SAFETY in the Chemical Laboratory

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...a Chem Ed feature

LIX. Safety Manuals and Handbooks

d. Harvard University-Responsibilities of Individuals in Safety Organization **and** *Handling and Storage of Flammable Liquids*

HARVARD UNIVERSITY
Office of the President

Massachusetts Hall
Cambridge, Massachusetts 02138

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To Deans of Faculties, Directors of Institutions for Advanced Study and Research, and Other Officers of Major Divisions Within the University:

One of the most important responsibilities of any institution is to insure the safety of all individuals associated with that institution. Safety is always a two-way street, and it is of profound importance that all those responsible for the administration of research and other activities should be continually aware of possible safety hazards and insure appropriate safety precautions.

At my request a University Committee on Environmental Health and Safety has outlined an organizational chart for a safety program throughout the University and has prepared a general statement listing the responsibilities which each member of this community has for insuring safety and avoiding accidents. I hope that every official to whom this letter and attachments are addressed will insure that this statement receives dissemination throughout his area of responsibility, so that together all of us can willingly and conscientiously take part in the general effort to reduce hazards to safety throughout the University.

Nathan M. Pusey

RESPONSIBILITIES OF INDIVIDUALS IN SAFETY ORGANIZATION

1. President of the University

(*a*) Publishes, for wide distribution, statement of policy concerning safety.

(*b*) Assumes institutional responsibility for the general pattern of safety practices and their efficient administration.

(*c*) Through the chain of administrative responsibility holds Deans, Directors of Laboratories, Department Heads, and Budgetary Officers accountable for safety of all appointees, employees, and personnel associated with the University.

2. University Committee on Environmental Health and Safety

(*a*) At the direction of the President establishes broad and consistent policies concerning Environmental Health and Safety throughout the University.

(*b*) Establishes policies and guidelines under which Environmental Health and Safety of the University Health Services will operate.

(*c*) Uses Environmental Health and Safety as the operational group of the committee.

3. Dean, Laboratory Director, Departmental Head, or Budgetary Officer

(*a*) Publishes statement of policy reflecting and amplifying President's statement as it pertains to his area.

(*b*) Has responsibility for safety program pertinent to the personnel and facilities under his direction.

(*c*) May appoint safety coordinator or engineer and/or safety committee as indicated and defines their duties.

(*d*) Promulgates safety policies as formulated by safety committee or others and holds senior faculty members, supervisors, or division heads responsible for their implementation and enforcement.

(*e*) Authorizes necessary expenditures for safety.

4. Safety Coordinator or Safety Engineer

(*a*) Coordinates safety activities and maintains liason with Environmental Health and Safety.

(*b*) The extent to which other responsibilities will be used will vary with the need of the specific area. A list of these is presented in Appendix A.

5. Local Safety Committee

(*a*) Responsibilities will be determined by Dean, Laboratory Director, Departmental Head or Budgetary Officer who appointed them and by the potential hazards.

6. Senior Faculty Member, Supervisor, or Division Head

(*a*) Is responsible for enforcement of safety policies promulgated by Dean, Laboratory Director, Departmental Head, or Budgetary Officer.

(*b*) Should be aware of potential hazards in his research or other activities and should institute appropriate safety precautions.

7. Junior Faculty Member, Student, or Employee

(*a*) Works in accordance with accepted safe practices.

(*b*) Reports unsafe conditions and practices.

(*c*) Observes safety rules and regulations.

(*d*) Makes safety suggestions.

(*e*) Does not undertake jobs he does not understand.

(*f*) Is responsible for his personal safety.

Editor's Note

To help those who may have responsibility for developing written safety guidelines for a laboratory, we continue a series of excerpts from some laboratory safety manuals and handbooks. The series will include examples of detailed safety practices, basic safety policies, reasonable safety regulations, and flexible administrative procedures. Table of contents is listed only to show extent of coverage and variations between organizations.

Specific questions or comments about any manual or handbook excerpt should be directed to the contact person noted at the end of the article. Whether or not they can provide copies of their manual will depend on the policy of their organization.

In a later issue, we plan to have a report of progress on the development of a comprehensive laboratory safety manual by the Research and Development Section of the National Safety Council, one of three groups active in laboratory safety. The American Chemical Society and the National Fire Protection Association both have committees working on guidelines and standards that will be appropriate in a laboratory safety manual. Purposes and activities of the three groups will be described here in the near future.

8. University Health Services, Environmental Health and Safety

(*a*) Acts as operational group of University Committee on Environmental Health and Safety.

(*b*) Offers assistance in form of safety engineering to any University group requesting the same.

(*c*) Performs periodic inspection of University and makes recommendations for improvement of unsafe conditions.

APPENDIX A

Other Possible Activities of Safety Coordination and/or Safety Engineer

1. Keeps and analyzes accident records.
2. Conducts educational activities for supervisors at all levels.
3. Conducts activities for stimulating and maintaining interest in safety of personnel in department.
4. Develops employee safety education programs.
5. Serves on departmental safety committee.
6. Supervises and appraises accident investigations.

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7. Promotes, plans and directs a regular program of safety inspections.
8. Checks for compliance with applicable safety laws and codes.
9. Issues regular reports showing safety performance and accident trends.
10. Serves in staff capacity.
11. Reviews all drawing, projects, and work orders concerning safety.
12. Insures adequate preventive maintenance program.
13. Establishes and maintains emergency and disaster plans.
14. Establishes and approves protective equipment requirements.
15. Establishes, promotes and administers safety procedures or standards.
16. Obtains assistance when required from Environmental Health and Safety.

HANDLING AND STORAGE OF FLAMMABLE LIQUIDS AT HARVARD UNIVERSITY

OUTLINE

INTRODUCTION

Purpose

This standard outlines and establishes consistent safe practices at Harvard University for the storing and handling of flammable liquids.

Scope

This standard shall apply to all users of flammable liquids in performing any task on University property or in performing any task under the auspices of the University.

This standard includes most of the uses of flammable liquids; where it is not complete the requirements of the National Fire Protection Association apply; where this standard conflicts with NFPA, this standard shall take precedence.

If compliance becomes unreasonable, the intent of the standard should be the guide.

If questions of interpretation arise, they should be directed to Environmental Health and Safety, University Health Services.

General Properties

Many flammable liquids are volatile by nature, and it is the combination of these vapors with the oxygen in the air, not the liquids themselves, that ignite and burn. The rate of evaporation varies greatly from one liquid to another and increases with temperature.

Such flammable mixtures may occur in open or closed containers, when leaks or spills occur, and when flammable liquids are heated. The degree of danger is determined largely by the flash point of the liquid, the concentration of the air-vapor mixture, and the possibility of a source of ignition that affords heat energy sufficient to ignite the mixture.

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Safety . . .

Vapors from a flammable liquid usually cannot be seen and may be difficult to detect unless a combustible gas indicator is used. Since in most cases the vapors are heavier than air, they tend to settle to the floor or other lowest level, even flowing down elevator shafts and stairways, or through air ducts to lower floors where they may create a serious fire or health hazard. It is recognized that flammable liquid vapors are subject to diffusion and convection and consequently the total area where free vapors exist can be hazardous.

Investigations of fires involving flammable or combustible liquids frequently indicate the cause as ignition of a vapor trail, and a resultant flashback, at a considerable distance from the source of the vapor.

Numerous sources of ignition exist in a great many places. Often it is difficult to eliminate or control them. Some common sources of ignition are open flames, hot surfaces, sparks resulting from contact of metals, operation of electrical equipment, and discharges of static electricity. Among others are smoking, matches and auto-ignition of substances.

The potential danger of fire and explosion presented by flammable liquids generally can be eliminated or minimized by strict observance of safe procedures in storing, dispensing, and handling them.

Flammable liquids also may present health hazards from both skin contact with the liquid and inhalation of toxic vapors. Some flammable liquids are primary skin irritants that destroy tissue, and some are skin sensitizers. A dermatitis may result because many of the liquids dissolve the natural skin oils. An inhalation hazard exists in all cases, varying in degree with the concentration and toxicity of the vapor. Information about toxicity of chemicals can be found in references listed in the appendix.

Some atmospheres that contain flammable vapors in concentrations below their lower explosive limits may still be harmful to health because of their toxicity.

DEFINITION OF TERMS

Classes of Flammable and Combustible Liquids

Liquids defined as "flammable" or "combustible" by the National Fire Protection Association (NFPA Standard No. 30) are those that have a flash point below 200°F. They are divided into three classes:

Class I-A Liquids having flash points below 73°F and boiling points below 100°F. Examples are: methyl ethyl ether, pentane-*n*.

Class I-B Liquids having flash points below 73°F and having boiling points at or above 100°F. Examples are: acetone, benzene, ethyl alcohol, gasoline.

Class I-C Liquids having flash points at or above 73°F and below 100°F. Examples are: turpentine, dibutyl ether-*n*, methyl alcohol 30% in water.

Class II Liquids with flash points at or above 100°F but below 140°F. Included in this group are hydrazine, methyl amyl acetate, kerosene, cyclohexanone, and camphor oil.

Class III-A (Termed "Combustible" rather than "Flammable") Liquids with flash points at or above 140°F but below 200°F. Among these liquids are carbolic acid, naphthalene, creosote oils, and aniline.

Flash Points

The flash point of a liquid is the lowest temperature at which it gives off enough vapor to form an ignitable mixture with the air near the surface of the liquid or within a vessel and to produce a flame when a source of ignition is brought close to the surface of the liquid. Several types of apparatuses are used for determining flash points.

For most liquids, the numerical value in degrees Fahrenheit of the closed cup ("CC") flash point is some 10 to 20 per cent lower than that of the open cup ("OC") flash point for the same liquid. When flash point figures are given, they usually are identified by the initials "OC."

Flammable (Explosive) Range

A prominent factor in rating the fire

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hazard of a liquid is its flammable range, sometimes referred to as explosive range. For each flammable or combustible liquid there is a minimum concentration of its vapor in air below which propagation of flame does not occur on contact with a source of ignition because the mixture is too "lean." There is also a maximum concentration of vapor in air above which propagation of flame does not occur because the mixture is too "rich." These boundary line mixtures, which vary greatly for different liquids, are known as the lower and upper explosive limits, and are usually expressed in terms of percentage by volume of vapor in air at sea level.

The flammable or explosive range includes all the concentrations of a vapor in air between the lower explosive limit (LEL) and the upper explosive limit (UEL). The lower explosive limit is of particular importance because, if this percentage is small, it will take only a small amount of a flammable or combustible liquid vaporized in air to form an ignitible mixture.

It also should be noted that if the concentration of vapor-air mixture is above the upper explosive limit, introduction of air (by ventilation or other means) will produce a mixture within the flammable range before a safe concentration of vapor below the lower explosive limit can be reached. See appendix for sources of information on the properties of specific flammable liquids.

Because published flammable range figures are determined at sea level, special consideration should be given to cases where other than normal pressure exists or where air is enriched by an increased concentration of a gas such as oxygen as a hyperbaric chambers.

Table 1 Flammable Liquids—Maximum Allowable Size of Containers

Container type	Class I-A: flash point <3°F, boiling point <100°F	Class I-B: flash point <73°F and boiling point >100°F	Class I-C: flash point >73°F and <100°F	Class II: flash point >100°F and <140°F	Class III: combustible liquids
Glass	1 pt	1 qt	1 gal	1 gal	1 gal
Approved high density polyethylene or metal	1 gal	5 gal	5 gal	5 gal	5 gal
		(in approved storage areas only. . .)			
Safety cans	2 gal	5 gal	5 gal	5 gal	5 gal
Metal drums ICC specifications (storage vaults only)	60 gal	60 gal	60 gal	60 gal	60 gal
Examples:	Ethyl ether Propylene oxide Pentane-*n*	Benzol Methyl alc. Gasoline Ethyl alc. Acetone Xylene Toluene	Ethyl mercaptan Turpentine Methyl alc. (30% in water)	Methyl amyl acetate Kerosene	Stoddard solvents Amyl alcohol Fuel oil

CONTAINERS

This document discusses only containers of 55 gallons or less. National Fire Protection Association, Fire Code No. 30, shall apply where containers in excess of 55 gallons are used.

Drums

Fifty-five gallon drums are often used to ship flammable liquids. The drums must meet rigid ICC standards to qualify as shipping containers for flammable liquids. However, such standards are not intended to qualify the drums as long-time storage containers. Many users assume that it is safe to store sealed drums exactly as they are received. To be safe for storage or dispensing, a drum must be protected against fire and explosion. Outside storage is preferred to inside storage. However, drums should be protected from the direct rays of the sun and other sources of heat. *The bung shall be replaced with a pressure and*

vacuum relief vent as soon as the sealed drum is opened. A pressure and vacuum relief vent shall be installed in a sealed drum of a flammable liquid if there is any chance that it will be exposed to the direct rays of the sun or, in any other way, subjected to considerable variations in temperature. If a drum leaks or is otherwise damaged, its contents shall be immediately transferred to a sound container that is clean or that previously held the same liquid.

Portable Containers

Probably the most common piece of equipment for handling small quantities of a flammable liquid is the portable safety can, ranging in size from one pint to five gallons. Safety cans are made in numerous styles with faucets, pouring spouts, or dispensing hoses. A tilt-type safety container mounted on a frame, which permits manual tipping of the can for dispensing contents, is available. Special safety cans are made for viscous liquids, such as rubber cement and heavy oils. End-use containers also are manufactured in many styles for many different applications. *Only FM or UL recognized* safety containers shall be considered acceptable for handling flammable liquids. . .* containers approved or listed specifically for the purpose, whether it is storing, carrying, dispensing, or end-use. The following "recognized" safeguards are available on safety containers as protective features against fire: self-closing caps or covers, provisions for pressure and vacuum relief, and flame arresters.

Flammable liquids often are purchased in small lightweight containers with screw caps, such as 1-gallon cans. Although these vessels must meet rigid standards to qualify as shipping containers, they do not necessarily afford the fire protection required of a container for storing, carrying, or dispensing flammable and combustible liquids. Frequently, in laboratories, offices and industrial establishments, common containers, such as glass or plastic bottles or simple metal cans, are used for storing, dispensing, and carrying small quantities of flammable liquids. Such containers may provide little or no protection against fire and explosion, and attempts to dispense materials from them often result in excessive spillage. Whenever possible, flammable liquids should be transferred from common containers to recognize safety containers. *In special cases where chemical purity must be maintained, storage in glass or plastic containers is permissible within the quantity limits of Table 1.* The problem of preserving chemical purity is

* The term "FM or UL recognized" (hereinafter shortened to "recognized") is used in this standard to designate safety containers and accessories that are approved for flammable liquids by Factory Mutual Engineering Division of Associated Factory Mutual Fire Insurance Companies, or that are tested and listed by Underwriters' Laboratories, Inc.

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best solved in many cases by use of recognized safety containers that are made of stainless steel or other relatively impervious metal or that are lined with a reaction-resistant material.

Protective Devices for Containers

Various devices have been developed to protect flammable liquid containers against fire and explosion and thus make safe handling and storage of these substances possible. They include self-closing covers or valves, pressure and vacuum relief devices, the flame arresters.

Self-Closing Covers retard the evaporation of liquids in storage and, by excluding outside air, minimize the chance of fire. Generally, self-closing covers on flammable liquid containers are classified into three types according to their method of closing: gravity, spring-action, and combination gravity and spring-action actuated by a fusible-link mechanism. The gravity type is used ordinarily on containers for oily waste and on treadle operated wash and dip tanks. It is so designed that it can be opened only part way and closes automatically when pressure is removed from the treadle bar. The spring-action cover is used most commonly on portable safety containers. It serves three vital safety functions: it provides over-pressure relief, it seals the container against leakage, and it minimizes evaporation and escape of vapors. The spring-action cap or cover is held open by hand pressure during dispensing or filling operations. When hand pressure is removed, the cover closes automatically to form a tight seal around the opening. The seal should be so effective that no significant leakage will occur even if the container is completely inverted. The combination type cover has a fusible-link mechanism for safe-guarding open vessels in which washing and cleaning operations are performed, and for protectively enclosing the flammable contents of trash cans and drums. The fusible-link, which holds the cover open, melts at a relatively low temperature, about 160°F. If a fire occurs in or near the containers, the fusible-link is designed to melt and allow the cover to fall through a combination of spring-action and gravity. The effect is one of quickly smothering a fire inside the container or preventing a fire outside of it from making entry.

Pressure-Relief Devices—Since most flammable liquids are volatile, it may be necessary to consider venting for relief of vapor pressure. Pressure from expanding vapor can build up within a container if it is exposed to the sun, the plant heating system, a fire, or other source of heat. If a means for relieving this pressure is not provided, it may become great enough to rupture the container, frequently allowing ignition of the vapors and spreading fire over the surrounding area. A pressure-relief device also will prevent excessive build-up of pressure within a drum that otherwise could cause contents to spew into the face or on the clothing of a person opening the vessel. The spring-action cover used to seal a portable safety container in itself provides pressure relief. As pressure builds up inside the container it forces the cover to rise against the spring just enough to permit the vapor to escape. The cover then closes automatically to a tight seal. The safety bung vent for storage drums operates in a similar manner. Internal pressure forces a valve to rise against a coil spring so that the vapors can escape. After the internal pressure has been relieved, the valve closes automatically to a tight seal.

Vacuum Relief Devices—Vents for vacuum relief are necessary for functional and safety reasons. A liquid can be dispensed in a continuous flow from a so-called closed container only if the space vacated by the liquid is vented to counteract formation of a vacuum. Vacuum relief also prevents collapse of flammable liquid containers due to sudden cooling. Vacuum relief is no problem in a portable safety container, if air can enter freely through a large pour opening and fill the space vacated by the liquid being dispensed. Vacuum relief vents normally are built into containers that have small dispensing apertures.

Safety . . .

Vacuum relief for storage drums often is combined with the pressure-relief vent. Manual vacuum relief is accomplished by loosening or lifting the bung vent to open a port which allows air to enter the drum. For auto-vacuum relief, a second valve is forced open by atmospheric pressure as liquid is withdrawn from the drum. When the pressure in the drum is equal to atmospheric pressure, the automatic vacuum relief valve closes to a tight seal.

Flame Arresters—A flame arrester, when installed on a flammable vent or opening, prevents propagation of a flame into the container. Its primary function is to absorb and dissipate heat, and thus to prevent the vapors within the container from being set aflame by an external source of ignition. The flame arrester screen should fit properly and be held in place securely so that its protective features are not defeated.

A metal having a high heat capacity is used to fabricate a flame arrester with sufficient surface area to absorb heat. The design should be one that will permit free passage of flammable liquids, and of vapors and air.

One type of flame arrester is constructed of one or more layers of metal screen or perforated metal. In the form of a double-wall cylinder, such an arrester is inserted into the pour opening (and separate fill opening, if provided) of a portable safety container. This type of a flame arrester is incorporated in the design of many venting and filling accessories for drums. Perforated metal in the form of metal plates is used as a flame arrester for plunger cans and other applicating cans.

Safety cans, drum fittings (for dispensing, venting, and filling), parts washer tanks, plunger cans, and other specialized containers can be obtained with built-in flame arresters. Flame arresters can be purchased separately and installed on many containers that do not have them.

The principle safety feature afforded by the flame arrester is protection against ignition of a flammable vapor within a container during filling or dispensing operations. This protection increases in importance with respect to containers that lack a vapor-tight seal, for example: a parts washer, a drain can, or a plunger can.

Identification

To help prevent the mixing of one liquid with another and to reduce the chance that one liquid will be mistaken for another, *Containers shall be clearly marked or identified as to contents. They should be kept clean at all times so that markings can be seen easily.*

Each container, including drums, used for storing or handling flammables shall

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be painted red or marked with red tape and have a label as follows:

(*a*) For flammable liquids having a flash point of 20°F (−7C) or below: DANGER—EXTREMELY FLAMMABLE—KEEP AWAY FROM HEAT, SPARKS, AND OPEN FLAMES. KEEP CLOSED WHEN NOT IN USE.

(*b*) For flammable liquids having a flash point from 20°F (−7C) to 140°F (60C): WARNING!—FLAMMABLE—KEEP AWAY FROM HEAT, SPARKS, AND OPEN FLAMES. KEEP CLOSED WHEN NOT IN USE.

(*c*) For combustible liquids having a flash point from 140°F (60C) to 200°F (93C): CAUTION!—COMBUSTIBLE—KEEP AWAY FROM HEAT AND OPEN FLAMES. KEEP CLOSED WHEN NOT IN USE.

USE

Control of Conditions

Controlled conditions are essential for safe handling of flammable liquids, regardless of the quantities involved. Therefore, the problems associated with each flammable liquid should be analyzed to determine the extent of the flammable and health hazards so that appropriate control measures can be taken. To control these hazards, the nature of the specific liquid, the amounts of vapor involved, the ignition sources, the kinds of operations, the usage temperature, and the type of building constructions all must be taken into consideration.

Since the relative degree of exposure varies widely, competent judgment should be obtained with respect to the necessity of safeguarding electrical equipment, ventilation requirements, the need for eliminating sparks, open flames and other sources of ignition, requisite handling procedures, and other factors relating to maintenance of safe environment.

Dispensing

Dispensing shall be done by an individual from only one drum at a time, and all dispensing of one material shall be completed by him before dispensing of another material is begun.

There are two recognized devices commonly used for dispensing small quantities of flammable liquids from drums: transfer pumps and drum faucets. Only pumps or faucets tested by such agencies as Factory Mutual Division of AFMFIC or Underwriters' Laboratories should be used. Plastic spigots are not approved and should never be used. Drums never should be pressurized, even slightly, to provide automatic dispensing.

Of the two devices, the safer is the hand-operated rotary type transfer pump which generally is installed in the end bung opening of a drum mounted in vertical position. When the pump handle is cranked, the liquid is pulled up through a suction tube and discharged through a hoze or nozzle. To provide pressure and vacuum relief, a drum vent should be installed in the appropriate drum opening. Only a recognized drum vent should be used. Drum transfer pumps permit immediate cutoff control to prevent overflow and spillage, can be reversed to siphon off excess in case of overfilling, and can be equipped with a drip return so that excess can drain back into the drum.

The hand operated, self-closing drum faucet is installed in the end bung opening of a drum placed in horizontal position. Liquid can be dispensed only while hand pressure is applied on the faucet handle or level. On release of hand pressure, the faucet valve automatically shuts off the gravity flow of the liquid. No practice should be permitted and no device should be used that would prevent the faucet from closing automatically when hand pressure is removed. Flexible metal or conductive rubber hoses may be installed on the faucets to facilitate dispensing into receiving containers that have small openings.

As general practice, recognized safety containers should be employed to receive flammable liquids from drums. Before the receiving container is used, it should be checked for correct labeling as to contents, installation and proper operation of the required protective devices, and generally good condition.

When pouring liquids into drums, recognized combination vent and fill units shall be used. These units are equipped with flame arresters, funnel attachments, and pressure and vacuum relief devices.

Bonding and Grounding

The action of transferring a liquid from one container to another may produce voltage potentials that can result in static sparks capable of igniting flammable vapors. *Because static charges can generate from this source and others, it is required that flammable liquid dispensing and receiving containers be bonded together before pouring. It is also required that large containers, such as drums, be connected to an adequate electrical ground when they are used as dispensing or receiving vessels.*

To be effective, all grounding and bonding connections must be metal to metal. Therefore, all dirt, paint, rust, or corrosion should be removed from points of contact before such connections are made.

A bond or ground connector should be composed of suitable conductive materials having adequate mechanical strength, corrosion resistance, and flexibility for the service intended. Since the bond or ground does not need to have low resistance, nearly any conductor size will be satisfactory (from an electrical standpoint.) *Size No. 10 wire is the minimum size which shall be used to assure adequate mechanical strength.* Solid conductors are satisfactory for fixed connections. Flexible conductors (stranded or braided ribbon wire) shall be used for bonds that are to be connected and disconnected frequently.

Conductors may be insulated or uninsulated. Uninsulated conductors are usually preferred since they allow easy detection of defects by visual inspections. If the conductor is insulated for mechanical protection it should be checked for continuity at regular intervals, depending on experience. Permanent connections may be made with screw-type ground clamps, brazing, welding, or other suitable means. Temporary connections may be made with spring (battery type) clamps, magnetic connectors, or other special clamps that provide metal to metal contact.

To ground a drum from which a flammable liquid is to be dispensed, one end of a conductor should be attached to the rim of the drum with a screw clamp and the other end of the conductor should be connected to a known ground with a sturdy bolt-on clamp or other suitable means.

Ventilation

Where flammable liquids are used, adequate local exhaust or general ventilation should be provided at the place of exposure. Requirements for removal or dilution of vapors should be set up for both health hazard and the flammability hazard. If the health hazard is especially high, protection should take the form of

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local exhaust removal of vapors or the wearing of respiratory protective equipment approved for the exposure of the U.S. Bureau of Mines.

If possible, operations requiring the use of a flammable or combustible liquid and the applications of heat should be isolated. An exhaust hood that conducts the vapor outside the building is recommended.

Flammable liquids in large quantities shall not be used in an area where recirculating air conditioning systems can expose people to an increasing concentration of vapor or where an exhaust system may carry a flammable mixture into another place where necessary precautions are not met.

Electrical

For Class I flammable liquids, electrical equipment shall conform to the requirements of the National Electrical Code No. 70 for Class I hazardous locations.

STORAGE

Rooms in which drums containing flammable liquids are stored and in which the liquids are dispensed should be considered potentially hazardous areas, but consistent application of basic fire and accident prevention rules should result in elimination or control of hazards. Special attention should be given to the location of the room, its arrangement, its ventilation, the equipment used, and the storage procedures.

Since the most effective way to control the hazard is to isolate it, the storage and dispensing room preferably should be located in a special building separated from other buildings. If this arrangement is not feasible and the room must be located inside the establishment, it should be constructed of walls, floor, and ceiling having at least two hours fire resistance and Class B fire doors as minimum protection. The room should be used for storage of flammable and combustible liquids only, and storage of other materials in it should be prohibited.

A storage and dispensing room located inside a building should be protected by an automatic fire extinguishing system (automatic sprinklers, carbon dioxide, dry chemical, or foam). *Strategically located portable fire extinguishers designed for use on Class B fires shall be located outside the room but near an entrance to it.*

The room should have both high and low level ventilation to the outside air, special trapped floor drainage facilities, and explosion relief in the form of pressure opening windows or a weak wall, providing on square foot of venting for every 50 cubic feet of room volume. *Storage limitations shall meet the specifications given in the Flammable and Combustible Liquids Code No. 30, Chapter 4.*

After provision for venting has been made, drums preferably should be stored on metal racks with end bung openings toward an aisle and side bung openings on top. The drums as well as the racks should be grounded.

Recognized drip pans with flame arresters should be installed or placed in front of the racks where floor drainage is inadequate.

Storage cabinets that are of a recognized type for holding containers of flammable and combustible liquids shall be installed. These cabinets should be located near the areas where the liquids are used. Such cabinets not only facilitate safe storage but also conserve time since individuals need not make frequent trips to remote storage areas whenever the limited quantities permitted at the point of use are exhausted. *Individual containers shall not exceed 5 gallons in capacity, and a total of not over 50 gallons shall be stored in any one cabinet. The place of storage shall be kept at least 10 feet away from a stairway, elevator, or exit unless guarded by a fire-resistive partition. The containers shall not be exposed to any source of heat. Flammable liquids shall not be stored in domestic type refrigerators unless properly modified to remove ignition sources.* Special refrigerators for this service are listed by Underwriters' Laboratories.

WASTE DISPOSAL

Cloth, paper, and other solid wastes that have been soaked with a flammable or combustible liquid shall be placed in a recognized disposal container.

Safety . . .

Recognized containers are made of metal and are equipped with self-closing covers. Such containers should be clearly labeled as to the type of waste they are intended to receive. The containers should be emptied at the end of each working day and their contents removed to a safe location and burned. *Flammable and combustible liquid waste shall be disposed of safely.* Most laws and ordinances strictly prohibit the pouring of flammable and combustible liquids into sinks or floor drains which connect with sanitary or storm sewer facilities. Standard 30 or 55 gallon drums or smaller recognized containers should be used for waste flammable and combustible liquid disposal, and they should be emptied periodically. They should be safeguarded against fire according to all applicable provisions that are specified for dispensing containers. The liquids should be disposed of by burning in a burner designed for flammable materials or delivered to a waste-liquids collection agency. In many cities, there are firms that collect waste liquids. In some instances, the original supplier will pick up used liquids for reclaiming and resale. For information on disposal agencies contact Environmental Health and Safety.

TRANSPORTATION

Flammable liquids cannot be transported safely in recognized safety cans when the containers are placed in the closed compartment of a vehicle. Since recognized safety cans incorporate pressure relief features in their design, changes in temperature and atmospheric pressure might cause vapors to escape from the containers.

In a confined space in a vehicle, such as a closed compartment of a truck, vapors escaping from a recognized container might ultimately reach explosive proportions. A spark, for instance, from the vehicle's electrical system or other source of ignition, could ignite a flammable mixture under such conditions. Therefore, the common practice of carrying a spare container of gasoline in the interior of a vehicle should be prohibited.

If gasoline or other flammable liquids must be transported, only vehicles suitably equipped or modified for such transport should be used. Provisions for safe temporary transport of small quantities of flammable liquids (5 gallons or less) should include: use of rugged pressure-resistant and nonventing containers; storage during transport in a well ventilated location; elimination of potential ignition hazards.

PROTECTIVE EQUIPMENT

Fire Extinguishment

Fire extinguishing methods for flammable or combustible liquid fires are:

(*a*) Exclusion of air by foam or by other smothering techniques.

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(*b*) Cooling below the fire point by water spray or water fog.
(*c*) Reducing the oxygen content of air with carbon dioxide.
(*d*) Interrupting the chemical chain reaction of the flame with dry chemical agents or a liquified gas agent.

Wherever flammable and combustible liquids are handled or used, enough portable fire extinguishers for use on Class B fires should be readily available to protect the specific area.

All employees shall be instructed as to where fire extinguishers are located and how they are used.

Personal Protection

On jobs where protection against the solvent action of a flammable or combustible liquid is required, users should wear gloves of a material that will not be affected by the solvent to be used.

Adequate eye protection shall be worn wherever flammable and combustible liquids are handled or processed, and where splashing or spraying may occur.

Users should guard against any part of their clothing becoming contaminated with a flammable or combustible liquid. If contamination does occur, they should be required to flush affected skin areas with water immediately and to change their clothing promptly before continuing to work.

PERSONNEL TRAINING

Safe practices on the part of users who handle flammable and combustible liquids are essential in the prevention of fire and explosion. *Before being permitted to undertake jobs that require the use of such liquids, users shall be fully instructed in their characteristics, hazards, and methods of control.*

Supervisors and persons in charge of laboratories should make frequent checks to assure that the required safe practices are being followed consistently. Among the basic safe practices users should be trained to observe are the following:

(*a*) Use only recognized containers in good condition, and keep them closed when they are not in use.
(*b*) Never use a container for any liquid other than that for which it is intended and so marked.
(*c*) Keep at the job site only that quantity of liquid needed and return any unused liquid to designated storage area.
(*d*) Clean up spills of liquids immediately. Dispose of clean-up rags into recognized containers. Never use sawdust to absorb a spill.
(*e*) Never smoke, use open flames, or strike sparks where there is a possibility of a flammable or combustible liquid.
(*f*) Check bonding and grounding connections for electrical continuity.

Only specially trained personnel should be assigned to work in storage and dispensing rooms. Periodic checks should be made for adherence to the prescribed safe practices, and, when necessary, refresher training should be given.

Employees should be kept constantly aware that flammable liquids are hazardous and must be handled with particular care. Posters and signs are among the means that can be used effectively. "No Smoking" signs should be posted conspicuously in buildings and areas where flammable liquids are stored or used.

APPENDIX

References

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