

# **NEC® Requirement Guidelines**

## **2002 Code Options for the Installation of Listed Less-Flammable Liquid-Filled Transformers**

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These guidelines represent Cooper Power Systems, Dielectric Fluids Products' understanding and interpretation of the National Electrical Code®, UL® Classification of R-Temp® and Envirotemp® FR3™ Fluids and Factory Mutual Loss Prevention Data 5-4/14-8 January 1997, Revised January 2001 in effect at the time of printing. It does not necessarily represent Cooper Power Systems' position on the protection and installation of less-flammable transformers.

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# GENERAL REQUIREMENTS

**NEC (NFPA) Recognition:** These guidelines focus on the requirements of Section 450.23 of the 2002 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 hydrocarbons (e.g. R-Temp® fluid), dimethylsiloxane, and ester based fluids (e.g. Envirotemp® 200 and Envirotemp® FR3™ fluids). Two Nationally Recognized Testing Laboratories (NRTL); Underwriters Laboratories® (UL) and FM Approvals (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 applications 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 station 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.

**2002 NEC Changes to Section 450.27:Oil-Insulated Transformers Installed Outdoors:** The requirements for installation of oil-insulated transformers installed outdoors per the 2002 NEC includes one significant change;

In cases 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:

- (1) Space requirements
- (2) Fire-resistant barriers
- (3) Automatic fire suppression systems
- (4) Enclosures that confine the oil of a ruptured transformer tank

**General NEC Requirements:** The requirements and options for the different types of indoor and outdoor installations are outlined in Tables 1 and 2. These guidelines also summarize the UL Classification and FM Approvals 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 are frequently retrofitted or retrofilled using less-flammable liquids. Section 110.34 sets minimum clear work space dimensions around transformers.

\* Refer to NFPA 220-1999 for definition of non-combustible Type I and II building construction.

**TABLE 1: NEC® SECTION 450.23 REQUIREMENTS – INDOOR INSTALLATIONS**

<p><b>INSTALLATION TYPE</b> Transformer rated ≤ 35 kV, installed in a non-combustible building with no combustible materials stored in area.</p> <p><b>NEC OPTIONS*</b></p> <ul style="list-style-type: none"> <li>■ Both liquid confinement, and either of the following listing requirements: <ul style="list-style-type: none"> <li>A. Underwriters Laboratories</li> <li>B. FM Approvals</li> </ul> </li> <li>or</li> <li>■ Both liquid confinement and auto extinguishment;</li> <li>or</li> <li>■ Vault per NEC 450, Part III.</li> </ul>	<p><b>INSTALLATION TYPE</b> Transformer rated ≤ 35 kV, installed in a combustible building or in a building with combustible materials stored in area.</p> <p><b>NEC OPTIONS*</b></p> <ul style="list-style-type: none"> <li>■ Both liquid confinement and auto-extinguishment</li> <li>or</li> <li>■ Vault per NEC 450, Part III.</li> </ul>	<p><b>INSTALLATION TYPE</b> Transformer rated &gt; 35 kV.</p> <p><b>NEC REQUIREMENT*</b></p> <ul style="list-style-type: none"> <li>■ Vault per NEC 450, Part III.</li> </ul>
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\* 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><b>INSTALLATION TYPE</b> Non-combustible building* and no combustible materials stored in area.</p> <p><b>NEC REQUIREMENT</b></p> <ul style="list-style-type: none"> <li>■ Either of the following listing requirements:** <ul style="list-style-type: none"> <li>A. Underwriters Laboratories</li> <li>B. FM Approvals</li> </ul> </li> </ul>	<p><b>INSTALLATION TYPE</b> Combustible building* or combustible materials stored in area.</p> <p><b>NEC REQUIREMENT</b></p> <ul style="list-style-type: none"> <li>■ In accordance with NEC Section 450.27, Oil Insulated Transformers Installed Outdoors i.e. space separation, fire barriers or water spray systems.</li> </ul>
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\* Refer to NFPA 220-1999 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

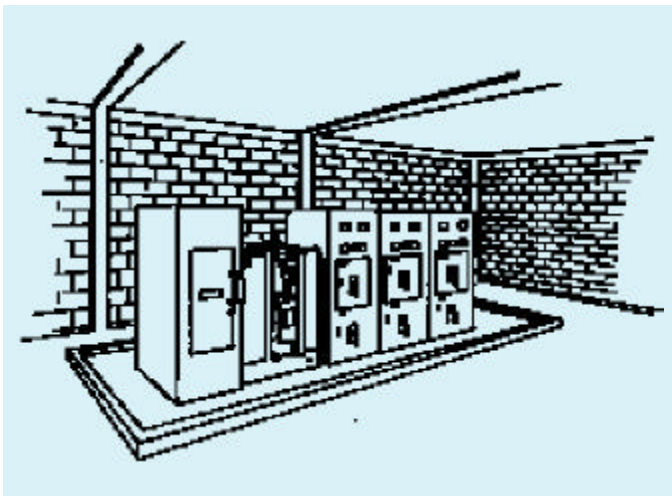
(Refer to Appendixes 1 and 2)

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 greater than 35 kV.

## INDOOR INSTALLATIONS RATED ≤ 35 kV

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



## INSTALLATION TYPE

*Transformer rated ≤ 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 Approvals; **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.
- The transformer be filled with a listed less-flammable insulating liquid with a minimum 300°C fire point.
- The installation comply with the listing requirements of the liquid in the transformer.

**If** the installation cannot meet the liquid listing requirement, it must be provided with an automatic fire extinguishing system and a liquid containment area **or** 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 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 220-1999 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 min. without rupture.
- Transformers be equipped with pressure relief devices with minimum pressure relief capacity per the UL Classification Marking.
- Transformer primaries be protected with over-current protection options per the UL Classification Marking.

Overcurrent Protection Option I, available exclusively with the R-Temp and Envirotemp FR3 Fluids' 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 R-Temp or Envirotemp FR3 fluid-filled transformer for a specific kVA rating, refer to the UL Classification Marking for the fluid shown in Table 3.


The UL Classification for Dow Corning 561 Silicone allows only fusing Option II. Per the DC561 Silicone Classification Marking, stand alone expulsion fuses may be used, but must be located outside the transformer tank. Refer to Table 4.

## TABLE 3: UL CLASSIFICATION MARKING FOR R-TEMP® AND ENVIROTEMP® FR3™ FLUIDS

			
CLASSIFIED BY UNDERWRITERS LABORATORIES INC.® AS TO FIRE HAZARDS ONLY. R-Temp® Fluid and Envirotemp® FR3™ Fluid Classed 4 to 5 less hazardous than paraffin oil in respect to Fire Hazard. May evolve flammable gases when decomposed by an electric arc. CLASSIFIED BY UNDERWRITERS LABORATORIES INC.® AS TO SECTION 450.23 OF THE 2002 NATIONAL ELECTRICAL CODE. 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 C1. Required use of current limiting fusing in the transformer primary having I <sup>t</sup> 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, <div style="text-align: center;">or</div> C2. Required use of overcurrent protection in the transformer primary having I <sup>t</sup> 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 <sup>t</sup> (A's)	OR Required Overcurrent Protection (+) Maximum I <sup>t</sup> (A'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 2002 National Electrical Code.  
 (++) Opening pressure, 10 psig maximum.

## TABLE 4: UL CLASSIFICATION MARKING FOR DOW CORNING® 561 FLUID

			
Classified by Underwriters Laboratories Inc. "As To Fire Hazard Only. 561™ Silicone Transformer Liquid (or 200 Fluid Special 50cSt Dielectric Grade). Classed 4 to 5 less hazardous than paraffin oil in respect to Fire Hazard. May evolve flammable gases when decomposed by an electric arc. Also Classified as a "less-flammable liquid" in compliance with 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 overcurrent protection in the transformer primary circuit having I <sup>t</sup> characteristics not exceeding the values in the following tabulation to limit possible high current arcing faults. 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 Overcurrent Protection (+) Maximum I <sup>t</sup> (A's)		Minimum Required Pressure Relief Capacity, (++) SCFM at 15 psi
45	700,000		35
75	800,000		35
112.5	900,000		35
150	1,000,000		50
225	1,200,000		100
300	1,400,000		100
500	1,900,000		350
750	2,200,000		350
1,000	3,400,000		350
1,500	4,500,000		700
2,000	6,000,000		700
2,500	7,500,000		5,000
3,000	9,000,000		5,000
3,750	11,000,000		5,000
5,000	14,000,000		5,000
7,500	14,000,000		5,000
10,000	14,000,000		5,000

(+) Must also meet overcurrent protection required in accordance with Section 450.3 of the 2002 National Electrical Code.  
 (++) Opening pressure, 10 psig maximum.



## LISTING OPTION - B

### Factory Mutual Requirements

#### Major Revisions:

- **FM no longer tests, lists, nor applies heat release rates for approved less-flammable dielectric liquids.**
- **FM Approval Standard 3990 for Transformers is now recognized by Occupational Safety and Health Administration (OSHA).**

The indoor installation requirements according to Factory Mutual Loss Prevention Data (LPD) 5-4/14-8, January 1997, revised January, 2001 consist of requirements for all transformer and fluid types. 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 Approval 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 psi for rectangular and 20 psi for cylindrical tanks. All transformer tanks shall be designed to withstand a pressure of 7 psi without permanent distortion.
- 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 5 and Section 2.3.3 of the FM Approval 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.
- The unit is filled with an FM Approved 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 (572°F) per the ASTM D92 Cleveland Open Cup Test Method.
- 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 6 and in Section 2.3.5 of the FM Approval 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: R-Temp and Envirottemp 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.
- The transformer shall have an additional nameplate with the FM Approval 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 Approved Less-Flammable fluids, refer to Factory Mutual Research Approval Guide P7825.

## LISTING OPTION - B Factory Mutual 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 and outdoor units greater than 2,500 kVA shall be equipped with alarm contacts on the pressure relief device and a rapid-rise relay.
- 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.
- 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 kPa)
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 6: FM Maximum I<sup>2</sup>t Let Through  
Required Ratings**

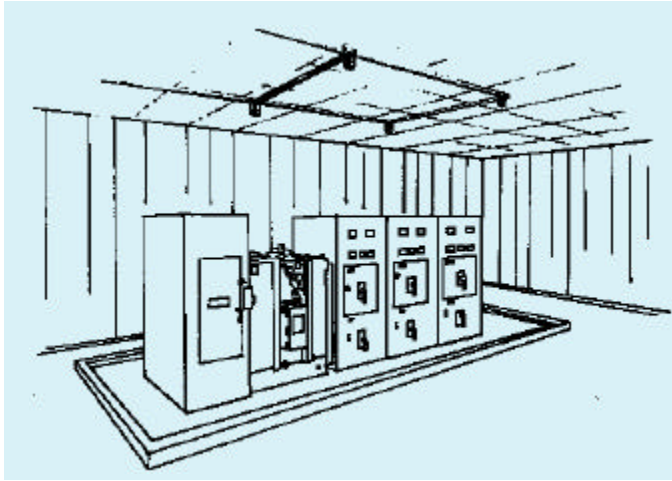
kVA Rating 3-Phase(1-Phase)	Current Limiting Fusing	Other Protection
45 (15)	500,000	700,000
75 (25)	500,000	800,000
112.5 (37.5)	550,000	900,000
150 (50)	600,000	1,000,000
225 (75)	650,000	1,200,000
300 (100)	750,000	1,400,000
500 (167)	900,000	1,900,000
750 (250)	1,100,000	2,200,000
1,000 (333)	1,250,000	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 ≤ 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 ≤ 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.

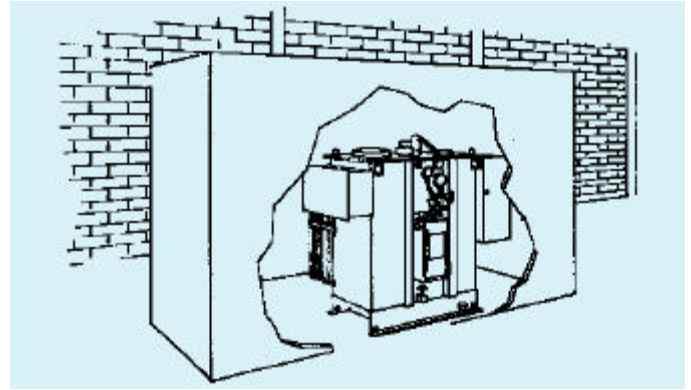
The installation of less-flammable liquid-insulated transformers indoors without a vault in Type I or II non-combustible building\* where no combustible materials are stored required that:

- A liquid containment area be provided.
- The transformer be filled with a listed less-flammable insulating liquid with a minimum 300°C fire point.
- 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 3-hour vault requirement permitting a 1-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 3-hour vault requirement permitting a 1-hour rated fire resistant rated room if equipped with an automatic extinguishing system.

\*Refer to NFPA 220-1999 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 Appendixes 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 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 safety margin.

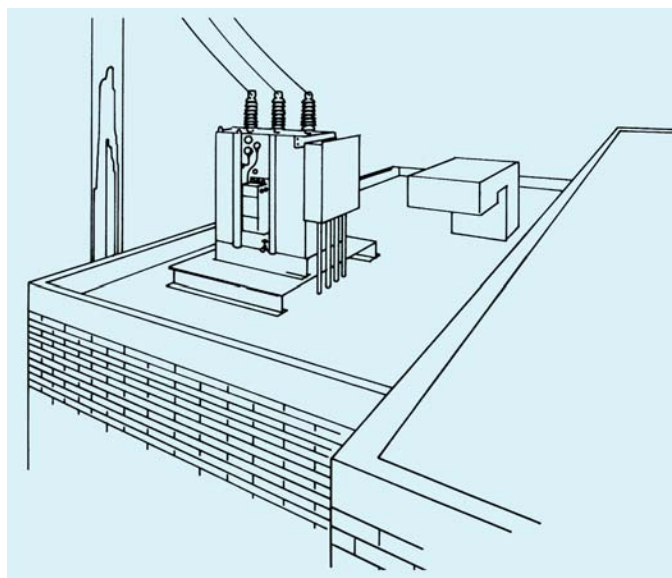
## Note on Outdoor Installations Using Conventional Mineral Oil per ANSI/IEEE:

ANSI/IEEE Standard 979-1984 (Reaff. 1994), Guide For Substation Fire Protection, recommends that transformers containing conventional mineral insulating oil be located not less than the distances listed in Table 7 from buildings. Where a transformer is located less than the specified minimum distance, fire-resistant wall construction should be used.

**Table 7: Clearance Requirements From Buildings For Conventional Mineral Oil-Filled Transformers**  
(per ANSI/IEEE Std. 979 – 1984, Reaff. 1994)

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 Approvals

Less-flammable liquid-insulated transformers are permitted to be installed outdoors 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 are not enforceable as code requirements.

\* Refer to NFPA 220-1999 for definition of non-combustible Type I and II building construction.

\*\* Per NFPA 226-1999, 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 min. without rupture.
- Transformers be equipped with pressure relief devices with minimum pressure relief capacity per the UL Classification Marking.
- Transformer primaries be protected with over-current protection options per the UL Classification Marking.

Overcurrent Protection Option I, available exclusively with the R-Temp and Envirotemp FR3 Fluids' 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 R-Temp or Envirotemp FR3 fluid-filled transformer for a specific kVA rating, refer to the UL Classification Marking for the fluid shown in Table 3.

The UL Classification for Dow Corning 561 Silicone allows only fusing Option II. Per the DC561 Silicone Classification Marking, stand alone expulsion fuses may be used, but must be located outside the transformer tank. Refer to Table 4.



## LISTING OPTION - B

### Factory Mutual Requirements

#### Major Revisions:

- **FM no longer tests, lists, nor applies heat release rates for approved less-flammable dielectric liquids.**
- **FM Approval Standard 3990 for Transformers is now recognized by Occupational Safety and Health Administration (OSHA).**

The outdoor installation requirements according to Factory Mutual Loss Prevention Data (LPD) 5-4/14-8, January 2001, consist of requirements for all transformer and fluid types. Specific requirements for less-flammable liquid-insulated transformers are included.

FM outdoor installation requirements are based on whether or not the transformer is FM Approved or equivalent (See pages 6-7). If not, the volume and type of insulating fluid used will dictate the safeguards required. Buildings and equipment exposed by transformers filled with conventional mineral oil or non-approved less-flammable fluids must comply with fluid containment requirements and be protected by space separation, fire barrier, or water spray systems. Installation of FM Approved transformers or transformers with FM Approved less-flammable fluids must comply with fluid containment requirements and separation distances described.

All separation requirements are measured from the inside edge of the confinement area, if required. The FM LPD provides detailed requirements for fire barriers in Section 2.3.11 and water spray exposure protection in Section 2.3.2.1.

**Containment:** Fluid containment requirements as detailed in Section 2.3.1.2 of the FM LPD depend on whether or not the transformer is FM Approved and on fluid quantity and exposure to buildings. For FM Approved transformers containment is only required when the transformer contains 660 gallons of fluid or more. For all other transformers liquid containment via curbing or pit is required for transformers containing more than 500 gallons of liquid and for transformers with 500 gallons or less where release of fluid would expose buildings. A building is considered "exposed" by a transformer if spilled fluid would flow toward the building.

## LISTING OPTION - B

### Factory Mutual Requirements (continued)

**Separation Distance:** Separation distance requirements are based on whether the transformer is FM Approved or equivalent, or the volume and type of insulating fluid. See Tables 8 and 9 for details.

**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. See pages 7-8 for details.

**TABLE 8. FM Required Separation Distance  
Between Outdoor Liquid Insulated Transformers and Building.\***

Liquid	FM Approved Transformer or Equivalent	Liquid Volume gal/(m <sup>3</sup> )	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	≤1000(3.8)	5(1.5)	5(1.5)	25(7.6)	25(7.6)
		>1000(3.8)	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)
		500-5000(1.9-19)	15(4.6)	25(7.6)	50(15.2)	50(15.2)
		>5000(19)	25(7.6)	50(15.2)	100(30.5)	100(30.5)

**TABLE 9. FM Outdoor Fluid Insulated Transformers  
Equipment Separation Distance.\***

Liquid	FM Approved Transformer or Equivalent	Fluid Volume gal/(m <sup>3</sup> )	Distance ft/(m)
Less-Flammable (Approved)	Yes	N/A	3(0.9)
	No	≤1000(3.8)	5(1.5)
		>1000(3.8)	25(7.6)
Mineral Oil	N/A	<500(1.9)	5(1.5)
		500-5000(1.9-19)	25(7.6)
		>5000(19)	50(15.2)

\* Tables 8 and 9 are reproductions of Separation Distance Table 2a and 2b from the FM LPD.



## OUTDOORS ON OR ADJACENT TO COMBUSTIBLE BUILDINGS OR COMBUSTIBLE MATERIALS

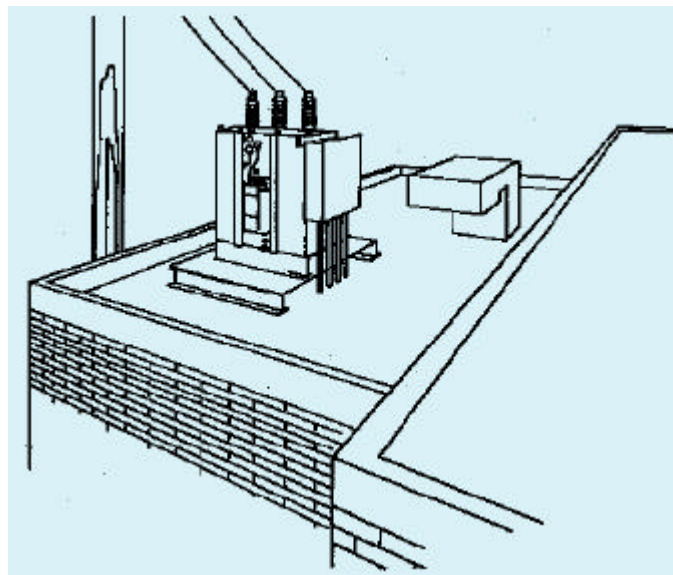
### INSTALLATION TYPE

*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.

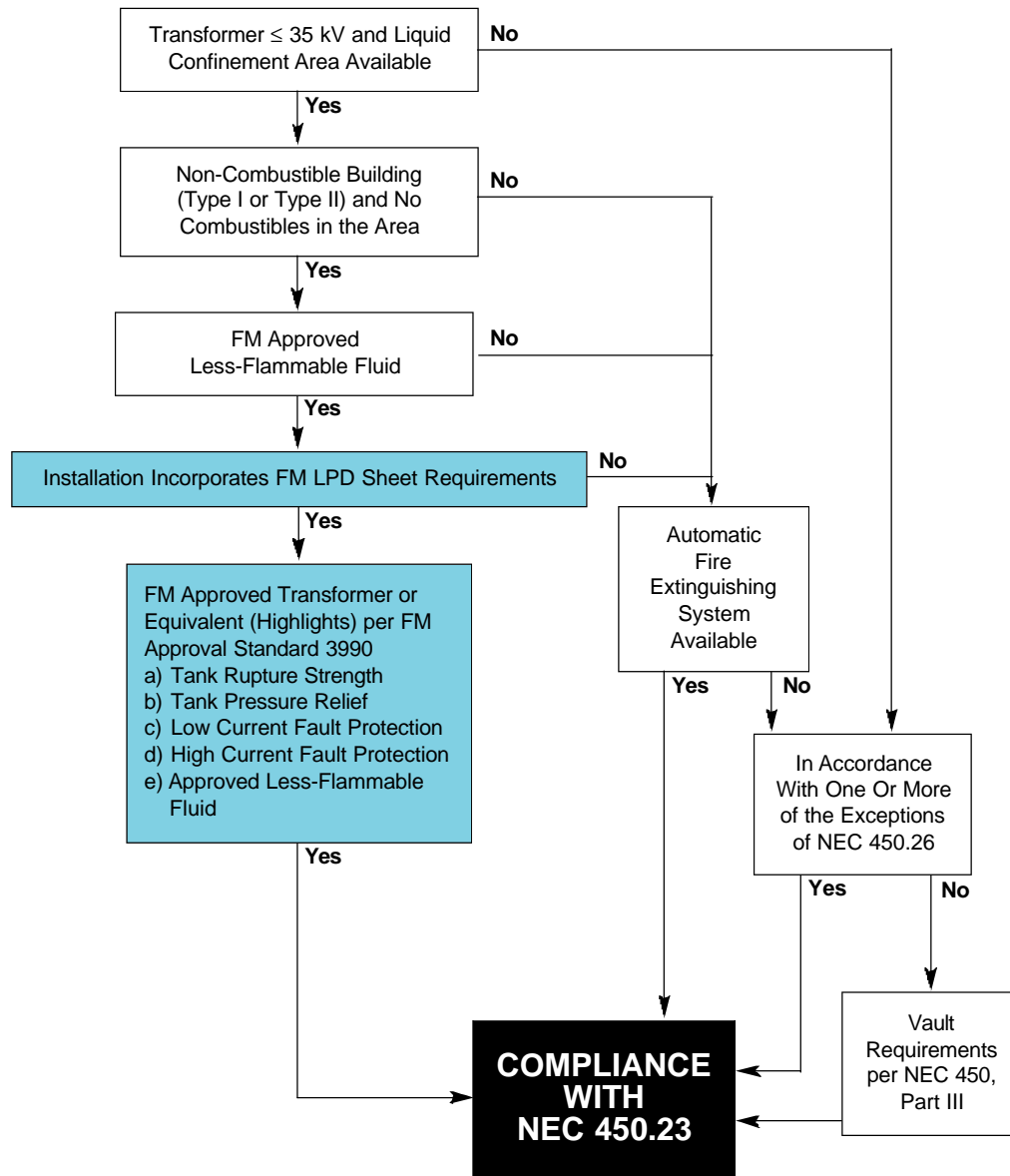


\*Refer to NFPA 220-1999, Section 2.1 for the definition of combustible building construction.

# Less-Flammable Liquid-Insulated Transformers

## Compliance to NEC® 2002 Section 450.23 per FM\* Listing

### Requirement Highlights for Indoor Installations



□ NEC Code Requirements

■ FM Listing Requirements

#### **FM Approved Fluids \*\***

R-Temp® Fluid (Fire Resistant Hydrocarbon)  
 Envirotemp® FR3™ Fluid (Natural Ester)  
 ABB Biotemp® (Natural Ester)  
 Dow Corning 561® (Silicone)  
 General Electric SF97-50 (Silicone)  
 M&I Materials MIDEL 7131 (Polyol Ester Hydrocarbon)  
 Union Carbide L-305 (Silicone)  
 Union Carbide Y-7582 (Silicone)

#### **FM Approved Transformers \*\*\***

Cooper Power Systems

\* FM Approvals Property Loss Prevention Data Sheet Jan. 1997, Rev. Jan. 2001

\*\* FM Approval Guide, January 2002

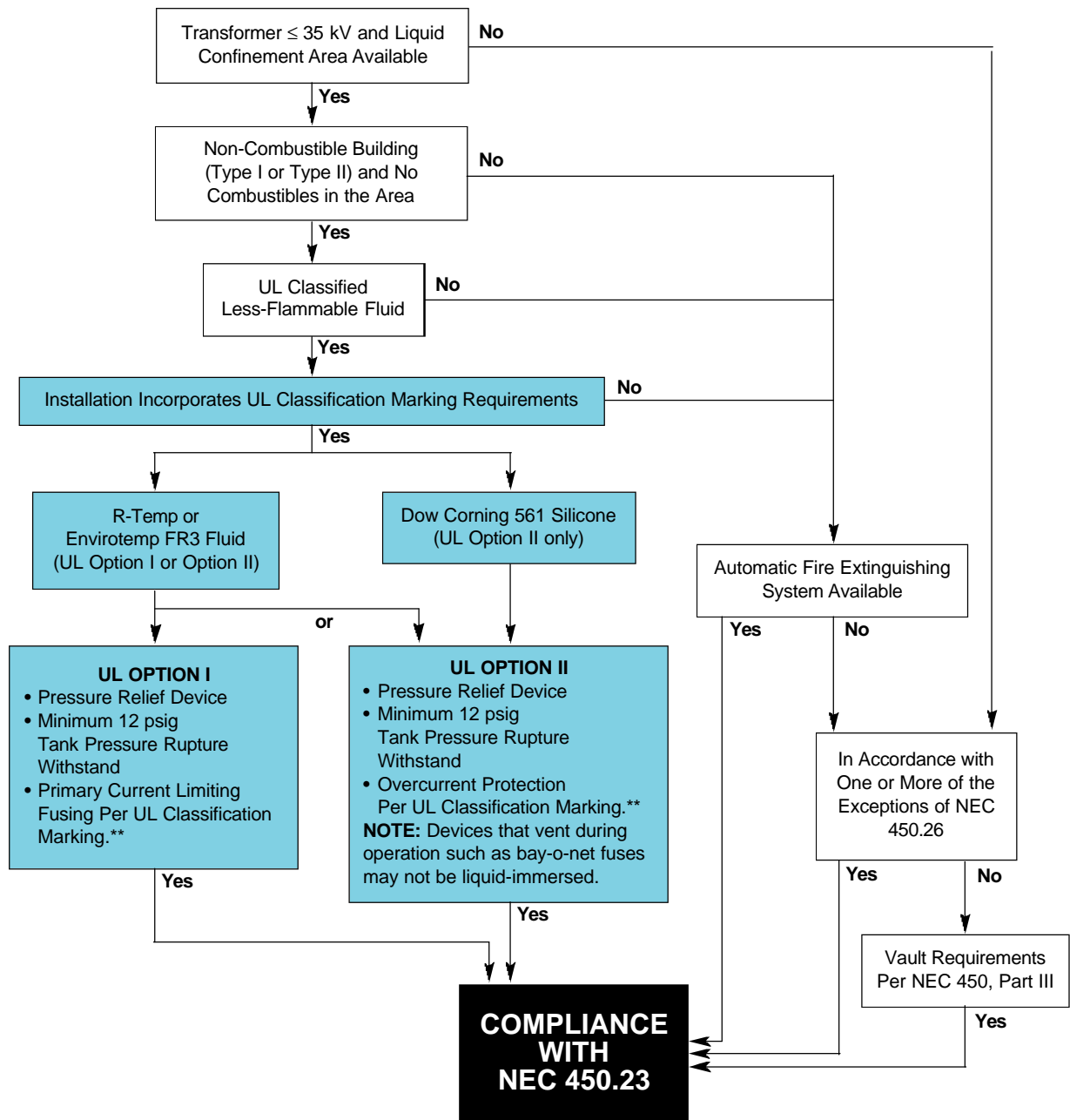
\*\*\* FM Approval Standard 3990, June 1997



# Less-Flammable Liquid-Insulated Transformers

## Compliance to NEC® 2002 Section 450.23 per UL\* Listing

### Requirement Highlights for Indoor Installations



□ NEC Code Requirements

■ UL Listing Requirements

#### UL Classified Fluids

R-Temp® Fluid (Fire Resistant Hydrocarbon)  
 Envirotemp® FR3™ Fluid (Natural Ester)  
 ABB Biotemp® (Natural Ester)  
 Dow Corning 561® (Silicone)  
 General Electric SF97-50 (Silicone)

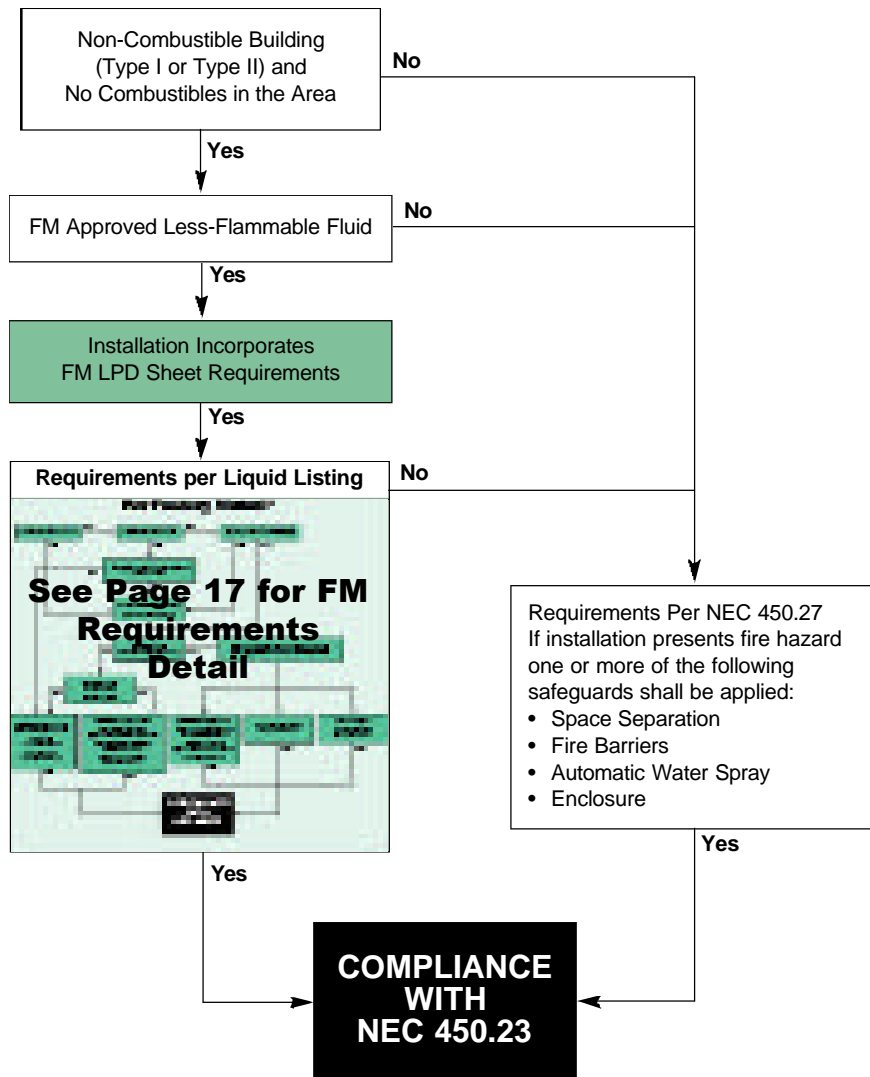
\* Underwriters Laboratories® Inc. Gas and Oil Equipment Directory - 2002.

\*\* UL Classification Option I available only for R-Temp and Envirotemp FR3 Fluids. See page 6 for details.

## Appendix 2

# Less-Flammable Liquid-Insulated Transformers Compliance to NEC® 2002 Section 450.23 per FM\* Listing

## Requirement Highlights for Outdoor Installations



- ☐ NEC Code Requirements
- ☒ FM Listing Requirements

### FM Approved Fluids \*\*

R-Temp® Fluid (Fire Resistant Hydrocarbon)  
 Envirotemp® FR3™ (Natural Ester)  
 ABB Biotemp™ (Natural Ester)  
 Dow Corning 561® (Silicone)  
 General Electric SF97-50 (Silicone)  
 M&I Materials MIDEL 7131 (Polyol Ester Hydrocarbon)  
 Union Carbide L-305 (Silicone)  
 Union Carbide Y-7582 (Silicone)

### FM Approved Transformers \*\*\*

Cooper Power Systems

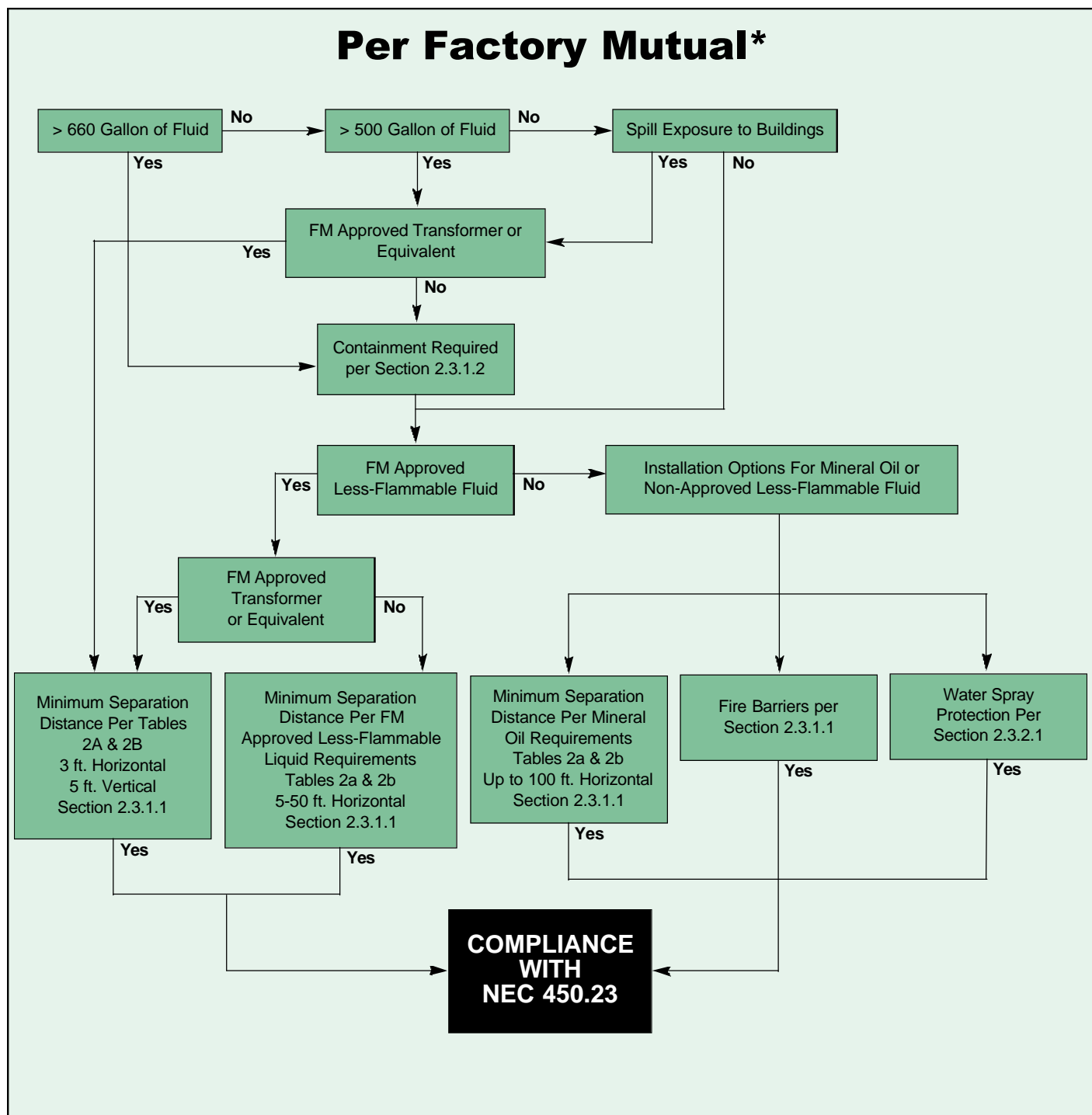
\* FM Approvals Property Loss Prevention Data Sheet Jan. 1997, Rev. January, 2001

\*\* FM Approval Guide, January 2002

\*\*\* FM Approval Standard 3990, June 1997

NOTES: 1) NEC Section 110.3 (b) applies if the listing chosen for compliance specifically addresses outdoor application.

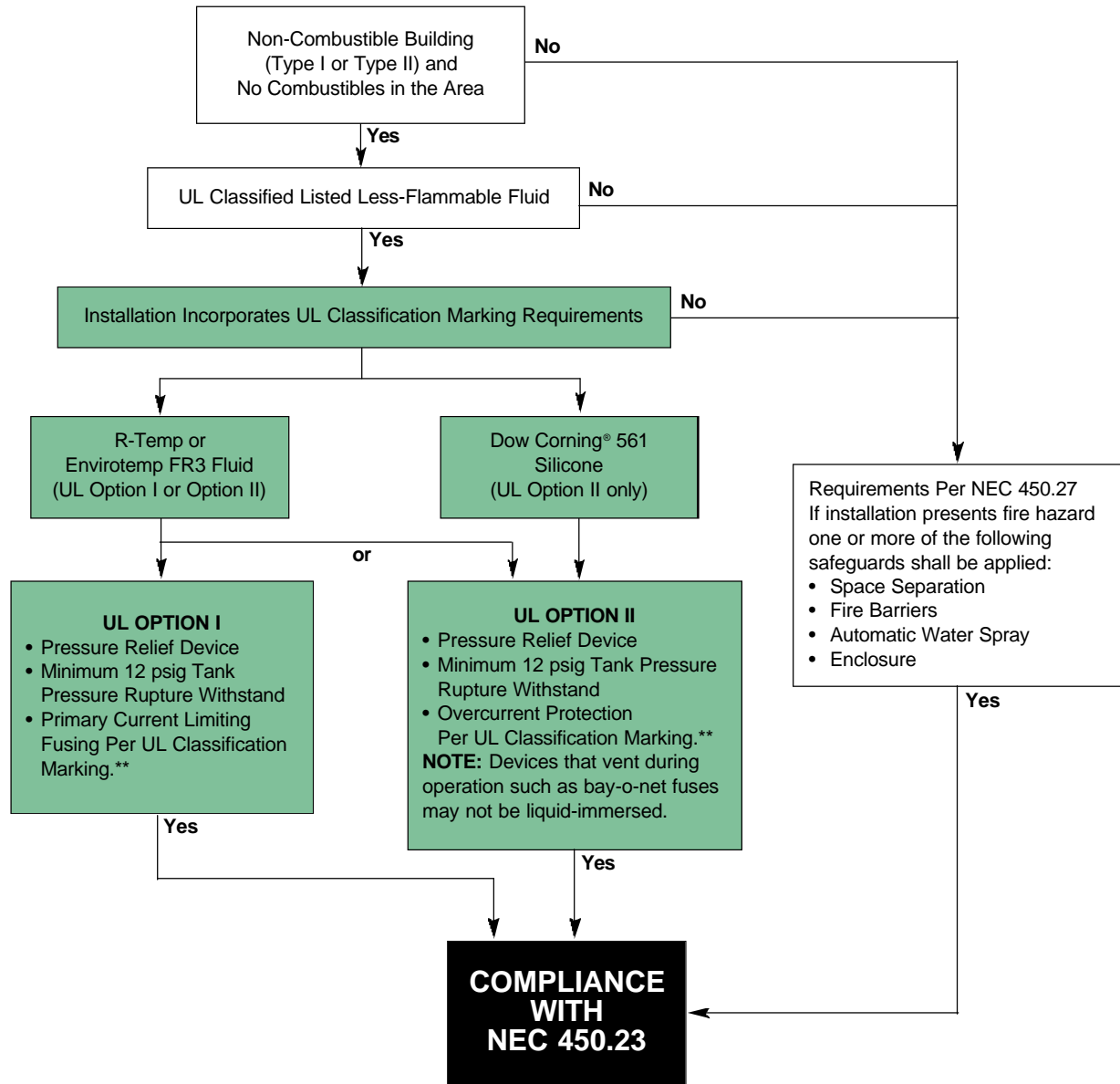
## Requirement Highlights for Outdoor Installations (continued)



\* FM Approvals Property Loss Prevention Data Sheet Jan. 1997, Rev. January, 2001  
 \*\* FM Approval Guide, January 2002

# Less-Flammable Liquid-Insulated Transformers Compliance to NEC® 2002 Section 450.23 per UL\* Listing

## Requirement Highlights for Outdoor Installations



□ NEC Code Requirements

■ UL Listing Requirements

### UL Classified Fluids\*

R-Temp® Fluid (Fire Resistant Hydrocarbon)  
Envirotemp® FR3™ (Natural Ester)  
ABB Biotemp® (Natural Ester)  
Dow Corning 561® (Silicone)  
General Electric SF97-50 (Silicone)

\* Underwriters Laboratories® Inc. Gas and Oil Equipment Directory - 2002.

\*\* UL Classification Option I, available only for R-Temp and Envirotemp FR3 Fluids, permits the use of liquid-immersed expulsion fusing. See page 6 for details.

NOTES: 1) NEC Section 110.3 (b) applies if the listing chosen for compliance specifically addresses outdoor application.

**Appendix 4**



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