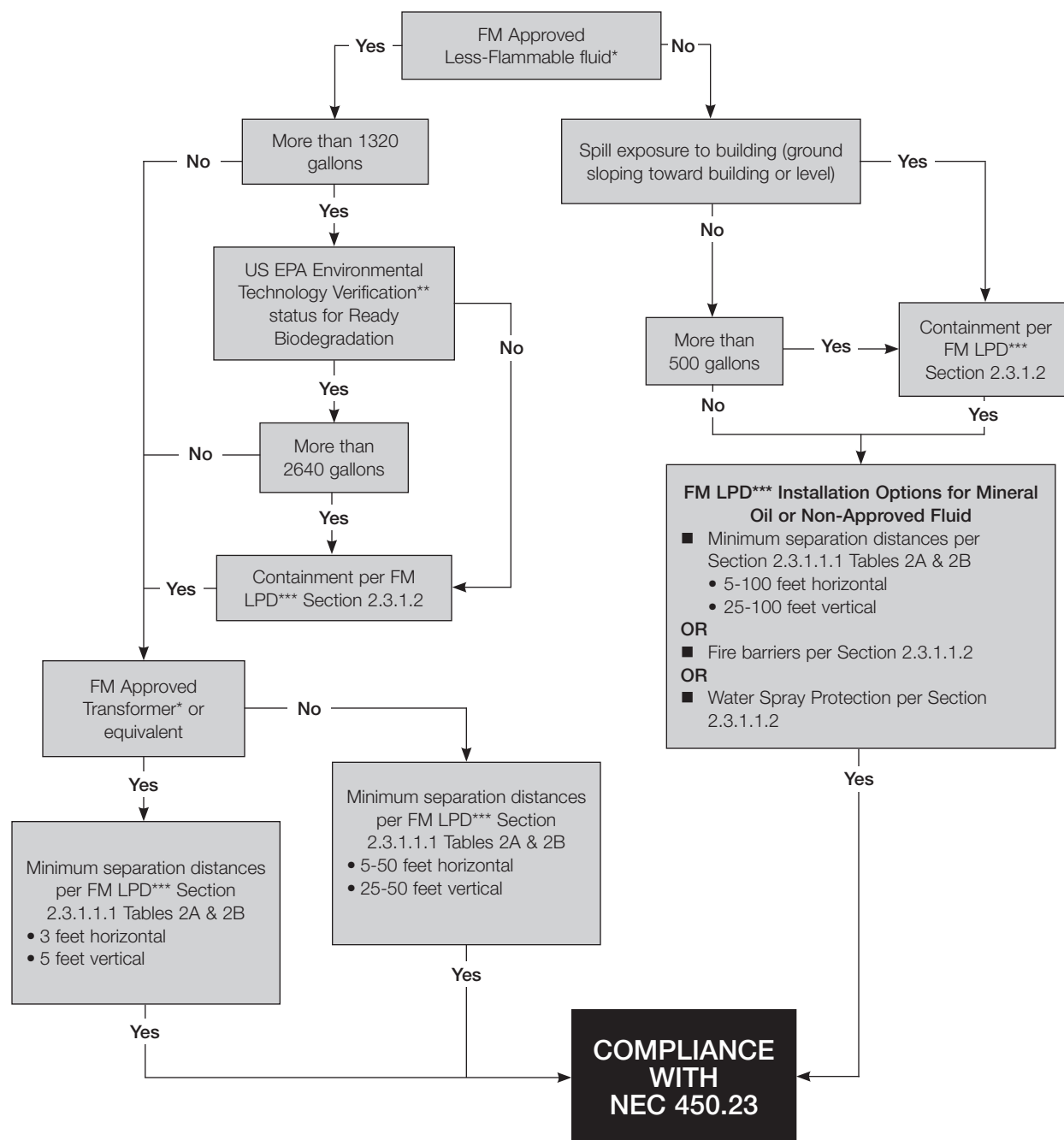
NOTE: NEC Section 110.3 (b) applies if the listing chosen for compliance specifically addresses outdoor application.

Appendix 3

Less-Flammable Liquid-Insulated Transformers Compliance to NEC 2008 Section 450.23 per FM Listing

Requirement Highlights for Outdoor Installations

FM Requirements Detail



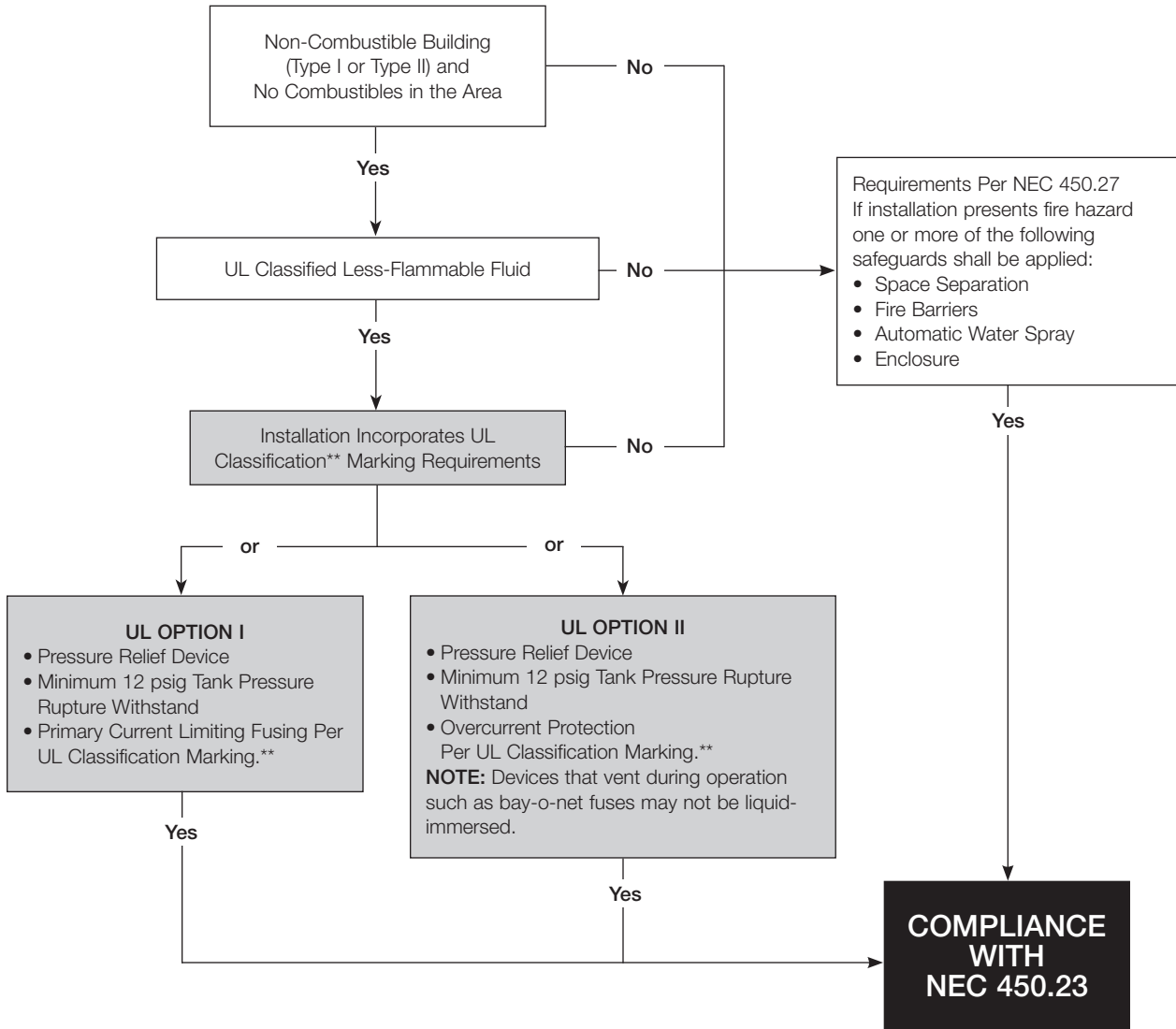
* FM Global Approval Guide

** Environmental Technology Verification Program, U.S. Environmental Protection Agency (Envirotemp FR3 fluid and BIOTEMP® fluid have ETV status for Ready Biodegradation)

*** FM Global Property Loss Prevention Data Sheets 5-4 — Transformers

Less-Flammable Liquid-Insulated Transformers Compliance to NEC 2008 Section 450.23 per UL Listing

Requirement Highlights for Outdoor Installations



- NEC Code Requirements
- UL Listing Requirements

UL Classified Transformer Fluids:*
 Envirotemp FR3 Fluid (natural ester), Option I or Option II
 Dow Corning® 561 (silicone), Option II only

* Refer to NFPA 220 for definition of non-combustible Type I and II building construction
 ** Transformer Fluids (EOVK), Underwriters Laboratories Certifications Directory

NOTES: UL Classification Dielectric Mediums (EOUV) states that "Liquids intended for use as dielectric and cooling mediums in electrical transformers are covered under Transformer Fluids (EOVK)."

Appendix 4

UL Classified Less-Flammable Fluids & UL Listed & Classified Transformers

Important Information to Assure Code Compliance Part A: Dielectric Coolants

Not all UL Classified dielectric coolants applied in transformers meet NEC Section 450.23 requirements.

Simply specifying that a transformer be filled with a UL Classified dielectric coolant is **not sufficient** to assure the transformer meets NEC Section 450.23 listing requirements.

UL has two classification categories for dielectric coolants:

- EOUV: Dielectric Mediums (See page 24 for EOUV.guideinfo)
- EOVK: Transformer Fluids (See page 26 for EOVK.guideinfo)

To assure compliance with NEC Section 450.23 listing requirements of UL, the dielectric coolant must be Classified as an EOVK Transformer Fluid as detailed in Part A2 of this appendix.

Part A1: UL Classification EOUV Dielectric Mediums

This category is a **fire hazard rating only**. All Classified Dielectric Mediums have the same fire hazard ratings, “Classed 4 to 5 less hazardous paraffin oil in respect to fire hazard”. Included in the EOUV Classification are requirements for minimum ignition temperature, fire point, and closed cup flash point. This Classification makes no reference to NEC 450.23, and does not classify the fluid as a “less-flammable liquid” in accordance with Section 450.23.

Table A1 - UL Classified EOUV Dielectric Mediums

| EOUV Dielectric Medium | Type |
|---|---------------|
| Cooper Power Systems Envirotemp FR3 | natural ester |
| ABB Power Technologies BIOTEMP® | natural ester |
| Momentive Performance Materials SF97-50 | silicone |
| Sopus Products Diala® HFX | HMWH |
| DSI Ventures Beta® | HMWH |
| Dow Corning® 561 | silicone |

This category covers liquids intended for use as dielectric and cooling mediums. Liquids intended for use as dielectric and cooling mediums in electrical transformers are covered under Transformer Fluids (EOVK).

Part A2: UL Classification EOVK Transformer Fluids

In addition to giving the requirements for minimum ignition temperature, fire point, and closed cup flash point, this category gives the **UL Use Restrictions** required for compliance with NEC 450.23 for the listed less flammable fluids.

Table A2 gives the fluids listed in the UL Directory having EOVK Classification.

Table A2 - UL Classified EOVK Transformer Fluids

| EOVK Transformer Fluids | Type |
|---|---------------|
| Cooper Power Systems Envirotemp FR3 fluid | natural ester |
| Dow Corning® 561 | silicone |

This category covers liquids intended for use as dielectric and cooling mediums in electrical transformers.

UL Classified Less-Flammable Fluids & UL Listed & Classified Transformers

Important Information to Assure Code Compliance Part B: UL Listed Transformers

Not all UL listed and classified transformers meet NEC Section 450.23 requirements.

Simply specifying that a transformer be UL Listed is not sufficient to assure the transformers meet NEC Section 450-23 listing requirements.

To assure UL Listed transformers meet NEC Section 450-23 requirements, the transformer must use an EOVK Transformer Fluid and meet its Use Restrictions (see Part A2).

Part B1: XPLH Transformers, Distribution, Liquid-filled Type, Over 600 Volts

UL transformer listing requirements, detailed in [UL GuideInfo XPLH](#), allow the use of mineral oil and other transformer coolants regardless of Classification status. These transformers are required to comply with various IEEE C57.12.00 standards listed in the [XPLH.GuideInfo](#) sheet. This guide states that transformers with the UL Listing mark are: “intended for installations with the requirements of NFPA 70, National Electrical Code”. Table B1 shows the manufacturers of UL Listed liquid-insulated transformers.

Table B1 - UL XPLH Listed Transformers

| XPLH Transformer Manufacturers |
|---|
| Cooper Power Systems |
| ABB Inc, South Boston VA |
| ABB Inc, Jefferson City MO |
| GE Co., Shreveport LA |
| Howard Industries Inc |
| Pacific Crest Transformers Inc |
| Pauwels Transformers Inc, Washington MO |
| Prolec GE, Monterrey MX |
| Square D, Nashville TN |
| Virginia Transformer Corp, Roanoke VA |

These transformers will display a single UL Listing Mark, the UL symbol, together with the word "LISTED," a control number, and the product name "Liquid-Filled Distribution Transformer" as in Figure B1.

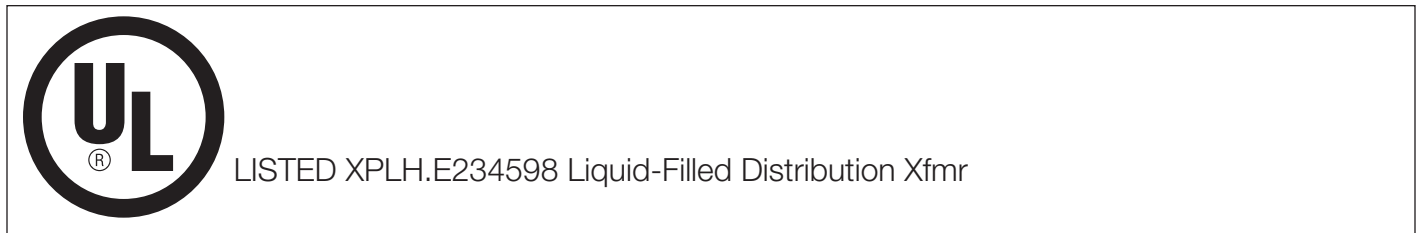


Figure B1 – Example transformer mark for a UL Listed ANSI-compliant transformer.

Appendix 5

UL Classified Less-Flammable Fluids & UL Listed & Classified Transformers

Important Information to Assure Code Compliance

Part A: Dielectric Coolants

Part B2: UL Listed and Classified Transformers for use as Less-Flammable Liquid-Insulated Transformer In Accordance With Sec. 450.23 of the NEC **

UL uses the same XPLH GuideInfo sheet noted above for transformers intended to meet the requirements of NEC section 450.23. However, the sub-header "USE AND INSTALLATION" adds the following requirements:

- Transformer must be provided with UL Classified "Less-Flammable Liquid, having a fire point of not less than 300°C"
- Transformer must be Marked to:
 - identify the product name and flammability rating of the liquid
 - indicate whether the liquid may evolve flammable gases when decomposed by an electric arc (as applicable)
 - list all the use restrictions provided for in the UL Classification of the liquid.

A UL Listed and Classified Transformer must display both a Listing mark and a Classification mark. See Figure B2.

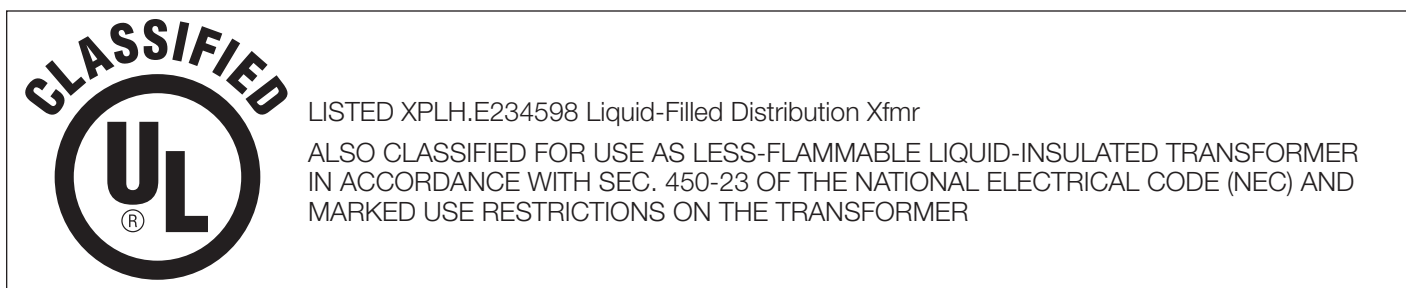


Figure B2
Example transformer mark for a UL Listed and Classified transformer filled with an UL EOVK Transformer Fluid and complying with its Use Requirements.

Cooper Power Systems Inc. manufactures UL listed and Classified Transformers for use as less-flammable liquid-insulated transformers in accordance with NEC Section 450.23. UL does not currently publish which transformer manufacturers offer the dual marking. Purchasers and users should confirm their UL Listed transformers also are UL Classified and the units have both respective UL logos for units that are intended for use in complying with NEC Section 450.23.

The transformer listing by UL should be referred to as an "UL Listed And Classified Transformer for Use as Less-Flammable Liquid-Insulated Transformer in Accordance with Sec. 450.23 Of The National Electric Code (NEC)".

** The source of the information of this section is the UL online certification Directory, XPHL.GuideInfo -Transformers, Distribution, Liquid-filled Type, Over 600 Volts on November 12, 2008. Copyright © Underwriters Laboratories Inc®.

UL Classified Less-Flammable Fluids & UL Listed & Classified Transformers

Important Information to Assure Code Compliance EOUV.GuidelInfo Dielectric Mediums **USE**

This category covers liquids intended for use as dielectric and cooling mediums. The liquids are not intended to replace mineral oil unless equipment is also designed for the specific liquid.

These products have been Classified as to their fire hazard only, using Underwriters Laboratories' method for Classification of the fire hazard of liquids. They have been rated on a numerical scale of hazard ranging from 0 to 100 as indicated in the table below:

| General Classification | Numerical Classification |
|------------------------|--------------------------|
| Diethyl ether | 100 |
| Gasoline | 90 to 100 |
| Ethyl alcohol | 60 to 70 |
| Kerosene | 30 to 40 ^a |
| Paraffin oil | 10 to 20 ^b |
| Water or nonflammable | 0 or nonflammable |

^a A standard kerosene of 100°F (37.8°C) flash point (closed cup) is rated 30 to 40.

^b A paraffin oil of 440°F (226.7°C) flash point (closed cup) is rated 10 to 20.

RELATED PRODUCTS

Liquids intended for use as dielectric and cooling mediums in electrical transformers are covered under Transformer Fluids (EOVK).

ADDITIONAL INFORMATION

For additional information, see Electrical Equipment for Use in Ordinary Locations (AALZ) and Flammable and Combustible Liquids and Gases Equipment (AAPQ).

REQUIREMENTS

The basic standard used to investigate products in this category is UL 340, "Tests for Comparative Flammability of Liquids."

UL MARK

The Classification Mark of Underwriters Laboratories Inc. on the product container is the only method provided by UL to identify products manufactured under its Classification and Follow-Up Service. The Classification Mark for these products includes the UL symbol, the word "CLASSIFIED" above the UL symbol (as illustrated in the Introduction of this Directory), and the following additional information:

[PRODUCT IDENTITY]
CLASSIFIED _____
AS TO FIRE HAZARD ONLY
Control No.

UL Classified Less-Flammable Fluids & UL Listed & Classified Transformers

Important Information to Assure Code Compliance

EOUV.GuidelInfo

Dielectric Mediums

USE

The Classification Mark may also include the following statement as appropriate:

MAY EVOLVE FLAMMABLE GASES WHEN DECOMPOSED BY AN ELECTRIC ARC

Last Updated on 2008-01-24."

Notice of Disclaimer

The appearance of a company's name or product in this database does not in itself assure that products so identified have been manufactured under UL's Follow-Up Service. Only those products bearing the UL Mark should be considered to be Listed and covered under UL's Follow-Up Service. Always look for the Mark on the product.

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id=1073986317&sequence=1](http://database.ul.com/cgi-bin/XYV/template/LISEXT/1FRAME/showpage.html?&name=EOUV.GuidelInfo&ccnshorttitle=Dielectric+Mediums&objid=1074233329&cfgid=1073741824&version=versionless&parent_id=1073986317&sequence=1)

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UL Classified Less-Flammable Fluids & UL Listed & Classified Transformers

Important Information to Assure Code Compliance EOUV.GuidelInfo Transformer Fluids (Dielectric Mediums) Transformer Fluids **USE**

This category covers liquids intended for use as dielectric and cooling mediums in electrical transformers.

These products have been Classified as to their fire hazard only, using Underwriters Laboratories' method for Classification of the fire hazard of liquids. They have been rated on a numerical scale of hazard ranging from 0 to 100 as indicated in the table below:

| General Classification | Numerical Classification |
|------------------------|--------------------------|
| Diethyl ether | 100 |
| Gasoline | 90 to 100 |
| Ethyl alcohol | 60 to 70 |
| Kerosene | 30 to 40 ^a |
| Paraffin oil | 10 to 20 ^b |
| Water or nonflammable | 0 or nonflammable |

a A standard kerosene of 100°F (37.8°C) flash point (closed cup) is rated 30 to 40.

b A paraffin oil of 440°F (226.7°C) flash point (closed cup) is rated 10 to 20.

USE RESTRICTIONS

Products Classified as "less-flammable liquid" may have use restrictions on the product container. Certain fluids have fuse use restrictions which require that the fuse must be either a type which does not vent under normal operation, or it must be installed external to the transformer tank.

ADDITIONAL INFORMATION

For additional information, see Dielectric Mediums (EOUV), Electrical Equipment for Use in Ordinary Locations (AALZ) and Flammable and Combustible Liquids and Gases Equipment (AAPQ).

REQUIREMENTS

The basic standard used to investigate products in this category is UL 340, "Tests for Comparative Flammability of Liquids."

These products are also Classified as a "less-flammable liquid" or "nonflammable fluid" in accordance with Sections 450.23 or 450.24 of ANSI/NFPA 70, "National Electrical Code."

UL MARK

The Classification Mark of Underwriters Laboratories Inc. on the product container is the only method provided by UL to identify products manufactured under its Classification and Follow-Up Service. The Classification Mark for these products includes the UL symbol, the word "CLASSIFIED" above the UL symbol (as illustrated in the Introduction of this Directory), and the following additional information:

[PRODUCT IDENTITY]
CLASSIFIED ____
AS TO FIRE HAZARD ONLY
Control No.

Appendix 5

UL Classified Less-Flammable Fluids & UL Listed & Classified Transformers

Important Information to Assure Code Compliance
EOUV.GuidelInfo
Transformer Fluids
(Dielectric Mediums) Transformer Fluids
USE

The Classification Mark may also include the following statement as appropriate:

**MAY EVOLVE FLAMMABLE GASES WHEN DECOMPOSED BY AN ELECTRIC ARC
ALSO CLASSIFIED AS A "LESS-FLAMMABLE LIQUID"
IN COMPLIANCE WITH THE NATIONAL ELECTRICAL CODE
WITH THE FOLLOWING "USE RESTRICTIONS"
ALSO CLASSIFIED AS A "NONFLAMMABLE FLUID"
IN COMPLIANCE WITH THE NATIONAL ELECTRICAL CODE
WITH THE FOLLOWING "USE RESTRICTIONS"**

Last Updated on 2008-01-2

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&ccnshorttitle=Transformer+Fluids&objid=1074233347&cfgid=1073741824&version=versionless&parent_
id=1073986320&sequence=1](http://database.ul.com/cgi-bin/XYV/template/LISEXT/1FRAME/showpage.html?name=EOVK.GuidelInfo&ccnshorttitle=Transformer+Fluids&objid=1074233347&cfgid=1073741824&version=versionless&parent_id=1073986320&sequence=1)
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