



# INDIANA UNIVERSITY

## Laboratory Safety Guideline

### Flammable Liquid Storage Properties, Classification, Quantities, Cabinets, Containers, and Refrigerators

#### Introduction

The Occupational Safety and Health Administration (OSHA), the National Fire Protection Association (NFPA), and the International Building Code (IBC) define flammable liquids as any chemical that has a flash point of less than 100°F (38°C)<sup>1</sup> and combustible liquids as those that have a flash point greater than 100°F (38°C). These are further categorized into the following subdivisions based on the flashpoint and/or boiling point.

#### Flammable Liquids:

- Class IA. Liquids having a flash point below 73°F (23°C) and having a boiling point below 100°F (38°C).
- Class IB. Liquids having a flash point below 73°F (23°C) and having a boiling point above 100°F (38°C).
- Class IC. Liquids having a flash point at or above 73°F (23°C) and below 100°F (38°C).

#### Combustible Liquids:

- Class II. Liquids having a closed cup flash point at or above 100°F (38°C) and below 140°F (60°C).
- Class IIIA. Liquids having a closed cup flash point at or above 140°F (60°C) and below 200°F (93°C).
- Class IIIB. Liquids having a closed cup flash point at or above 200°F (93°C).

#### Classification of Flammable and Combustible Liquids

	Flammable Liquids		Combustible Liquids			
Boiling Point (°F)	BP ≥ 100°F	Class IB Flammable Liquid	Class IC Flammable Liquid	Class II Combustible Liquid	Class IIIA Combustible Liquid	Class IIIB Combustible Liquid
	BP ≤ 100°F	Class IA Flammable Liquid				
	FP < 73°F	73°F < FP < 100°F	100°F < FP < 140°F	140°F ≤ FP < 200°F	FP ≥ 200°F	
	Flash Point (°F)					

The properties of flammable materials are of critical importance in the safe storage and use of these materials. The flash point of a liquid is defined as the minimum temperature at which a liquid gives off sufficient vapor to ignite in the presence of a source of ignition. Remember, it is the vapor that burns and not the liquid.

- The Department of Transportation (DOT) and American National Standards Institute (ANSI) define flammable liquids as those with a flash point less than 140°F which includes NFPA Class II combustible liquids.



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The following table provides the flashpoint, boiling point, and NFPA classifications of some common laboratory chemicals:

Properties and NFPA Classification of Some Common Laboratory Chemicals			
Chemical	Flash Point °F (°C)	Boiling Point	NFPA Classification
Acetic Acid, Glacial	103 (39)	245 (118)	II
Acetone	-4 (-20)	133 (56)	IB
Acetaldehyde	-38 (-39)	70 (21)	IA
Acetonitrile	42 (6)	179 (82)	IB
Acrylonitrile	32 (0)	171 (77)	IB
Benzene	12 (-11)	176 (80)	IB
tert- Butyl Alcohol	52 (11)	181 (83)	IB
Cyclohexene	<20 (<-7)	181 (83)	IB
Dioxane	54 (12)	214 (101)	IB
Ethyl Acetate	24 (-4)	171 (77)	IB
Ethyl Alcohol	55 (13)	173 (78)	IB
Ethyl Ether	-49 (-45)	95 (35)	IA
Gasoline	-45 (-43)	100-400 (38-204)	IB
Hexane	-7 (-22)	156 (69)	IB
Isopropanol	53 (12)	183 (83)	IB
Methanol	52 (11)	174 (64)	IB
Methylene Chloride	None	104 (40)	None
Methyl Ethyl Keytone	16 (-9)	176 (80)	IB
Pentane	<-40 (<-40)	97 (36)	IA
Petroleum Ether	<0 (<-18)	95-140 (35-60)	IA-IB
Propyl Alcohol	74 (23)	207 (97)	IC
n-Propyl Ether	70 (21)	194 (90)	IB
Pyridine	68 (20)	239 (115)	IB
Tetrahydrofuran	6 (-14)	151 (66)	IB
Toluene	40 (4)	230 (111)	IB
Triethylamine	16 (-7)	193 (89)	IB
m - Xylene	77(25)	282 (38)	IC

Mixtures of soluble flammable chemicals and water also affect the flammable properties of these solutions. The following table summarizes the various properties of ethyl alcohol and water solutions.

Properties of Ethyl Alcohol Solutions												
Percent Ethyl Alcohol In Water	100% (200 Proof)	96%	95%	80%	70%	60%	50% (100 Proof)	40%	30%	20%	10%	5%
Flash Point °F (°C)	55 (13)	62 (17)	63 (17)	68 (20)	70 (21)	72 (22)	75 (24)	79 (26)	85 (29)	97 (36)	120 (49)	144 (62)
NFPA Class	IB	IB	IB	IB	IB	IB	IC	IC	IC	IC	II	IIIA

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#### Quantity Limits (per Fire Control Area)

The total quantity of flammable or combustible liquids allowed in a fire control area (laboratory or suite of laboratories) are limited by the location in the building and the construction specifications. Typical laboratories are not constructed to high hazard group specifications (check with the facility manager).

The following table shows the maximum allowable quantities that can be stored in a single fire control area (laboratory or suite of laboratories) per floor. Note that quantities may be increased when using approved flammable cabinets and in areas equipped with fire suppression sprinklers. The maximum allowable quantity is the total aggregate quantity of liquids stored inside cabinets, outside cabinets, and in safety cans.

International Fire Code (IFC) Maximum Allowable Quantities in Storage per Fire Control Area Unless Constructed to High Hazard Group (H-2 or H-3) Specifications (Gallons)						
Hazardous Material	Class	Basement (75%)	Ground Floor (100%)	First Floor (75%)	Second Floor (50%)	Third Floor and Above (12.5%)
Flammable liquid	IA	22.5 <sup>a,b</sup>	30 <sup>a,b</sup>	22.5 <sup>a,b</sup>	15 <sup>a,b</sup>	3.75 <sup>a,b</sup>
	IB	45 <sup>a,b</sup>	60 <sup>a,b</sup>	45 <sup>a,b</sup>	30 <sup>a,b</sup>	7.5 <sup>a,b</sup>
	IC	67.5 <sup>a,b</sup>	90 <sup>a,b</sup>	67.5 <sup>a,b</sup>	45 <sup>a,b</sup>	11.25 <sup>a,b</sup>
Combination of Flammable Liquids (IA,IB,IC)	IA+IB+IC	90 <sup>a,b,d</sup>	120 <sup>a,b,d</sup>	90 <sup>a,b,d</sup>	60 <sup>a,b,d</sup>	15 <sup>a,b,d</sup>
Combustible liquid	II	90 <sup>a,b</sup>	120 <sup>a,b</sup>	90 <sup>a,b</sup>	60 <sup>a,b</sup>	15 <sup>a,b</sup>
	IIIA		330 <sup>a,b</sup>			
	IIIB		13,200 <sup>b,c</sup>			

- Notes: a. Maximum quantities shall be increased 100% for buildings equipped throughout with an automatic sprinkler system. Where note b applies, the increase for both shall be applied accumulatively.  
 b. Quantities shall be increased 100% when stored in approved cabinets, gas cabinets, exhausted enclosures, or safety cans as specified by the *International Fire Code*. Where note d applies, the increase for both shall be applied accumulatively.  
 c. The permitted quantities shall not be limited in buildings equipped throughout with an automatic sprinkler system and provided with exhaust ventilation.  
 d. Containing not more than the maximum allowable quantity per control area of Class 1A, 1B, or 1C flammable liquids.

#### Quantity Limits Outside Flammable Storage Cabinets

No more than ten (10) gallons of flammable or combustible liquids may be stored outside a flammable cabinet (with the exception of materials stored in approved safety cans).

#### Quantity Limits Inside Flammable Storage Cabinets

Flammable liquids stored inside flammable storage cabinets are limited to 60 gallons of Class 1A flammable liquids per cabinet. The total volume of combined classes of flammable and combustible liquids may not exceed 120 gallons per cabinet.



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#### Storage Cabinets

Flammable Cabinets must meet the construction specifications of the National Fire Protection Association (NFPA), Flammable and Combustible Liquids Code, NFPA 30. Cabinets should be placed so that they do not block or impede egress.

NFPA 30 does not require flammable cabinets to be ventilated. If not vented, the vent openings must be sealed. If vented, the vent openings must be equipped with spark arrestors. The supply and exhaust must be ducted to the outside and the flow must be installed with supply provided at the top and exhaust exiting at the bottom of the cabinet.

Grounding is also not required unless Class IA flammable liquids are being dispensed from the cabinet. If grounding is desired the cabinets must be grounded to a static grounding terminal and **not** to the ground of an electrical receptacle.

Some state regulations require a spring activated door closing mechanism. These are not required but may be utilized if desired. Keep doors closed when not obtaining or returning materials to the cabinet.

#### Storage Containers

The National Fire Protection Association (NFPA 45) Standard on Fire Protection for Laboratories Using Chemicals defines the maximum allowable capacity for containers used in laboratories.

Individual glass containers of Class IA liquids must not exceed 1 pint (500 ml) capacity. Individual glass containers of Class 1B liquids must not exceed 1 quart (1 liter) capacity. *Exception:* Class I-A and I-B liquids may be stored in factory-shipped glass containers up to 1-gallon or 4-liter capacity if the required liquid purity would be affected by storage in metal containers or if the liquid would cause excessive corrosion of a metal container.

Class I-A liquids can be stored in metal containers not larger than 1 gallon (4 liters) capacity, or U.L. listed safety cans not larger than 2 gallons (8 liters) capacity.

For liquids other than Class I-A liquids, the capacity of the containers regardless of type (i.e., metal, glass, etc.) must not exceed five (5) gallons each.

National Fire Protection Association (NFPA) 45 Standard on Fire Protection for Laboratories Using Chemicals Maximum Allowable Container Capacity					
Container Type	Flammable Liquids			Combustible Liquids	
	Class IA	Class IB	Class IC	Class II	Class III
Glass	1 pt. (500 ml)	1 qt. (1 L)	1.1 gal. (4 L)	1.1 gal. (4 L)	5 gal. (20 L)
Metal (other than DOT drums)	1.1 gal. (4 L)	5 gal. (20 L)	5 gal. (20 L)	5 gal. (20 L)	5 gal. (20 L)
Safety Cans	2.6 gal. (10 L)	5 gal. (20 L)	5 gal. (20 L)	5 gal. (20 L)	5 gal. (20 L)
Metal Drum (DOT Spec.)	1.1 gal. (4 L)	5 gal. (20 L)	5 gal. (20 L)	60 gal. (227 L)	60 gal. (227 L)
Polyethylene (DOT Spec. 34, UN 1H1)	1.1 gal. (4 L)	5 gal. (20 L)	5 gal. (20 L)	60 gal. (227 L)	60 gal. (227 L)

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#### Storage Refrigerators

Improper storage of flammable liquids in household-type domestic refrigerators can be very dangerous and present the risk of personal injury and/or property damage. The accumulation of vapors in this confined space can result in an explosion or fire if these vapors are ignited by the various electrical components inside the refrigerator compartment. These sources of ignition include temperature controls, thermostats, relays, light switches, light assemblies, defrost mechanisms, fans, and even mechanical door latches.



There are four types of refrigerators found in laboratories:

1. Domestic refrigerator/freezers used for storage of non-flammable chemicals only.
2. Modified domestic refrigerators that have all the electrical components re-located outside the inner compartment to make them suitable for the storage of flammable liquids.
3. Laboratory-safe or flammable material refrigerator/freezers used for the storage of flammable chemicals in laboratories.
4. Explosion proof refrigerator/freezers used for the storage of flammable chemicals in hazardous locations.

Storage of chemicals in refrigerated environments requires proper precautions:

- Keep all containers tightly closed.
- No open containers (no open beakers, test tubes, flasks, bottles, or other containers).
- Make sure that the integrity of the container and the lid or stopper is adequate.

#### Domestic Refrigerator/Freezers

Domestic household refrigerators have internal components located inside the inner compartment such as thermostats, lights, and switches that can create a spark capable of igniting vapors from flammable liquids stored inside.

This type of refrigerator is the lowest cost so many labs use this type of refrigerator for storing non-flammable chemicals. Domestic Refrigerators must be labeled properly. Flammable materials must never be stored in this type of refrigerator.



#### Modified Domestic Refrigerator/Freezers

Some laboratories have existing modified domestic household refrigerators that have had the internal components re-located outside the inner compartment by qualified electricians to make them safe for storage of flammable materials. The National Fire Protection Association (NFPA 45) Standard on Fire Protection for Laboratories Using Chemicals, describes the modification procedure and the proper notices to be used. This practice is not recommended.





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Extreme caution should be exercised because in some cases not all the possible sources of ignition may have been isolated. Using previously modified refrigerators is acceptable if the laboratory inspects them regularly for defects such as frayed wiring. Defective refrigerators should not be used to store flammable materials.

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

#### Laboratory-Safe or Flammable Material Refrigerator/Freezers

Laboratory-safe refrigerators are designed to prevent ignition of flammable vapors or gases that may be present **inside** the refrigerator only. Laboratory-safe or flammable material refrigerator/freezers should be purchased whenever a refrigerator is needed to store flammable liquid.



These refrigerator/freezers are designed to prevent ignition of flammable vapors inside the storage compartment. All the electrical components in this type of refrigerator are located outside the refrigerator, and the compressor is sealed or located at the top of the unit. Flammable material refrigerators also may incorporate design features such as thresholds, self-closing doors, magnetic door gaskets, and special inner shell materials that control or limit the damage should a reaction occur within the storage compartment. The refrigerators must be U.L. Listed as Flammable Material Storage Refrigerators. Ultra low freezers (less than -40°F) generally cannot be approved for storage of flammable materials.

#### Explosion Proof Refrigerator/Freezers

Explosion-proof refrigerators are designed to prevent ignition of flammable vapors or gases that may be present **inside and outside** the refrigerator. This type of refrigerator is used in locations such as solvent dispensing rooms, where a flammable atmosphere may develop at some time in the room. Explosion-proof refrigerators have very limited use and require special hazardous-location wiring rather than the simple plug-in type power cord.



#### References

*International Fire Code*, 2000, Chapter 27, Hazardous Materials – General Provisions, Tables 2703.1.1(1) & 2703.1.1(2).

*Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids*, NFPA 325, National Fire Protection Association.

*Flammable and Combustible Liquids Code*, NFPA 30, National Fire Protection Association.

*Standard on Fire Protection for Laboratories Using Chemicals*, NFPA 45, National Fire Protection Association.