

Laboratory Safety Manual

Section 6 Fire Safety

INTRODUCTION

PURPOSE

Both flammable and combustible materials are commonplace in most Duke Laboratories. For this reason, all laboratory employees should be aware of the risks in their work spaces and understand how to respond appropriately should a fire occur. Employees who take the time to familiarize themselves with the location of safety devices (i.e., fire extinguishers, pull alarms, safety showers, fire blankets, etc.) and proper route of egress before an accident occurs are more likely to respond to an emergency situation in a calm and efficient manner.

Duke employees are encouraged to implement the RACE acronym in the case of a fire. RACE is defined as the following:

Remove all individuals from the affected area

Activate the pull alarm and dial 911

Close all doors and windows

Extinguish the fire

OESO Fire Safety Division uses the recommendations contained in the National Fire Protection Association (NFPA) Codes as minimum guidelines to acceptable practices. A number of the NFPA Codes have been incorporated into the Occupational Safety and Health Act (OSHA) Standards and the North Carolina State Building Code. Questions regarding the applicability of specific NFPA Codes should be directed to the OESO Fire Safety Division (919-684-5609).

The basic standards for the storage and use of flammable and combustible liquids applicable to laboratory operations listed here are by no means comprehensive but represent those cited most frequently during laboratory audits and building inspections.

Defining Flammable and Combustible Materials

Combustible Liquids

The National Fire Protection Association (NFPA) and North Carolina Building Code (Fire Code) define combustible liquids as any liquid having a flash point at or above 100°F. Combustible liquids are divided into subclasses as follows:

Class	Flashpoint (Closed Cup)
II	At or above 100 but below 140°F.
IIIA	At or above 140 but below 200°F.
IIIB	At or above 200°F.

Flammable Liquids

The National Fire Protection Association and North Carolina Building Code define flammable liquids as any liquid having a flash point below 100°F and having a vapor pressure exceeding 2068.6 mm Hg (40 psia) at 100°F. Flammable liquids are also known as Class I liquids and are divided into subclasses as follows:

Class	Flashpoint (Closed Cup)	Boiling Point
IA	Below 73°F.	Below 100°F.
IB	Below 73°F.	100°F or above.
IC	73-99°F.	

List of Flammable Liquids by NFPA Classification

The following list of flammable and combustible liquids was developed to assist users in the proper classification and storage of flammable and combustible liquids in the laboratory. This information is meant to be an illustrative list of common flammable and combustible liquids. If you are unsure of the material classification of materials you are working with, contact Duke OESO Fire Safety Division (919-684-5609).

Class IA Flammable Liquids (Flash point at or below 73 F, boiling point at or below 100 F)		
1-1 Dichloroethylene	Ethyl Chloride	Pentane
Acetaldehyde	Isopentane	Petroleum Ether
Collodion	Isopropyl Chloride	Propylene Oxide
Ethylamine	Methyl Ethyl Ether	
Ethyl Ether	Methyl Formate	

Class IB Flammable Liquids (Flash point below 73 F, boiling point at or below 100 F)		
Acetone	Gasoline	Octane
Benzene	Hexane	Propyl Acetate
Butyl Alcohol	Methyl Acetate	Isopropyl Acetate
Carbon Disulfide	Methyl Alcohol	Isopropyl Alcohol
1,2-Dichloroethylene	Methylcyclohexan	Toluene
Ethyl Acetate	Methyl Ethyl Ketone	Butyl Acetate
Ethyl Alcohol	Methyl Propyl Ketone	
Ethyl Benzene	VM&P Naphtha	

Class IC Flammable Liquids (Flash point at or below 73 F, boiling point at or below 100 F)		
Amyl Acetate	Isopropanol	Styrene (Monomer)
Amyl Alcohol	Methyl Alcohol	Turpentine
Butyl	Methyl Isobutyl Ketone	Xylene
Dibutyl Ether	Naptha	
Isoamyyyl Acetate	Propyl Alcohol	

Class II Combustible Liquids (Flash point at or above 100 F, and below 140 F)		
Acetic Acid	Hydrazine	Methyl Lactate
Camphor Oil	Kerosene	Mineral Spirits
Cellosolve Acetate	Naptha (coal tar)	Varsol
Cyclohexane	Naptha (high flash)	
Fuel Oil #1, 2, 4 & 5	Methyl Cellosolve	

Class III A Combustible Liquids (Flash point at or above 140 F, and below 200 F)		
Aniline	Formic Acid	Isophorone
Butyl Cellosolve	Furfural	Nitrobenzene
Carbolic Acid	Furfuryl Alcohol	Phenol
Cyclohexanol	Naphthalenes	Pine Oil

Class III B Combustible Liquids (Flash point at or above 140 F, and below 200 F)		
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Cellosolve Solvent	Formalin	Picric Acid
Ethylene Glycol	Glycerin	

In keeping with the United Nations' Globally Harmonized System for Classification and Labeling of Chemicals (GHS), The Occupational Safety and Health Administration defines Flammable Liquids in 4 categories:

Category	Criteria
1	Flash point <23 °C (73.4 °F) and initial boiling point ≤35 °C (95 °F).
2	Flash point <23 °C (73.4 °F) and initial boiling point >35 °C (95 °F).
3	Flash point ≥23 °C (73.4 °F) and ≤60 °C (140 °F).
4	Flash point >60 °C (140 °F) and ≤93 °C (199.4 °F).

Flammable Solids

OSHA defines flammable solids as powdered, granular, or pasty chemicals which are dangerous if they can be easily ignited by brief contact with an ignition source, such as a burning match, and if the flame spreads rapidly, or which may cause or contribute to fire through friction. Flammable solids include materials which, in contact with water, emit flammable gases.

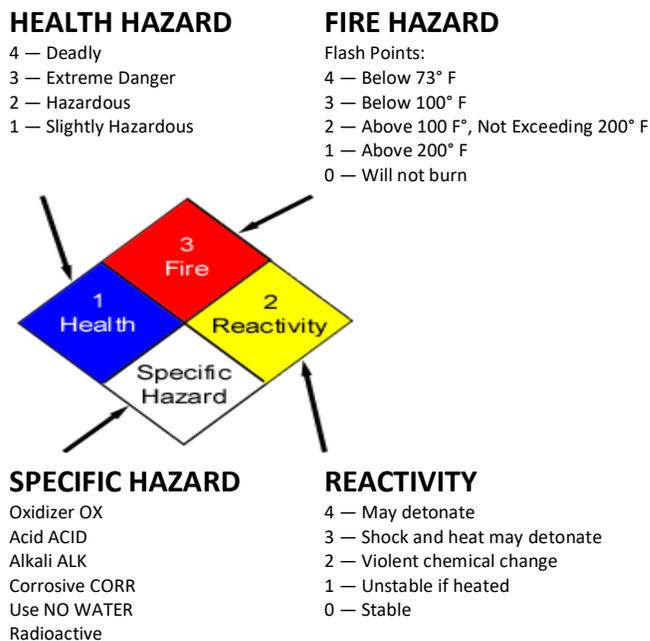
Flammable Gas

OSHA defines a flammable gas as a gas having a flammable range with air at a temperature of 20°C (68°F) and a standard pressure of 101.3 kPa (14.7 psi).

National Fire Protection Association (NFPA) System for Classification of Hazards

The NFPA diamond is a symbol used to identify the hazards associated with a given chemical to rescue workers. Frequently this symbol is found on the sides of buildings where chemicals are stored and on chemical containers. Below are shown the various hazards symbolized by the diamond and the numerical code which indicates the severity of the hazard. Class IA & IB flammable liquids have an NFPA Fire Hazard rating of 4. Class IC flammable liquids are rated as 3. Combustible liquids are rated as 1, or 2.

In this labeling system, the number 4 is associated with higher hazards, and the numbers 1 and 0 with lower hazards. (This is the opposite order from the GHS Hazard Categories.)



Globally Harmonized System (GHS) Classification and Labeling

The OSHA Hazard Communication Standard, based on the United Nations’ Globally Harmonized System for Classification and Labeling of Chemicals (GHS), requires labeling using signal words, hazard statements, pictograms, and precautionary statements. Some of the required label elements for flammable liquids are shown below:

	Category 1	Category 2	Category 3	Category 4
Pictogram				<i>(None)</i>
Signal Word	Danger	Danger	Warning	Warning
Hazard Statement	Extremely flammable liquid and vapor	Highly flammable liquid and vapor	Flammable liquid and vapor	Combustible liquid

In this labeling system, the number 1 is associated with higher hazards, and the number 4 with lower hazards. (This the opposite order from the NFPA ratings.)

SAFE STORAGE AND HANDLING OF FLAMMABLE CHEMICALS

The laboratory's chemical hygiene plan should contain written standard operating procedures for those chemicals that pose a fire risk in the laboratory. Safety data sheets (SDSs) are available from the manufacturer or through OESO's website. OESO may be consulted on safety practices for particular chemicals.

Safe storage and handling practices for flammable chemicals are detailed below. See also the [Hazardous Materials Policy](#) in the University Safety Manual, [Section 3 - Chemical Safety](#) in this Laboratory Safety Manual, and the [OESO Guidelines for Flammable Liquids](#).

Storage:

Flammable chemicals must be stored in appropriate areas within the laboratory and away from any potentially incompatible materials.

Storage of Flammable Liquids in Flammable Storage Cabinets

The total stored volume of flammable liquids in approved storage cabinets shall not exceed 20 gallons per one hundred square feet with a maximum of 10 gallons per one hundred square feet being Class I liquid, as defined by the North Carolina Fire Code. All storage cabinets for flammable liquids shall meet NFPA 30 requirements. Not more than 60 gallons of flammable liquids may be stored in any single storage cabinet.

Storage of Flammable Liquids Outside of Flammable Storage Cabinets

The total capacity of flammable liquids not currently in use outside an approved storage cabinet shall not exceed 10 gallons per laboratory. A laboratory is defined as a room, or suite of rooms, separated from adjacent areas by walls and doors having at least a one hour fire rating. In regards to flammable liquid storage only, OESO Fire Safety does not limit or define the square footage of a laboratory. A Fire Safety Specialist may provide further guidance to the laboratory if the 10 gallon storage limit is exceeded. Chemical containers that are not actively being used must not be stored in the work area of chemical fume hoods. Too much clutter can disrupt air-flow patterns and potentially compromise worker protection.

Storage of Flammable Liquids in Refrigerators and Freezers

Class I flammable liquids as defined by the North Carolina Fire Code shall not be stored in unapproved or residential-type refrigerators. Storage of flammable liquids in well-sealed containers is permissible in listed flammable storage refrigerators labeled to indicate that they are approved for storing flammable liquids. See Supplement C "Storage of Flammable Chemicals in Refrigerators" for additional information.

Per enforcement directive from the City of Durham Fire Marshal, all laboratory refrigerators and freezers must be labeled to indicate whether or not they are suitable for storing flammable liquids.

Refrigerators and freezers utilized throughout the University, Hospital, and Medical Center generally fall within the following three categories:

1. Those designed to store flammable liquids with all electrical equipment that meets Class I, Division I requirements.
2. Those that have been modified by a licensed electrician to meet the Class I, Division I requirements.
3. Those “residential-type” refrigerators that cannot be utilized to store flammable liquids, but are used to store other chemicals or laboratory reagents.

Those refrigerators and freezers which fall into either category 1 or 2 will require a blue and white label which states that the device is approved for flammable storage. Those which fall into category 3 will require a red and white label be affixed which states that the appliance is not approved for flammable storage.

To request aid in identifying the category in which an appliance falls, contact the OESO Fire Safety Division at 919-684-5609.

Handling and Use:

Purchases of flammable chemicals should be kept to a minimum.

All sources of ignition (e.g., Bunsen burners, hot plates, and electrical equipment) must be eliminated from areas in which flammable or combustible chemicals are used.

Use the chemical fume hood to capture vapors when appreciable quantities of flammable substances are being used.

Keep containers of flammable chemicals closed at all times when not in use.

Classes of Fires

Class A fires are those which involve ordinary combustible materials such as wood, paper or cloth. These fires should be extinguished by using a dry chemical extinguisher. Water is effective in extinguishing these type fires, however, water extinguishers are rarely found in the Medical Center.

Class B fires are those which involve flammable liquids, gases, oil, paint and greases. Either dry chemical or carbon dioxide extinguishers should be used to extinguish these type fires. Note: flammable liquids may re-ignite after being extinguished. **DO NOT USE WATER!**

Class C fires are those which involve electricity. Either dry chemical or carbon dioxide extinguishers should be used to extinguish these type fires. **DO NOT USE WATER!**

Class D fires are those which involve combustible metals such as magnesium or sodium. Water can react with sodium and other alkali metals explosively, therefore **DO NOT USE WATER!** Also understand that CO₂ extinguishers are unlikely to be able to contain a Class D fire.

Fire Extinguishers

There are three basic types of portable fire extinguishers found throughout the Medical Center and University. These include dry chemical, carbon dioxide and halotron extinguishers. These devices are to be used to extinguish small or beginning fires. Any employee wishing to operate an extinguisher should contact the OESO Fire Safety Division at 919-684-5609.

CO 2 Fire Extinguishers

The carbon dioxide extinguisher is rated to extinguish Class B and C fires. The carbon dioxide is in the extinguisher as a liquid under pressure, and is discharged as a gas. Extinguishing is accomplished by removing the oxygen from the fire. Carbon dioxide is a “clean” agent which will evaporate and leave no residue.

Dry Chemical Extinguishers

Dry chemical extinguishers are intended for use on Class A, B or C fires. Best results are obtained by attacking the near edge of the fire and progressing forward, moving the nozzle rapidly with a side-to-side sweeping motion. Discharge should be continued after flames are extinguished (especially on Class A fires) to prevent possible re-ignition.

Halotron Extinguishers

Halotron is a clean fire extinguishing agent which is a safe and environmentally acceptable replacement for halon 1211. Halotron, which is discharged as a liquid which rapidly evaporates, will be used throughout many patient care areas.

Class D Fire Extinguishers

These types of fire extinguishers are rarely used in the Medical Center and University. Laboratories using potentially flammable metals should contact the Fire Safety Division at 919-684-5609 for information about getting a Class D extinguisher. Extinguishers for Class D fires must match the type of metal that is burning. Usually a list of metals for which the extinguisher is appropriate is shown on the extinguisher’s labeling. [*Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards*](#) recommends the use of Met-L-X or Met-L-Kyl extinguishers.

All employees should be familiar with the location of extinguishers in his or her work area. In order to operate an extinguisher appropriately, one must implement the PASS acronym which stands for:

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- P**—Pull the pin
 - A**—Aim the nozzle at the base of a fire
 - S**—Squeeze the handle
 - S**—Sweep the base of the fire
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Fire Drills

Fire drills are conducted in all University, Hospital and Medical Center buildings by OESO Fire Safety on a routine basis. If your laboratory hasn't participated in a complete evacuation drill in the past year, contact Fire Safety at 919-684-5609 to schedule a drill in your area.

Site-Specific Fire Plan

Your Site-Specific Fire Plan (SSFP) consists of two parts. Part I contains information specific to your work area. To access this document, click on the link below and select your organization and your specific work area. Print this document, have the manager/supervisor sign it, and store it in your work area as the cover page for Part II of the SSFP.

Note: The prefix on the document title is your fire zone.

Part I: <http://www.safety.duke.edu/fire-life-safety/site-specific-fire-plans>

Part II: Contains generic information that applies to all Duke Facilities. Print this document and store it in your work area with Part I of the SSFP.

[Duke Hospital, Duke Eye Center, Radiology, MRI, Children's Health Center](#)

[Cancer Center](#)

[Duke Clinic](#)

[University Buildings/Medical Center Buildings](#)

[Duke Medicine Pavilion](#)

If your department/work area is located in more than one fire zone, be sure to print a copy of Part I and Part II for each zone. You will not need to return a copy of the signature page of the SSFP to OESO Fire Safety Division - signatures are to be retained by the department/work area. If you need assistance in locating your SSFP, please contact OESO Fire Safety Division (919-684-5609)

REFERENCES

Occupational Safety and Health Standards, Fire Protection; 29 CFR 1910 Subpart L
North Carolina Building Code, Volume V, Fire Prevention
National Fire Protection Association (NFPA) Standards