CodeNotes™

Flammable and Combustible Liquids – 2009 IFC®

Introduction

This Code Notes was prepared for use by building and fire code officials to understand the hazards of and requirements for storing and using flammable and combustible liquids. It supports the proper use of 2009 *International Fire Code*® (IFC®) Chapters 27 and 34 by providing a summary of the requirements for the common activities regulated by the IFC. References are included to particular sections of the 2008 edition of NFPA 30, *Flammable and Combustible Liquids Code*.

It is not intended to explain or provide requirements for detailed or complex engineering installations involving flammable and combustible liquids. If the fire code official believes the process is beyond his or her skills, he or she can require a Technical Report and Opinion by applying the requirements in IFC Section 104.7.2 or Section 414.1.3 of the 2009 *International Building Code*® (IBC®).

This Code Notes is organized into several steps. They assist in identifying the hazards of flammable and combustible liquids, determining the classification of flammable and combustible liquids and summarizing the IFC general provisions that ensure that the packaging is adequate for the stored material, control sources of ignition and ensure that the system is liquid tight and has no leaks.

- Hazards of flammable and combustible liquids
- Classification of flammable and combustible liquids
- Packaging of flammable and combustible liquids
- IFC permit requirements for flammable and combustible liquids

What Are Flammable and Combustible Liquids and What Are Their Hazards?

Flammable and combustible liquids are hydrocarbons produced from the refining of fossil fuels or biological mass. They are composed of carbon and hydrogen molecules and may also contain oxygen or nitrogen. The IFC regulates these liquids because they exhibit a very high heat release for a given mass. For example, paper has a heat release rate of about 8,000 British thermal units per pound (Btu/lb). Conversely, a liquid such as benzene or toluene (which is formulated in gasoline) has heat release rates of about 24,000-26,000 Btu/lb. This means it liberates far more heat that can accelerate fire spread. The liquids are also regulated because their vapors are easily ignited. The vapors can find remote ignition sources, ignite, and return to the source of the spill or release at velocities exceeding 50-100 feet/second. They are capable of forming pool fires that can liberate tremendous amounts of radiant energy that can ignite other combustible materials.

All flammable and combustible liquids exhibit a flammable range in air. This flammable range is expressed as a percentage volume of vapor in air in which ignition can occur. The flammable range is measured at normal temperature and pressure [68°F at 14.7 pounds per square inch absolute (PSIA)]. A flammable range is increased as temperature is increased or if the atmosphere contains more than 23 percent oxygen by volume (see Figure 1).

Unleaded gasoline generally has a flammable range between 1.4 percent and 7.6 percent by volume in air. These values indicate the lower and upper flammability limit (LFL and UFL), respectively. If an ignition source is introduced when the vapors are in their flammable range, ignition will occur.

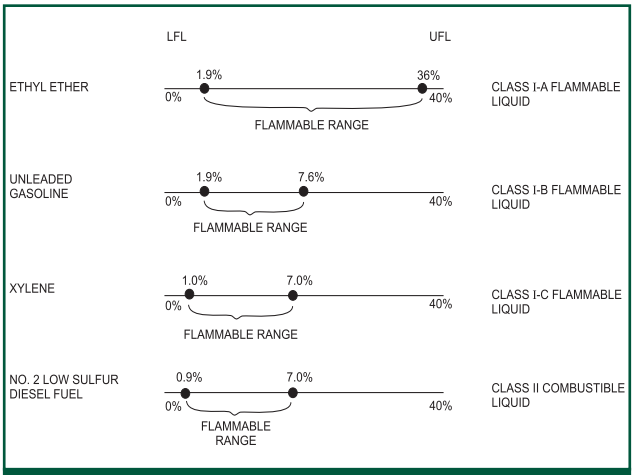

Figure 1 Flammable Ranges for Common Flammable and Combustible Liquids

Testing the vapor pressure of a flammable or combustible liquid is another measurement of a liquid's hazard. Vapor pressure is the measurement of the pressure exerted by a vapor in equilibrium with its liquid phase. All liquids can evaporate at a given temperature and vapor pressure is a measurement of the pressure developed during the test. The higher the liquid's vapor pressure, the more easily it will evaporate at normal temperature and atmospheric pressure.

Vapor pressure is commonly measured in millimeters of mercury (mmHg). The higher a liquid's vapor pressure, the more easily the liquid will evaporate. Because flammable and combustible liquid fires result from the ignition of the vapors, a liquid with a high vapor pressure is more easily ignited when compared to a liquid with a lower vapor pressure. For example, kerosene (Class II combustible liquid) has a vapor pressure of 1 mmHg at 68°F. Conversely, acetone (Class IB flammable liquid) has a vapor pressure of around 245 mmHg at 68°F.

Using only the vapor pressure, the example illustrates that acetone generates a far greater volume of vapor at a given temperature when compared to kerosene, meaning acetone will be more easily ignited. This is confirmed by the classification of acetone as a flammable liquid while kerosene is a combustible liquid.

For certain chemical families of flammable and combustible liquids, there is a direct correlation between their vapor pressure and flammable range in that liquids having a higher vapor pressure can have broader flammable ranges, when compared to those with a lower vapor pressure.

STEP 1: Determine the Hazard Classification of Flammable and Combustible Liquids

Liquids are classified as either **flammable** or **combustible** as a result of flash point and boiling point temperature tests. Flash point temperature is defined in Section 3402.1. The flash point tests specified in the IFC use closed cup test apparatus. Closed cup test apparatus are used because they have a higher degree of reproducibility. Code officials should confirm that the flash point test was performed using a closed cup testing device (see Figure 2).

Secrets of the CodeNotes™: Material Safety Data Sheets (MSDS) commonly indicate the type of flash point apparatus used. Closed cup test methods are commonly abbreviated by the preparer of the MSDS. Common abbreviations are "CC" (Closed Cup) "Pensky" or "PM" (Pensky-Martens) or "SETA" (Setaflash). A MSDS marked to indicate an "OC" indicates an Open Cup flash test, which is not permitted because all of the standards adopted in the IFC are closed cup flash point tests.

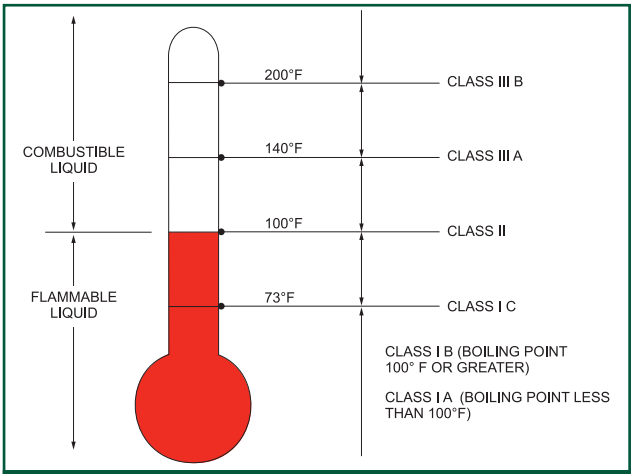

Figure 2 Flammable and Combustible Liquids Classification Thermometer

For the purpose of this CodeNotes, the term "liquid" means "flammable or combustible liquid." The classifications are shown in Table 1:

TABLE 1: IFC CLASSIFICATION OF LIQUIDS

CATEGORY	CLASS	FLASH POINT TEMP. (°F)	BOILING POINT TEMP. (°F)
Flammable	Class IA	<73°F	< 100°F
	Class IB	<73°F	≥100°F
	Class IC	>73°F & < 100°F	NA
Combustible	Class II	100°F to 140°F	
	Class IIIA	>140°F & < 200°F	
	Class IIIB	>200°F	

<: Less than
>: Greater than
NA: Not applicable

One misconception is that the IFC and the U.S. Department of Transportation (DOT) use the same classification system. The classification methods are completely different because DOT is concerned with the hazards of materials while in transportation, such as by movement on road, rail, pipeline or barge. Table 2 shows the difference between the IFC and DOT liquid classification systems:

TABLE 2: COMPARISON OF IFC AND DOT CLASSIFICATIONS FOR LIQUIDS

IFC CLASSIFICATION		DOT CLASSIFICATION
CATEGORY	CLASS	
Flammable	Class IA	Flammable
	Class IB	
	Class IC	
Combustible	Class II	
	Class IIIA	Combustible
	Class IIIB	Not regulated

Secrets of the CodeNotes™: Containers marked with DOT Flammable Liquid placards may contain Class II combustible liquids (see Figure 3). Proper classification of liquids requires the flash point and boiling point temperatures.

Figure 3 DOT Flammable Liquid Placard and DOT Combustible Liquid Placard

The following liquids are exempt from regulation in IFC Chapter 34:

- Liquids stored and dispensed at motor fuel-dispensing facilities and repair garages. Apply IFC Chapter 22 requirements for these liquids.
- Alcoholic beverages in consumer packaging in containers not exceeding 1.3 gallons.
- Fuel oil tanks and containers connected to oil-burning appliances.
- Refrigerants and refrigerant oils. Apply IFC Section 606 for these liquids.
- Liquids that have no fire point.
- Aerosols regulated by IFC Chapter 28.
- Liquids without flash point temperatures.
- Storage of distilled spirits and wines in wooden barrels and casks.

TABLE 3: CLASSIFICATION OF COMMON LIQUIDS[1]

LIQUID	IFC CLASSIFICATION
Acetone	Class IB Flammable
B100 Biodiesel	Class IIIB Combustible
Ethyl alcohol	Class IB Flammable
Heptane	Class IB Flammable
Hexane	Class IB Flammable
Isopropyl alcohol	Class IB Flammable
Kerosene	Class IIIA Combustible
Gasoline	Class IB Flammable
Ethanol/gasoline (E85)	Class IB Flammable
Methyl ethyl ketone	Class IB Flammable
Methyl isobutyl ketone	Class IB Flammable
Mineral spirits	Class II Combustible
Toluene	Class IB Flammable
VM&P solvent	Class IIIA Combustible
Xylene	Class IC Flammable

1. It is the responsibility of the permit applicant to classify the hazardous materials properly.

STEP 2: Confirm that the Flammable and Combustible Liquids Packaging Is Acceptable

Liquid packaging is regulated by the IFC. Packaging will be in the form of a container, portable tank or stationary tank. These are defined in IFC 2701.2:

CONTAINER: A vessel of 60 gallons or less in capacity used for transporting or storing hazardous materials. The definition excludes piping systems, engine fuel tanks and engines.

PORTABLE TANK: A packaging of more than 60 gallons, capacity designed primarily to be loaded into or on or temporarily attached to a transport vehicle or ship and is equipped with a means to facilitate handling by mechanical means.

STATIONARY TANK: Packaging designed primarily for stationary installations not intended for loading, unloading or attachment to a transport vehicle as part of its normal operation.

IFC Section 3404.3.1 specifies that containers and portable tanks must be approved. The requirements for containers and portable tanks are found in Table 9.4.3 of NFPA 30.

Intermediate Bulk Containers (IBCs) are a form of a portable tank. They can be constructed of carbon or stainless steel or can be constructed of plastic or multiple layers of fiberboard. IBCs can have a capacity of 300 to 700 gallons. The type of IBC that is permitted to store liquids is determined by the materials of construction and its United Nations (UN) classification number. For example, a Rigid Plastic IBC has a UN designation as UN 31H1. A review of NFPA 30 Table 9.4.3 confirms that such an IBC is not permitted for the storage of Class I flammable liquids. This prohibition is because plastic portable tanks can fail rapidly when exposed to pool fires involving flammable liquids.

Secrets of the CodeNotes™: Storing one or more IBCs containing Class I or II liquids indoors requires the building to be classified as a Group H occupancy.

Stationary tanks are commonly used for storing liquids. Stationary tanks are classified as underground or above-ground storage tanks. Underground storage tanks are buried in soil so they have minimal inspection requirements (see step number 7).

Above-ground storage tanks (ASTs) are stationary tanks designed to store liquids at atmospheric pressure. ASTs that will be encountered by the users of this Code Notes are typically shop fabricated, meaning they are fabricated in a shop and shipped to a location for storage and use (see Figure 4).

Figure 4 A 6,000 gallon, above-ground Storage Tank

Secrets of the CodeNotes™: IFC Section 3404.2.7 requires shop-fabricated storage tanks to be constructed in accordance with NFPA 30. NFPA 30 requires these types of tanks be listed to nationally recognized standards, such as UL 142, *Steel Aboveground Tanks for Flammable and Combustible Liquids*. A manufacturer nameplate is attached to all shop-fabricated tanks that demonstrate compliance with the IFC and NFPA 30.

STEP 3: Apply the IFC® Operational and Construction Permit Requirements

Before an inspection can be performed, it is important to obtain a Hazardous Materials Inventory Statement (HMIS). Section 2701.5.2 authorizes the fire code official to require an HMIS as part of the operational permit for the storage and handling of liquids. The HMIS will identify the physical state, hazards and amounts of hazardous materials in storage and use.

Section 105.6.16 specifies when an operational permit is required for flammable and combustible liquids. Table 4 contains the permit quantity values for when an operational permit is required.

TABLE 4: PERMIT AMOUNTS FOR LIQUIDS

CLASS	INDOOR AMOUNT	OUTDOOR AMOUNT
Class I	> 5 gal.	> 10 gal.
Class II & IIIA	> 25 gal.	> 60 gal.
Class IIIB	An Operational Permit is required when its class of liquid is stored and used for fuel motor vehicles or where connected to fuel-burning equipment. Fuel oil and used motor oil used for space heating or water heating are exempted.	

Note that Section 105.6.16 Subsections 2.1 and 2.2 exempt fuel tanks of motor vehicles, mobile power plants and aircrafts and flammable paints or coatings when they are used for maintenance or painting for a period of not more than 30 days. Section 105.6.16 also requires an operational permit for certain activities including:

- Subsection 6: Facilities that produce, process, transport, store, dispense or use liquids.
- Subsection 9: Facilities that manufacture, process, blend or refine liquids.
- Subsection 10: Dispensing of liquid fuels into motor vehicle fuel tanks at commercial, industrial, governmental or manufacturing establishments.

Section 105.7.7 requires a construction permit for the installation of:

- Subsection 2: Facilities that produce, process, transport, store, dispense or use liquids.
- Subsection 3: To install, alter, remove, abandon or dispose of a liquid storage tank.

Figure 5 Oil-Burning Equipment Such as Listed Waste Class IIIB Oil Burners Used to Heat an Automobile Repair Facility are Exempt from an IFC Operational Permit. (Photograph courtesy of Clean Burn Energy Technologies, Leola, PA)

Conclusion

Flammable and combustible liquids exhibit a flash point and boiling point temperature. These liquids will ignite when they are within their flammable range, which is the range between the lower flammable limit and upper flammable limit. A liquid is flammable if its closed cup flash point temperature is less than 100°F – if its flash point temperature is 100°F or greater, it is classified as a combustible liquid.

The liquid classification system used by the IFC is different than the classification system used by the U.S. Department of Transportation. Code officials should not rely on DOT labels or placards as a basis for classifying flammable and combustible liquids.

The IFC contains a number of requirements for liquids packaging and they are different for liquids packaged in containers, portable tanks or stationary tanks.

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