1 Introduction

This document offers a short and concise overview of flammable and combustible liquids. Understanding the following content is a crucial prerequisite in understanding basic safety fundamentals such as 1) hazard awareness, 2) engineering controls, 3) work practices, 4) PPE and 5) emergency response for working with flammable and combustible liquids.

2 Scope

The guideline applies to lab personnel, and it has been developed to assist them in the preparation of lab specific SOPs.

3 Procedure

3.1 Introduction to Flammable and Combustible liquids

To prevent fires in labs, flammable and combustible liquids require special precautions for their storage, handling and use. The National Fire Protection Agency (NFPA) has developed guidelines for the safe storage and use of flammable and combustible liquids in laboratories.

Flammable Liquids:

Flammable liquids are classified as Class I Liquids and are described as any liquid that has a flash point below 100°F (37.8°C). Class I liquids are further classified as follows:

(a) Class IA Liquids — those liquids that have flash points below 73°F (22.8°C) and boiling points below 100°F (37.8°C);
(b) Class IB Liquids — those liquids that have flash points below 73°F (22.8°C) and boiling points at or above 100°F (37.8°C);
(c) Class IC Liquids — those liquids that have flash points at or above 73°F (22.8°C), but below 100°F (37.8°C).

Combustible Liquids:

Combustible liquids are classified as Class II or III Liquids and are described as any liquid that has a flash point at or above 100°F (37.8°C). Combustible liquids are classified as Class II or Class III as follows:

(a) Class II Liquid — any liquid that has a flash point at or above 100°F (37.8°C) and below 140°F (60°C);
(b) Class IIIA — any liquid that has a flash point at or above 140°F (60°C), but below 200°F (93°C);
(c) Class IIIB — any liquid that has a flash point at or above 200°F (93°C).

3.2 Storage Considerations

Flammable or Combustible Liquid Limits ([1]per lab unit):

[1]Per NFPA 45 a lab unit is defined as a separate fire area. For a Class B building a fire area requires a 1 hour rated fire separation. At KAUST an entire lab neighborhood (area), about 10,000 ft² is considered a single lab unit.

Flammable liquid storage limits shall be maintained as low as reasonably achievable. To comply with fire code, flammable liquids shall not exceed a limit of 10 gallons (38 l) per 100 ft² (9.3m²) of lab space. See examples below:

LAB SIZE	MAXIMUM QUANTITY ALLOWED (in storage cabinets, under hoods, in safety cans, service corridor, etc.)
10,000 FT² (929M²)	600 US gallons (2,292 L)
5,000 FT² (557M²)	300 US gallons (1,136 L)
2,000 FT² (186M²)	60 US gallons (227.3 L)

- Flammable liquids shall be stored inside flammable liquid storage cabinets when not in use. No more than 10 US gallons (38 L) flammable liquids should be stored on the open bench.

Quantity Limits Per Container Type:

	Flammability degree F (degree C)		Max. Size per Container Type				Max. QTY
	Flash Point	Boiling Point	Glass	Metal	Plastic	Safety Can*	Flammable Cabinet**
Flammable Liquids							
Class IA	below 73 (23 C)	below 100 (38 C)	1 pint (500 ml)	1 gallon (4 l)	1 gallon (4 l)	2 gallon (8 l)	60 gallon (240 l)
Class IB	below 73 (23 C)	above 100 (38 C)	1 quart (1 liter)	5 gallon (20 l)	5 gallon (20 l)	5 gallon (20 l)	60 gallon (240 l)
Class IC	73 – 100 (23 C – 38 C)	N/A	1 gallon (4 l)	5 gallon (20 l)	5 gallon (20 l)	5 gallon (20 l)	60 gallon (240 l)
Combustible Liquids							
Class II	100 – 140 (38 C – 60 C)	N/A	1 gallon (4 l)	5 gallon (20 l)	5 gallon (20 l)	5 gallon (20 l)	60 gallon (240 l)
Class IIIA	140 – 200	N/A	5 gallon (20 l)	5 gallon (20 l)	5 gallon (20 l)	5 gallon (20 l)	120 gallon (480 l)

	(60 C – 93 C)						
Class IIIB	> 200 (93 C)	N/A	5 gallon (20 l)	5 gallon (20 l)	5 gallon (20 l)	5 gallon (20 l)	N/A

* U.L. Approved
** Max. 3 cabinets per fire area

A fire area is considered a lab area that has a one-hour fire separation rating. A maximum of 10 gallons (40 l) of class I and/or II liquids may be stored in any fire area outside of safety cans.
A maximum of 25 gallons (100 l) of class I and/or II liquids may be stored in any fire area inside of safety cans.

Note: 1 Gallon = 3.79 L

Containers

- Flammable liquids should be used in the smallest practical size container. Larger size (20 l or more) containers should not be poured due to risk of spill. Manual dispensing devices (pumps) designed for use with flammable liquids must be obtained and used.
- Where larger amounts of flammables are unavoidable, they should be stored in approved safety cans. A safety can is designed to safely relieve internal pressure when exposed to fire conditions. They have a spring closing lid and a flashback arrestor.

Flammable Storage Cabinets

- A flammable storage cabinet is designed and constructed to protect the contents from external fires.
- There are limits on the amount of flammable liquids that can be safely stored in cabinets.
- Venting of flammable storage cabinets is not required: the NFPA Technical Committee on General Storage of Flammable Liquids considers that providing vents to storage cabinets reduces the limited fire protection provided by such cabinets because a single walled duct will transmit heat faster than a double-walled cabinet. *Ventilation of storage cabinets is recommended only when highly odoriferous conditions exist.* Ventilation requires a steel duct and an appropriate exhaust fan discharging to an appropriate location outside the building. If you think your flammable cabinet needs to be vented, then contact HSE at hse@kaust.edu.sa for more information.
- Grounding of flammable storage cabinets is not required unless Class 1A flammable liquids are dispensed from them.
- A maximum of three (3) flammable material storage cabinets shall be located within a single fire area.
- Flammable Liquid Storage Cabinets shall NOT be located near exit doorways, stairways, or in a location that would impede egress. See the Service Corridor Usage Guidelines for more information**.**

Refrigerators

- Only refrigerators and freezers approved for flammable storage should be used for the storage of flammable materials. All laboratory refrigerators and freezers must be labeled to indicate whether or not they are suitable for storing flammable liquids.

3.3 Dispensing and Control of Ignition

- Dispensing of Class I liquids to or from containers less than or equal to 5 gallons (20 L) in capacity shall be performed in one of the following locations:
  - In a chemical fume hood or,
  - In an area provided with ventilation adequate to prevent accumulations of flammable vapor/air mixtures from exceeding 25 percent of the lower flammable limit or,
  - Inside a flammable liquid storage room arranged for dispensing Class I flammable liquids.

- Dispensing of Class I liquids to or from containers greater than 5 gallons (20 L) shall be performed in one of the following locations:
  - In a separate area outside the building or,
  - Inside a flammable liquid storage room arranged for dispensing Class I flammable liquids.

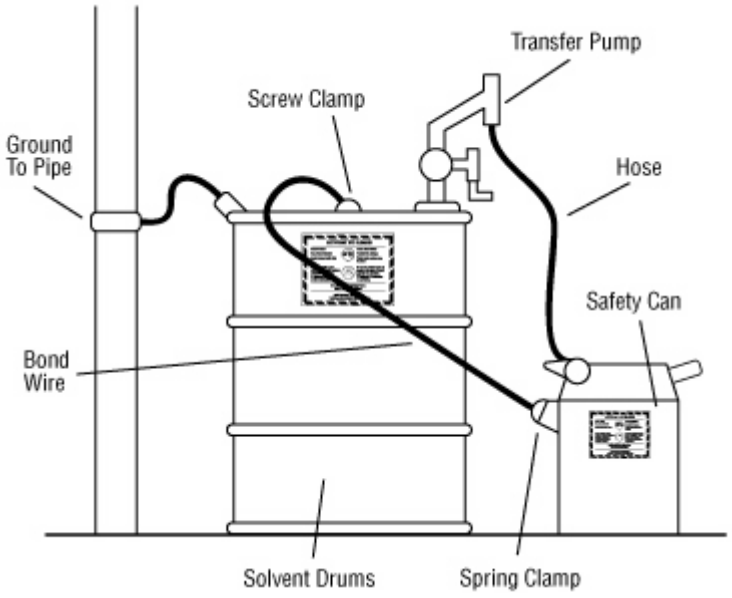
- Class I liquids shall not be transferred between conductive containers of greater than 1.3 gallon (5 L) capacity unless the containers are electrically interconnected by direct bonding or by indirect bonding through a common grounding system.

- The use of squeeze bottles is currently permitted, since their use greatly reduces spills and the small rate of intermittent discharge through a squeeze bottle's discharge tube has not proven to be a hazard.

3.4 Dispensing flammable liquids from 5 gallon pails

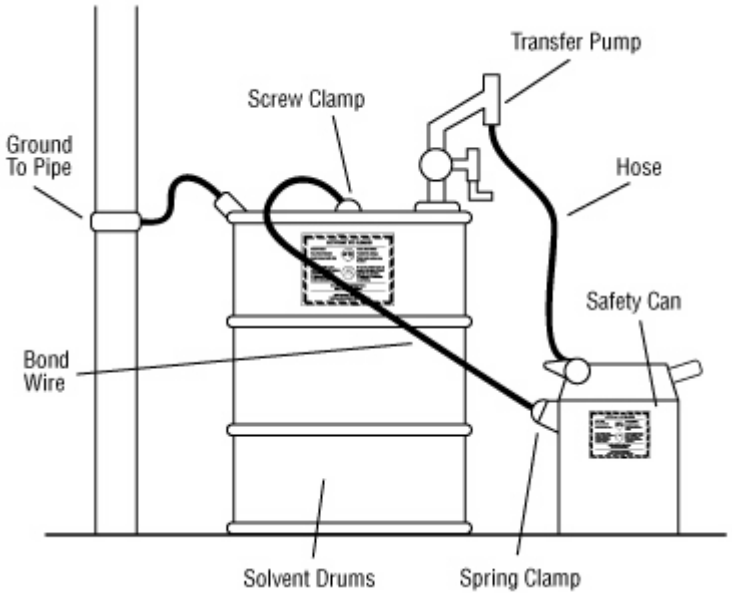
- Manual dispensing pumps for 5-gallon (20 l) pails/cans shall be used; flammable liquids in large size containers should never be poured due to risk of spill.

- The following applies for the dispensing of flammable and combustible liquids from containers greater than 5 gallons (20 L):



3.5 Heating

- Heating equipment or heating baths with flammable liquids or combustible liquids heated to their flash points shall be placed in a chemical fume hood or shall be vented to a safe location to control vapors.
- All unattended electrical heating equipment shall be equipped with a manual reset over-temperature shutoff switch, in addition to normal temperature controls, if overheating could result in a fire or explosion.
- Heating equipment with circulation fans shall be equipped with an interlock arranged to disconnect current to the heating element if the fan fails.
- Electrically heated constant temperature baths shall be equipped with overtemperature shutoff switches in addition to normal temperature controls, if overheating could result in a fire or an explosion.
- Bath containers shall be of noncombustible materials.
- Burners, induction heaters, ovens, furnaces, and other heat-producing equipment shall be located a safe distance from areas where temperature-sensitive and flammable materials and compressed gases are handled.
- Flammable chemicals should be used in chemical fume hoods to prevent the accumulation of flammable concentration of vapors.
- Control all ignition sources in areas where flammable liquids are used. Do not use Bunsen burners or other open flames to heat flammable liquids. Steam baths, oil baths, heating mantles and hot air or nitrogen baths are preferred.
- Some electrical equipment including switches, stirrers, motors and relays can produce sparks and ignite vapors. Use equipment with spark-free, intrinsically safe induction motors or air motors to avoid producing sparks. Many stirrers, Variacs, outlet strips, ovens, heat tape, hot plates and heat guns do NOT conform to these requirements.



3.6 Personal Protective Equipment

- Safety goggles preferred, safety glasses acceptable, gloves, long sleeved lab coat, closed toe shoes

3.7 Disposal

- Flammable or combustible liquids should not be allowed down the sink or drain.
- Collect as hazardous waste following KAUST hazardous waste disposal procedure.

4 References

- OSHA 3404-11R (2011) – Laboratory Safety Guidance
- KAUST Laboratory Safety Manual
- HSE-RST-Chem001M – Chemical Safety Program

5 Help

Questions about this guideline? Contact: hse@kaust.edu.sa