Introduction

Flammable and combustible liquids are around us every day. These materials are not only in the laboratory, but also in our homes. Some of these liquids, such as gasoline, we use as fuel in our automobiles. Common flammable and combustible liquids used in the laboratories are toluene, acetone and xylene. This training provides a basic description of flammable and combustible liquids, permissible quantities of these liquids within laboratory use areas, and various storage containers and storage methods within a laboratory environment. The list below provides the definitions of some of the terms used when discussing flammable or combustible liquids.

Definitions of Terms Relating to Flammable and Combustible Liquids

Vapor density is a measure of a vapor's weight when compared to air. Air is assigned a value of 1. More dense vapors tend to sink to floor level while lighter, less dense vapors tend to rise to ceiling level. This property must be taken into account when working with flammable or combustible liquids outside of fume hoods. Most flammable liquid vapors are heavier than air. These vapors can travel some distance and encounter ignition sources remote from the workstation.

Vapor pressure is a measure of liquids volatility. A high vapor pressure is usually an indication of a volatile liquid, or one that readily vaporizes.

Volatility is the tendency or ability of a liquid to vaporize.

Auto ignition temperature is the minimum temperature at which a vapor-air mixture will spontaneously ignite, without the necessity of a spark or flame.

Flash point is the minimum temperature at which sufficient vapor is given off to form an ignitable mixture with air, near the surface of the liquid or within the vessel used.

Boiling point is the temperature at which the vapor pressure of a liquid equals the surrounding atmospheric pressure.

Flammable range is the proportion of vapor to air mixture that is ignitable and is expressed in terms of percentage of vapor in air by volume. The flammable range is bounded by the **lower flammable limit** and the **upper flammable limit**.

Lower flammable limit (LFL) is the minimum concentration of flammable liquid vapor in air that will support the propagation of a flame upon contact with an ignition source.

Upper flammable limit (UFL) is the maximum concentration of flammable vapor in air that will support the propagation of flame upon contact with an ignition source.
Flammable and combustible liquids are classified by the National Fire Protection Association (NFPA) and the Occupational Safety and Health Administration (OSHA) according to the flash point and boiling point. Once the flash point and boiling point have been determined (from reference materials such as the safety data sheet) the material can be easily classified using the OSHA/NFPA scheme. Class IA is most flammable and poses the greatest risk in a lab. Class IIIB poses the least risk.

Flammable Liquids

Class I - Any liquid with a closed-cup flash point below 100F.

Class IA - Liquids with flash points below 73F (22.8C) and boiling points below 100F (37.8C). Examples include: diethyl ether, acetaldehyde

Class IB - Liquids with flash points below 73F (22.8C) and boiling points at or above 100F (37.8C). Examples include: acetone, toluene, ethyl alcohol, methyl alcohol, hexane

Class IC - Liquids with flash points at or above 73F (22.8C), but below 100F (37.8C). Examples include: xylene, isoamyl acetate, propanol.

Combustible Liquids

Class II - Liquids with a flash point at or above 100F (37.8C) and below 140F (60C). Examples include: acetic acid, formic acid, mineral spirits

Class III - Liquids with a flash point at or above 140F (60C).

Class IIIA - Liquids with a flash point at or above 140F (60C), but below 200F (93C). Examples: formalin, phenol, toluidine

Class IIIB - Liquids with a flash point at or above 200F (93C). Examples: benzyl alcohol, glycerine, ethylene glycol

Hazards

There are two primary hazards associated with flammable and combustible liquids: explosion and fire. Fires and explosions have caused extensive physical damage and in some cases loss of life or serious injuries in laboratories and biotechnology firms [source: Occupational Safety and Health Administration (OSHA) accident database].

It is not the flammable and combustible liquids that burn or explode, but rather their vapors. These vapors are produced from the evaporation of the liquid and can ignite when an ignition source is present and the temperature of the liquid is above its flash point. Flammable and combustible liquids vaporize and form flammable mixtures with air when in open containers, when leaks occur, or when heated. By definition, most flammable liquids are normally stored and handled below their flash points. Another characteristic of flammable liquids is that they have a concentration range in which their vapors can ignite. Some ranges are very wide, for example, acetylene, 2.5%-100%, while acetone vapors can be ignited in the range of 2.5%-12.8%.

Controls

Substitution

Whenever possible, consider replacing flammable liquids with less flammable liquids, that is, ones with higher flashpoints and lower vapor pressures.

Engineering Controls

Investigate the purchase of shutoff systems for heating equipment that would monitor temperatures independent of the equipment thermostat and would disconnect power to the heating equipment when the set temperature was exceeded.

Avoid the use of heating baths using oils. When flammable liquids are used in heating baths, place the bath in a fume hood to keep flammable vapors from accumulating.

Ventilate areas in which vapors may accumulate.

Safety Can

Transfer of Class I and Class II liquids from storage containers of less than 5 gallons should be conducted in a hood, ventilated area, or within a flammable liquid storage room approved for this operation. When storing greater than 5

gallons of flammable liquids, the use of a safety can is recommended.

Administrative Controls

Smoking should not be permitted in areas where flammable or combustible materials are used or stored.

Wherever possible, separate ignition sources and flammable chemicals. For example, when manipulating flammable chemicals in a fume hood, remove any electrical equipment not necessary to the operation.

Bond and ground electrical tools that contact the liquid and its vapor to prevent sparks (from static accumulation) from igniting vapors.

Eliminate or avoid the use of open flames, such as Bunsen burners, in areas where flammable or combustible vapors may be present. Where open flames must be used, be sure to attend to and monitor the operation.

Label laboratory chemicals in an explicit manner with standardized coding (such as the NFPA diamond) so that flammability can easily be determined; *OR* with the name of chemical and the hazard associated with the chemical (e.g., ethanol, flammable).

Limit the amount of flammable liquid removed from storage to the minimum amount used within an 8-hour period.

Limit the quantity of Class IA flammable liquids (flash point <100F) stored outside the flammable liquid cabinet to less than 25 gallons.

Limit the quantity of Class IB, IC, II, or III flammable liquids (flash point <100F) stored outside the flammable liquid cabinet to less than 120 gallons, unless these liquids are stored in portable tanks. In that case, the limit can be increased to 660 gallons.

If a new chemical is being synthesized and the flammability is unknown, provide the highest level of precautions. For example if it is a liquid, assume it is a Class IA flammable liquid.

Carefully monitor distillation equipment, especially glass, for flaws and cracks prior to use with flammable liquids. Leaks and breaks may allow vapors to escape and accumulate, possibly presenting a fire hazard.

Class I and Class II liquids, when being transferred from a storage container of more than 5 gallons, should be transferred in an area outside the building or in a separate storage room that complies with either NFPA 30 or 29 CFR 1910.106.

Flammable and combustible liquids should only be stored in approved containers. Approval for containers is based on specifications developed by organizations such as the NFPA, Factory Mutual Engineering Corporation (FM), or the American National Standards Institute (ANSI).

Safety Checklist

Chemical Health & Safety Hazards

1. Are solvents and other chemicals stored in vapor-tight containers and/or storage cabinets?
2. Are containers labeled as to their contents, hazards, and other warnings?
3. Are all flammable and combustible liquids stored in listed flammable liquids cabinets when not in use?
4. Are all containers containing flammable and combustible liquids appropriately labeled and identified?
5. Is the quantity of flammable and combustible liquids that has been removed from the flammable liquids cabinet limited to the minimum amount needed to complete the project/experiment within an 8-hour period?

Fire Prevention

1. Are personnel aware of locations of fire extinguishers, fire alarms, and emergency exits?
2. Are doors to flammable liquid cabinets kept in the closed position?
3. Are flammable liquids not kept in flammable liquid cabinets stored and dispensed from approved safety cans?
4. Is the quantity of Class 1 flammable liquids (flash point <100 F) stored outside the flammable liquid cabinet less than 25 gallons?

5. Are heat and ignition sources located apart from where flammable chemicals are used?

Fire Extinguishers

1. Are fire extinguishers fully charged and tagged for the current inspection?
2. Are fire extinguishers properly mounted, clearly marked, and in an easily accessible, unobstructed location?