S. A. Abou Baker / ICEHM2000, Cairo University, Egypt, September, 2000, page 420- 441

FIRE HAZARDS CAUSED BY Flammable and COMBUSTIBLE MATERIALS

Safia Ahmed Abou Baker
Faculty of Commerce - Assiut University
Department of Mathematics, Statistics and Insurance

The most common hazard that surrounds us, whether at work or at home, is the presence of combustible materials that can be ignited, leading to a fire. However, if proper control methods are applied, the risk of injury, illness, and property damage can be reduced to an acceptable level.

The aim of this paper is to minimize the risk from fire caused by flammable and combustible materials through Risk Reduction Programs. In order to do that this paper has been divided into the following sections:

Section (I) Introduction
Section (2) Overview of Regulations.
Section (3) Risk Reduction Programs.
Section (4) Recommendations.

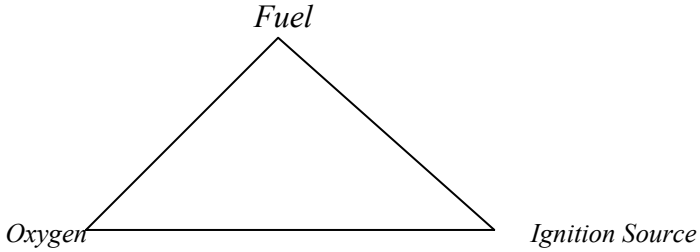
SECTION (1) INTRODUCTION:

School art classrooms, conservation laboratories, art studios, … ect., stocked with flammable and combustible liquids, gases and solids, contain all the elements of a potential fire.

The fire traingle[1]:

For a fire to start, three conditions must be met at the same time. There must be something to burn (a fuel), a source of oxygen (an oxidizer), sufficient energy to start a chain reaction (an ignition source). These three necessary factors are each at the concerns of an equilateral traingle, the fire traingle, whose overlap is a chain reaction that results in the rapid oxidation of a fuel (fire). The fire traingle is illustrated in figure (1) as follows.

figure (1)
The Fire Traingle



Fuels: Fuels are materials that burn, the higher the tempreture, the easier and quicker they burn. Common fuels include: *solvents*, such as acetone, alcohols and toluene, *gases*, like acetyene and propane, and *solids,* such as wood, paper and ordinary trash.

Oxidizers: The second leg of the fire traingle is the oxidizer. Although ordinary air is 80% non-burning nitrigen, the remaining 20% is oxygen, and is more than enough to support combustion. Some materials release oxygen when they burn. These substances, called "*oxidizers*" or " *oxidizing agents*" are capable of releasing oxygen to a potential fire. Common oxidizers include acids, specially nitric and perchoric acids, chlorine dioxide, and other oxidizing agents such as potassium permanganate and potassium chlorate. These oxidizers must be stored away from all flammable materials.

Source of Ignition: The final leg of the fire traingle, is the ignition source. An ignition source can be a lit cigarette, a spark, static electricity, arcs from faulty electrical equipment, a hot plate, a projector, or even a hot light bulb. The hot surface of a drying oven or heating until may also be at a high enough temperature to serve as an ignition sources.

Combination of a fuel and a source of oxygen, along with a source of ignition can result in a fire.

Fire Propagation: Recent studies inicate that propagation or spread of a fire is dependent on a fourth factor (*chemical chain*) reactions of free radicals produced by heat. So the fire traingle actually would be better described as a fire tetrahedron of fuel, oxidizer, source of ignition and uninhibited chain reactions.

Flammable and Combustible Materials[2]:

Flammable and combustible materials are liquids that can burn. They are classified, or grouped as either flammable or combustible, by their flashpoints. Generally speaking, flammable liquids will ignite (catch on fire) and burn easily usually at normal working temperatures. Combustibale liquids have the ability to burn at tempretures that are usually above working temperatures. There are several specific technical criteria and test methods for identifying flammable and combustible liquids.

In general the are three classess of combusitble matrials:

1. **Ordinary solid**, e.g. wood, paper, rags, and plastics.
2. **Fluids**, e.g. liquid and gaseous fuels. Liquids are futher divided into the following classifications:

    - Class **lA** liquids have a flash point of less than 73 ^{o}F (22.8 C^{o}) and a boiling point of less than 100 ^{o}F (37.8 ^{o}C).
    - Class **lB** liquids have a flash point of less than 73 ^{o}F (22.8 C^{o}) and a boiling point 100 ^{o}F (37.8 ^{o}C) or greater.
    - Class **lC** liquids have a flash point of less than 73 ^{o}F (22.8 C^{o}) or greater but less than 100 ^{o}F (37.8 ^{o}C).
    - Class **ll** liquids have a flash point of 100 ^{o}F (37.8 ^{o}C) or greater but less than 140 ^{o}F (60 ^{o}C).
    - Class **lll** liquids have a flash point of 140 ^{o}F (60 ^{o}C) or greater.

3. **Other**, e.g. oxidizing chemicals fast-reacting or explosive materials, and combustible metals. Undesirable reactions from these materials can be surprisingly fast and can easily cause secondary fires

Hazardous Materials[3]:
Classes of hazardous materials areas follows:

Class 1: Explosives
Class 2: Gasses
Class 3: Flammable and Combustible liquids
Class 4: Flammable Solids
Class 5: Oxidizers and orgnic peroxides
Class 6: Poisons
Class 7: Radioactive materials: A material, liquid or solid, that causes visible destruction or irreversible alteration to human skin or a liquid that has a sever corrosion rate on steel or aluminum.
Class 9: Miscellaneous: A material which presents a hazard during transport, but which is not included in any other hazard class (such as hazardous substance or a hazardohs waste).

ORM-D: Other regulated material: A material which, although otherwise subjected to regulations, presents a limited hazard during transportation due to its form, quantity and packaging.

Types of fires:

There are four basic types of fires:
Class A Fires (common solids): The most common fire, called *class A*, involves burning wood, paper or trash. These fires start everyday and have the ability to spread rapidly to other materials. Waste paper, piles of old newspapers are a frequent fuels for class A fires. Water is an excellent extinguishing agent for class A fires.

Class B Fires (flammable liquids): Class B fires involve flammable and combsutible liquids. Burining liquids can flow rapidly and can spread a fire. Water will usually not extinguish this type of fire. The burning liquid, will float and spread the fire further.

Class C Fires (electrical equipment): Fires in energized electrical equipment, called *class C,* are especially dangerous for firefighters. In addition to the danters associated with the fire, the potential for eletrocution exists. Never attempt to put out a class C fire with water, unless the electrical connection has been severed.

Class D Fires (burning metals): Burning metals, called *phrophoric metals,* such as megnesium and sodium are the toughest to put out, and are called *class D.* By their very nature, they are unresponsive to convential fire extinguishers. Special extinguishing agents must be used or the fire may be smothered with dry sand.

There are many world-wide organizations provide research and studies on health and safety of fire. These are[4]:

Rutal/Metro of Tennessee, handles medical and fire emergency in Knox County. *Int's Association of Fire Fighters*, AFL-CIO affiliate covering US and Canda provides legislative news, health and safety information, and a list of regional organizations committees. *Levitt Safety,* canadian company distributes, rents, and services health and fire safety equipment. *MSDS_Search 2000,* provides Material Safety Data Sheet with information that covers hazardous ingredients, health effects, fire data and first aid procedures. *Safety & Occupational Health*, describes general government policies and speech on safety, occupational health, fire and emergency services, and radiation. *University of Oklahoma Health Science Center-Police*, Department of Police and Public Safety offers safety tips, crime anaylsis, personnel details, and emergency procedures for bombs or fires. *Fire Department of New Yourk-Health Safety*, offers basic first-aid brochures, bicycle safety and emergency medical service details. *National Institute for Occupational Safety and Health* (*NIOSH)*, provids services, publications, research, news, job vacancies, and directory. *NYC-GOV- The Official New York City Web Site*, provides message from the mayor, city agencies, business publications and directory, local news, and attractions. *U of M Environmental Health and Safety*, University of Minnesota department which provides information about safety issues concerning products such as asbesos, chemicals, and industrial waste. *World Safety. Com Link and Resource Center,* provides links to more than 4000 safety, envieonmental, and fire protection sites. *OSU Environmental Health and Safety*, these are: OSU Environmental Health and Safety, Departments Asbestos Emergency Response & Fire/Safety Maintenance, Hazard Communication, Hazardous Materials, Inspections Safety, Training Safety, and Training information Video. *Environmental Health and Safety Department*, these are: ALERT EHSD Vision/Mission, SEARCh Photogallery Employment, CSHEMA 2001 Map of the parking lot. Agricultural Safety, FAQ's Audio Visual Library Biological Safety Accident/Injury Asbestos Awarnes. *Envorinmental Health and Safety Department , University of Utah*, these are: Environmental Health and Safety, Occupational Health & Hygiene, Chemical and Biological Inventory, Chemical Hygene, Laboratory Inspection Biological Safety Fire and Safety Alert Compresed Gas. *CCOHS Health & Safety Internet Directory*, Canadian Center for Occupationa Health and Safety provides a compendium of links on this subject.

In order to fulfill the purposes of this paper we will illustrate how fires start, and methods for their prevention. Two programs, LLNL Programs as example of Health & Safety of fire, and Personnel Assurance Program (PAP) as example of Health & Safety of explosion, will be explained.

SECTION (2): OVERVIEW OF REGULATIONS:

Regulations:

For transportation regulation purpose, the U.S. Department of Transportation classifies all liquids with a flash point below 100 ^{o}F as *FLAMMABLE*, and all liquids with flash points at or above 100 ^{o}F as *COMBUSTIBLE.* For storage regulation purposes, the National Fire Protection Association (NFPA) has further subdivided falmmable liquids into Classes IA, IB, and IC, and combustible liquids into Classes II, IIIA and IIIB.

Material Safety Data Sheet (MSDS)[5]:

MSDS is a document that contains information on the potential health effects of exposure and how to work safely with the chemical product. It is an essential starting point of the development of a complete health and safety program. It contains hazard evaluations on the use, storage, handling and emergency procedures all related to the material. The MSDS contains much more information about the material than the label and it is prepared by the supplier. It is intended to tell what the hazards of the product are, how to use the product safely, what to expect if the recommendations are not followed, what to do if accidents occur, how to regonize symptoms of overexposure, and what to do if such incidents occur. The Controlled Products Regulations (CPR) prescribe what information must be present in detail.

In Canda, every material the is controlled by Workplace Hazardous Materials Information System (WHMIS) must have an accompanying MSDS theat is specific to each individual product or material (both the product name and supplier on the MSDS must match the material in use).

There are 9 categories of information that must be present on an MSDS in Canada, these categories are specified in the Controlled Products Regulations and include:

1. Product information: product identifier (name), manufacture and suppliers names, addresses, and emergency phone numbers.
2. Hazardous Ingredients
3. Physical Data
4. Fire or Explosion Data
5. Reactivity Data: information on the chemical istability of a product and the substances it may react with
6. Toxicological Properties: health effects
7. Preventative Measures
8. First Aid Measures
9. Preparation information: who is responsible for prepatation and data of preparation of MSDS

The employers must make sure that all controlled products have an up-to-date (less than three years old) MSDS when it enters the workplace.the MSDSs must be readily avaialble to the workers who are exposed to the controlled product and to the health and safety committee or representative. If a controlled product is made in the workplace, the employer has a duty to make an MSDS for any of these products

Applicability:

The regualtion requirements and guidance is apply to all work processes, including those performed by subcontractors, gustes, visitors, and construction or labor contractors.

SECTION (3):
RISK REDUCTION:

Fire and Explosion hazards caused by flammable and combustible liquids:

At normal room temperatures, flammable liquids can give off enough vapour to form burnable mixtures with air. As a result, they can be a serious fire hazard. Flammable liquids fires burn bery fast. They also give off a lot of heat and often clouds of thick, black, toxic smoke.

Combustible liquids at temperatures above their flashpoint also release enough vapour to form burnable mixtures with air. Hot combustible liquids can be as serious a fire hazard as flammable liquids.

Spray mists of flammable and combustible liquids in air may burn at any temperature if an ignition source is present. The vapours of flammable and combustible liquids are usually invisible. They can be hard to detect unless special instruments are used.

Most flammable and combustible liquids flow easily. A small spill can cover a large area of workplace or floor. Burning liquids can flow under doors, down stairs and even into neighbouring buildings, spreading fire widely. Materials like wood, caboard and cloth can easily absorb flammable and combustible liquids. Even after a spill has been cleaned up, a dangerous amount of liquid could still remain in surrounding materials or clothing, giving off hazardous vapours.
The most obvious harm be the danger of a fire or explosion. After the immediate danger of a fire, there are sometimes other properties of these liquids that may be hazardous to the body. Falmmable and combustible liquids can also be cause health problems depending on the specific material and route of exposure (breathing the vapour/mist, eye or skin contact, or swallowing). Some flammable and combustible liqiuds are corrosive. Many undergo dangerous chemical reactions if they contact incompatible chemicals such as oxidizing materials, or if they are store improperly. The MSDS and suppliers labels on the containers should tell one about all the hazards for the flammable and combustible liquids that he works with.

In some cases fire can be prevented by displacing the air with a non-burning atmosfere, like helium, argon or pure nitrogen. Fire prevention consits of making sure that the three legs of the fire traingle never met. Since it is impossible to eliminate oxygen from the fire traingle, fire prevention depends on trying to eliminate sources of ignition and restricting the amount of flammable and combustible liquids.

Fire Risk Mitigation Methods:

Some simple rules that should always be followed to eliminate sources of ignition include:

- Smoking must be prohibited in all laboratory areas,
- All electrical equipment in vetilated hoods and spray booths must be explosion-proof and well maintained,

- Intense sources of lights, such as projectors and lasers, should be kept away from flammable materials.

Storage: Some of the major way to reduce fire hazards in the storage of flammable and combustible liquid are:

- Choosing the least hazardous materials possible,
- Reducing the amounts stored to a minimum, and,
- Using safe storage procedures and containers.

Labeling: Save storage of flammable materials requirs that the materials be adequately labeled as to their contents, fire hazards, and safe handling procedures. Flammable liquids should carry the following label:
"DANGER – FLAMMABLE – KEEP AWAY FROM HEAT, SPARKS AND OPEN FLAMS, KEEP CLOSED WHEN NOT IN USE.

Information perlinent to preventing and extinguishing fires is contained in section V of the product's Materials Safety Data Sheet (MSDS). This section contains the material's flash point and flammability rang, as well as the proper fire fighting equipment to use in the event of fire. This data and the information about the product's pysical properties contained in section IV are valuable for proper labeling and comparing product's flammability and choosing less hazardous materials.

Another method of labeling is the NEPA system of hazard identification. This is a symbol hazard system intended for use on fixed locations, such as laboratory enterances, storage rooms, etc. It tells a firefighter or other person of the hazards in the area. This NEPA system uses the "NEPA diamond" as the symbol. The number 0 to 4 are placed in the three upper quadrants of the diamond. These represent the degree of of hazard for health hazard, flammability, and reactivity. The number 0 indicates the less degree of hazard, and 4 the highest. The bottom quadrant is often used for the rediation hazard symbol or water reactivity(a letterW with bar through it).

Storage amount: There are fire codes limit the amounts of flammable and combustible liquids that can be stored in various locations.

Residentail buildings with not more than three dwelling units are allowed to store a maximum of 25 gallons of Class I and II liquids. In apartment buildings with more than three dwelling units, the maximum storage outside a flammable storage cabinet or approved storage room is 10 gallons of Class I and II liquids.

Building of public assembly, such as museums or schools, a maximum of 10 gallons of Class I and II liquids may be stored in a single fire area. A maxium of 25 gallons of Class I and II liquids may be stored in safety cans outside a special storage room or flammable storage cabinet. More than 60 gallons of Class IIIA liquids must be stored in a flammable storage cabinet or special storage room., more than 60 gallons is not allowed in residences with three or more dwelling units.

Storage Areas: The best location to store large amount of flammable and combustible liquids is in a separate outside building. If this is not possible, then a suitable flammable storage cabinet or inside storage rooms should be built. NEPA Flammable and Combustible Liquids Code, describes the requirements for inside

storage rooms. These can include walls, floor and ceilling with a fire resistance rating of 2 hours, Class B fire doors, automatic fire protection systems, and mechanical ventilation, depending on the amount stored.

Storage Containers: All containers of flammable and combustible liquids must be stored in accordance with established safety procedures that isolated incompatible materials from each other. In addition the amounts stored should be kept to a minimum to reduce the risk of fire.

Portable Safety cans: Quantities of flammable liquids exceeding one pint should be stored in safety cans that are approved or listed by recognized testing laboratories. These have self-closing covers, flame arrestor screens, and pressure release devices. Similar containers are used for storage of waste solvents.

Drums: Liquids often come in 5-gallon and 55-gallon drums. The maximum size of drum that should be stored is 5 gallons, 55 gallon drums should only be stored in a separate area away from heat and sunlight.

Flammable Storage Cabinet: If the amounts of flammable and combustible liquids present are too small to warrant a separate storage room, they should be stored in a flammable storage cabinet that has been built to meet OSHA and NPEA standards. Cabinets should be labeled in large letters FLAMMABLE – KEEP FIRE AWAY. A maximum of 120 gallons of Class I, II and IIIA liquids may be stored in a flammable storage cabinet, of these total, not more than 60 gallons may be of Classes I and II. A maximum of not more than three such cabinets may be located in a given fire area.

Dispensing: Many fires are started by the improper dispensig of flammable liquids. The pouring and mixing of flammable mateials should be restricted to a special well ventilated area. When dispensing from drums, use approved transfer pumps or drum faucets. When pouring flammable liquids from a drum to a metal container, ground the drum and bond the metal container to the drum to prevent the build-up of any static charge. This bonding is done with a braided wire with large metal clips to connect the drum and container, and a grounding line from the drum to a ground.

Spills and leakas: Flammable liquid spills can be reduced, and in some cases eliminated, by proper training and good housekeeping tecniques, should a spill occur, it must be quickly and safety cleaned up to prevent its flammable vapors form igniting. A metal container should be used to contain the absorbed flammable material, and disposed of separately from the regular trash, perferably wrapped in a separate plastic bag.

Fire Fighting:

If we do not succeed in preventing a fire, then we have to extinguish it. The timely use of the proper fire extinguisher will slow a fire, and give professional fire fighrters time to arrive. There is a wide varitety of fire extiguishers, each designed to fight a particular type of fire. The use of the wrong fire extinguisher will prove ineffective on a fire, and may even spread the fire.

LLNL Fire Risk Reduction Programs[6]:

To minimize the risk of fire, LLNL maintans an improved level of fire protection and a reduced level of risk by:

- Designing facilities using fire-resistant materials or those of limited combustibility.
- Using building materials and components that have tested and approved by a nationally recognized testing laboratory (NRTL), when applicable.
- Providing and maintaing adequate corridors, exits, and fire barries (including door assemblies, dampers, and windows).
- Controlling the presence and use of ignition sources and combusttibles within each facility.
- Conducting periodic inseptions, tests, and maintenance of fire hazards and areas are not sufficiently protected.
- Conducting periodic insepections, tests, and maintenance of fire and life safety equipment and systems to ensure that they operate properly.

Safe Handling of Liquid Combustibles:

- Obtain a material safety data sheet (MSDS) for any combustible of flammable liquid from the supplier of the chemical or product or from Chem Track. An MSDS can be obtained by accessing the Chem Track Website, or by contacting the Chem Track/MSDS hotline, or emailing tne MSDS Coordinator.
- Use safely cans to store flammable and combustiable liquids that are to be dispensed. The following table (1) indicate maximum sizes of containers for combustible and falmmable liquids.

Table (1)
Maxium sizes of containers for combustible and flammable liquid

Container type*	Flammable liquids			Combustible liquid	
	Class **LA**	Class** **lB**	Class **lC**	Class **ll**	Class **lll**
Glass	1 pt	1 pt	1 gal	1 gal	5 gal
Metals (other than DOT drums) Or approved plastic	1 gal	5 gal	5 gal	5 gal	5 gal
Safety cans	2 gal	5 gal	5 gal	5 gal	5 gal
Metal drums (DOT specification)	60 gal	60 gal	60 gal	60 gal	60 gal
Approved portable tanks	600 gal	600 gal	600 gal	600 gal	600 gal

* Class lA and class lB liquids may be stored in glass containers (capacity < 1 gal) if the required liquid purity (such as ACS anayltical reagent grade or higher would be affected by storage in metal containers or if the liquid can cause excessive corrosion of the metal container.

** Container exemptions: medicines, baverage, foodstuffs, cosmetics, and othe common consumer items, provided such items have been packaged accordingly to commonly accepted practices for retail sales.

Source: H & SM Chapter 25,
http://www.llnl.gov/es-and-h/hsm/chap25.html

- When using liquids, ventilate the area to prevent bulidup of ignitable vapor/air mixtures or inhalation of toxic vapors or gases.

- Carefully avoid ignition sources, e.g. hot material, flames, and sparking equipment, in general vicinity of such liquids.
- Use approved containers to store flammable and combustible liquid waste to be kept inside a building. Sepecially designed safety cans for flammable liquid wastes are available. Lable the container for FLAMMABLE LIQUID ONLY. If necessary, contact the environmental analyst to Hazardous Waste Management technician for additional labling requirements. Never put corrosive materials in a flammable-liquid waste container, a fire explosion could result. Waste may be transferred to drums or other larger shipping containers that meet the Department of Transportation (DOT) requirements storing such materials outside buildings.
- Electrically interconnect (i.e. bond) equipment likely to produce a static spark.
- Limit the quantity of such materials in operating areas. Therefore, additional requirements may be necessary in cases where storage conditions, use conditions, or process operations cause a flammable or combusitable liquid to be naturally or artificially heated to or above its falsh point. Such additional requirements may include consideration for items such as ventilation, electrical area classifications, and exposure to ignition sources because of increased flammable vapor production, consult your ES & H team for further assistance.

Storage cabinets: The following liquids shall be stored in approved flammable-liquid storage or inside storage room specifically designed for the safe storage of flammable and combusiable liquids:

- Class lA flammable liquids (including wastes) in quantities greater than 25 gal in containers.
- Class lB, lC, ll liquids (including wastes) in quantities greater than 120 gal in conainers.

Flammeable and combustible liquids removed from flammable-liquid storage cabinets should be returned to the cobinet when not in use. Storage cabinet should be:

- Placed where agress is not obstructed.
- Properly lied dowm to meet seismic requirements.
- Vented outdoors (if ventilation is required) in such a manner that the cabinets' fire resistence is not compromised. Consult your ES & H Team industrial hygienist for ventilation requirement.

Safety Cans: Safety cans are constructed of stainless steel, Monel, or tin and are equipped with a flame arrestor and spring-loaded cap on both the filling and pouring spouts. The double-perforated metal surface of the flame-arrestor screen prevents flames from entering the container. Safety cans are available for both dispensing products and collecting waste. Safety cans have been tested and listed by an NRTL and shall not be modified.

Drums and Drum-Storage Areas: The following precautions should be observed for drums and drum-storage areas:

- Store drums in the vertical position.

- Keep drums bungs closed when liquids are not being transferred into or out of drums.
- Shield drums from sunlight.
- When transferring flammable liquids drums, use an approved funnel with an installed flash arrestor.
- Allow a minimum distance of 25 ft between a drum-storage area and a building. No minimium distance requirement applies to a drum-storage area that faces a blank masonry wall.
- Post o NO SMOKING sign in a drum-storage area. (this sign is available from the health and safety techniciain for your area ES & H. Team).
- Keep an emergency spil kit near a drum-storage area. The kit consists of a grabage can, dust pan, whisk broom, and absorbing compound. The absorbing compound is available from the Storage Catalog.
- Install a 20-Ib, dry chemical fire extinguisher no less than 10 ft and no more than 50 ft from a drum-storage area. Contact the ES & H Team fire protection engineer for assistance in acquiring fire extinguishers.

Transportation: For requirements and guidance involving the transprotantion of hazardous materials, refer to the LLNL Onsite Hazardous Material Packaging and Transprotation Safety Manual.

Safe Handling of Other Combustibles:
Many other combustible materials (e.g. oxidizing chemicals, fast-reacting or Explosive materials, and combustiable metals) present special fire safety and extinguishing problems.

Refrigerator Storage: Commercially available, household refrigerators contain built-in ignition sources and shall not be used to store flammable liquids or explosive chemicals. Examples of such ignitions sources include light bulbs, swiches, temperature controls, standard plugs, motor-starting relays, thermat-overload devices, and heater strips (for frost control).

Anyone who needs a refrigerator to store flammable liquids or explosives should contact the area ES & H Team about available rfrigerators specially designed and approved for such use. Refrigerators and freezers that have either been specially designed or modified to store flammable and/or combustible liquids safety shall be labeled.

Permits for Welding, Burning, or Other Hazardous Operations: As part of LLNL program to control fire hazards, permits are required for welding, soldering, and other hot-work operations with a high fire potential. To obtian permits or additional information call the Emergency Dispatch Center or Fire Department.

Operations requiring permits include the following:
- Cutting and welding (i.e., arc, oxyacetylene, and heliarc welding) outside of an approved location.
- Using tar pots in roofing or road work.
- Using open fires fo any purpose.
- Barbecuin.

- Altering, maintaining, or modifying any system that contains, or may contain, explosives or flammable liquids or gases when using heat-producing, spark-producing or impact tools (e.g., electric power tools and cartidge-acuated tools). Permits shall be posted in the work area until the work is completed.

Approved locations for hor work are areas that have been either designed specially for that purpose or modified to accommodate such operations safely. These areas shall be reviewed by the Hazards Control Department to ensure that the necessary safeguards (e.g., adequate ventilation, noncombustible construction, and proper gas distribution systems) have been installed.

Portable Electric Appliances: Portable appliances should be obtained from Central Supply because Laboratory specifications ensure that such items meet the requirements of Underwriters Laboratories (UL) or another NRTL and are safe to use under approved circumstances. Do not use electric appiances near combustible or expolsive vapors or dust. When installing or operating a portable electric appliance, the following precautions should be observed:

- Place noncombustible material under the appliance.
- Maintain a clearance of at least 12 in." between the appliance and any combustible material.
- Ensure that the appliance is properly grounded or double-insulated.
- Use only those appliances that have been listed or labeled by an NRT (e.g., UL or Factory Matual Research Corporation.
- Keep the area immediately around the appliance clean and free of combustibles.
- Ensure that electircal service is adequate for the appliance.

Appliances that remain energized during off-hours may become a fire hazard. When an appliance that contains a heating element (e.g., a coffee maker or portable heater) is to remain energized while unattended, a timer should be used to control the appliance's operation. A timer should be sent to automatically de-energize and appliance during off-hours and energize it no more than 30 minutes before personnel arrive in the area.

Fire Protection Equipment: Fire protection equipment in operating areas consists of both fixed and portable items to detect fires, alert personnel, and suppres and minimize the spread of fire. Fixed equipment includes detectors, alarms, fire doors, fire dampers, automatic sprinkler systems, and other automatic fire-suppression systems. Portable equipment consists of fire extinguishers, which are required and available in buildings, and any specialized equipment that a fire-fighting team may bring to an area.

Before installing any fire protection equipment, consult ES&H Team, which is responsible for ensuring that the equipment selected is apporpriate, reliable, and compatible with other systems in use at LLNL.

Fire Detection and Alarms: Several types of fire-detection systems will detect fire and transmit an alarm to the emergency dispatcher to intitate emergency action. In

high-hazard areas, fire detectors also altert the building occupants and, in some cases, actibate an automatic estinguishing system.

Fire detection and alarm systems shall be designed, installed, and maintained in accordance with the requirements of the applicable LLNL Facilities Specification and NFPA code or standard. The Plant Engineering Department normally performs the required testing and maintenance.

Fixed Fire-Suppression Systems: Fires can be suppressed using automatic sprinklers or other automatic fire protection systems (such as carbon dioxide, Inergen, or dry chemical). The sprinkler head of an automatic sprinkler system contains a heat-sensitive element that usually activates at 165 ^{o}F (70 ^{o}C), causing the sprinkler head to open and spray water over the fire. The action of water flowing through the sprinkler line activates an alarm at the Emergency Dispatch Center.

Sprinkler heads can be damaged and their functions impaired by mechanical or thermal abuse or careless handling. To ensure that sprinkler systems operate properly, workers and supervisiors shall observe the following:

- Contact the Plant Engineering Pipe Shop to have protective cages installed over sprinkler heads wherever mechinical damage is likely.
- Keep normal and maintenance-type heat sources (e.g., torches and soldering irons) away from sprinkler heads.
- Keep furniture, equipment, and other materials away from sprinkler heads so as not to interfere with the water-spray pattern.
- Allow 18 in.” of clearance below sprinkler heads. Materials located closer than 18 in,” interfere with the sprinkler’s water-spray pattern
- Provide at least 3 ft of clearance around sprinkler control valves to allow fire-safety personnel access to them.
- Do not paint sprinkler heads.
- Do not use sprinkler piping to support other objects, such as plants ans wiring.
- Ask the ES&H Team fire protection engineer to review the sprinkler system before modifying a work space (permanent or temporary) or insallting large equipment items.

Gasesous fire-supperssion systems, such as those containing carbon dioxide, Inergen, or Halon, are used to control or extinguish fires in normally unoccupied spaces. Such systems shall be designed, installed, and maintained in accordance with the applicable LLNL Facilities Specification and NFPA code or standard. The Plant Engineering Department normally performs the required testing and maintenance.

Fire Extinguishers: Fire extinguishers are manually operated, portable devices that discharge an extinguishing agent when properly activated. They are designed as a method of controlling a fire during the time between discovery and arrival of the Fire Department. It is essential that personnel be familiar with the location and type of extinguishers in their work areas. However, it is unsafe for personnel to use a fire extinguisher to control a fire if they have not taken the one-hour fire extinguisher training class conducted by

the Hazards Control Department. Personnel who have not been trained in the use of fire extinguishers shall not attempt to use them.

Successfully extinguishing a fire depends on the following (in the order perference):

- Notifying the Fire Department immediately upon learning of a fire.
- Having to proper knowledge and training in the use of fire extinguishers.
- Choosing the proper extinguishing agent.
- Using an extinguisher of the proper size for the size of the fire.
- Properly operating the extinguisher before attampting to extinguish the fire.

The following table (2) shows the effective extinguishers for burning material

Table (2)
Effective extinguishers for burning materials

Class of fire	Characteristics of burning materials	Extinguisher
Class A	Ordinary combusitable materials, such as cellulose products, wood, paper, cloth, plastics, or rubber.	Water, multipurpose dry chemical (ABC), or Halon
Class B	Fammable or combusitable liquids, such as oils, gasoline, alcohol, and solvents*	Carbon dioxide, Halon, or dry chemical (BC or ABC)*
Class C	Enrgized electrical equipment or wiring**	Carbon dioxide, Halon, or dry chemicla (BC or ABC)**
Class D	Burning magnesium, thorium, uranium, potassium, or sodium metals	G-1 power (special graphite) or Metl-X (sodium choride)

* Do not use water on a flammable or combustible liqiud fire because it will spread and accelerate the fire. An explosion may result if water is used.

** Do not use water on energized electric equipment. Many electrical fires involving personnel computers, photocopiers, or similar equipment can be controlled by safely turning off tne equipment's power.

Source: H & SM Chapter 25,
http://www.llnl.gov/es-and-h/hsm/chap25.html

The Emergency Management Division performs a monthly inspection of fire extinguishers using a checklist verifying that:

- Seals and tamper indicatodrs are not broken or missing.

- The extinguisher is full (fullness is determined by weighing or "hefting").
- There is no obvious physical damage, corrosion, leakage, or clogged nozzles.
- The pressure-gauge teading or indicators is in the operable range or position.

In addition to monthly inspection, annual miantenance of fire extinguishers is performed by a qualified fire extinguisher service technician assigned to the Water Operations Group of the Plant Engineering Department. This thorough eximination also includes any necesseary repair or replacement and is intended to give maximum assurance that extinguishers will operate effectively and safely. Facility management should consider verifying the inspections as part of their self-assessment program.

Fire Barriers: Fire barriers, such as fire doors and windows, fire dampers, and fire walls, are placed in strategic locations to block the spread of smoke and fire. The following requirements concerning fire barriers shall be observed:

- Fire doors shall never be blocked or wedged open.
- Fire doors shall be allowed to operate freely and without obstructions.
- Fire doors contain lables from testing laboratories, these labels shall never be removed or painted over.
- All penetrations made in walls and floors to accommodate piping, electrical conduit, wiring, or ducts shall be properly sealed with approved fire-stopping materials.
- Celling tiles removed to accommodate maintenance or construction activities shall be replaced at the completion of the job or whenever work on the prohect is significantly delayed (i.e., two weeks or longer).
- Certain fire doors (e.g., horizontal or vertrical silding and rolling-type doors) shall be inspected and tested annually for proper operatinon. The Plant Engineering Department normally performs tne requiredd inspection and tests.

Fire Hydrants: Fire ydrants are intended primarily for use by the Emergency Management Division in emergency situations. Howevere, the Fire Chief may permit the use of fire hydrants for temporary activities (e.g., connections by gardeners and construction subscontractors).

The following precautions shall be observed when using fire hydrants:

- Use only valved outlets provided by the Plant Engingeering Pip Shop.
- Use only a hydrant spanner provided by the Pip Shop, other types of wrenches can damage the flast on the valve stem.
- When opening a hydrant valve, slowly open the valve to the fully open position, then close one-eighth of a turn to minimize the likehood of the valve being inadvertently forced in the wrong position and damaged.
- When turning off the flow of water, close the valve slowly.
- After using a hydrant, manually screw on the caps (i.e., hand-tighten only).

Means of Egress:

- All laboratory buildings are provided with egress systems (e.g., corridors, starirs, and doors) to meet the requirements of NFPA life safey code. Egress systems provide building occupants with a safe way out of the building and the Fire Department with a way into buildings when responding to emergencies. To maintain the integrity of egress systems, the requirements below shall be observed.

Corridors:

- When used as part of an egress system, corridors shall have a minimum clear width of 44 in." in office buildings and 36 in." in laboratory buildings. In certain cases, corridors in existing laboratory or shop buildings may be permitted to have a clear width of 28 in.".
- Corridors shall always remain free of obstructions and impediments.

Exit Doors:

- An exit door and the routes to it shall be illuminated and properly identified with appropriate signs. Emergency lighting may also be required.
- Do not use locks or fastening devices that would prevent free escape form the building.
- An exit door shall be openable by a single operation. Do not use locks requiring multiple operations or special knowledge or effort to open.
- Minimum door width shall not be less than 28 in".
- An exit door and the floor area on both sides of it shall be kept clear and accessible at all times.

When conflicts arise regarding security requirements and safe exiting requirements, contact your area's ES&H Team leader, who can arrange for the proper parties to resolve the issue.

Capacities of Meeting Rooms: The number of people allowed to occupy a facility at any one time shall not exceed the facility's ability to safely accommodate them. This personnel limit is referred to as a room or building's "occupant toad" or "capacity".

The sponsor of a talk or meeting shall be responsible for ensuring that the number of people attending the function does not exceed the room or building's occupant load. This requirement applies to all meetings and presentations conducted in Laboratory facilities. The Laboratory's phone book contains a listing of available meeting rooms along with the occupant load of each.

Construction Areas: Construction areas shall be maintained in a fire-safe condition. Such efforts include maintaining egress paths and ensuring that a construction site is accessible to the Fire Department. The Fire Department should be consulted regarding specific access requirements for construction sites. Accumulations of combustible waste material, dust, and debris shall be removed from structures and their immediate vicinity at the end of each work shift or more frequently if necessary for safe opereations.

Subcontractors shall be made aware of the following:

- The need for permits and portable fire extinguishers.
- Provisions for the safe use of combustible materials.
- Requirements for storing flammable and combustible liqiuds in approved safely containers.
- Requirements for disposing of excess construction materials.
- LLNL's emergency telephone numbers.

Each LLNL representative who supervises a subcontractor is responsible for ensuring that the above information is communicated to the subcontractor. In facilities under construction, automatic sprinkler systems shall be placed in service as soon as possible, even if no working detection or flow alarm system is in place yet.

Fire Department Access: Proper access to all LLNL facilities is important to ensure a timely response to emergencies. Fire lanes have been established throughout the laboratory so that the Fire Department can access buildings when responding to emergencies. Fire lanes are posted and shall be kept clear at all times. No vehicles are allowed to park in a fire lane under any circumstances. The safeguards and Security Department will issue a traffic citation to any behicle that is improperly parked in a designated fire lane. The Fire Department reviews all plants for building construction, tailer relocation, and fencing changes to ensure proper access.

Emergency Reporting: For emergency reporting purpose, at least one readily accessible analog telephone shall be located in each LLNL facility. This telephone shall be in an area that is not subject to being locked (e.g., a lobby or hallway). For a larger facility, multiple telephones shall be placed so that the travel distance from any location in the facility to the nearest telephone is no more than 200 ft.

Candles: The following precautions shall be taken to ensure safety:

- Never leave a burning candle unattended. Extinguish all candles before leaving a room.
- Keep candles away from items that can catch fire (e.g., papers, books, and combustible holiday decorations).
- Place candles in sturdy candleholders that wil not tip over. Make sure the candleholders are made of noncombustible materials and are designed to protect the candle flame.
- Always place a buirning candle on a heat-resistant surface. A candleholder can become hot and ignite or damage the surface on which it is placed.

Fire Protection Assessment: To ensure that DOE fire safety objectives for worker protection, property conservation, and programmatic continutiy are met, all laboratory facilities shall be subject to a fire protection assessment at least every three years. A fire protection engineer with knowledge and experience in applying fire safety codes and standards to diverse facilities should perform this assessment. The formality of the assessment depends on the facility's classification (i.e., nuclear or non-nuclear) and monetary or programmatic loss potentials.

The fire protection assessment of nucler facilities and all facilities with a maxium possible fire loss (MPFL) potential of $ 5 million or more is carried out in the form of

a fire hazard analysis (FHA). This analysis should include details obout the facility's fire protection features and esitmates of the monetary and programmatic loss potentials associated with that facility. The analysis shall be fullt documented.

For all non-nuclear facilities and facilities with a MPFL of less than $ 5 million, assessment is in the form of a facility fire protection assessment. This assessment is less rigorous and eximines fewer aspects of the overall fire protection features of a building. The documentation for this assessment typically includes a listing of deficiencies uncovered.

Responsibilities: General responsbilities for all workers, and managers and supervisors are described as follows:
Workers: Workers are responsible for being aware of and following the work controls identified in this document. When those work controls cannot be followed, the worker shall contact his supervisor for guidance.
Managers and Supervisors:

- Ensure that the work areas comply with the work controls identified in this document.
- Ensure that the operating areas are kept orderly and free of potential sources of ignition.
- Notify the ES&H Team of any operational changes that alter the fire risk in the work areas so that protection can be adjusted accordingly.
- Ensure that fire protection assessments are performed for the facilities.

Training : OSHA regulations require that anyone who uses a fire extinguisher be trained in its use.

SECTION (4): RECOMMENDATIONS:

This section provides general safe work practices[7] to use where flammable and combustible materials are used or stored as follows:

1. **Substitute with less hazards material where possible:** substitution can be the best way to avoid or reduce a hazard. Often, though, it is not easy or even possible to find a nonflammable or less flammable substitute to do the job effectively and safely. Start by obtaining material safely data sheets (MSDSs) for all possible substitute materials. Find out about all the hazards (fire, health, chemical reactivity) of these materials before making any changes. *Choose the least hazardous material that can do the job effectively and safely. Learn how to work safely with them also.*

2. **Ignition sources:** For flammable or combustible liquid fire to start, a mixture of vapour and air must be ignited. There are many possible ignition sources:
   - Sparks from electrical tools and equipment,
   - Sparks, arcs and hot metal surfaces from welding and cutting,
   - Tobacco smoking,
   - Open flames from portable torches and heating units, boilers, pilot lights, ovens, and driers.

- Hot surfaces such as boilers, furnaces, steam pipes, electric lamps, hot plates irons, electric coils and hot bearings.
- Embers and sparks from incinerators, grinding and crushing operations
- Sparks caused by static electricity from rotating belts, mixing operations or improper transfer of flammable or hot combustible liquids.

  We can eliminate many of these ignition sources by:
  - *Removing open flames and spark-production equipment.*
  - *Non-smoking around these liquids.*
  - *Using approved explosion-proof equipment in hazards areas.*

3. **Ventilation:** Well-designed and maintained ventilation systems remove flammable vapours from the workplace and reduce the risk of fire and health problems.
In baking and drying ovens, enclosed air-drying spaces, ventilation duct work or other enclosures where workers are not normally exposed to the vapour, *keep vapour levels to 20% or less of the LFL.*

4. **Store flammable and combustible liquid containers properly:** Store flammable and combustible liquids according to the laws, including, fire, and electrical codes that may apply to particular workplace. These laws specify the kinds of storage areas allowed for these liquids.
In all cases, allow only trained, authorized people into storage areas. Before storing, inspect all incoming containers to ensure that they are not damaged and are properly labeled. Don't accept delivery of defective containers.
In general, store containers of flammable and combustible liquids separately, away from process and production areas, and away from other materials. *This separation will reduce the spread of any fire to other materials in storage. It will also protect the stored flammable and combustible liquids form exposure to fires in other areas, an accidental contact with incompatible materials.*
Keep containers closed when not in use.
Keep the amount of materials in storage as small as possible. It is a good practice to keep no more than one day's supply of flammable and combustible liquids in immediate work area. Return any leftover material to the proper storeroom or storage cabinet at the end of the day.

5. **A Good Storage Area:** Store flammable and combustible liquids in areas that are:

- Well ventilated to reduce vapour concentrations,
- Free of ignition sources,
- Cool (temperature controlled) and dry,
- Supplied with adequate firefighting and spill clean-up equipment,
- Away from elevators, building and room exits, or main aisles leading to exits,
- Accessible by firefighters,
- Labeled with suitable warning signs. For example: "No Smoking",

Avoid storing flammable and combustible liquids in basements. Ground floor storage is usually preferred as it provides easier access for emergency situations.

Inspect storage areas regularly for any deficiencies such as damaged or leaking containers, poor ventilation or non-approved equipment.

6. **Handle Drums Safely:** Many workplaces receive flammable liquids in large metal drums or barrels, the fill smaller containers from them. Moving full drums weighing hundreds of pounds by hand can be difficult and hazardous. *Specially designed drum cradles are available for moving drums around and can also be used as individual drum storage racks. Check all containers used regularly to make sure that they are not damaged.*

7. **Dispense Flammable and Combustible liquids carefully:** Take care when dispensing or transferring flammable and combustible liquids form one container to another. *Dispense from only one container at a time. Finish dispensing one material before starting to dispense another. Be sure containers are closed after dispensing to control hazardous vapours and to avoid accidental spills. Check these devices periodically to be sure that they work properly and do not leak. Never dispense flammable and combustible liquids near ignition sources. Always make sure that metal containers are bonded and ground when dispensing.*

8. **Dispose of Waste Material Safely:** Cleary label all waste containers with their contents. *Never pour waste flammable and combustible liquids down sinks or drains. Dispose of them through hazardous waste collection and disposal companies. Dispose of these wastes according to the environmental laws.*

9. **Practice Good Housekeeping and maintain equipment:** *Regular equipment inspection and maintenance are important for controlling the hazards of flammable and combustible liquids.*

10. **Proper Personal Protective Equipment:** *Wear the PPE necessary for the job you are doing.*

11. **In Emergency:** In emergencies like chemical fires and spills, act fast:
    - *Leave the area at once if you are not trained to handle the problem or if it is clearly beyond your control.*
    - *Alert other people in the area to the emergency.*
    - *Call the fire department immediately.*
    - *Report the problem to the people responsible for handling emergencies.*
    - *Obtain first aid if you have been exposed to harmful chemicals and remove all contaminated clothes. Emergency eyewash stations and safety showers should be present wherever accidental exposure to materials that can damage skin or eyes might occur.*
    - *Only trained people, equipped with proper tools and protective equipment, should handle the emergency.*
    - *Planning, training and practicing for emergencies are important so that everyone knows what they must do.*

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