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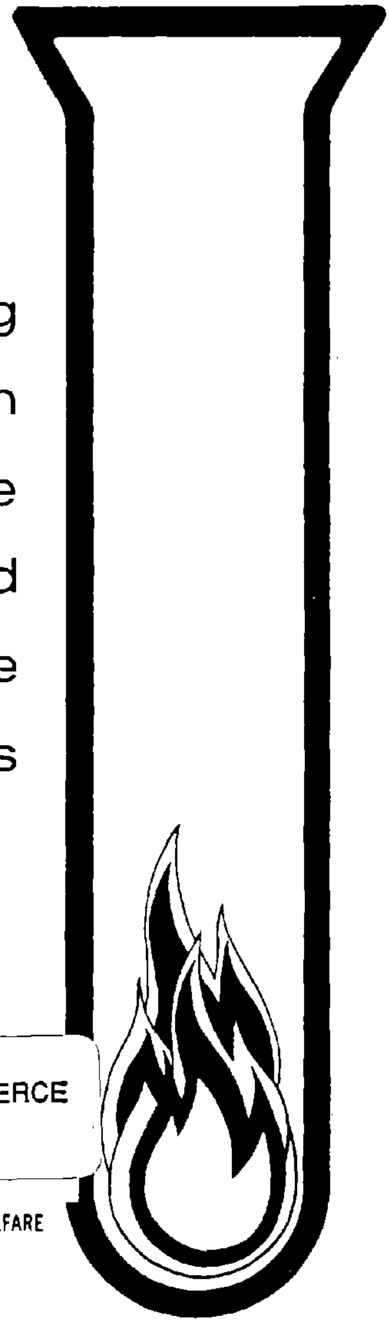
NIOSH

Working Safely with Flammable and Combustible Liquids



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U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Center for Disease Control
National Institute for Occupational Safety and Health

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WORKING SAFELY WITH FLAMMABLE AND COMBUSTIBLE LIQUIDS

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Center for Disease Control
National Institute for Occupational Safety and Health
Division of Technical Services
Cincinnati, Ohio

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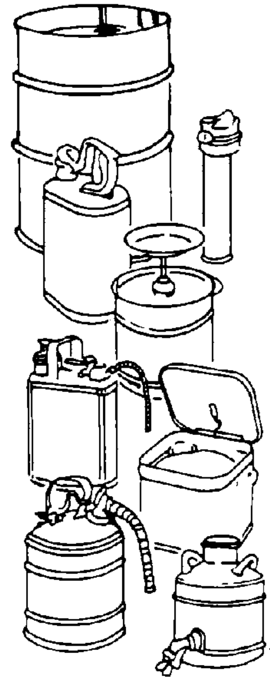
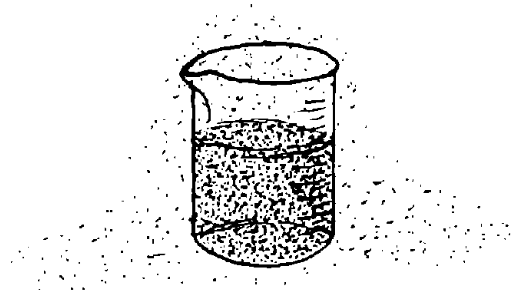


A FLAMMABLE or a COMBUSTIBLE LIQUID will catch fire and burn. Many of the commonly used solvents, waxes, cleaners, adhesives, thinners, and polishes are flammable or combustible liquids. All liquid fuels -- gasoline, diesel oil, and jet fuel are also in this category. This booklet will discuss the hazards of flammable and combustible liquids -- fire and explosion hazards, health hazards, and ways to prevent property damage or injury to your health.

UNDERSTANDING LIQUID FIRES

Liquids are made up of molecules. These molecules are tightly packed together, but at the surface of the liquid they can escape and mix with the air.



Molecules which escape from a liquid make up the VAPOR.

The odors of liquids -- gasoline, perfume, coffee, etc. -- are caused by molecules of these liquids evaporating, mixing with air and reaching your nose. The vapors of flammable and combustible liquids can mix with air and burn if they contact an ignition source. When a liquid burns, it is the molecules of vapor which provide fuel for the fire. The liquid itself does not burn. The amount of vapor which escapes from a liquid depends in part on its temperature. The warmer a liquid gets, the more vapor escapes.

Escaping water vapor makes the teapot whistle when the water's hot.

FLASH POINTS

The lowest temperature at which a liquid releases enough vapor to start burning is called the FLASH POINT. The flash point is used to classify the relative fire hazards of liquids. Liquids classified as FLAMMABLE have flash points below 100 Degrees Fahrenheit. These liquids will release enough vapor to form burnable mixtures with air at temperatures below 100 Degrees Fahrenheit. Liquids classified as COMBUSTIBLE have flash points above 100 Degrees Fahrenheit. These liquids must be heated to temperatures greater than 100 Degrees Fahrenheit before they will release enough vapor to form burnable mixtures. One way this happens is when these liquids (or liquid sprays) come in contact with a hot surface.

****

At normal room temperature, flammable liquids
are a much greater fire hazard
than combustible liquids.
Don't use a flammable liquid when a
combustible liquid will do the job.

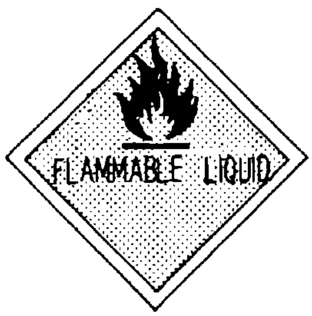
****

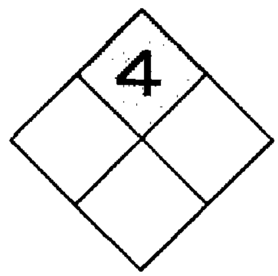
FLAMMABLE LIQUIDS

*have flash points below 100 Degrees Fahrenheit

*are labeled as Class IA, IB, or IC Liquids

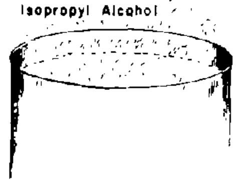
*are numbered as 4 or 3 in the red block of the diamond-shaped National Fire Protection Association (NFPA) hazard identification diagram, or marked as flammable with a Department of Transportation (DOT) label.





COMMON FLAMMABLE LIQUIDS are:

Carbon Disulfide
Ether
Acetone
Benzene (Benzol)
Gasoline
Petroleum Ether (Petroleum Naptha or Benzine)
Lacquer Thinner
Alcohol (Undiluted)
MEK (Methyl Ethyl Ketone)
Toluene
VM+P Naptha
Turpentine
Xylene
Isopropyl Alcohol



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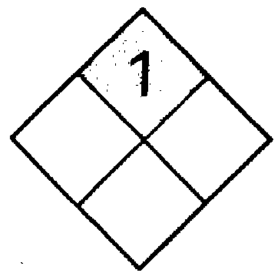
COMBUSTIBLE LIQUIDS

*have flash points above 100 Degrees Fahrenheit

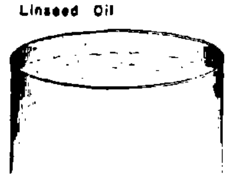
*are labeled as Class II, IIIA, or IIIB Liquids

*are numbered as 2 or 1 in the red block of the diamond-shaped NFPA hazard identification diagram, or marked as combustible with a DOT label.



COMMON COMBUSTIBLE LIQUIDS are:

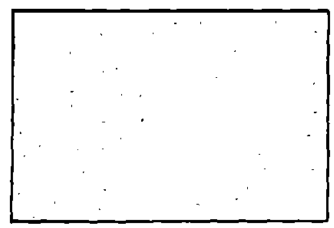
Fuel Oils
Kerosene
Ethylene Glycol
Butyl Cellosolve
Creosote Oil
Formaldehyde (37% Solution)
Mineral Oil
Mineral Spirits (360°)
Safety Solvent (140°)
Phenol
Hydraulic Fluid
Transformormer Oil
Quenching Oil
Linseed Oil



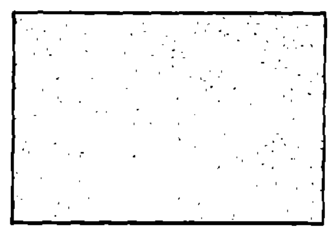
THE FLAMMABLE RANGE

When a liquid is warmer than its flash point, enough molecules (vapor) are escaping to create a FLAMMABLE (BURNABLE) MIXTURE. The concentrations of vapor and air which will burn and spread flame are within the FLAMMABLE OR EXPLOSIVE RANGE.

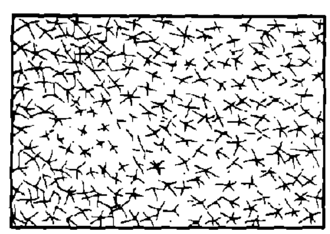
A vapor and air mixture below this range is below the lower flammable or explosive limit (LFL or LEL). These mixtures are too lean to burn.



A vapor and air mixture above this range is above the upper flammable or explosive limit (UFL or UEL). These mixtures are too rich to burn.

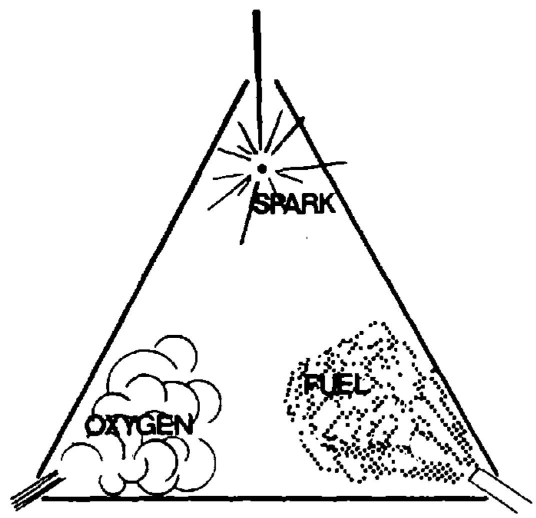


Each liquid has its own characteristic flammable or explosive range.
A vapor and air mixture in this range can burn or explode.
For gasoline, the range is 1.4 to 7.6 percent (vapor in air).
For methanol, the range is 6.7 to 36.0 percent.



IGNITION SOURCES

The three ingredients of a fire are illustrated in the FIRE TRIANGLE.

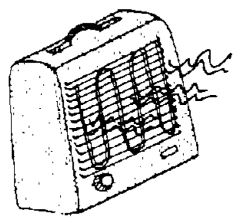


A liquid above its flash point releases enough vapor to form a burnable mixture with air. If this mixture of fuel (vapor) in air (oxygen) comes in contact with a spark (or other ignition source), an explosion and fire can result.

In an auto engine, a burnable mixture of gasoline vapor and air is ignited by the spark plug. In the workplace, there are many possible ignition sources.

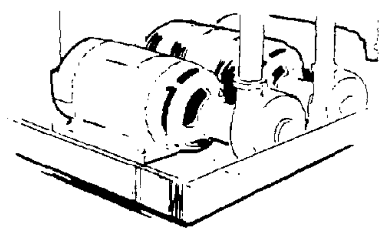
COMMON IGNITION SOURCES INCLUDE:

HOT SURFACES



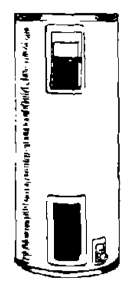
Hot Plates and Electric coils

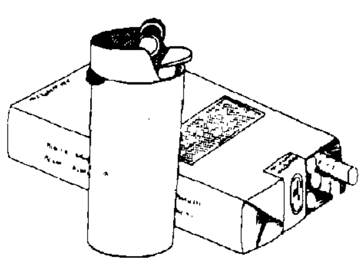
Overheated Bearings



OPEN FLAMES

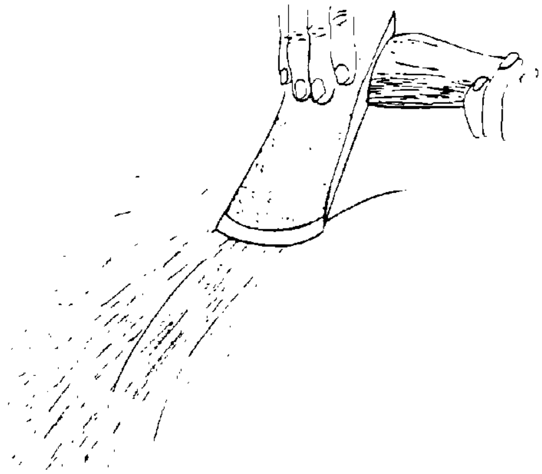
Pilot Lights





Smoking Materials

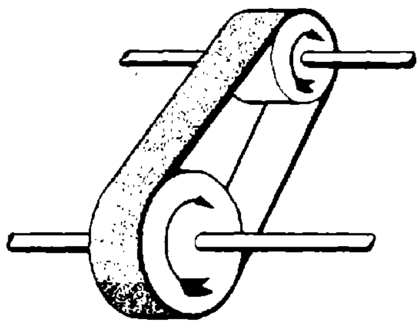
HOT PARTICLES AND EMBERS



Grinders

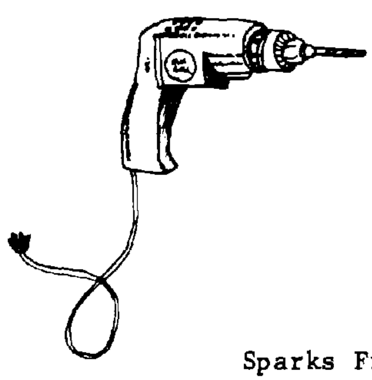
Welding

SPARKS



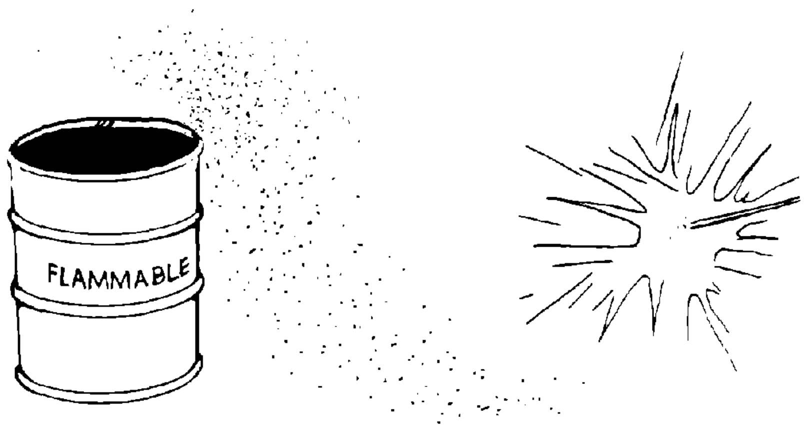
Static Electricity From Rotating Belts

Static Electricity From Transferring Liquids



Sparks From Electrical Tools

Vapors of flammable and combustible liquids are heavier than air. In still air, they tend to settle and collect in lower areas, and the trail of vapors can spread far from the liquid itself. If this vapor trail contacts a source of ignition, the resulting fire can FLASHBACK to the source of the vapors.



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Flashback and fire can occur even though the liquid and the ignition source are far apart.

****

FIRE PREVENTION

The dangerous combination of vapor and air meeting an ignition source takes place all the time. Fire experts estimate that around 65,000 fires a year are caused by flammable and combustible liquids. These fires are cause painful injuries, and loss of life or jobs.

Fires and explosions of these liquids can be prevented by:

*keeping the liquid vapors confined so they can't mix with air, or by ventilating the area with fresh air. When liquids are sprayed indoors, such as in spray painting, ventilated booths or rooms must be used.

*removing all possible ignition sources

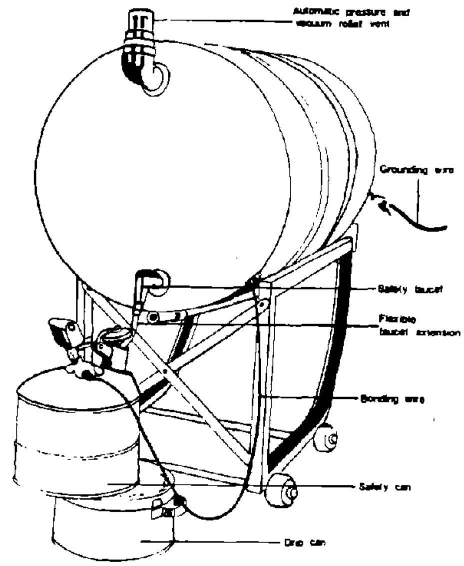
*removing the air (oxygen) necessary for the fire to burn

Keeping the vapors confined is best done by using the proper equipment for storing and handling flammable and combustible liquids.

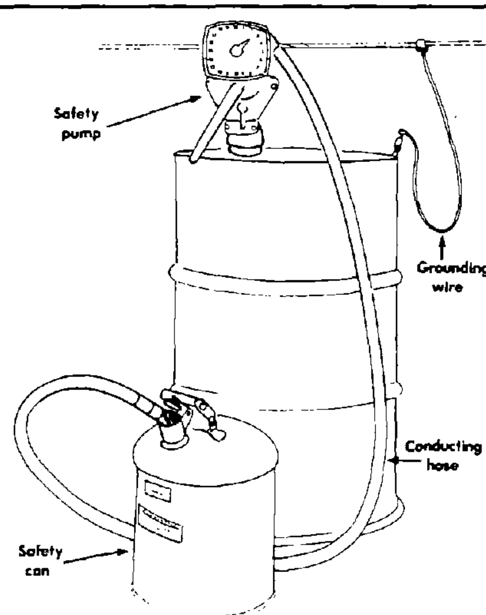
HANDLING LIQUIDS

Liquids can be safely handled with equipment similar to that shown below.

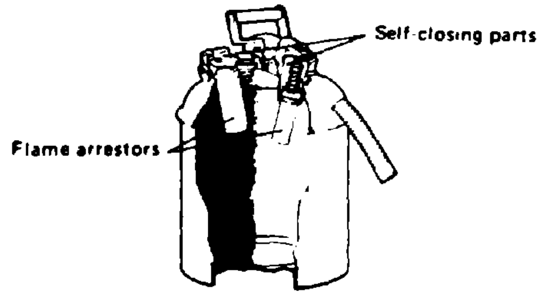
Gravity flow from vented drums



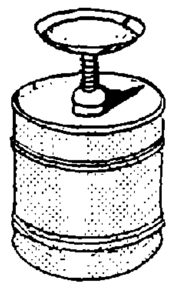
Drum pump



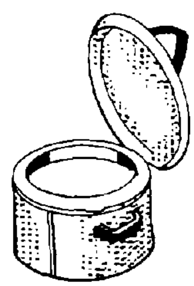
Safety cans with
spring-loaded
closures

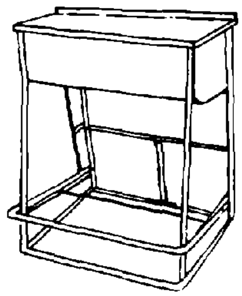


Plunger Cans

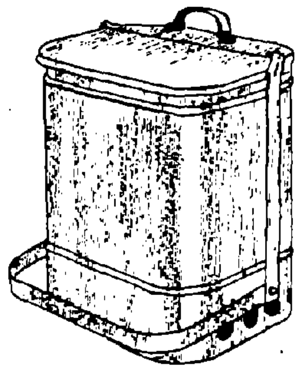


Covered Bench Cans





Covered Dip and Rinse tanks with self-closing lids and fusible links



Safety Disposal Cans

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Equipment such as that described will prevent vapors from escaping.
Open containers, buckets, cans, tanks, and drums should never be used for flammable and combustible liquids.

****

STORING LIQUIDS

The best way to store flammable and combustible liquids is in a separate isolated building. If this isn't possible, they should be stored in a special room with fire-resistant walls, doors, ceilings. and floors.

The storage room should be:

*protected with an automatic fire-protection system (sprinklers, foam, carbon dioxide)

*provided with a portable fire extinguisher outside the room, near the entrance

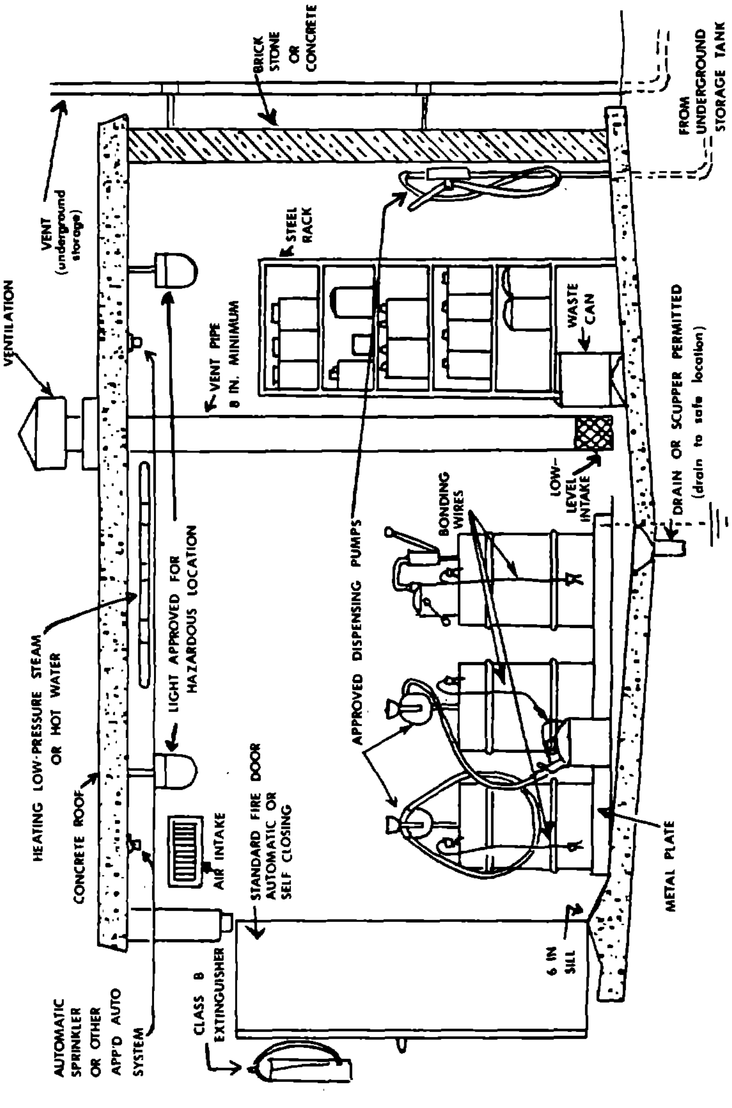
*ventilated to the outside air at a rate providing at least six air changes per hour

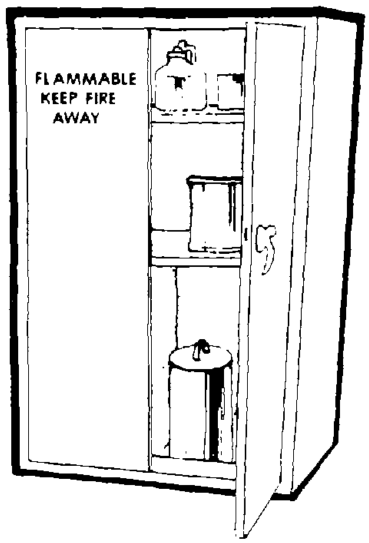
*labeled with signs warning that flammable and combustible liquids are stored inside, and that all fire must be kept away

*provided with raised sills or ramps at doorways, or a grated trench which drains to a safe location

*equipped with explosion-proof lighting and electrical fixtures

When a reserve supply of liquids is stored in drums, the drums should be placed so they are not exposed to direct rays of the sun, or any other source of heat. As soon as a drum is opened, a pressure and vacuum relief vent should be installed.


VENTILATION
VENT (underground storage)
BRICK STONE OR CONCRETE
FROM UNDERGROUND STORAGE TANK
STEEL RACK
WASTE CAN
VENT PIPE 8 IN. MINIMUM
DRAIN OR SCUPPER PERMITTED (drain to safe location)
LOW-LEVEL INTAKE
BONDING WIRES
APPROVED DISPENSING PUMPS
HEATING LOW-PRESSURE STEAM OR HOT WATER
LIGHT APPROVED FOR HAZARDOUS LOCATION
CONCRETE ROOF
AIR INTAKE
STANDARD FIRE DOOR AUTOMATIC OR SELF CLOSING
METAL PLATE
6 IN SILL
CLASS B EXTINGUISHER
AUTOMATIC SPRINKLER OR OTHER APP'D AUTO SYSTEM



When small quantities of liquids are stored near their point of use, they should be kept in an approved flammable liquid cabinet. It is a good practice to keep only one day's supply of flammable and combustible liquids at the worksite. The reserve supply should be kept in the fireproof cabinet or room.

ELIMINATING IGNITION SOURCES

Eliminating possible ignition sources is essential in preventing fires. Most workplaces have many possible ignition sources -- some of these are listed on pages 8 to 11 in the preceding section on ignition sources.

Many potential ignition sources can be eliminated by:

*prohibiting smoking around flammable and combustible liquids

*maintaining good housekeeping practices

*removing open flames and spark or ember producing equipment

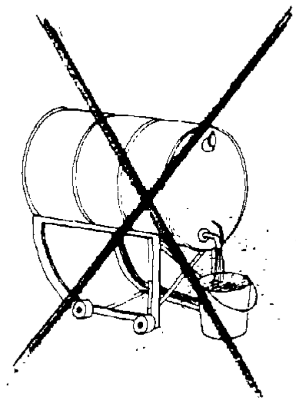
*using only approved, explosion proof equipment in hazardous locations

BONDING AND GROUNDING

A very dangerous ignition source is the STATIC ELECTRICITY which builds up when liquids are transferred from one container to another.

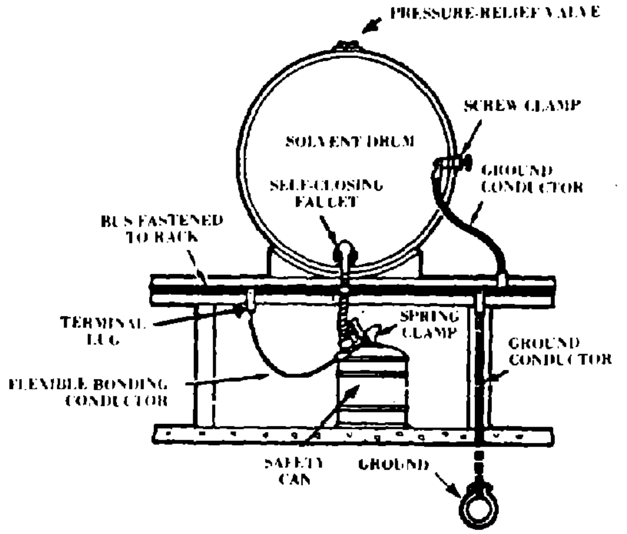
When some materials rub together, an electric charge is produced. This can happen when you comb your hair, walk across a rug on a dry day, or when liquids flow from one container to another.

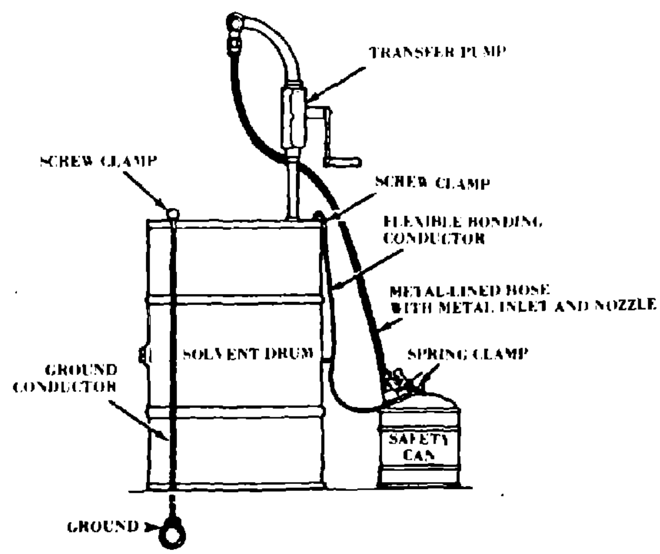
Transferring liquids this way is a double danger -- both an ignitable vapor mixture and static sparks can form. Sparks are prevented by BONDING AND GROUNDING containers before transferring liquids.



BONDING is done by making an electrical connection between the containers. The best way to do this is with a FLEXIBLE BONDING CONDUCTOR -- a bonding strap or wire. Bonding can also be done by maintaining a solid metal to metal contact between the containers. This way is not as sure as using a bonding strap or wire.

GROUNDING is done by providing a path for static charge to drain off to the earth. Grounding straps and wires must be connected to known grounds such as water pipes, grounded metal building framework, and metallic underground gas piping systems. All grounding equipment must be periodically tested to make sure it is still effective.





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BONDING AND GROUNDING are essential for safe handling of flammable and combustible liquids.

****

REMOVING OXYGEN

Another way of preventing flammable and combustible liquid fires is by excluding air (oxygen) and replacing it with a gas in which burning cannot take place. This process, called inerting, can often be done inside equipment or tanks, but it cannot be used in the general workplace.

FIRE PROTECTION

When a fire starts in a flammable or combustible liquid, things start happening fast. Fires in these liquids can give off intense heat and smoke, while spreading rapidly. Some liquids generate hazardous decomposition products when they burn, so a relatively small fire could produce a very dangerous atmosphere.

Imagine that a liquid fire started on your job.

You'd have to come up with some fast answers to these questions:

> *How big is the fire? Would a portable fire extinguisher do any good?

These are important questions. Using a portable extinguisher is like first aid. You wouldn't put a band-aid on a broken leg, and you shouldn't try to put out a large fire with a portable extinguisher. You could be wasting valuable time by trying to fight a fire before you sound the alarm.

> *Has anyone turned in the fire alarm?

All fires must be reported. Even if you put a fire out yourself, there's a chance it could reignite unless the cause of the fire is discovered and eliminated.

> *What are the chances of the fire spreading? Is it better just to get everyone out?

It may be that the best thing you can do is to spread the alarm and help others get to a safe area.

> *Has anyone been hurt?

Burn victims need <u>immediate</u> medical attention. Getting medical help for an injured person may be the best thing you can do.

****

Good employee training will help answer these questions.

****

TRAINING

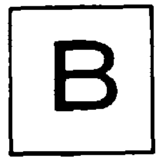
When a fire starts in a flammable or combustible liquid, the first few moments will probably determine how large and destructive the fire will be. If there has been an effective fire training program, everyone should know what to do when a fire starts. Without good training, the chances of serious damage to life and property are much greater.

Training in the use of portable fire extinguishers is a good way to increase the awareness of the fire hazards, as well as improving the effectiveness of fire extinguishers when they are used. Actual practice in extinguishing fires with extinguishers which are due for recharge is good experience. No one is likely to forget experiencing the intense heat and smoke some liquid fires can produce.

PORTABLE EXTINGUISHERS

If you decide that a portable extinguisher will control the fire, be sure you use the right type of extinguisher. Of course you should know where the extinguishers are. Look around your job -- would you know where they are if a fire started?

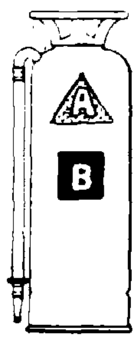
A flammable or combustible liquid fire is known as a CLASS B FIRE. Extinguishers approved for use on these fires are labeled with a red square with a B inside.



Any extinguisher with this "B" can be used on liquid fires. EXTINGUISHERS LABELED "B", "A - B", "B - C", or "A - B - C" CAN ALL BE USED.

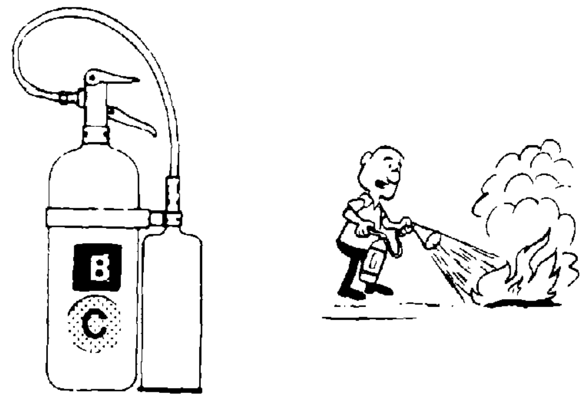
The following types of extinguishers can be used on class B fires:

FOAM extinguishes fires by floating on the surface of the burning liquid and excluding oxygen. Some foams also form a sealing film over the fuel surface.



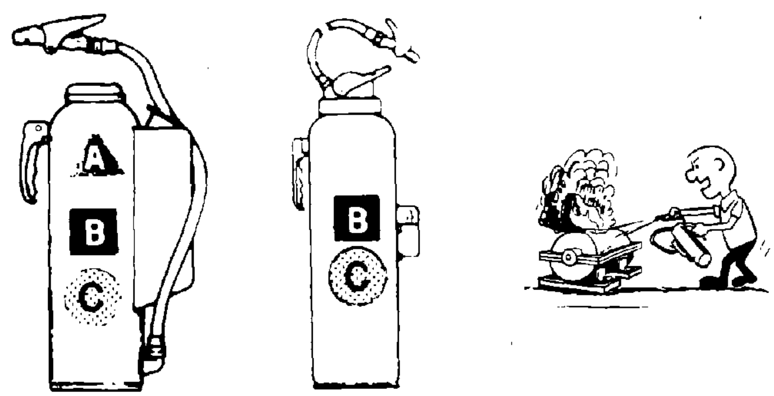
To use this type of extinguisher, spray the foam onto the fire and let the foam fall through the flames.

CARBON DIOXIDE extinguishes fires by displacing the oxygen so the fire cannot continue to burn.



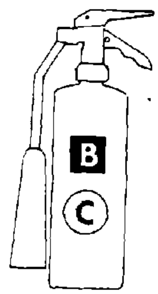
To use this type of extinguisher, first direct the discharge at the edge of the fire as close to the flames as possible, then forward and upward through the flames, moving the nozzle from side-to-side.

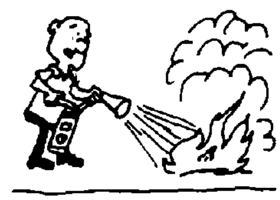
The exact mechanisms of DRY CHEMICAL extinguishing action are not definitely known. Fire experts believe that the chemical interrupts chemical reactions which are taking place in the fire.



To use this type of extinguisher, direct the powder at the base of the flame, and move the nozzle rapidly in a side-to-side sweeping motion.

LIQUIFIED GAS extinguishers contain a halogenated chemical (Halon). Fire experts believe that these extinguishers work by disrupting the chemical reactions in the fire.





To use this type of extinguisher, direct the discharge as close to the fire as possible, first at the edge of the flames, then moving through the flames in a sweeping, side-to-side motion.

****
Always look for the symbol "B" before using any extinguisher on a liquid fire.
Never use water -- it will only spread the flame, or cause it to flare up.
****

PERSONAL PROTECTION

So far, this book has discussed fire prevention and protection when handling flammable and combustible liquids. Fire isn't the only danger associated with these liquids -- many of them can be very hazardous to your health.

There are thousands of liquids in use which are health hazards. No matter which liquids you use or how you use them, the following basic rules are worth remembering:

*AVOID SKIN CONTACT. Most flammable and combustible liquids will remove the oils from the skin and cause irritation, cracking, rashes, or infection. Wear protective gloves and aprons if there is a chance of skin contact. Always wash liquids from your skin with non-abrasive soap or hand cleaner.

*DON'T BREATHE THE VAPORS. Avoid breathing vapors of any liquid -- use these liquids only in a well ventilated area. If ventilation is not possible, use an approved respirator. Be especially cautious when working in confined spaces.

*PROTECT YOUR EYES. Always wear safety glasses or goggles when pouring flammable or combustible liquids. If you spray these liquids, or if there is a chance of liquids splashing in your face, a full face shield should be used.

If someone is splashed with a harmful or a burning liquid, he may not be able to help himself. Chemical splashes and burns can be very painful, and each worker must depend on his coworkers for help in an emergency. If someone is splashed, get him to running water immediately. Flush the splashed area with water for at least 15 minutes, and remove contaminated clothing while flushing with water. Get medical attention immediately.

If someone is burned or splashed with burning liquid, put out the fire with water (not a chemical extinguisher) or by smothering the flames, and get medical attention immediately.

WASTE DISPOSAL

This subject deserves special mention. Used or dirty solvent, cleaning liquids, and rags or papers soaked with flammable or combustible liquid are often not treated with respect because they have served their purpose.

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Waste materials can present extreme fire and health hazards.
Waste materials must be placed in fireproof, covered containers, which are emptied daily.

****

Never pour waste flammable or combustible liquids into sinks or drains which go to sewer facilities or storm drains where they may explode or burn.

SUMMARY

Flammable and combustible liquids are used in many ways on many jobs. They can cause fires and personal injury if they are not stored, handled, and used with caution.

PROPER EQUIPMENT MUST BE USED to prevent hazardous vapors from escaping: SAFETY FAUCETS OR PUMPS on drums, SAFETY CANS for transferring liquids, and COVERED BENCH CANS AND RINSE TANKS.

Sources of ignition: HOT SURFACES, OPEN FLAMES, HOT PARTICLES AND SPARKS, must be eliminated from areas where flammable and combustible liquids are stored or used.

Special attention must be given to BONDING AND GROUNDING containers when these liquids are transferred.

Many liquids are HEALTH HAZARDS. Precautions should be taken to prevent inhalation of their vapors and direct contact of the liquid with the skin and eyes.

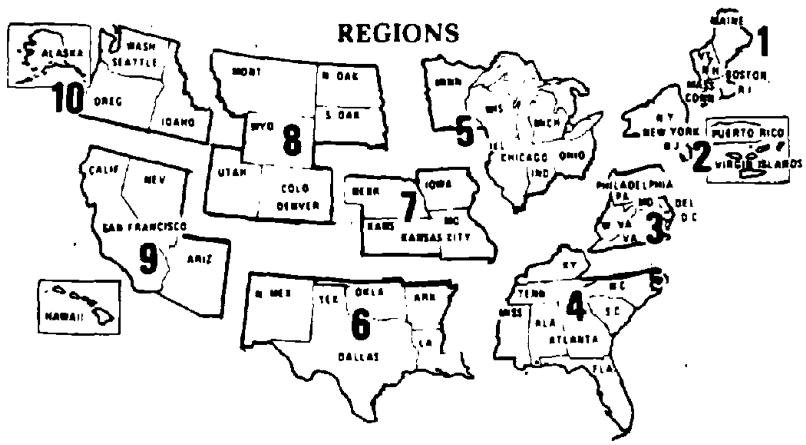
Special attention must be given to SAFE DISPOSAL OF WASTE MATERIAL.

If a fire starts, the right kind of EXTINGUISHER must be used or it could make the fire worse. Fire extinguishers labeled with a "B" are approved for flammable and combustible liquid fires.

REMEMBER -- Flammable and combustible liquids can be used safely, but the responsibility for safe handling is in your hands. By following the procedures in this book, you can protect your health, your safety, your fellow workers, and your job. It's up to you.

NIOSH AND OSHA REGIONAL OFFICES

The following pages list NIOSH and OSHA regional offices. Either of these facilities serving the state can provide information on the Occupational Safety and Health Act including questions on standards interpretations, voluntary compliance information, copies of the OSHA Standards, OSH Act, Employee Rights Posting Notice, and other OSHA publications.



NIOSH REGIONAL OFFICES

DHEW, Region I
JFK Federal Bldg.
Room 1401
Boston, Massachusetts 02203
617/223-6668

DHEW, Region II
26 Federal Plaza, Room 3300
New York, New York 10007
212/264-2485

DHEW, Region III
P. O. Box 13716
Philadelphia, PA 19101
215/596-6716

DHEW, Region IV
101 Marietta Tower
Atlanta, GA 30323
404/221-2396

DHEW, Region V
300 South Wacker Dr.
33rd Floor
Chicago, IL 60606
312/886-3651

DHEW, Region VI
1200 Main Tower Bldg.
Dallas, Texas 75202
214/655-3081

DHEW, Region VII
601 E. 12th St.
5th Floor West
Kansas City, Missouri 64106
816/374-5332

DHEW, Region VIII
11037 Federal Bldg.
Denver, Colorado 80294
303/837-3979

DHEW, Region IX
50 United Nation Plaza, Rm. 231
San Francisco, CA 94102
415/556-3781

DHEW, Region X
1321 Second Ave., Mail Stop 502
Seattle, Washington 98101
206/442-0530

OSHA REGIONAL OFFICES

Region I
U.S. Department of Labor
Occupational Safety and Health Administration
JFK Building, Room 1804
Boston, Massachusetts 02203 .. Telephone: 617/223-6712/3

Region II
U.S. Department of Labor
Occupational Safety and Health Administration
1515 Broadway (1 Astor Plaza), Room 3445
New York, New York 10036 .. Telephone. 212/971-5941/2

Region III
U.S. Department of Labor
Occupational Safety and Health Administration
15220 Gateway Center, 3535 Market Street
Philadelphia, Pennsylvania 19104 .. Telephone 215/596-1201

Region IV
U.S. Department of Labor
Occupational Safety and Health Administration
1375 Peachtree Street, N.E. Suite 587
Atlanta, Georgia 30309 .. Telephone 404/526-3573/4 or 2281/2

Region V
U.S. Department of Labor
Occupational Safety and Health Administration
230 S. Dearborn, 32nd Floor
Chicago, Illinois 60604 .. Telephone. 312/353-4716/7

Region VI
U.S. Department of Labor
Occupational Safety and Health Administration
555 Griffin Square Building, Room 602
Dallas, Texas 75202 .. Telephone: 214/749-2477/8/9 or 2567

Region VII
U.S. Department of Labor
Occupational Safety and Health Administration
Federal Building, Room 3000, 911 Walnut Street
Kansas City, Missouri 64106 .. Telephone: 816/374-5861

Region VIII
U.S. Department of Labor
Occupational Safety and Health Administration
Federal Building, Room 15010, 1961 Stout Street
Denver, Colorado 80202 .. Telephone 303/837-3883

Region IX
U.S. Department of Labor
Occupational Safety and Health Administration
9470 Federal Building, 450 Golden Gate Avenue
Post Office Box 36017
San Francisco, California 94102 .. Telephone 415/556-0584

Region X
U.S. Department of Labor
Occupational Safety and Health Administration
6048 Federal Office Building, 909 First Avenue
Seattle, Washington 98174 .. Telephone: 206/442-5930

☆ U.S. GOVERNMENT PRINTING OFFICE: 1978—760-578/22 Region No. 5-2

EMERGENCY INFORMATION

FIRE

Telephone Fire Department ______________________
Nearest Alarm Box at ______________________

CRIME

Telephone Police ______________________

INJURY/ILLNESSES

Avoid infection of minor injuries; always get medical attention or skilled first aid.

Doctor ______________________
Office ______________________ Tel. __________
Residence ______________________ Tel. __________

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Hospital ______________________
Address ______________________ Tel. __________
Ambulance ______________________
Address ______________________ Tel. __________

(In emergencies, get medical attention and transportation elsewhere if necessary.)

In all cases of Fire, Crime, Accident, or Sickness, promptly notify:

1. Name ______________________ Office Tel. __________
   Address ______________________ Res. Tel. __________

or

2. Name ______________________ Office Tel. __________
   Address ______________________ Res. Tel. __________

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15. Supplementary Notes

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16. Abstracts

ABSTRACT: The fire, explosion, and safety hazards of flammable and combustible liquids are described. Physical properties, flash points, flammable ranges, and ignition sources are included for common flammable and combustible liquids. Fire prevention methods, including liquid handling and storage, bonding and grounding, and removal of ignition sources and oxygen, are discussed. Fire protection training, and the use of portable fire extinguishers are described. Personal protection guidelines are included, along with first aid procedures. Waste disposal also is discussed. Addresses of NIOSH and OSHA regional offices are included.

17. Key Words and Document Analysis. 17a. Descriptors

KEYWORDS: NIOSH-Publication, Chemical-industry, Safety-practices, Accident-research, Control-methods, Work-environment, Occupational-health, Combustible-liquids

17b. Identifiers/Open-Ended Terms

17c. COSATI Field/Group

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