Knoxville Campus Policy: SAFS020-K - Use and Storage of Flammable and Combustible Liquids	
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Environmental Health & Safety

Use and Storage of Flammable and Combustible Liquids

UTK Environmental Health & Safety Guide FS-020

This policy provides guidelines on use and storage of flammable liquids

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Purpose, Applicability, and Scope

Purpose: It shall be the policy of the University of Tennessee that special precautions shall be taken in areas where flammable or combustible liquids are used, stored, or dispensed to reduce fire and explosion hazards.

Applicability: This shall apply to all students, staff and faculty on the Knoxville campus of the University of Tennessee.

Scope: This standard shall apply to the management of flammable and combustible liquids found on university property or under the control of university operations in leased space. This standard shall not apply to operations solely under the control of a third party (contractor) that does not impact the safety of UT employees or students, and does not apply to flammable and combustible liquids that have been deemed waste and are being handled under the University's hazardous waste management program.

Abbreviations and Definitions

Abbreviations

FM – Factory Mutual

OSHA – Occupational Safety and Health Administration

NFPA – National Fire Protection Association

SDS – Safety Data Sheets

UL – Underwriters Laboratories

Definitions

Aerosol – A material which is dispensed from its container as a mist, spray, or foam propellant under pressure. Classified as a Class I flammable liquid.

Boiling Point – The temperature at which a liquid's vapor pressure is equal to the atmospheric pressure. Liquids with low boiling points are very volatile.

Bonding – The process of providing an electrically conductive pathway between dispensing container and a receiving container.

Combustible Liquids – Liquids with flash points at or above 100oF. Combustible liquids are subdivided into Class II, IIIA and IIIB liquids.

Fire Area – An area of a building separated from the remainder of the building by construction having a fire resistance of at least 1 hour and having all communicating openings properly protected by an assembly having a fire resistance rating of at least 1 hour.

Flammable (Explosive) Limits/Flammable (Explosive) Range – The terms flammable and explosive are used interchangeably since unconfined vapors mixed in air will burn while confined vapors will produce an explosion. The minimum vapor concentration in air that, when ignited, will propagate a flame is the lower flammable limit (LFL or LEL). The maximum vapor concentration in air that when ignited will propagate a flame is the upper flammable or explosive limit (UFL or UEL).

Flammable Storage Cabinet – A "flammable storage cabinet" is an Underwriters Laboratory (UL), or Factory Mutual (FM) listed storage cabinet designed in accordance with National Fire Protection Association (NFPA) 30 guidelines.

Flash Point – The temperature at which a liquid gives off vapor sufficient to form an ignitable mixture with the air near the surface of the liquid or within the vessel used as determined by appropriate test procedure.

Ground and Bonding Process – When flammable and combustible liquids travel through a pipe or through the air, static charges are accumulated. Grounding and bonding is necessary during the transfer of Class I flammable liquids to prevent a static spark from igniting the flammable vapors.

Safety Can – A metal container of not more than 5 gallon capacity which is UL/FM Approved and is provided with a flame arrestor, a spring-closing lid and spout cover designed to relieve internal pressure when subjected to fire exposure.

Vapor Density – The weight of a volume of pure vapor or gas (with no air present) compared to the weight of an equal volume of dry air at the same temperature and pressure. A vapor density figure less than one indicates the vapor is lighter than air. A figure greater than one indicates the vapor is heavier than air.

Vapor Pressure – A measure of the pressure created by a liquid's vapor at a specific temperature. Flammable or combustible liquids with a high vapor pressure at room temperature are more hazardous than liquids with lower vapor pressures because they will produce more flammable vapor without heating.

Roles and Responsibilities

Departments shall:

- Provide proper storage for flammable liquids.
- Ensure proper training is provided to employees and students who work with flammable liquids.
- Ensure containers are properly labeled and disposed.

Supervisors shall:

- Provide adequate training in the use and storage of flammable liquids.
- Monitor for proper use and storage.
- Keep only the minimum amount required on hand.
- Ensure SDSs are current for all flammable liquids.

Employees and Students shall:

- Follow all storage and use requirements.
- Report deficiencies in storage and use to supervisors.
- Immediately report spills to supervisors.

EHS shall:

- Provide guidance and training on proper flammable storage usage and storage.
- Revise these guidelines as needed.

Procedures

Hazards Description

Flammable and combustible liquids are easily ignited and difficult to extinguish. Combustible liquids require heating for ignition and are easier to extinguish. Flammable and combustible liquids produce a high heat release rate once ignited (i.e., fires produce high temperatures in a short period of time), and associated fires spread rapidly.

Vapors from flammable and combustible liquids can be present at room temperature and can form explosive mixtures with air. Some liquids are unstable or very reactive (e.g., burn when exposed to air without an ignition source, susceptible to spontaneous heating, react violently with other materials including water). These characteristics combine to create a significant fire and/or explosion hazard.

Since the vapors generated from flammable liquids are most often heavier than air, they will seek the lowest available level in a building. This movement of vapors can produce potentially dangerous conditions far removed from the actual vapor source. Flammable vapor, if not removed by ventilation, can flow to an ignition source and flash back to the vapor source.

The volatility of the liquid is increased when externally heated at or above its flash point. Overall, an increase in temperature will increase the hazard created by a flammable or combustible liquid by increasing its vapor's flammable range. Due to this, heated Class II and Class III liquids should be subject to all applicable requirements for Class I and Class II liquids respectively.

Combustible liquids vaporize and form flammable mixtures with air in open containers, when leaks occur, or when heated. To control these potential hazards, several properties of these materials, such as volatility, flashpoint, flammability range and auto ignition temperatures must be understood. Information on the properties of a specific liquid can be found in that liquid's safety data sheet (SDS), or other reference material. NFPA 45 is the reference to determine the permissible amount of flammable liquids used in teaching and research laboratories.

National Fire Protection Association (NFPA) hazard classifications for flammable and combustible liquids are listed below:

NFPA Hazard classification for flammable liquids			
Class	**Flash point**	**Boiling point**	**Examples**
I-A	below 73°F (23°C)	below 100°F (38°C)	diethyl ether, pentane, ligroin, petroleum ether
I-B	below 73°F (23°C)	at or above 100°F (38°C)	acetone, benzene, cyclohexane, ethanol
I-C	73-100°F (24-38°C)	—	p-xylene
Hazard classification for combustible liquids			
II	101-140°F (39-60°C)	—	diesel fuel, motor oil, kerosene, cleaning solvents
III-A	141-199°F (61-93°C)	—	paints (oil base), linseed oil, mineral oil
III-B	200°F (93°C) or above	—	paints (oil base), neat's-foot oil

Considerations for working with and storing flammable liquids

- Know the locations of fire alarms, pull stations, fire extinguishers, safety showers, and other emergency equipment.
- Read the SDS for each flammable liquid prior to use and wear personal protective equipment as indicated in the SDS or the lab's Chemical Hygiene Plan. If a building or departmental flammable solvent storage room with a fire suppression system is available, store flammable materials there until they are needed and remove only the amount necessary for a particular experiment or task.
- Store flammable liquids in a flammable storage cabinet. A variety of commercially manufactured cabinets are available.
- When flammable liquids must be stored outside a flammable storage cabinet, use approved safety cans whenever possible. They have spring-loaded lids and an internal screen which prevents combustion of the contents.
- Do not use large polypropylene ("Nalgene") containers with stopcocks or valves at the bottom to store flammable liquids. These valves frequently leak and are unsafe in a fire.

- Never store flammable liquids in a standard or domestic refrigerator or freezer. Flammable liquids that must be chilled or frozen require specially designed “spark-proof” refrigerators or freezers.
- Minimize the amount of flammable liquids in your lab. Buy only what is needed in the immediate future, and buy the smallest size that you need. Excess flammable solvents risk a fire, a dangerous spill and, if you are exposed to them, your health. Unused surpluses create an unnecessary disposal cost for the University.

Storage Limits for Chemicals

- Avoid storing flammable liquids on high shelves or in direct sunlight.
- Store flammable liquids in a well ventilated area.
- Caution: Never use environmental rooms (also called cold/warm rooms) to store flammable, combustible, or other hazardous materials. Environmental rooms have many ignition sources and little or no outside air circulation. You can use small quantities of flammable or hazardous materials (500 ml) in these spaces, but do not store them there.
- In the laboratory, store flammables in a UL-approved (or equivalent) flammable storage cabinet. Unless a cabinet is marked as approved for storage of flammable liquids, flammable solvents may not be stored there. In general, do not store flammable liquids in cabinets below fume hoods or sinks.
- Flammable liquids should be stored separately from strong oxidizers, corrosives and other incompatible materials. It is best to store flammable liquids in an approved storage cabinet dedicated solely for that purpose.
- Keep the flammable liquid containers closed when not in use.
- Storage of flammable liquids or other hazardous chemicals on floors should be extremely limited. When storage on floors is unavoidable, secondary containment bins that can contain at least 110% of the volume of the largest container being stored are required.
- Storage of flammable liquids must not block any route of egress.
- On the benchtop, limit the storage of flammable liquids to those in immediate use. Handle flammable chemicals in areas free from ignition sources.
- It is best to store bottles of flammable liquids in a tray or pan (secondary containment) to catch any spills, especially if chemicals are being stored on the floor.
- When working with open containers, use a laboratory fume hood to control the accumulation of flammable vapor.

- Use plastic trays when storing chemicals in freezers. This prevents the bottles from becoming embedded in ice and frost that often forms in freezers. It also contains spills and drips.

Flammable Storage Cabinets

With a flammable storage cabinet, the allowable quantities are doubled. Only certified cabinets listed by Factory Mutual, Underwriter's Laboratory, or other qualified testing agencies should be purchased. The requirements for a flammable storage cabinet are:

- Doors shall be well fitted, self-closing, and equipped with a latching device.
- All flammable storage cabinets must be clearly labeled with a sign that reads: "Flammable – Keep Fire Away".
- Flammable storage cabinets should never be located by exit doors and located an appropriate distance from sources of ignition, sparks, or open flames including, but not limited to, cutting and welding frictional heat, static, mechanical sparks, or hot surfaces.
- Flammable storage cabinets should not be used to store corrosives, as they may corrode the cabinet.

- The venting of flammable storage cabinets is not recommended, as it reduces its fire protection effectiveness. If venting is required to prevent chemical exposure or to reduce odorous vapors, the installation has to be done by a qualified person.
- New cabinets shall be Underwriter's Laboratory/Factory Mutual Research Corporation approved or has verification of meeting NFPA 30 requirements.
- No more than three cabinets shall be grouped together in a single fire area.
- Shall not be used to store compressed gas cylinders along with flammable liquids. Such cabinets may be used to store only compressed gas cylinders.
- The total amount of liquids stored in one cabinet shall not exceed 60 gallons 227.1L) of Class I or II liquids or 120 gallons (454.2L) or Class III liquids.

Refrigerators

Take precautions when storing flammable chemicals in a refrigerator. Refrigerator temperatures may be higher than the flash points of flammable liquids. Compressors and circuits are often located at the

bottom of the refrigerator where vapors from small spills or leaks can accumulate. Electrical sparks from a conventional refrigerator can then ignite the flammable vapors that build up inside. Unless a cold room is ventilated and has a fire suppression sprinkler system, do not store flammable liquids there.

Two kinds of refrigerators are approved for storage of flammables:

1. Flammable liquid storage refrigerators. These have no spark sources within the refrigerator cabinet. There are, however, spark sources outside the refrigerator cabinet from switches, motors, relays, etc. These spark sources can ignite flammable vapors present outside of the refrigerator. A bottle of flammable liquid that drops and breaks near one of these refrigerators can easily be ignited by the sparks.
2. Explosion-proof refrigerators. These refrigerators are considerably more expensive because they have all spark sources completely sealed inside and are safe for flammable atmospheres both within and outside of the refrigerator cabinet.

Transferring Liquids

The main objective in working safely with flammable liquids is to avoid accumulation of vapors and to control sources of ignition.

Besides the more obvious ignition sources, such as open flames from Bunsen burners, matches and cigarette smoking, less obvious sources, such as electrical equipment, static electricity and gas-fired heating devices should be considered.

Some electrical equipment, including switches, stirrers, motors, and relays can produce sparks that can ignite vapors. Although some newer equipment has spark-free induction motors, the on-off switches and speed controls may be able to produce a spark when they are adjusted because they have exposed contacts. One solution is to remove any switches located on the device and insert a switch on the cord near the plug end.

Pouring flammable liquids can generate static electricity. The development of static electricity is related to the humidity levels in the area. Cold, dry atmospheres are more likely to facilitate static electricity. Bonding or using ground straps for metallic or non-metallic containers can prevent static generation.

- Control all ignition sources in areas where flammable liquids are used. Smoking, open flames and spark producing equipment should not be used.
- Use bottle carriers for transporting glass containers.
- Use equipment with spark-free, intrinsically safe induction motors or air motors to avoid producing sparks. These motors must meet National Electric Safety Code (US DOC, 1993) Class 1,

Division 2, Group C-D explosion resistance specifications. Many stirrers, Variacs, outlet strips, ovens, heat tape, hot plates and heat guns do not conform to these code requirements.

- Avoid using equipment with series-wound motors, since they are likely to produce sparks.
- Do not heat flammable liquids with an open flame. Steam baths, salt and sand baths, oil and wax baths, heating mantles and hot air or nitrogen baths are preferable.
- Minimize the production of vapors and the associated risk of ignition by flashback. Vapors from flammable liquids are denser than air and tend to sink to the floor level where they can spread over a large area.
- Do not distill flammable substances under reduced pressure.
- Splash proof goggles in addition to standard laboratory personal protective equipment (PPE) consisting of a lab coat, closed toe shoes and nitrile gloves should be worn while pouring flammable liquids. Pouring larger volumes may require additional PPE consisting of thicker gloves and an apron.

Bonding and Grounding

- Always bond metal containers to metal receivers when transferring large volumes of flammable liquids or gases.
- Electrically bond metal containers when transferring flammable liquids from one to another. Bonding can be direct, as a wire attached to both containers, or indirect, as through a common ground system.
- When grounding non-metallic containers, contact must be made directly to the liquid, rather than to the container.
- In the rare circumstance that static cannot be avoided, proceed slowly to give the charge time to disperse or conduct the procedure in an inert atmosphere.
- Static electricity can ignite flammable gases or vapors. If static electricity is a problem, minimize static electricity by spraying with an antistatic agent. Use nonconductive materials (floors, mats, etc.) and grounding straps on instruments and machines, especially when transferring flammable chemicals between metal containers. These reduce the risk of generating static sparks. The greatest hazard from static electricity is in the winter when the air is dry.

Additional Considerations

Flammable and Combustible Solids

Flammable solids often encountered in the laboratory include alkali metals, magnesium metal, metallic hydrides, some organometallic compounds, and sulfur. Many flammable solids react with water and cannot be extinguished with conventional dry chemical or carbon dioxide extinguishers.

- Ensure Class D extinguishers are available where flammable solids are used or stored.
- Sand can usually be used to smother a fire involving flammable solids. Keep a container of sand near the work area.
- If a flammable, water-reactive solid is spilled onto skin, brush off as much as possible, and then flush with copious amounts of water.
- NEVER use a carbon dioxide fire extinguisher for fires involving lithium aluminum hydride (LAH). LAH reacts explosively with carbon dioxide.

Catalyst Ignition

Some hydrogenated catalysts, such as palladium, platinum oxide, and Raney nickel, when recovered from hydrogenation reactions, may become saturated with hydrogen and present a fire or explosion hazard.

- Carefully filter the catalyst.
- Do not allow the filter cake to become dry.
- Place the funnel containing moist catalyst into a water bath immediately.

Purge gases, such as nitrogen or argon, may be used so that the catalyst can be filtered and handled in an inert atmosphere.

Flammable Aerosols

Flammable liquids in pressurized containers may rupture and aerosolize when exposed to heat, creating a highly flammable vapor cloud. As with flammable liquids, these should be stored in a flammable storage cabinet.

Drums Containing Flammable and Combustible Liquids

- Provisions shall be made for bonding and grounding while dispensing flammable or combustible liquids from drums.

- Drums with a capacity of 55 gallons or more shall be included in the Spill Prevention Control and Countermeasures Plan (SPCC). One key element of this standard is secondary containment.
- Provisions for secondary containment should be made where multiple drums less than 55 gallon capacity are stored.
- Bungs shall be kept in place except when product is being added to or removed from the drum.
- Drum storage of flammable liquids generally necessitate the need for additional controls such as a fire suppression system, storage in a flammable liquid storage cabinet or fire-rated room.
- All drum shall be marked as to their contents.

Inspections

EHS shall inspect all facilities on an annual basis. The management of flammable and combustible liquids shall be reviewed at this time. Deficiencies shall be noted on the inspection report and communicated the appropriate individual for corrections.

Record Keeping

EHS shall maintain records of all inspection reports and training records for a minimum of 10 years.

Training

EHS can provide general training on the use of flammable liquids upon request.

Regulatory Drivers and References

NFPA 30, 45, 101

OSHA 29 CFR 1910.106

OSHA 29 CFR 1926.152

DOT 49 CFR 172

Disclaimer

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Appendices

FS-020 Flammable Liquids Guidelines (downloadable pdf)

Appendix A: Guidelines for Calculating Limits on Flammable Liquid Storage in Campus Laboratories