

2020 NEC requirement guidelines for the installation of listed less-flammable liquid-filled transformers

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General requirements

NEC (NFPA 70) recognition: These guidelines focus on the requirements of Section 450.23 of the 2020 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.

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 liquid 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 liquids like natural esters. Section 110.34 sets minimum clear work space dimensions around transformers.

Note:

The intention of this guide is focused on the NEC requirements for the installation of transformers. However, the user of the guide should be aware that not all transformer installations are under the jurisdiction to require compliance to NEC, such as the NESC, the National Electrical Safety Code. Transformer owned and operated by electric Utilities typically follow the NESC guidelines.

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 liquid 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.

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

Indoor installation options (Refer to appendices 1 and 4)

450.23 Less-flammable liquid-insulated transformers

Transformers insulated with listed less-flammable liquids that have a fire point of not less than 300°C shall be permitted to be installed in accordance with 450.23(A) or 450.23(B).

Table 1. NEC section 450.23 requirements – (A) indoor installation. Indoor installations shall be permitted in accordance with one of the following:

- (1) In Type I or Type II buildings*, in areas where all of the following requirements are met:
 - a. The transformer is rated 35,000 volts or less
 - b. No combustible materials are stored
 - c. A liquid confinement area is provided
 - d. The installation complies with all the restrictions provided for in the listing of the liquid
- Informational note: Such restrictions may include, but are not limited to: maximum pressure of the tank, use of a pressure relief valve, appropriate fuse types and proper sizing of overcurrent protection.
- (2) With an automatic fire extinguishing system and a liquid confinement area, provided the transformer is rated 35,000 volts or less
 - (3) In accordance with 450.26**

Type I and Type II building definition

Type I – Fire-resistive

This concrete and steel structure, called fire resistive when first built at the turn of the century, is supposed to confine a fire by its construction. This type of construction in which the building elements are of non-combustible materials, such as concrete and steel. The roof is also of non-combustible material, such as concrete or steel.

Type II – Non-combustible

This type of building has steel or concrete walls, floors, and structural framework similar to type I construction; however, the roof covering material is combustible. The roof covering of a type II building can be a layer of asphalt waterproofing, with a combustible felt paper covering. Another layer of asphalt may be mopped over the felt paper.

NFPA 450.26 information

450.26 Oil-insulated transformers installed indoors.

Oil insulated transformers installed indoors shall be installed in a vault constructed as specified in Part III of this article.

Exception No. 1: Where the total capacity does not exceed 112½ kVA, the vault specified in Part III of this article shall be permitted to be constructed of reinforced concrete that is less than 100 mm (4 in.) thick.

Exception No. 2: Where the nominal voltage does not exceed 1000 volts, a vault shall not be required if suitable arrangements are made to prevent a transformer oil fire from igniting other materials and the total capacity in one location does not exceed 10 kVA in a section of the building classified as combustible or 75 kVA where the surrounding structure is classified as fire-resistant construction.

Exception No. 3: Electric furnace transformers that have a total rating not exceeding 75 kVA shall be permitted to be installed without a vault in a building or room of fire-resistant construction, provided suitable arrangements are made to prevent a transformer oil fire from spreading to other combustible material.

Exception No. 4: A transformer that has a total rating not exceeding 75 kVA and a supply voltage of 1000 volts or less that is an integral part of charged-particle-accelerating equipment shall be permitted to be installed without a vault in a building or room of non-combustible or fire-resistant construction, providing suitable arrangements are made to prevent a transformer oil fire from spreading to other combustible material.

Exception No. 5: Transformers shall be permitted to be installed in a detached building that does not comply with Part III of this article if neither the building nor its content present a fire hazard to any other building or property, and if the building is used only in supplying electric service and the interior is accessible only to qualified persons.

Exception No. 6: Oil insulated transformers shall be permitted to be used without a vault in portable or mobile surface mining equipment (such as electric excavator) if each of the following conditions are met:

- Provisions are made for draining leaking fluid to the ground
- Safe egress is provided for personnel
- A minimum of 6 mm (1/4 in) steel barrier is provided for personnel protection

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

** No additional NEC article 450.23 safeguards are required if one or more of exceptions 1 - 6 of Section 450.26, Oil-Insulated Transformers Installed Indoors apply.

Example – Option (A)(1), indoor installation rated ≤ 35 kV

Without a vault in Type I or II building*, non-combustible materials with liquid containment pan.



*Refer to NFPA 220 for more information about Type I and Type II building construction.

Outdoor installation options (Refer to appendices 2 and 5)

Outdoor installations using less-flammable liquid-insulated transformers must comply with NEC section 450.23, which defines the requirements for the two installations options as detailed in Table 2:

Table 2. NEC Section 450.23 requirements – Less-flammable liquid filled transformers shall be permitted to be installed outdoors, attached to, adjacent to, or on the roof of building, where installed according with (1) or (2).

1. For Type I or Type II buildings*, the installation shall comply with all the restrictions provided for in the listing of the liquid.

Informational note No. 1: Installations adjacent to combustible material, fire escapes or door and window openings may require additional safeguards such as those listed in 450.27.

Informational note No. 2: Such restrictions may include, but are not limited to: maximum pressure of the tank, use of a pressure relief valve, appropriate fuse types and proper sizing of overcurrent protection.

or

2. In accordance with 450.27

Informational note No. 1: As used in this section, Type I and Type II buildings refers to Type I and Type II building construction as defined in NFPA 220-2018, Standard on types of building construction. Combustible materials refers to those materials not classified as non-combustible or limited-combustible as defined in NFPA 220-2018, *Standard on types of building construction*.

Informational note No. 2: See definition of Listed in Article 100.

450.27 Oil-insulated transformers installed outdoors

Combustible material, combustible buildings and parts of buildings, fire escapes, and door and window openings shall be safeguarded from fires originating in oil-insulated transformers installed on roofs, attached to or adjacent to a building or combustible material.

In case where the transformer installation presents a fire hazard, one or more of the following safeguards shall be applied according to the degree of hazard involved:

- Space separation
- Fire resistant barriers
- Automatic fire suppression systems
- Enclosures that confine the oil of a rupture transformer tank

Oil enclosures shall be permitted to consist of fire-resistant dikes, curbed areas or basins, or trenches filled with coarse, crushed stone. Oil enclosures shall be provided with trapped drains where the exposure and the quantity of oil involved are such that removal of oil is important.

Informational note: For additional information on transformers installed on poles or structures or underground, see ANSI/IEEE C2-2017, National Electrical Safety Code.

*Refer to NFPA 220 for more information about Type I and Type II building construction.

As in 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 liquid instead of conventional mineral oil. Transformers installed according to the listing requirements of less-flammable liquids will provide an even greater margin of safety.

Outdoor installations using conventional mineral oil, per IEEE 979

Spatial separation of outdoor mineral-oil-insulated equipment

Electrical equipment installed outdoors and containing mineral oil should be separated from other equipment, buildings, and the adjacent property line to minimize the impact of a major fire. Spatial separation is an effective method for reducing fire spread or damage from mineral-oil-filled equipment fires.

There are two methods for determining acceptable minimum separation distances. Prescriptive guidelines are presented in 7.2 followed by a performance-based alternative discussed in 7.3. The prescriptive method is most commonly used, but this method may not provide adequate protection for all site conditions. The performance-based method indicates a level of protection that more accurately models the specific site conditions.

Per Section 1.3 General: The predominant dielectric insulating fluid for transformers is mineral oil, and mineral oil constitutes one of the primary fire hazards in the substation. Consequently, much of this guide addresses hazards and protection measures based on mineral oil fires. There are several alternative fluids with improved fire safety properties (higher flash and fire points), known as "less-flammable" dielectric fluids, which have been introduced. Many of these fluids have been recognized as reducing the hazard and the risk of a fire occurring relative to mineral oil. Use of a "less flammable" fluid is one means to reduce the risk of fire at a substation. See 8.4.2 and A.21 for additional information on these fluids.

* Refer to NFPA 220 for definition of non-combustible or limited 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.

Example of outdoors on or adjacent to Type I and Type II buildings non-combustible building* and no combustible material stored in the area



NEC options for transformer listing **

Indoor installation

At the time of the publication of this guide, two nationally recognized testing entities list less-flammable insulating liquids and publish their respective listing requirements:

A. Underwriters Laboratories classifications

B. FM Global approvals

It is optional which of the listings are used to comply with 450.23.

For indoor installations, if the transformers are provided with less-flammable liquid insulation and are installed without a vault in a Type I or Type II non-combustible building* where no combustible material is storage, it requires:

- 1) A liquid confinement area be provided.

Liquid containment may include:

- Containment pan
- Curbing
- Room containment (e.g. door sill)

- 2) The transformer be filled with a listed less-flammable insulating liquid with a minimum of 300°C fire point.

- 3) The installation complies with all restrictions provided for in the listing of the liquid.

or

A liquid confinement area, as indicated above and an automatic fire extinguishing system.

If the transformer has a **non-listed** insulating liquid, provide individual containment for the content of the transformer to prevent spills from flowing to another transformers or important equipment in the room.

or

It must be installed in a vault complying with the 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 are listed.

Points in Section 450.26 are also valid for less-flammable liquid-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 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 more information about Type I and Type II building construction.

**No additional NEC article 450.23 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 with respect to fire hazard.

Flash point (closed cup) 255°C (491°F). 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":

- For use only in 3-phase transformers having tanks capable of withstanding an internal pressure of 12 psig without rupture.
- 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
- 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
- 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 3-phase transformer rating kVA	Required protection Required current limiting fusing (+) maximum I ² t (A ² s)	Or Required overcurrent protection (+) maximum I ² t (A ² s)	Required prc 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

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Fire protection for indoor transformers (FM Global requirement)

If transformers are to be located indoors, provide a detached dedicated building or room with location and construction safeguards as described in Fig. 1 and Table 4 (reference to Fig. 2a and Table 4 of FM DS 5-4). If transformers are to be located within cut-off rooms for exposure protection, ensure the cooling characteristics of the transformer are not compromised. This applies to dry or liquid filled insulated transformers.

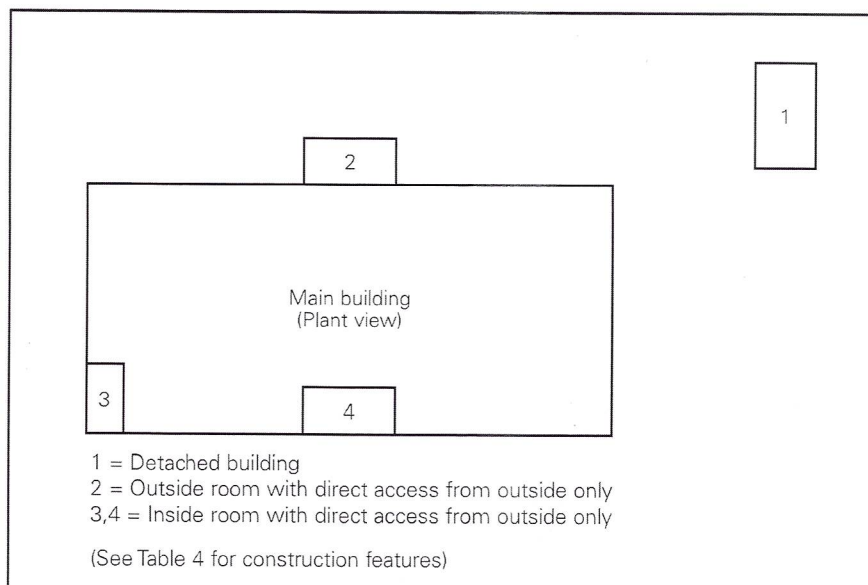


Fig 1. Locations from transformer buildings and rooms*

Table 4. Recommended construction for transformer buildings and rooms**

Transformer type	Fluid type	Fluid volume in largest transformer	Room or building fire rating ^a	Fire protection for transformer liquids ^a
Dry or gas insulated ^b	Not applicable	Not applicable	Non combustible	None ^c
FM Approved or equivalent ^d	FM Approved liquid	Any ^e	Non combustible	None ^c
Non-approved transformers	FM Approved liquids	Any ^e	One-hour fire-rated	None ^c
			Non combustible	Per section 2.2.3 ^f
	Non Approved liquids	Less than 100 gal (380 L) ^e	One-hour fire-rated	None ^c
			More than 100 gal (380 L) ^e	Three-hour fire-rated with subdivisions if multiple transformers ^f
		More than 100 gal (380 L) ^e	Three-hour fire-rated with multiple transformers and no subdivision	Per section 2.2.3 ^f
			One-hour fire-rated with single transformer	Per section 2.2.3 ^f

^a Transformers in location 1 may also be treated as outdoor transformers in accordance with Section 2.3

^b With no oil-filled bushings, oil-filled tap changer or other oil-filled accessories that could increase the fire hazard

^c See also Section 2.2.3.4 for protection of combustibles other than transformer liquids

^d Section 3.3 describes FM approved and equivalent transformers

^e Provide liquid spill containment in accordance with section 2.2.1.4

^f Automatic sprinklers, foam-water sprinklers or water mist. Also provide emergency drainage for sprinklers discharge per Section 2.2.1.5

^g Subdivide room or building with three-hour fire-rated construction for each transformer if multiple transformers are present

* Fig. 1 is based on the information provided on Fig. 2 of the FM document DS 5-4 dated 07-2019.

** Table 4 is based on the information provided on Table 4 of the FM document DS 5-4 dated 07-2019.

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 dated 1-2018, 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 3.2.3 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 liquid* to reduce the probability of ignition of the liquid. Less-flammable liquids, 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 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 3.2.5 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 liquids, 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), Indoor units greater than 500 kVA should be provided with alarm contacts on the pressure relief device and units greater than 2500 kVA, in all locations 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 5: 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
Over 10000 KVA (3333 1Ø)	12600

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

Table 6. 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) and over	3,000,000	14,000,000

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

**NEC options for transformer listing –
outdoor installations**

The NEC allows two different options for the listing of the installed liquid transformers:

(A) Underwriters Laboratories**(B) FM Global**

For outdoor installations, the FM approval indicates that the Spill containment requirements for environmental protection and related regulations are outside the scope of the DS 5-4. Some considerations can still be provided.

1. If an accidental release of transformer fluid could expose a main building or adjacent equipment or storage, provide the liquid filled transformer with a spill containment
2. Design the spill containment system in accordance with Chapter 7 of IEEE STD 980.

or

It must be installed in accordance with NEC section 450.27, oil insulated transformers installed outdoors, i.e. space separation, fire barriers or water spray systems

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 describe in Section 450.27. Fine Print Notes (FNP) 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 or limited-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 liquids must comply with FM LPD requirements for containment and separation distances. The FM LPD provides detailed requirements for fire barriers in Section 2.3.1.1.1 and water spray exposure protection in Section 2.3.2.1.

Fluid containment requirements as detailed in Section 2.3.1.4 of the FM LPD are:

- Provide a liquid containment when accidental release of fluid could expose the main building, adjacent equipment or storage
- Design the containment per IEEE 980
- Where water spray is provided, install additional containment or direct discharge water, this per DS 7-83
- Provide system for removal of rainwater from the containment area
- Extend containment perimeter at least 5 ft for transformers with up to 1000 gal and 8 ft for transformers with more than 1000 gal

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 liquid as well as the non-approved FM transformer, the horizontal distance is measured from closest inside edge of the spill containment barrier area and the two-hour fire barrier.

Per approval standard 3990 dated 1-2018, the transformer must be located 5 ft (1.5 m) from doors, fire escapes and windows

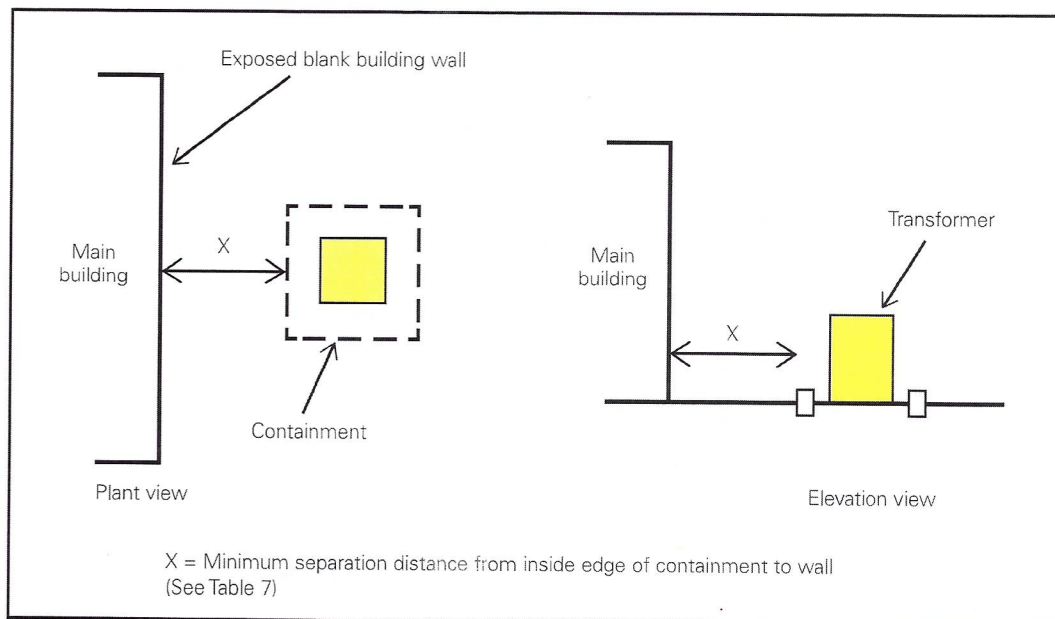


Fig 2. Minimum horizontal separation distance between outdoor liquid-insulated transformer and exposed walls of main building*

Table 7. Separation for exposure protection of main building walls (see Fig. 2) **

Fluid or transformer type	Fluid volume, gal (m ³)	Minimum horizontal distance from containment to expose building wall (dimension X in Fig. 2)		
		Two-hour fire-rated wall ft (m)	Non-combustible wall ¹ ft (m)	Combustible wall ¹ ft (m)
FM Approved transformer or equivalent	Per approval listing	3 (0.9)	3 (0.9)	3 (0.9)
FM Approved liquid in non-approved transformer	< 10,000 (38)	5 (1.5)	5 (1.5)	25 (7.6)
	>10,000 (38)	15 (4.6)	15 (4.6)	50 (15.2)
Non-approved transformer liquid	<500 (1.9)	5 (1.5)	15 (4.6)	25 (7.6)
	<5000 (19)	15 (4.6)	25 (7.6)	50 (15.2)
	>5000 (19)	25 (7.6)	50 (15.2)	100 (30.5)

¹ For definition of combustible and non-combustible construction material, see Appendix A of DS 1-1. Fire safe building construction and materials

* Figure 2 is based on the information provided on Fig. 3 of the FM document DS 5-4 dated 07-2019.

** Table 7 is based on the information provided on Table 5 of the FM document DS 5-4 dated 07-2019.

Listing option - B

FM Global requirements (continued)

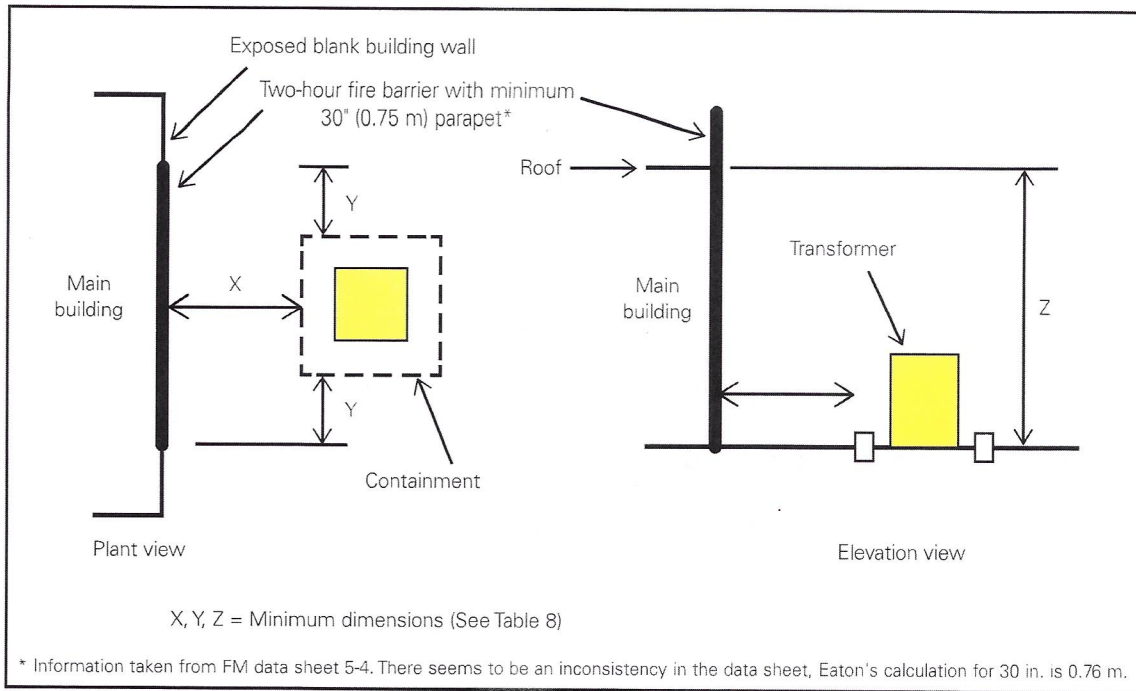


Fig 3. Use of two-hour fire barriers and separation distances for protection of exposed main building walls*

Table 8. Separation and extent of two-hour fire barrier for protection of main building walls (for dimensions refer to Fig. 3)**

Fluid type	Fluid volume, gal (m ³)	Separation and extent of two-hour fire barrier		
		Dimensions ^{1,2} (See Fig. 3)	Non-combustible wall ³ ft (m)	Combustible wall ³ ft (m)
FM Approved transformer fluid	< 10,000 (38)	X	5 (1.5)	5 (1.5)
		Y	5 (1.5)	25 (7.6)
		Z	25 (7.6)	25 (7.6)
	>10,000 (38)	X	15 (4.6)	15 (4.6)
		Y	15 (4.6)	50 (15.2)
		Z	50 (15.2)	50 (15.2)
Non-approved transformer liquid	<500 (1.9)	X	5 (1.5)	5 (1.5)
		Y	15 (4.6)	25 (7.6)
		Z	25 (7.6)	25 (7.6)
	≤5000 (19)	X	15 (4.6)	15 (4.6)
		Y	25 (7.6)	50 (15.2)
		Z	50 (15.2)	50 (15.2)
>5000 (19)	X	25 (7.6)	25 (7.6)	
	Y	50 (15.2)	100 (30.5)	
	Z	100 (30.5)	100 (30.5)	

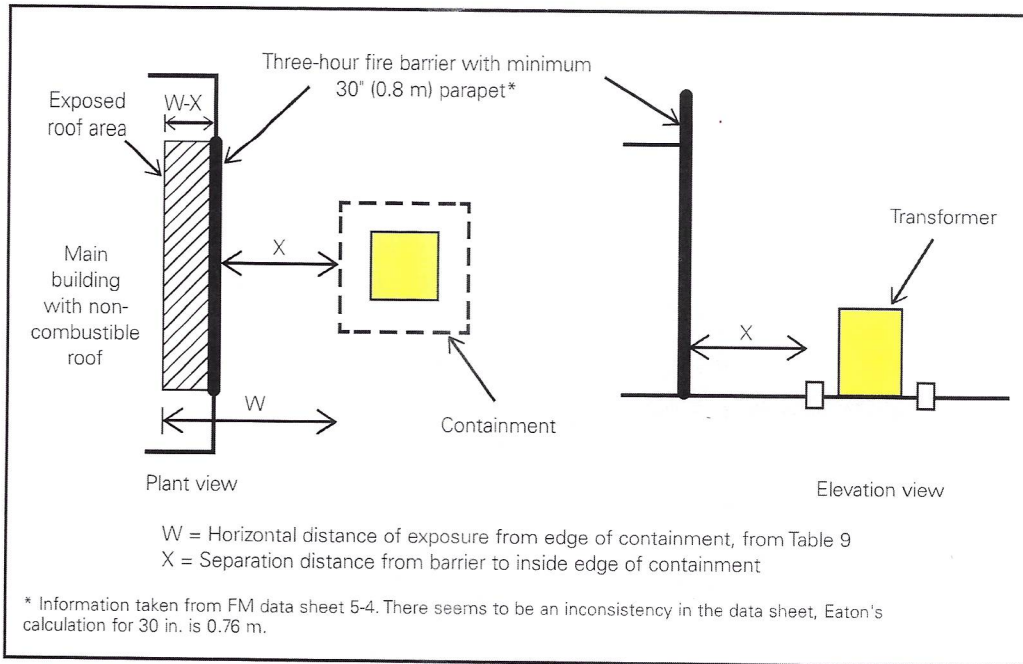
¹ The X distances refer to minimum separation between the closest inside edge of the spill containment area and the two-hour fire barrier. These are the same as Table 5 (of DS 5-4) for two-hour fire-rated walls. Dimension Y is the horizontal extent of the barrier starting from the respective edge of containment.

² Barrier vertical extent is dimension Z in the table of the building height plus 30 in. (0.75 m) parapet, whichever is less.

³ For definitions of combustible and non-combustible construction material, see Appendix A of DS 1-1. *Fire building construction and materials*

* Figure 3 is based on the information provided on Fig. 4 of the FM document DS 5-4 dated 07-2019.

** Table 8 is based on the information provided on Table 6 of the FM document DS 5-4 dated 07-2019.

Listing option - B**FM Global requirements (continued)****Fig 4. Determination of exposed roof area*****Table 9. Transformer fire exposure to non-combustible building roof where separation from wall is based on three-hour fire barrier or water spray protection****

Liquid type	Maximum liquid volume gal (m ³)	Building height ft (m)	W (see Fig. 4) ft (m)
Non-approved transformer fluid	<1000 (3.8)	Any	Not exposed
	Any	≥50 (15)	Not exposed
	1000 – 5000 (3.8 – 19)	≥25 (7.5)	Not exposed
	1000 – 5000 (3.8 – 19)	<25 (7.5)	15 (4.5)
	>5000 (19)	<50 (15)	25 (7.5)

Table 10. Minimum separation distance between adjacent transformers ***

Liquid type	FM Approved transformer or equivalent	Liquid volume gal (m ³)	Distance ft (m)
FM Approved transformer fluid	Yes	N/A	3 (0.9)
	No	≤10000 (38)	5 (1.5)
	No	>10000 (38)	25 (7.6)
Non-approved transformer fluid	N/A	<500 (1.9)	5 (1.5)
	N/A	≤5000 (19)	25 (7.6)
	N/A	>5000 (19)	50 (15.2)

Note: If the separation distance between transformers on Table 10 are not met and barriers are not provided, install water spray protection on each transformer per Section 2.3.2 of the FMDS0504 dated 07-2019.

* Figure 4 is based on the information provided on Fig. 5 of the FM document DS 5-4 dated 07-2019.

** Table 9 is based on the information provided on Table 7 of the FM document DS 5-4 dated 07-2019.

*** Table 10 is based on the information provided on Table 8 of the FM document DS 5-4 dated 07-2019.

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 liquid-filled transformers significantly reduce the possibility that the installation presents a fire hazard compared to conventional mineral oil.

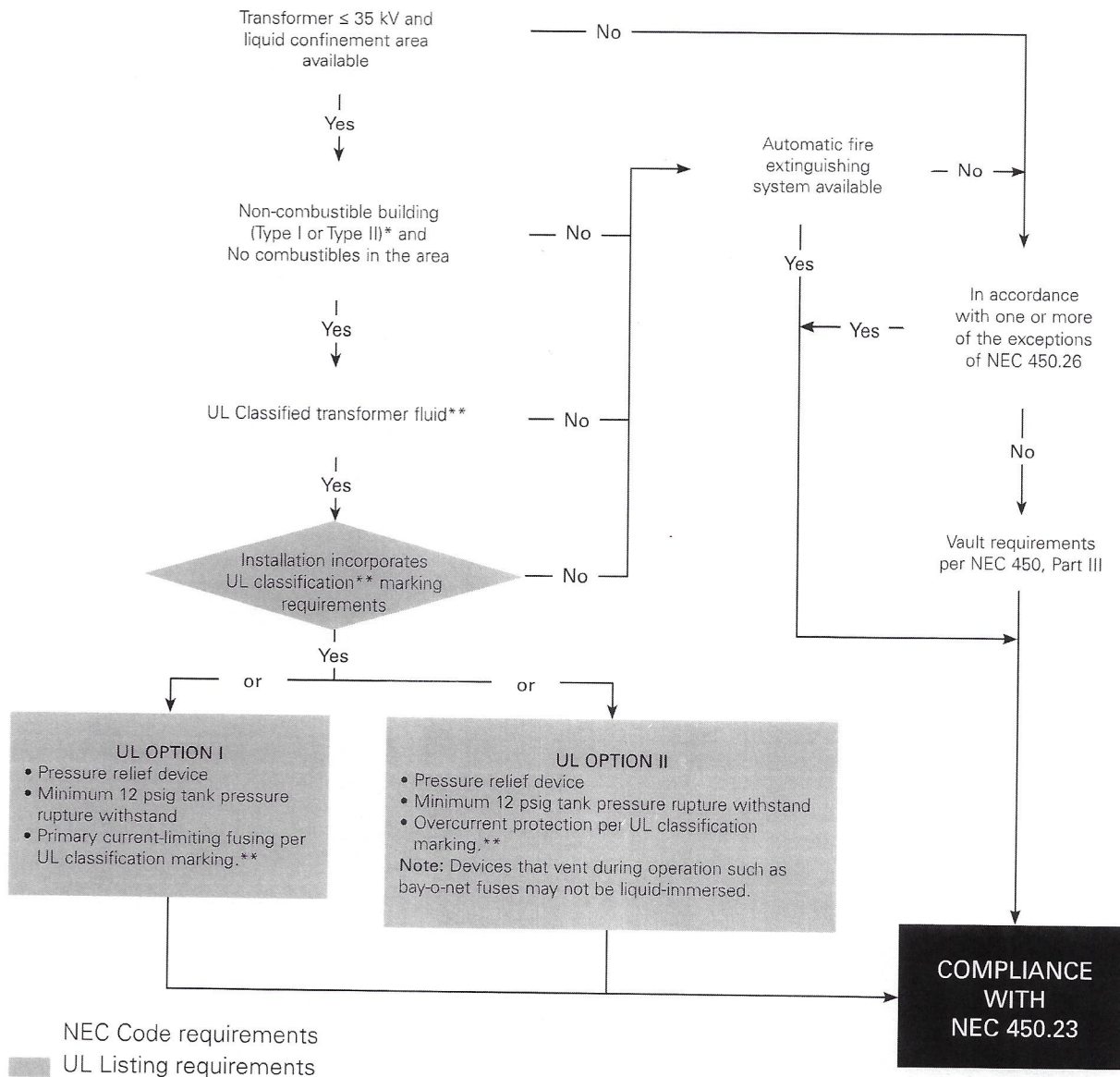


*Refer to NFPA 220 for definition of non-combustible or limited-combustible Type I and II building construction.

Appendix 1 - Indoor installations per UL Listing requirements

Less-flammable liquid-insulated transformers compliance to NEC Section 450.23 per UL Listing

Requirement highlights



UL Classified transformer fluids:**

Cargill Envirottemp 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

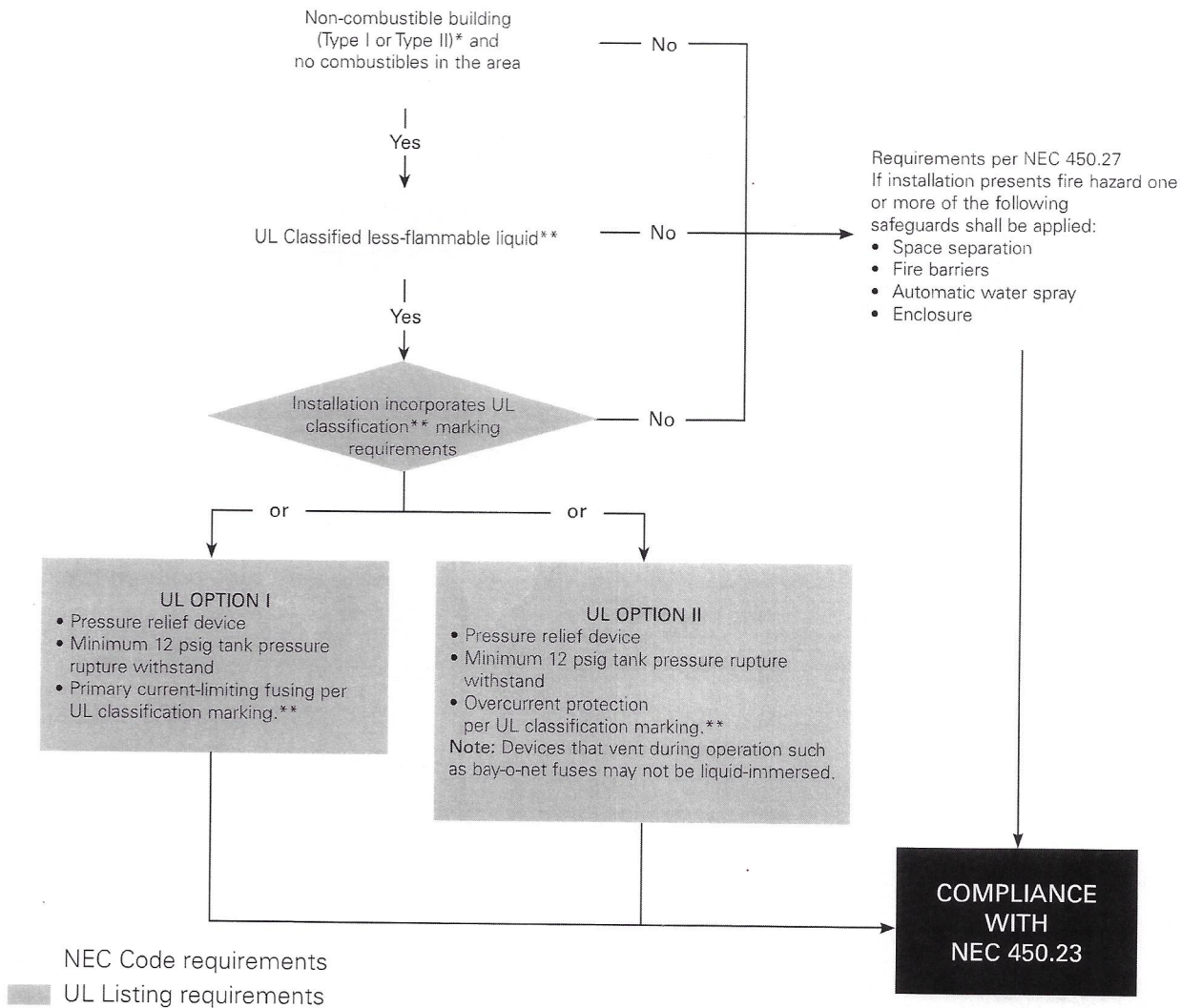
Note: UL classification dielectric mediums (EOUV) states that "Liquids intended for use as dielectric and cooling mediums in electrical transformers are covered under transformer fluids (EOVK)."

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Appendix 2 - Outdoor installations per UL Listing requirements

Less-flammable liquid-insulated transformers compliance to NEC Section 450.23 per UL Listing

Requirement highlights



UL Classified transformer fluids:*

Cargill Envirottemp 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 3

UL Classified less-flammable liquids and UL Listed & Classified transformers

Important information to assure code compliance Part A: Dielectric liquids

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

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

UL has two classification categories for dielectric liquids:

- EOUV: Dielectric mediums
- EOVK: Transformer fluids

To assure compliance with NEC Section 450.23 listing requirements of UL, the dielectric liquid 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
Cargill Incorporated Envirotemp FR3	Natural ester
Momentive Performance Materials SF97-50	Silicone
Sopus Products Diala™ HFX	HMWH
DSI Ventures Beta™	HMWH
Dielectricos Vegetales SAS	Natural ester
Dong Nam Petroleum Ind. Co Ltd	Natural ester
Dow Silicone Co Ltd	Silicone
Dow Silicone Corp	Silicone
M&I Materials Ltd	Synthetic ester
Prolec GE International SRL de CV	Natural ester
Yi Chiu Chemical & Technical Co Ltd	Insulating oil
Zeus Oil & Chemical Co. Ltd	Paraffin oil
Guang Dong Jooyin New Material Technology Co. LTD	Natural ester

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
Cargill Incorporated Envirotemp FR3 fluid	Natural ester
Dow Silicone Corp	Silicone
Dong Nam Petroleum Ind Co. Ltd	Natural ester

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

[†] This list includes all the insulating liquid manufacturers listed by UL and FM Global as of the date of this publication. Refer to UL and FM Global for the latest lists. Reprinted from the Online Certifications Directory with permission from UL © 2018 UL LLC.

Appendix 3 (continued)

UL Classified less-flammable liquids and 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 or EOUV dielectric medium 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
EATON Cooper Power series
ABB Inc, South Boston VA
ABB Inc, Jefferson City MO
GE Co., Shreveport LA
Howard Industries Inc, Laurel, MS
Prolec GE, Monterrey MX
Virginia Transformer Corp, Roanoke VA
ERMCO, Dyersburg, TN
Maddox Industrial Transformer LLC, Mauldin, SC
Niagara Transformer Corp., Buffalo, NY
Schneider Electric USA, Nashville, TN
Siemens Energy INC, Richland, MS
Solomon Corporation, Solomon, KS
Southwest Electric, Oklahoma City, OK
Sunbelt Transformer INC, Temple, TX
Vantran Industries INC, Waco, TX
HC Transformer and Switchgear, Torrance, CA
WEG Transformers USA, Washington, MO

Note: This is a partial list of the XPLH listed transformers.

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.

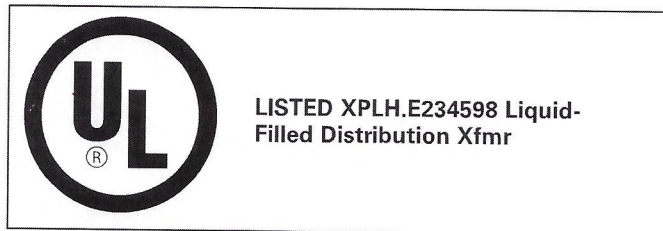


Figure B1 – Example transformer mark for a UL Listed ANSI-compliant transformer.

[‡] This list includes all the insulating liquid manufacturers listed by UL and FM Global as of the date of this publication. Refer to UL and FM Global for the latest lists. Reprinted from the Online Certifications Directory with permission from UL © 2018 UL LLC.

Appendix 3 (continued)

UL Classified less-flammable liquids and 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 Fig. B2.

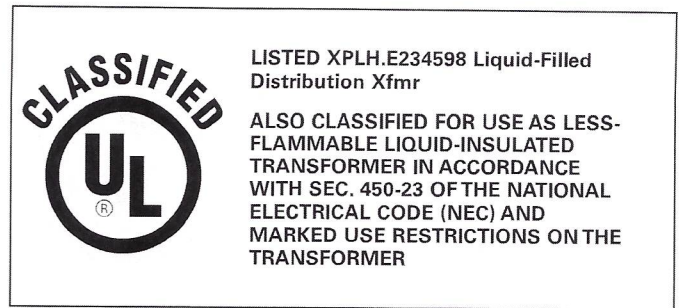


Figure B2. Example transformer mark for a UL Listed and Classified transformer filled with an UL EOVK transformer fluid and complying with its use requirements.

Eaton manufacturers 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 a "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)";

Appendix 3 (continued)

UL Classified less-flammable liquids and UL Listed & Classified transformers

Important information to assure code compliance EOUV GuideInfo: 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 certified 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
Between gasoline and ethyl alcohol	80 to 90
Between ethyl alcohol and gasoline	70 to 80
Ethyl alcohol	60 to 70
Between ethyl alcohol and kerosene	50 to 60
Between kerosene and ethyl alcohol	40 to 50
Kerosene	30 to 40
Between kerosene and paraffin oil	20 to 30
Paraffin oil	10 to 20
Less hazardous than paraffin oil	0 to 10
Water or nonflammable	0 or nonflammable

Note: Dielectric media/transformer fluids including mineral oil, natural and synthetic esters, silicone oil and refined petroleum oil exhibiting flammability temperature limits > 464°F (240°C) may be assigned a numerical fire hazard rating of "4-5 Less hazardous than paraffin oil."

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 ANSI/UL 340 "Tests for Comparative Flammability of Liquids."

UL mark

The certification 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 certification mark for these products includes the UL symbol, the word "CERTIFIED" and "SAFETY"; the geographical identifier(s) and the file number.

Additional certification markings

Products covered under this category are additionally marked with the following information:

AS TO FIRE HAZARD ONLY

These products may also be marked with the following statement:

MAY EVOLVE FLAMMABLE GASES WHEN DECOMPOSED BY AN ELECTRIC ARC

Alternate UL mark

The classification mark of UL 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 3 (continued)

UL Classified less-flammable liquids and UL Listed & Classified transformers

Important information to assure code compliance EOUV GuideInfo: Dielectric mediums use

The classification mark may also include the following statement as appropriate:

MAY EVOLVE FLAMMABLE GASES WHEN DECOMPOSED BY AN ELECTRIC ARC

UL, in performing its function in accordance with its objectives, does not assume or undertake to discharge any responsibility of the manufacturer or any other party. UL shall not incur any obligation or liability for any loss, expense or damages, including incidental or consequential damages, arising out of or in connection with the use, interpretation of, or reliance upon this guide information.

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 certified and covered under UL's follow-up service. Always look for the mark on the product.

Appendix 3 (continued)

UL Classified less-flammable liquids and UL Listed & Classified transformers

Important information to assure code compliance EOVK GuideInfo: Transformer fluids (dielectric mediums) use

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

These products have been certified 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
Between gasoline and ethyl alcohol	80 to 90
Between ethyl alcohol and gasoline	70 to 80
Ethyl alcohol	60 to 70
Between ethyl alcohol and kerosene	50 to 60
Between kerosene and ethyl alcohol	40 to 50
Kerosene	30 to 40
Between kerosene and paraffin oil	20 to 30
Paraffin oil	10 to 20
Less hazardous than paraffin oil	0 to 10
Water or nonflammable	0 or nonflammable

Note: Dielectric media/transformer fluids including mineral oil, natural and synthetic esters, silicone oil and refined petroleum oil exhibiting flammability temperature limits > 464°F (240°C) may be assigned a numerical fire hazard rating of "4-5 less hazardous than paraffin oil."

Related products

Liquids intended for use as dielectric and cooling mediums are covered under dielectric mediums (EOUV).

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 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 ANSI/UL 340 "Tests for Comparative Flammability of Liquids."

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

UL mark

The certification mark of Underwriters Laboratories Inc. on the product container is the only method provided by UL to identify products manufactured under its certification and follow-up service. The certification mark for these products includes the UL symbol, the word "CERTIFIED" and "SAFETY"; the geographical identifier(s) and a file number.

Additional certification markings

Products covered under this category are additionally marked with the following information:

AS TO FIRE HAZARD ONLY

These products may also be marked with one or more of the following statements:

MAY EVOLVE FLAMMABLE GASES WHEN DECOMPOSED BY AN ELECTRIC ARC

ALSO CERTIFIED AS A "LESS-FLAMMABLE LIQUID" IN COMPLIANCE WITH THE NATIONAL ELECTRICAL CODE WITH "USE RESTRICTIONS"

ALSO CERTIFIED AS A "NONFLAMMABLE LIQUID" IN COMPLIANCE WITH THE NATIONAL ELECTRICAL CODE WITH "USE RESTRICTIONS"

Alternate UL mark

The classification mark of UL 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 3 (continued)

UL Classified less-flammable liquids and UL Listed & Classified transformers

Important information to assure code compliance EOVK GuideInfo: Transformer fluids (dielectric mediums) 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 liquid”

In compliance with the national electrical code

With the following “use restrictions”

UL, in performing its functions in accordance with its objectives, does not assume or undertake to discharge any responsibility of the manufacturer or any other party. UL shall not incur any obligation or liability for any loss, expense or damages, including incidental or consequential damages, arising out of or in connection with the use, interpretation of, or reliance upon this guide Information.

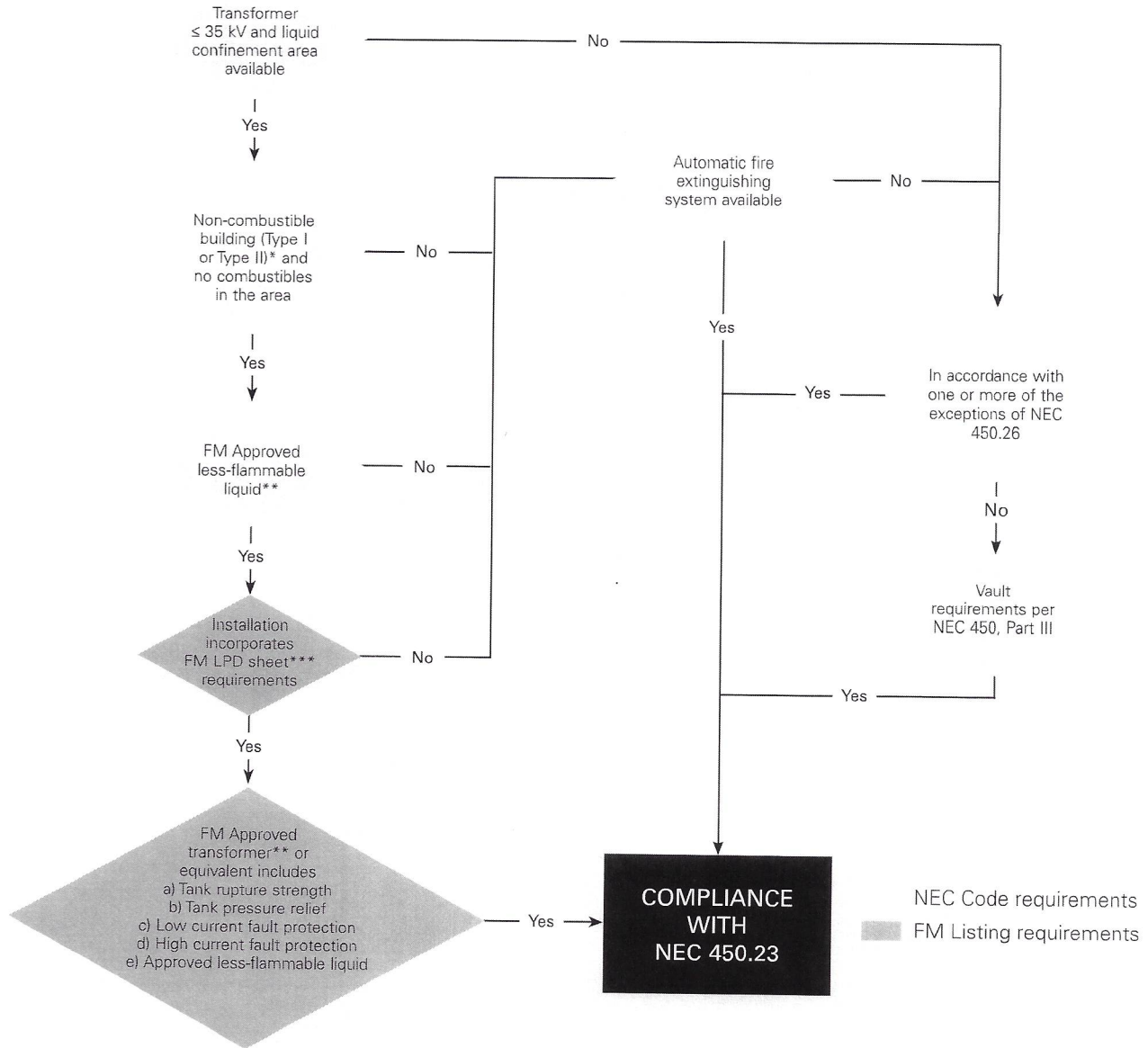
Notice of disclaimer

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 certified and covered under UL's follow-up service. Always look for the mark on the product.

Appendix 4 - Indoor installations per FM Listing requirements

Less-flammable liquid-insulated transformers compliance to NEC Section 450.23 per FM Listing

Requirement highlights



FM Approved fluids include: ‡

Cargill Envirotemp FR3 Fluid (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)

Momentive Performance Mat SF97-50
 Prolec GE Int'l VG-100

FM Approved transformers include: ‡

EATON Cooper Power series
 ABB
 Siemens
 Eaton Cutler-Hammer
 GE Energy
 Square-D
 Prolec GE Int'l
 Wilson Transformer

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

** FM Global Approval Guide

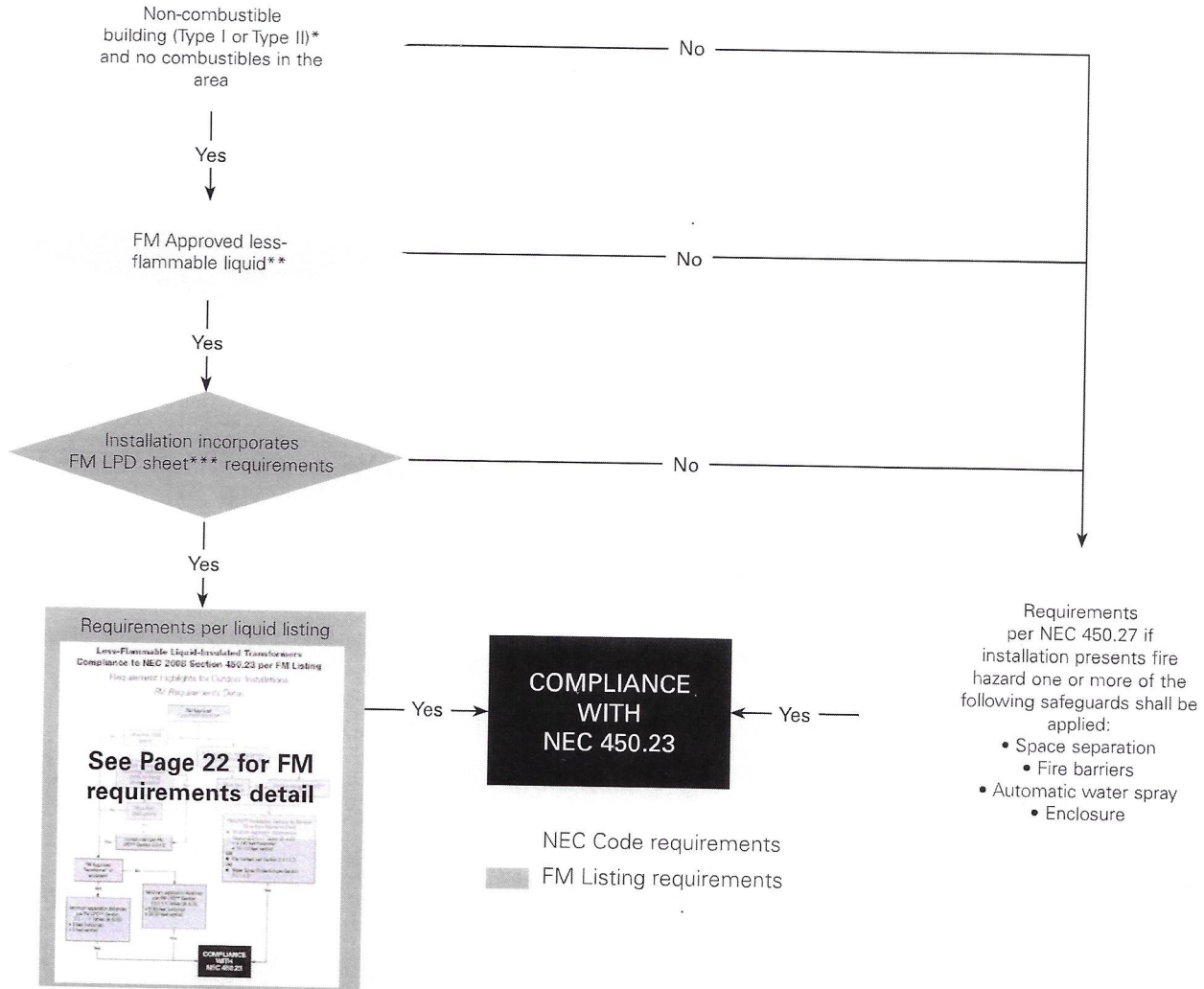
*** FM Global Property Loss Prevention Data Sheets 5-4 — Transformers

‡ This list includes all the insulating liquid manufacturers listed by UL and FM Global as of the date of this publication. Refer to UL and FM Global for the latest lists.

Appendix 5 - Outdoor installations per FM Listing requirements

Less-flammable liquid-insulated transformers compliance to NEC Section 450.23 per FM*** Listing

Requirement highlights



FM Approved fluids include: **

- Cargill Envirotemp FR3 Fluid (natural ester)
- M&I Materials MIDEL™ 7131 (synthetic ester)
- Dow Chemical L-305, Y-7582 (silicone)
- DSI Alpha-1™, Beta™ (hydrocarbon)
- Dow Corning™ 561 (silicone)
- Momentive Performance Mat SF97-50
- Prolec GE Int'l VG-100
- A&A Frattelli Parodi SPA (Parsol 2S, Electra 7426 & Tras 24)
- Archer Daniel Midland (ADM NE-100)
- DONGNAM Petroleum Ind. Co. Ltd. (Biotran 35)
- Savita Polymers Limited (Biotransol HF)
- TOTAL Lubrifiants (ISOVOLTINE BIO VE)

FM Approved transformers include: **

- | | |
|---------------------------|-------------------------------------|
| EATON Cooper Power series | Wilson transformer Co. PTY Ltd |
| ABB | Square-D Schneider |
| Siemens | Qingdao Cahors Electrical Equipment |
| Eaton | WEG transformers |
| Prolec GE International | |

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

** FM Global Approval Guide

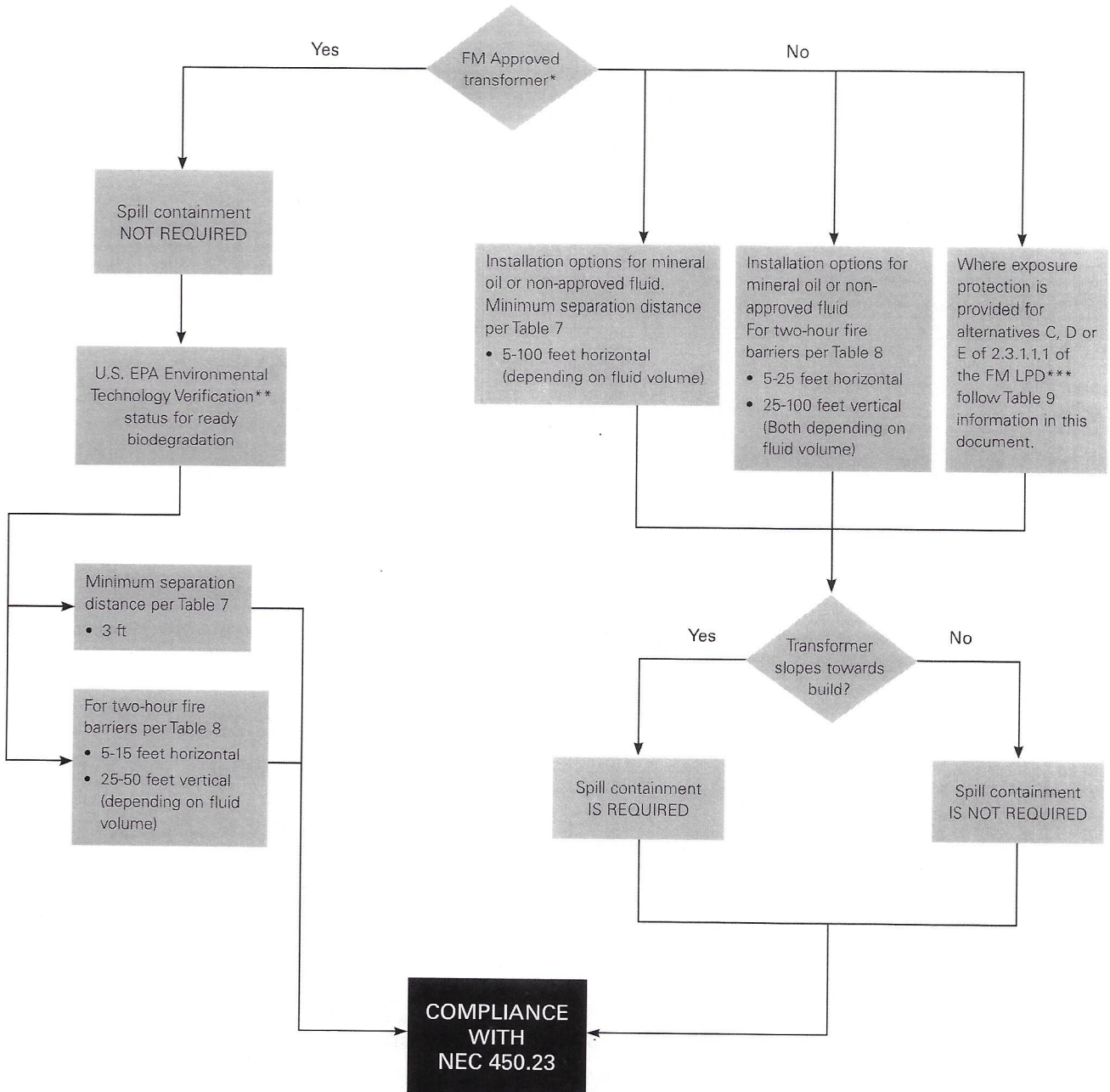
*** FM Global Property Loss Prevention Data Sheets 5-4 — Transformers

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

Appendix 5 - Outdoor installations per FM Listing requirements (continued)

Less-flammable liquid-insulated transformers compliance to NEC Section 450.23 per FM Listing

FM requirements detail for outdoor installations



* 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

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Reference Data TD900001EN

Effective October 2021

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Publication No. TD900001EN
October 2021

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