FESHM 6020.5: IGINITABLE LIQUIDS

Revision History

Author	Description of Change	Revision Date
Jim Niehoff	Initial release	May 2018

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1.0 INTRODUCTION

The recommendations contained herein are for the prevention of and protection against fires and explosions in occupancies handling, processing, or transferring ignitable liquids. Additional recommendations may be needed on a case by case basis to provide adequate prevention and protection subject to hazardous chemical reactions. For the purpose of this document, the term "ignitable liquid" is defined as any liquid that has a measurable flash point which refers to the closed-cup or open-cup flash point.

This chapter covers liquids labeled as "flammable" or "combustible", in accordance with state, federal, or international codes and/or regulations. This chapter also covers liquids that codes and/or regulations may not address, such as those with a flash point above 2008F (938C).

This chapter regulates the storage, handling, and use of ignitable liquids. Although US Department of Transportation (DOT) regulations govern the construction of tank vehicles and the interstate transportation of ignitable liquids, this chapter regulates the parking, garaging, filling, and discharging of tank vehicles, and related operations, materials and processes related to ignitable liquids.

This chapter does not include incidental storage and use of ignitable liquids. All incidental storage and use must be approved by Division Safety Officer (DSO) and included in the Hazardous Chemical Inventory. The following table can be used for guidance in conjunction with consultation of the DSO. Of particular concern is the location of incidental storage and use with the proximity of combustibles and ignition sources. This table is based on a single-story facility. For underground storage and use, consult with the Fire Hazard Safety subcommittee.

Incidental Storage and Use (3)				
Liquid	**Liquid Class**	**Category (GH-SDS_**	**Gallons (1)**	**Gallons (2)**
Flammable Liquids	IA	1 or 2	30 (115L)	10 (38L)
	IB & IC	2	120 (460L)	30 (115L)
Combustible Liquid	II	3	120 (460L)	30 (115L)
	IIIA	4	330 (1,265L)	80 (300L)
	IIIB	--	13,200 (50,600L)	3,300 (12,650L)

(1) Storage in operating areas in identified controlled storage area, such as listed flammable cabinets. as specified in OSHA and NFPA 30. The volume of Class I, Class II, and Class IIIA liquids stored in an individual storage cabinet shall not exceed 120 gallons (460 L).

(2) Use in operating areas outside of identified storage areas, not more than ten 10 gallons of Class IA or 30 gallons of Class IB & IC liquids can be outside of an approved flammable storage container; however, is subject to potential review of Fire Hazard Safety Subcommittee, Industrial Hygiene, and Division Safety Officer reviews. Quantities listed are from NFPA 30, 2018, Table 18.5.4 & 29 CFR OSHA 1910.109.

(3) Flammable liquids shall not be stored or used so as to limit use of exits, stairways, or area normally used for the safe egress.

2.0 DEFINITIONS

- **Appropriate Governing Code** – A national, state, or local code or standard that specifies design, fabrication, and operation requirements and practices that must be followed.
- **Boiling Point** – The temperature at which a liquid's vapor pressure is equal to the atmospheric pressure on the liquid. The boiling point is measured at an atmospheric pressure of 14.7 psi absolute (approximately 1 bar absolute). The boiling point of an ignitable liquid permits the comparison of liquid volatility without knowing the vapor pressures. Liquids with low boiling points are very volatile and extremely flammable.
- **Container** - Any can, barrel, or drum.
  - *Closed Container* - A container so sealed by means of a lid or other device that neither liquid nor vapor will escape from it at ordinary temperatures.
  - *Portable container (tank)* - A closed container having a liquid capacity over 60 gallons (227 liters) and not intended for fixed installation
  - *Safety container (can)* – An approved container, of not more than 5.3 gallons (20 liters) capacity, having a screen or strainer, pour opening having a spring-closing lid and spout cover and so designed that it will safely relieve internal pressure when subject to fire exposure.
- **Control Area** – A facility or portion of a facility within which flammable or combustible liquids are allowed to be stored, dispensed, and used.
- **Cryogenic Fluids** – A fluid with a boiling point lower than -1308F (-908C) at an absolute pressure of 14.7 psi (101.325 kPa).
- **Flash Point** – The minimum temperature to which a liquid must be heated, in a standardized apparatus, so that a transient flame moves over the liquid when a small pilot flame is applied
- **Flammable Storage Cabinet** – Storage Cabinet that meets the requirements of NFPA 30, 2018, Edition, Section 9.5.3.
- **Fire Point** – The lowest temperature at which a liquid must be heated in a standardized apparatus, so that sustained combustion results when a small pilot flame is applied, and long as the liquid is at normal atmospheric pressure.
- **Fire Area** – An area of a facility separated from the remainder by construction having a fire resistance of at least 1 hour or higher.
- **Ignitable Liquid –** Any liquid or liquid mixture that will burn. A liquid will burn if it has a measurable flash point and/or boiling point. Ignitable liquids include flammable liquids and combustible liquids. For the purpose of defining ignitable liquid, NFPA 30 shall be used as the classification and is defined into two categories, flammable and combustible.

Flammable Liquid

Class	Flash Point	Boiling Point
IA	<738F (<22.88C)	<1008F (<37.88C)
IB	<738F (<22.88C)	≥1008F (≥37.88C)
IC	≥738F (<22.88C) to <1008F (<37.88C)	Not Applicable

Combustible Liquid

Class	Flash Point	Boiling Point
II	≥1008F (≥37.88C) to ≤1408F (≤608C)	Not Applicable
IIIA	>1408F (>608C) to <2008F (<938C)	Not Applicable
IIIB	≥2008F (≥938C)	Not Applicable

Reference the Technical Appendix for a comparative of Classification of Liquids between various agencies.

- **Heat Release Rate** – The rate at which thermal energy is released by a fire, often expressed as kilowatts per unit of burning area. It consists of a combination of convective, radiative, and conductive heat. It can be calculated from the mass burning rate if the heat of combustion and combustion efficiency are known.

3.0 RESPONSIBILITIES

The responsibilities are supplement to the FESHM Chapter 6010, Section 4.0.

3.1 Cryogenics Safety Subcommittee

The Cryogenic Safety Subcommittee is responsible for providing guidance and review to the laboratory concerning all engineering systems operating with flammable and non-flammable cryogenic fluids.

3.2 Fire Hazard Safety Subcommittee

The Fire Hazard Safety Subcommittee is responsible for providing guidance and review of flammable liquids storage and use.

3.3 Division Safety Officer

The Division Safety Officer is responsible for assisting in the review process and providing guidance in the storage and use of ignitable liquids.

3.4 ESH&Q Industrial Hygiene Group

The Industrial Hygiene is responsible for providing guidance and review of the use of ignitable and carcinogens type chemicals/liquids.

3.5 Mechanical Safety Subcommittee

The Mechanical Safety Subcommittee is responsible for providing guidance and review to the piping processes and vessels.

4.0 EVALUATION OF HAZARD

Ignitable liquid fires increase in severity with increased pool size. Fire severity will be minimized if the ignitable liquid can be contained within the equipment or contained to small footprint on the floor. If the ignitable liquid is released from the equipment and forms a large pool, there is the potential for a large fire. Recommendations for passive and active fire protection features will vary depending on the severity of the potential fire hazard. The intent is to limit the amount of ignitable liquids that can

become involved in a fire. To evaluate the process or storage, the actual exposure created by ignitable liquids must be analyzed by conducting a hazard analysis. Evaluate each step separately prior to handling/processing/use to determine the actual exposure created by the ignitable liquid. For additional information, reference NFPA 30 Chapter 6 and FM Data Sheet 7-32.

4.1 Fire Hazard

The overall severity of the fire hazard depends on the amount of liquid and the surrounding occupancy. A highly sensitive occupancy, e.g., clean room, may not be able to tolerate even a few gallons (liters) of burning liquid. The factors that need consideration prior for fire hazard evaluation include:

- The quantity of ignitable liquid involved;
- Ignition sources (e.g., open flames, lightning, cutting and welding, electrical sparks, static electricity, frictional heat or sparks)
- Use conditions (e.g., temperature, pressure, flow rate);
- Equipment/piping arrangements (e.g., open, closed, interconnected, welded, flanged);
- Equipment/pipe location (e.g., indoors, outdoors, at grade, in a cutoff room, in an assembly/detector hall);
- Building factors such as containment and or vent line or ventilation;
- Emergency planning (e.g., shutting down or isolating equipment, egress for safe evacuation).

4.2 Explosion Hazard

An explosion hazard exists in a building, room, or piece of equipment when all of the following elements exist:

- Fuel
- Oxidizer
- Confinement
- Ignition Source
- Fuel Dispersion

4.2.1. Potential Building/Room Explosion

The potential for a building/room explosion hazard exists when any of the following are true:

- An ignitable liquid is handled/processed/used at or above its atmospheric boiling point, and has a flash point at or below 4258F (2188C).
- The process uses an ignitable liquid with a boiling point at or below 1008F (388C).
- A piece of equipment with a defined equipment explosion hazard occupies more than 10% of the building/room's volume and is not protected in accordance with building code.

4.2.2. Potential Equipment Explosion

The potential for equipment explosion hazard exists when any of the following are true:

- An ignitable liquid is handled/processed/used at or above its flash point and there is a vapor space within the equipment.

- An ignitable liquid exists as a mist within the equipment due to a mechanical process (e.g. spraying, mixing).

5.0 STORAGE & HANDLING/PROCESSES

Areas where flammable liquids are stored, handled, dispensed (process) or mixed shall be designed in accordance with NFPA 30, Table 7.3.3 titled Electrical Area Classifications. The extent of the classified area is allowed to be reduced, or eliminated, where sufficient technical justification is provided through the Operational Readiness Review process and a review by the appropriate laboratory safety subcommittees.

Other general considerations should be given, such as sources of ignition, e.g., static electricity, friction heat, or sparks from mechanical equipment, reference NFPA 30 and FM Data Sheet 7-32.

5.1 Storage and Handling

5.1.1. Safety Containers

Drums, portable tanks, and intermediate bulk containers shall comply with NFPA 30.

5.1.2. Containment, Drainage, and Spill Control

Storage areas shall be designed and operated to prevent the discharge of liquids to waterways, sewers, etc. Containment system shall be in accordance with other applicable FESHM chapters.

5.1.3. Venting

Listed or approved flame arresters or pressure-vacuum (PV) vents that remain closed unless venting under pressure or vacuum conditions shall be installed in accordance with the appropriate governing codes/standards. For further information, see FM Global Property Loss Prevention Data Sheet 7-32 titled Ignitable Liquid Operations.

5.2 Processes

5.2.1. Pumping

Choosing a pump, ensure the following:

- Compatibility of the pump, packing, and trim with the liquid being handled;
- Use cast steel construction for the pumps;
- Pump casing, impeller, and other moving parts of non-sparking materials.
- Provide pumps with high-integrity seals (dual seals) or use seal-less pumps;
- Positive displacement pumps shall be provided with pressure relief devices, in accordance with NFPA 30.
- Design should consider electrical, intrinsically safe wiring including pumps

5.2.2. Piping

Piping system components shall be designed, fabricated, and installed in accordance with FESHM Chapter 5031.1, ASME, and NFPA 30, Chapter 27. Piping standards include but are not limited to:

Piping Use	Standard
Power Piping	ASME B31.1
Process Piping	ASME B31.3
Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids	ASME B31.4
Building Services Piping	ASME B31.9

5.2.3. Emergency Shutoff

Provide ignitable liquid process system with an emergency shutoff valve or electronic button to ensure prompt shutdown of all liquid flow in the event of a fire, spill, leak, or explosion.

6.0 REFERENCES

- 29 CFR 1910.106, (OSHA) Flammable Liquids
- American National Standards Institute (ANSI) Z400.1/Z129.1, Hazardous Workplace Chemicals – Hazard Evaluation and Safety Data Sheet and Precautionary Labeling Preparation
- United Nations – Globally Harmonized System (UN-GHS)
- United States – Department of Transportation (DOT)
- International Fire Code (IFC) Chapter 50 and 57, 2015 Edition
- National Fire Protection Association
  - NFPA 1, Fire Code, Chapter 66, 2015 Edition
  - NFPA 30, Flammable and Combustible Liquids Code, 2015 Edition
  - NFPA 45, Standard on Fire Protection for Laboratories Using Chemicals, 2015 Edition
- Factory Mutual Insurance, Property Loss Prevention Data Sheet 7-32, 2014 Edition
- Principles of Fire Protection Chemistry and Physics, 3rd Edition, 1998
- Fermilab Environmental, Safety, & Health (ES&H) Manual:
  - Chapter 5031.1, Piping Systems
  - Chapter 6010, Fire Protection Program
  - Chapter 9100, Electrical Safety Program

7.0 TECHNICAL APPENDICES

The below table is derived from NFPA 30, 2018, Appendix A.4.3.

Agency	Agency Classification	8 F	8 C	NFPA 30 Definition	NFPA 30 Classification	NFPA Flash Point 8 F	NFPA Flash Point 8 C
ANSI* Z129.1	Flammable	<141	<60.5	Flammable Combustible	Class I Class II Class IIIA	<100 ≥100 to <140 ≥140 to <200	<60.5 ≥37.8 to <60 ≥60 to <93
	Combustible	≥141 to <200	≥60.5 to <93	Combustible	Class IIIA	≥140 to <200	≥60 to <93
DOT	Flammable	<141	<60.5	Flammable Combustible	Class I Class II Class IIIA	<100 ≥100 to <140 ≥140 to <200	<37.8 ≥37.8 to <60 ≥60 to <93
	Combustible	≥141 to <200	≥60.5 to <93	Combustible	Class IIIA	≥140 to <200	≥60 to <93
DOT *HM-181 Domestic Exemption*	Flammable	<100	<37.8	Flammable	Class I	<100	<37.8
	Combustible	≥100 to <200	≥37.8 to <93	Combustible	Class II Class IIIA	≥100 to <140 ≥140 to <200	≥37.8 to <60 ≥60 to <93
UN	Flammable	<141	<60.5	Flammable Combustible	Class I Class II Class IIIA	<100 ≥100 to <140 ≥140 to <200	<37.8 ≥37.8 to <60 ≥60 to <93
	Combustible	≥141 to <200	≥60.5 to <93	Combustible	Class IIIA	≥140 to <200	≥60 to <93
29 CFR 1910.106 OSHA**	Flammable	<100		Flammable	Class I	<100	<37.8
	Combustible	≥100		Combustible	Class II Class IIIA Class IIIB**	≥100 to <140 ≥140 to <200 ≥200	≥37.8 to <60 ≥60 to <93 ≥93

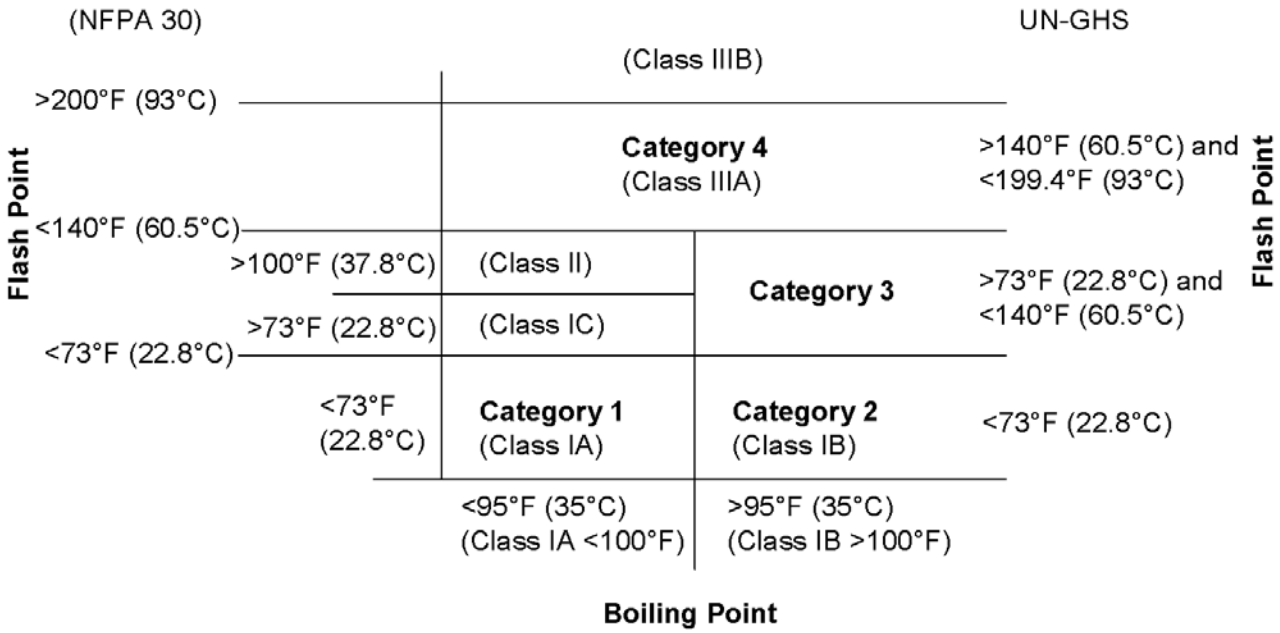
**ANSI Considers Class IA Liquid extremely flammable*

***2012, OSHA adopted UN-GHS and renamed to categories – See 29 CFR 1910.106 for Class IIIB exemptions*

Table below provides a summary of Global Harmonized System and NFPA 30 Classification

Criteria	UN GHS Category	NFPA 30 Classification
Flash Point <738F (238C) and initial boiling point ≤958F (358C)	Flammable 1	Class IA
Flash Point <738F (238C) and initial boiling point >958F (358C)	Flammable 2	Class IA or Class IB
Flash Point ≥738F (238C) to ≤1408F (60.58C)	Flammable 3	Class IC to Class II
Flash Point >1408F (60.58C) to ≤199.48F (938C)	Flammable 4	Class IIIA
Flash point above >2008F (938C)	Not Addressed	Class IIIB

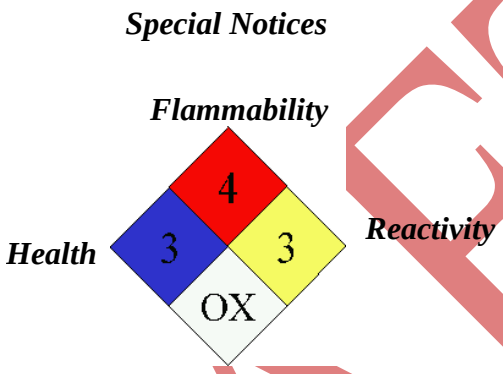
Diagram of NFPA 30 and comparison of OSHA's UN- categories



Note: Category and Flammable are interchangeable.

NFPA FIRE DIAMONDS & GHS SYMBOLS
SAFETY DATA SHEETS (SDS)

The **NFPA** (National Fire Protection Association) 704 or *NFPA Diamond* is the standard for the identification of hazardous materials and emergency response. These signs can be found on reagent bottles, gas tanks, vehicles that transport chemicals, and doors to rooms containing certain chemicals. Their main purpose is to quickly indicate to first responders the dangers presented by the substances present. However, the fire diamond is useful for anyone, especially a student, who is handling chemicals.



This diamond shaped sign is divided into 4 sections: health (blue, left), flammability (red, top), reactivity (yellow, right), and specific warnings (white, bottom). For the first three categories, the severity of the danger is indicated by a scale of 0 (minimal hazard) to 4 (extreme hazard).

Flammability

Materials with

	Flashpoint	Boiling Point
4	< 23 □C (73 □F)	> 38 □C (100 □F)
3	< 23 □C > 23 □C	≥ 38 □C < 38 □C
2	38 to 93 □C	
1	> 93 □C (200 □F)	
0	Material normally doesn't burn	

Health

Materials with an oral LD50

4	≤ 5 mg / kg
3	5 – 50 mg / kg
2	50 – 500 mg / kg
1	500 – 2000 mg / kg
0	> 2000 mg / kg

Reactivity

Material Behavior:

	Reactivity	Conditions
4	explosion	normal pressure & temperature
3	explosion	strong initiating source
2	chemical change	elevated pressure & temperature
1	unstable	elevated temperature
0	stable	

Special

~~W~~	Water Reactive
OX	Oxidizer
COR	Corrosive
☢	Radioactive

Definitions of terms used in the table above:

Flash point: the lowest temperature at which a substance will vaporize and catch fire.

LD50 (median lethal dose): the amount of a substance needed to kill 50% of the population. **Oxidizer** (oxidizing agent): a chemical that will take electrons away from another chemical (thereby oxidizing that other chemical). *Examples:* $KMnO_4$, H_2O_2, NaOCl (bleach), $K_2Cr_2O_7$. **Corrosive** (caustic): a chemical that will damage or destroy another substance. *Examples:* strong acids (HCl, H_2SO_4) & bases (NaOH), strong oxidizers (concentrated H_2O_2).

The **Global Harmonized System** (**GHS**) was created by the United Nations in the 1990s. The goal was to create a set of symbols that would be universally understood. Nine pictograms are used to depict the classes of hazards associated with chemicals.

 **Flammables, Self Reactives, & Pyrophorics**	 **Skin, Eye, & Metal Corrosives**	 **Irritants & Sensitizers**
 **Oxidizers**	 **Gases under Pressure**	 **Carcinogen, Mutagen, Teratogen**
 **Explosives & Peroxides**	 **Environmental Effects**	 **Acute Toxicity / Fatal**

The best information source for the NFPA values (numerical values, the colored diamond is not displayed) and the GHS symbols is a chemical's **Safety Data Sheet (SDS)**. A SDS provides more detailed information on a chemical's reactivity - containing guidelines for the chemical's handling, storage, and disposal. Furthermore, the health effects of and the emergency procedures for exposure to a chemical are an integral part of a SDS. Always look up the SDSs for the chemicals you will use in lab. Note: Only neutral compounds have SDS, ions do not. To start, look up chemicals you are familiar with - like table salt (NaCl), sucrose ($C_{12}H_{22}O_{11}$), ethanol (C_2H_5O, drinking alcohol), and sodium cyanide (NaCN). This activity will help give you the perspective needed when evaluating a SDS.

The two links below provide online access to these documents:

UC Irvine's Environmental Health & Safety SDS website: http://www.ehs.uci.edu/msds.html
(If off-campus, go through the Library's website and use the "Connect from off-campus" link.)

Chemical Manufacturer with User-Friendly website:

Sigma-Aldrich**:** http://www.sigmaaldrich.com/united-states.html

(Type chemical name into the search field in the upper right corner. When the chemical comes up, click on MSDS on the right side just before the price.)

Other websites:

7.1 NFPA: National Fire Protection Association website:

http://www.nfpa.org

7.2 GHS 1st Edition (2003) website:

http://www.unece.org/trans/danger/publi/ghs/ghs_rev00/00files_e.html