

# Code Review for the Storage of Flammable and Combustible Liquids in Refrigerators

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## I. INTRODUCTION

This document was prepared to list the requirements for the storage of flammable and combustible liquids in refrigerators. These requirements are based on the 2004 edition of the *Fire Protection for Laboratories Using Chemicals Code*, NFPA-45, the 2008 edition of the *Flammable and Combustible Liquids Code*, NFPA-30 and the 2008 edition of the *National Electric Code*, NFPA-70.

## II. EXECUTIVE SUMMARY

Flammable and combustible liquids storage is to follow all of the code requirements listed below. The construction and the classification of the refrigerator and separation of flammable/combustible liquids from any ignition sources are two important aspects of the code requirements. Flammable liquids are never to be stored in an unmodified domestic refrigerator; there are far too many ignition sources within them. When storing flammable types of liquids within an approved refrigerator it is extremely important to use the proper container, which does not include one that is open, lightly stoppered or one that can be easily punctured or ruptured.

The refrigerator in which the flammable liquids are stored needs to be explosionproof, "laboratory-safe" or a "modified domestic" model. Requirements for each of these types of refrigerators are explained in more detail within NFPA 45 (see section III.1-7 in this report) of the code review. Hazardous electrical locations training and certification are needed to modify a domestic refrigerator to store flammable liquids. Domestic refrigerators that have been modified by a qualified and certified firm or individual are considered "modified domestic" refrigerators. Even with the correct type of refrigerator, the quantities of flammable liquids needs to be limited to the amount allowed in a flammable liquid storage cabinet as shown in NFPA 30 (see section III.8-12 in this report). The refrigerator storing the flammable/combustible liquids is to be placed in the correct storage area, i.e., Class I, Division 1 or 2 according to NFPA 70 (see section III.13-23 in this report). Please read through the General Code Requirements below for more information.

### III. GENERAL CODE REQUIREMENTS

1. **REFRIGERATOR SIGNAGE:** Section 12.2.2.1 of NFPA-45 states that each refrigerator, freezer, or cooler is to be prominently marked to indicate whether or not it meets the requirements for safe storage of flammable liquids.
2. **LISTED REFRIGERATORS:** Section 12.2.2.2 of NFPA-45 states that refrigerators, freezers, and other cooling equipment used to store or cool flammable liquids is to be listed special purpose units for use in laboratories in commercial occupancies or units listed for Class I, Division I locations, as described in Article 501 of NFPA 70 (III.17-23).
3. **MODIFIED REFRIGERATORS:** Section 12.2.2.2.1 of NFPA-45 states that domestic refrigerators, freezers, and other cooling equipment are to be permitted to store or cool flammable liquids if modified as follows:
  - (1) Any electrical equipment located within the outer shell, within the storage compartment, on the door, or on the door frame is to meet the requirements for Class I, Division 1 locations, as described in Article 501 of NFPA 70 (III.17-23).
  - (2) Electrical equipment mounted on the outside of the storage compartment is to be installed in one of the following ways:
    - (1) To meet the requirements for Class I, Division 2 locations
    - (2) To be located above the storage compartment
    - (3) To be located on the outside surface of the equipment where exposure to hazardous concentrations of vapors will be minimal
4. Section 12.2.2.3 of NFPA-45 states that refrigerators, freezers, and cooling equipment located in a laboratory work area designated as a Class I location, as specified in the Exception to 5.6.2 (below), is to be approved for Class I, Division 1 or 2 locations and is to be installed in accordance with Article 501 of NFPA 70 (III.17-23).
  - (1) Section 5.6.2 of NFPA-45 states that Laboratory work areas, laboratory units, and chemical fume hood interiors are to be considered as unclassified electrically with respect to Article 500 of NFPA 70 (III.13-16).

**Exception:** Under some conditions of hazard, it could be necessary to classify a laboratory work area, or a part thereof, as a hazardous location, for the purpose of designating the electrical installations. [See 10.5.5 (electrical motors) (not applicable) and 12.2.2.2 (refrigerators) (shown above).]
5. Section A.12.2.2.1 of NFPA-45 states that Figure A.12.2.2.1 gives examples of labels that can be used on laboratory refrigerators. (Figure 1 gives suggestions from the University of Colorado of labels that should be used on laboratory refrigerators).

Figure A.12.2.2.1: Examples of labels to be used in laboratory refrigerators

Do not store flammable solvents  
in this refrigerator.

Label used for unmodified domestic models

Notice: This is not an explosionproof refrigerator, but  
it has been designed to permit safe storage of materials  
producing flammable vapors. Containers should be  
well-stoppered or tightly closed.

Label for “laboratory-safe” or “modified domestic” models

Figure 1: University approved labels for laboratory refrigerators

DO NOT STORE FLAMMABLE OR  
COMBUSTIBLE SOLVENTS IN THIS  
REFRIGERATOR

Label for unmodified domestic refrigerators

THIS IS NOT AN EXPLOSIONPROOF REFRIGERATOR, BUT IT HAS BEEN  
CONSTRUCTED OR MODIFIED FOR THE SAFE STORAGE OF MATERIALS  
WHICH MAY PRODUCE FLAMMALBLE VAPORS. CONTIANERS MUST BE  
WELL-STOPPERED OR TIGHTLY CLOSED AND NOT EASILY RUPTURED.

Label for “modified domestic” and “laboratory-safe” refrigerators

THIS IS AN EXPLOSIONPROOF REFRIGERATOR. THIS  
REFRIGERATOR IS INTENDED FOR THE COOLED STORAGE OF  
FLAMMABLE SOLVENTS, INCLUDING MATERIALS IN EASILY  
RUPTURED OR OPEN CONTAINERS OF FLAMMABLE LIQUIDS.

Label for explosionproof refrigerators

6. Section A.12.2.2.2 of NFPA-45 states that protection against the ignition of flammable vapors in refrigerated equipment is available through three types of laboratory refrigerators: explosionproof, “laboratory-safe” (or explosion-safe), and “modified domestic” models.

Explosionproof refrigeration equipment is designed to protect against ignition of flammable vapors both inside and outside the refrigerated storage compartment. This type if intended and recommended for environments such as pilot plants or laboratory work areas where all electrical equipment is required to meet the requirements of Article 501 of NFPA 70 (III.17-23).

The design concepts of the explosion-safe or “laboratory-safe” type of refrigerator are based on the typical laboratory environment. The primary intent is to eliminate ignition of vapors inside the storage compartment by sources also within the compartment. In addition, commercially available “laboratory-safe” refrigerators incorporate such design features as thresholds, self-closing doors, friction latches or magnetic door gaskets, and special

materials for the inner shell. All of these features are intended to control or limit the damage should an exothermic reaction occur within the storage compartment. Finally, the compressor and its circuits and controls are located at the top of the unit to further reduce the potential for ignition of floor-level vapors. In general, the design features of a commercially available “laboratory-safe” refrigerator are such that they provide important safeguards not easily available through modification of domestic models.

7. Section A.12.2.2.2.1 of NFPA-45 states that the use of domestic refrigerators for the storage of typical laboratory solvents presents a significant hazard to the laboratory work area. Refrigerator temperatures are almost universally higher than the flash points of the flammable liquids most often stored in them. In addition to vapor accumulation, a domestic refrigerator contains readily available ignition sources, such as thermostats, light switches, and heater strips, all within or exposed to the refrigerated storage compartment. Furthermore, the compressor and its circuits are typically located at the bottom of the unit, where vapors from flammable liquid spills or leaks could easily accumulate.

Although not considered optimum protection, it is possible to modify domestic refrigerators to achieve some degree of protection. However, the modification process can be applied only to manual defrost refrigerators; the self-defrosting models cannot be successfully modified to provide even minimum safeguards against vapor ignition. The minimum procedures for modification include the following:

- (1) Relocation of manual temperature controls to the exterior of the storage compartment, sealing all points where capillary tubing or wiring formerly entered the storage compartment
- (2) Removal of light switches and light assemblies and sealing of all resulting openings
- (3) Replacement of positive mechanical door latches with magnetic door gaskets

Regardless of the approach used (explosionproof, “laboratory-safe”, “modified domestic”, or unmodified domestic), every laboratory refrigerator should be clearly marked to indicate whether or not it is safe for storage of flammable materials. Internal laboratory procedures should ensure that laboratory refrigerators are being properly used.

8. Section 9.3.2 of NFPA-30 states that for the purposes of Chapters 9 through 16 (applicable sections included), unstable liquids are to be treated as Class IA liquids.
9. Section 9.3.3.1 of NFPA-30 states that storage of liquids is not to physically obstruct a means of egress.
10. Section 9.3.6 of NFPA-30 states that Class I liquids are not to be permitted to be stored in basements.

11. Section 9.3.7 of NFPA-30 states that Class II and Class IIIA liquids are to be permitted to be stored in basements, provided the basement is protected in accordance with Chapter 16 (if needed, contact FLS for this information).
12. Section 9.3.8 of NFPA-30 states that Class IIIB liquids are to be permitted to be stored in basements.
13. Section 500.5(A) of NFPA-70 states that locations are to be classified depending on the properties of the flammable gas, flammable liquid-produced vapor, combustible-liquid produced vapors, combustible dusts, or fiber/flyings that may be present, and the likelihood that a flammable or combustible concentration or quantity is present. Each room, section, or area is to be considered individually in determining its classification.

Code Clarification / Fire Protection Note (FPN): Through the exercise of ingenuity in the layout of electrical installations for hazardous (classified) locations, it is frequently possible to locate much of the equipment in a reduced level of classification or in an unclassified location and, thus, to reduce the amount of special equipment required.

Rooms and areas containing ammonia refrigeration systems that are equipped with adequate mechanical ventilation may be classified as “unclassified” locations.

FPN: For further information regarding classification and ventilation of areas involving ammonia, see ANSI/ASHRAE 15-1994, *Safety Code for Mechanical Refrigeration*, and ANSI/CGA G2.1-1989, *Safety Requirements for the Storage and Handling of Anhydrous Ammonia*.
14. Section 500.5(B) of NFPA-70 states that Class I locations are those in which flammable gases, flammable liquid-produced vapors, or combustible liquid-produced vapors are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures. Class I locations are to include those specified in 500.5(B)(1) and (B)(2).
15. Section 500.5(B)(1) of NFPA-70 states that a Class I, Division 1 location is a location:
  - (1) In which ignitable concentrations of flammable gases, flammable liquid-produced vapors, or combustible liquid-produced vapors can exist under normal operating conditions, or
  - (2) In which ignitable concentrations of such flammable gases, flammable liquid-produced vapors, or combustible liquids above their flash point may exist frequently because of repair or maintenance operations or because of leakage, or
  - (3) In which breakdowns or faulty operations of equipment or processes might release ignitable concentrations of flammable gases, flammable liquid-produced vapors, or combustible liquid-produced vapors and might also cause simultaneous failure of electrical equipment in such a way as to directly cause the electrical equipment to become a source of ignition.

FPN No. 1: This classification usually includes the following locations:

- (1) Where volatile flammable liquids or liquefied flammable gases are transferred from one container to another
- (2) Interiors of spray booths and areas in the vicinity of spraying or painting operations where volatile flammable solvents are used
- (3) Locations containing open tanks or vats of volatile flammable liquids
- (4) Drying rooms or compartments for the evaporation of flammable solvents
- (5) Locations containing fat- and oil-extraction equipment using volatile flammable solvents
- (6) Portions of cleaning and dyeing plants where flammable liquids are used
- (7) Gas generator rooms and other portions of gas manufacturing plants where flammable gas may escape
- (8) Inadequately ventilated pump rooms for flammable gas or for volatile flammable liquids
- (9) The interiors of refrigerators and freezers in which volatile flammable materials are stored in open, lightly stoppered, or easily ruptured containers
- (10) All other locations where ignitable concentrations of flammable vapors or gases are likely to occur in the course of normal operations

FPN No. 2: In some Division 1 locations, ignitable concentrations of flammable gases or vapors may be present continuously or for long periods of time. Examples include the following:

- (1) The inside of inadequately vented enclosures containing instruments normally venting flammable gases or vapors to the interior of the enclosure
- (2) The inside of vented tanks containing volatile flammable liquids
- (3) The area between the inner and outer roof sections of a floating roof tank containing volatile flammable fluids
- (4) Inadequately ventilated areas within spraying or coating operations using volatile flammable fluids
- (5) The interior of an exhaust duct that is used to vent ignitable concentrations of gases or vapors

Experience has demonstrated the prudence of avoiding the installation of instrumentation or other electrical equipment in these particular areas altogether or where it cannot be avoided because it is essential to the process and other locations are not feasible [see 500.5(A), FPN] using electrical equipment or instrumentation approved for the specific application or consisting of intrinsically safe systems as described in Article 504.

16. Section 500.5(B)(2) of NFPA-70 states that a Class I, Division 2 location is a location

- (4) In which volatile flammable gases, flammable liquid-produced vapors, or combustible liquid-produced vapors are handled, processed, or used, but in which the liquids, vapors, or gases will normally be confined within closed containers or closed systems from which they can escape only in case of accidental rupture or breakdown of such containers or systems or in case of abnormal operation of equipment, or
- (5) In which ignitable concentrations of flammable gases, flammable liquid-produced vapors, or combustible liquid-produced vapors are normally prevented by positive mechanical ventilation and which might become hazardous through failure or abnormal operation of the ventilating equipment, or
- (6) That is adjacent to a Class I, Division 1 location, and to which ignitable concentrations of flammable gases, flammable liquid-produced vapors, or

combustible liquid-produced vapors above their flash points might occasionally be communicated unless such communication is prevented by adequate positive-pressure ventilation from a source of clean air and effective safe guards against ventilation failure are provided.

FPN No. 1: This classification usually includes locations where volatile flammable liquids or flammable gases or vapors are used but than, in the judgment of the authority having jurisdiction, would become hazardous only in case of an accident or of some unusual operating condition. The quantity of flammable material that might escape in case of accident, the adequacy of ventilating equipment, the total area involved, and the record of the industry or business with respect to explosions or fires are all factors that merit consideration in determining the classification and extent of each location.

FPN No. 2: Piping without valves, checks, meters, and similar devices would not ordinarily introduce a hazardous condition even though used for flammable liquids or gases. Depending on factors such as the quantity and size of the containers and ventilation, locations used for the storage of flammable liquids or liquefied or compressed gases in sealed containers may be considered either hazardous (classified) or unclassified locations. See NFPA 30-2008, *Flammable and Combustible Liquids Code*, and NFPA 58-2008, *Liquefied Petroleum Gas Code* (not included).

17. Section 501.10 of NFPA-70 states that wiring methods are to comply with 501.10(A) or (B).
- (A) Class I, Division 1.
- (1) In Class I, Division 1 locations, the wiring methods in (1) through (4) are to be permitted.
- (1) Threaded rigid metal conduit or threaded steel intermediate metal conduit.
- Exception:** Type PVC conduit and Type RTRC conduit are to be permitted where encased in concrete envelope a minimum of 2 in. thick and provided with not less than 24 in. of cover measured from the top of the conduit to grade. Threaded rigid metal conduit or threaded steel intermediate metal conduit is to be used for the last 24 in. of the underground run to emergence or to the point of connection to the aboveground raceway. An equipment grounding conductor is to be included to provide for electrical continuity of the raceway system and for grounding of non-current-carrying metal parts.
- (2) Type MI cable with termination fittings listed for the location. Type MI cable is to be installed and supported in a manner to avoid tensile stress at the termination fittings.
- (3) In industrial establishments with restricted public access, where the conditions of maintenance and supervision ensure that only qualified persons service the installation, Type MC-HL cable, listed for use in Class I, Zone 1, or Division 1 locations, with a gas/vaportight continuous corrugated metallic sheath, an overall jacket of suitable polymeric material, a separate equipment grounding conductor(s) and provided with termination fittings listed for the application.

- (4) In industrial establishments with restricted public access, where the conditions of maintenance and supervision ensure that only qualified persons service the installation, Type ITC-HL cable, listed for use in Class I, Zone 1, or Division 1 locations, with a gas/vaportight continuous corrugated metallic sheath, an overall jacket of suitable polymeric material and provided with termination fittings listed for the application.
  - (2) Where necessary to employ flexible connections, as at motor terminals, flexible fittings listed for Class I, Division 1 locations or flexible cord are to be permitted.
  - (3) All boxes and fittings are to be approved for Class I, Division I.
18. Section 501.15 of NFPA-70 states that seals in conduit and cable systems are to comply with 501.15(A) through (F). Sealing compound is to be used in Type MI cable termination fittings to exclude moisture and other fluids from the cable insulation.
- (A) In Class I, Division 1 locations, conduit seals are to be located in accordance with 501.15(A)(1) through (A)(4).
- (1) In each conduit entry into an explosionproof enclosure where either of the following apply:
    - (1) The enclosure contains apparatus, such as switches, circuit breakers, fuses, relays, or resistors that may produce arcs, sparks, or high temperatures that are considered to be an ignition source in normal operation.
    - (2) The entry is metric designator 53 (trade size 2) or larger and the enclosure contains terminals, splices, or taps.
- For the purposes of this section, high temperatures are to be considered to be any temperatures exceeding 80 percent of the autoignition temperature in degrees Celsius of the gas or vapor involved.
- Factory-sealed enclosures are not to be considered to serve as a seal for another adjacent explosionproof enclosure that is required to have a conduit seal.
- Conduit seals are to be installed within 18 in. from the enclosure. Only explosionproof unions, couplings, reducers, elbows, capped elbows, and conduit bodies similar to L, T, and Cross types that are not larger than the trade size of the conduit are to be permitted between the sealing fitting and the explosionproof enclosure.
- (2) In each conduit entry into a pressurized enclosure where the conduit is not pressurized as part of the protection system. Conduit seals are to be installed within 18 in. from the pressurized enclosure.
  - (3) Where two or more explosionproof enclosures for which conduit seals are required under 501.15(A)(1) are connected by nipples or runs of conduit not more than 36 in. long, a single conduit seal in each such nipple connection or run of conduit is to be considered sufficient if located not more than 18 in. from either enclosure.

- (4) In each conduit run leaving a Class I, Division 1 location. The sealing fitting is to be permitted on either side of the boundary of such location within 10 ft of the boundary and is to be designed and installed so as to minimize the amount of gas or vapor within the Division 1 portion of the conduit from being communicated to the conduit beyond the seal. Except for listed explosionproof reducers at the conduit seal, there is to be no union, coupling, box, or fitting between the conduit seal and the point at which the conduit leaves the Division 1 location.
19. Section 501.20 of NFPA-70 states that where condensed vapors or liquids may collect on, or come in contact with, the insulation on conductors, such insulation is to be of a type identified for use under such conditions; or the insulations is to be protected by a sheath of lead or by other approved means.
20. Section 501.25 of NFPA-70 states that in Class I, Divisions 1 and 2 there are to be no uninsulated exposed parts, such as electrical conductors, buses, terminals, or components, that operate at more than 30 volts (15 volts in wet locations).
21. Section 501.30 of NFPA-70 states that wiring and equipment in Class I, Division 1 and 2 locations is to be grounded as specified in Article 250 and in accordance with the requirements of 501.30(A) and (B). (Please contact FLS if more information is required).
- (A) The locknut-bushing and double-locknut types of contacts are not to be depended on for bonding purposes, but bonding jumpers with proper fittings or other approved means of bonding are to be used. Such means of bonding are to apply to all intervening raceways, fittings, boxes, enclosures, and so forth between Class I locations and the point of grounding for service equipment or point of grounding of a separately derived system.
- (B) Flexible metal conduit and liquidtight flexible metal conduit is not to be used as the sole ground-fault current path.
22. Section 501.35(A) of NFPA-70 states that surge arresters, surge-protective devices, and capacitors are to be installed in enclosures identified for Class I, Division 1 locations. Surge-protective capacitors are to be of a type designed for specific duty.
23. Section 501.40 of NFPA-70 states that in a Class I, Division 1 location, a multiwire branch circuit is not to be permitted.

#### IV. DEFINITIONS

1. Section 4.3.1 of NFPA-30 states that flammable liquids are to be classified as Class I liquids and are to be further subclassified in accordance with the following:
  - (1) Class IA Liquid – Any liquid that has a flash point below 73° F and a boiling point below 100° F
  - (2) Class IB Liquid – Any liquid that has a flash point below 73° F and a boiling point at or above 100° F
  - (3) Class IC Liquid – Any liquid that has a flash point at or above 73° F, but below 100° F.
  
2. Section 4.3.2 of NFPA-30 states that combustible liquids are to be classified in accordance with the following:
  - (1) Class II Liquid – Any liquid that has a flash point at or above 100° F and below 140° F
  - (2) Class III Liquid – Any liquid that has a flash point at or above 140° F
    - i. Class IIIA Liquid – Any liquid that has a flash point at or above 140° F, but below 200° F
    - ii. Class IIIB Liquid – Any liquid that has a flash point at or above 200° F