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ABSTRACT

This student module on safe handling and use of flammable and combustible materials is one of 50 modules concerned with job safety and health. This module introduces the student to the hazards of flammable and combustible materials and the measures necessary to control those hazards. Following the introduction, 14 objectives (each keyed to a page in the text) the student is expected to accomplish are listed (e.g., Discuss the types of approved safety containers). Then each objective is taught in detail, sometimes accompanied by illustrations. Learning activities are included. A list of references and answers to learning activities complete the module. (CT)

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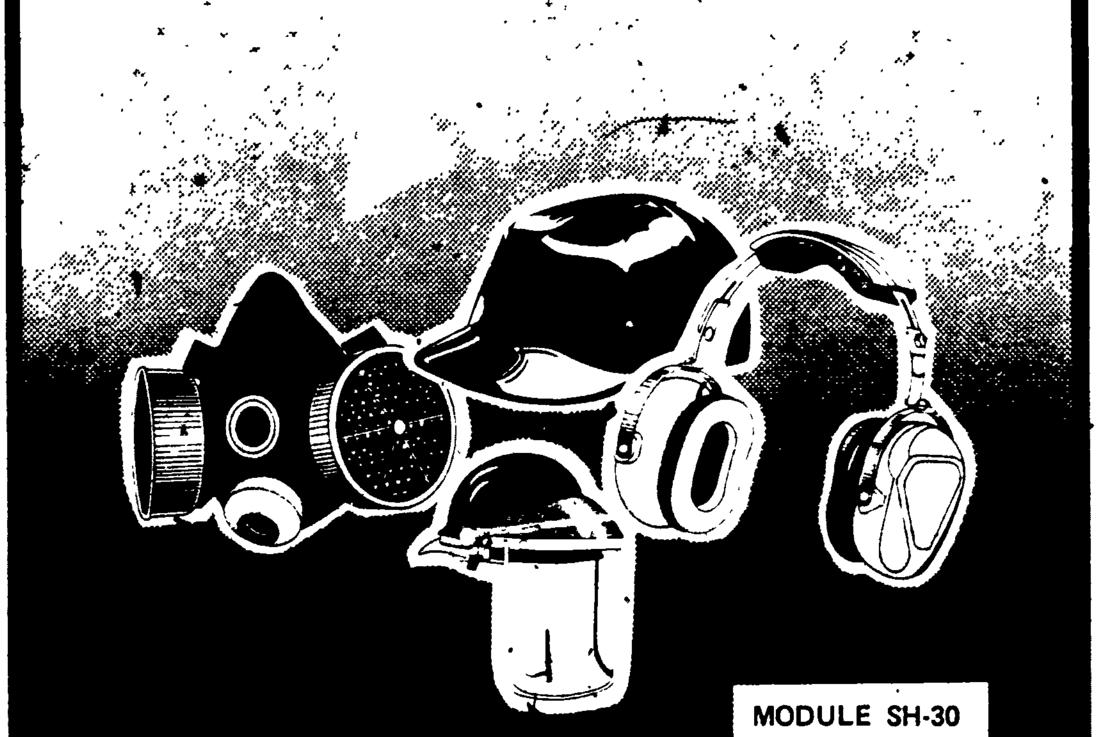
SAFETY AND HEALTH

SAFE HANDLING AND USE OF FLAMMABLE AND COMBUSTIBLE MATERIALS



MODULE SH-30

CORD

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CORD

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INTRODUCTION

Many of the materials that are commonly used in industry today will catch fire and burn. Solvents, waxes, cleaners, adhesives, thinners, and polishers are usually flammable or combustible liquids. All liquid fuels — gasoline, diesel oil, and jet fuel are also in this category. Gases used for industrial purposes may be stored in liquified form or as compressed gases in high pressure cylinders. Proper handling procedures for these gases are essential since many of them have an extremely high potential for causing fires and explosions. Other flammable gases may be produced as by-products of industrial operations. Dusts produced by agricultural or manufacturing processes are another major source of explosions and fires in industry.

It is not possible to list the handling precautions for all flammable and combustible materials used in American industry, for these are thousands. This module is intended as an introduction to the hazards of flammable and combustible materials and the measures necessary to control those hazards.

Flammable and combustible liquids are discussed at length, including terms and classifications. Common ignition sources, storage procedures, storage facilities, personal protective equipment, and fire fighting equipment are discussed. The hazards of flammable gases and combustible materials, especially dusts, are described briefly.

Finally, the classes of hazardous locations are defined by OSHA (Occupational Safety and Health Administration) and as related to powered industrial trucks are described. These classes may provide the student with a useful way of understanding the relative hazards of various flammable and combustible materials.

OBJECTIVES

Upon completion of this module, the student should be able to:

1. Define flammable liquids, combustible liquids, flash point, auto-ignition temperature, and flammable or explosive range. (Page 3)
2. Explain briefly what is meant by flammable range or explosive range. (Page 6)

3. Identify the OSHA classifications for flammable and combustible liquids. (Page 8)
4. Identify 12 common ignition sources and precautionary measures that may be taken regarding them. (Page 10)
5. Explain in a sentence or two the need for bonding and grounding where flammable liquids are poured, and the difference between the two terms. (Page 13)
6. Discuss the types of approved safety containers. (Page 15)
7. Describe the requirements associated with indoor storage of flammable and combustible liquids. (Page 17)
8. Discuss the requirements necessary for service stations and refueling areas. (Page 20)
9. List at least five articles of protective equipment useful when working with flammables and combustibles. (Page 21)
10. Describe fixed and portable fire fighting equipment for use with flammables and combustibles. (Page 23)
11. Discuss the hazards of flammable gases used for industrial purposes. (Page 26)
12. Describe the hazards associated with plastics, textiles, and some combustible wastes. (Page 30)
13. Describe two ways that dust explosions can be prevented. (Page 30)
14. Identify the classes of hazardous locations as defined by OSHA. (Page 32)

OBJECTIVE 1: Define flammable liquids, combustible liquids, flash point, auto-ignition temperature, and flammable or explosive range.

For a fire to occur, four ingredients or conditions must be present. These four fundamentals are referred to as the fire pyramid (Figure 1). There must be fuel, oxygen (in the air), heat, and a chain reaction. Fuel may be provided by liquids that will burn as well as by oily rags, sawdust, paper, scrap, and other materials. Oxygen is usually in plentiful supply from the air itself. Heat may be provided by electrical sparks, open flames, hot particles, and embers, as well as many other sources. The fourth side of the fire pyramid is a chain reaction between fuel and oxygen.

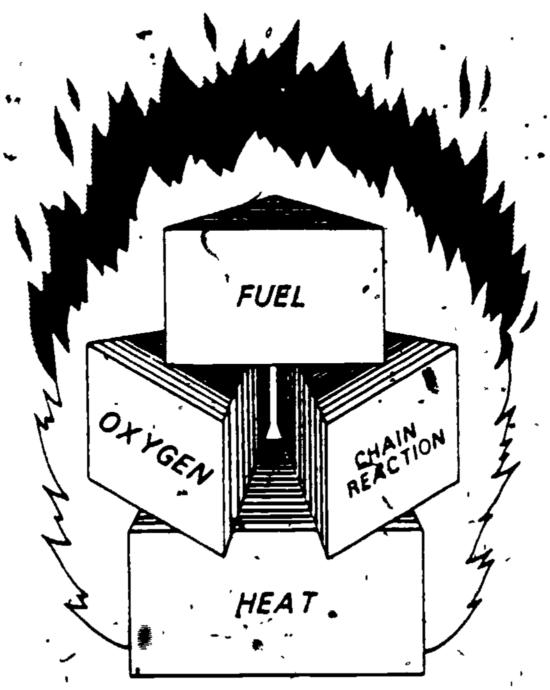

Figure 1. The fire pyramid.

FLASH POINT, FLAMMABLE, AND COMBUSTIBLE LIQUIDS

Many of the liquids that are commonly used in industry today will catch fire and burn; that is, they will ignite. Ignitable liquids burn easily and rapidly. Fires fueled by ignitable liquids are harder to extinguish than some other kinds of fires. In addition, vapors from ignitable liquids are likely to explode.

An ignitable liquid tends to evaporate and become a vapor as the temperature goes up or the pressure goes down. Just as water vapor escapes from a pond or a pool of water, vapor escapes from other liquids. When an ignitable liquid burns, it is the vapor that provides the fuel for the fire.

The lowest temperature at which a liquid releases enough vapor to support 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°F. Liquids classified as combustible have flashpoints above 100° F. These liquids must be heated to temperatures greater than 100°F before they will release enough vapor to form burnable mixtures.

At normal room temperatures, flammable liquids are a much greater fire hazard than combustible liquids. Therefore, combustible liquids — wherever they will do the job — should be used instead of flammable liquids.

Some examples of flammable liquids and combustible liquids that are used in industry are listed in Table 1.

TABLE 1. FLAMMABLE LIQUIDS AND COMBUSTIBLE LIQUIDS COMMONLY USED IN INDUSTRY.

Flammable Liquids	Combustible Liquids
Carbon Disulfide	Fuel Oils
Ether	Kerosene
Acetone	Ethylene Glycol
Benzene (Benzol)	Butyl Cellosoive
Gasoline	Cresote oil
Petroleum Ether (Petroleum Naptha or Benzine)	Formaldehyde (37% Solution)
Laquer Thinner	Mineral Oil
Alcohol (Undiluted)	Mineral Spirits
MEK (Methy Ethyl Ketone)	Phenol
Toluene	Hydraulic Fluid
VM + P Naptha	Transformer Oil
Turpentine	Quenching Oil
Xylene	Linseed Oil
Isopropyl Alcohol	

AUTO-IGNITION TEMPERATURE

Auto-ignition temperature is the lowest temperatures at which a flammable gas or vapor-oil mixture will ignite from its own heat source or from contact with a heated surface without the necessity of a spark or flame. Vapors and gases will ignite spontaneously at a lower temperature in pure oxygen than in air. The majority of vapors and gases will not self ignite in air until they reach temperatures of about 550°F to 900°F. Therefore, the greatest danger of fire in using and handling combustible and flammable liquids comes not from auto-ignition but from common ignition sources such as sparks, flames, and static electricity.

ACTIVITY 1:*

1. Define:
   a. Flash point ______________________
   ____
   b. Flammable liquid ______________________
   ____
   c. Combustible liquid ______________________
   ____

2. Complete the statements below by choosing the best word to fit the blank.
   a. At normal room temperatures, __________ liquids are the greatest fire hazard. (combustible, flammable)
   b. The greatest danger in handling flammable and combustible liquids comes from __________ __________. (auto ignition, common ignition sources)

*Answers to Activities appear on page 37.

OBJECTIVE 2: Explain briefly what is meant by flammable range or explosive range.

When a liquid is warmer than its flash point, enough vapor is escaping to create a mixture that will burn. The mixture of vapor and air in concentrations that will burn and spread flame are said to be in the FLAMMABLE RANGE or EXPLOSIVE RANGE.

When a vapor reaches the minimum concentration in air at which the mixture of vapor and air will burn, the lower flammable limit, or LFL, has been reached. Below the lower flammable limit, the vapor and air mixture is too lean to burn.

There is a point at which the concentration of vapor in air becomes too great for the mixture to burn. That point is known as the upper flammable limit, or UFL. Above the upper flammable limit, the mixture is too rich to burn (as occurs when an automobile engine is flooded).

Figure 2 represents the flammable range of gasoline, assuming that temperature and pressure remain constant. Flammable range is the difference between lower and upper flammable limits. The difference is expressed as the

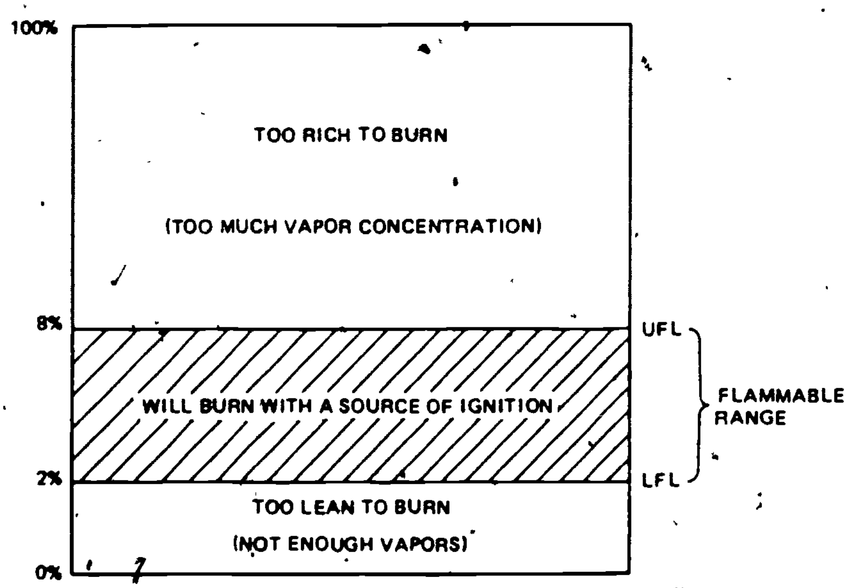

Figure 2. Flammable range of gasoline.

percentage of vapor in air by volume. Each liquid has its own characteristic flammable or explosive range. For gasoline, the range is 1.4 to 7.6 percent.

The flammable range of a liquid is affected very little by normal variations in atmospheric pressure, temperature, or humidity; but at very high temperatures, the UFL is raised and the LFL is lowered, thereby increasing the flammable range. If a liquid is used in or around processes involving high-temperatures, the limits given for room temperatures are no longer applicable. Heating a liquid increases the hazard tremendously.

Another important thing to know about flammable and combustible liquids is that vapors of these liquids are heavier than air. Flammable and combustible liquid vapors tend to settle on the floor or flow downhill unless carried up by rising air currents. A trail of vapors can travel far from the source of ignition and settle and collect in lower areas. If this vapor trail contacts a source of ignition, the resulting fire can flashback to the source of the vapors and cause a large fire or an explosion.

ACTIVITY 2:

1. Choose the best answer:

   Flammable range refers to —

   a. The difference between lower and upper flammable limits.
   b. The range of mixtures of vapor and air in concentrations that will burn.
   c. The range of mixtures of vapor and air that are too rich to burn.
   d. a and b.
   e. b and c.

2. Mark the statements true or false.

   _____ a. Flammable range is the same for all liquids that will burn.

   _____ b. Flammable range and explosive range mean the same thing.

   _____ c. Vapors can flow for long distances, leaving a trail back to their source.

> **OBJECTIVE 3:** Identify the OSHA classifications for flammable and combustible liquids.

Liquids are legally classified according to how much of a fire hazard they present; different safety measures are necessary for using and storing each class of ignitable liquid.

CLASS I

Class I includes all liquids defined as flammable (those that a flash point below 100 degrees Fahrenheit). Some common Class I liquids are: acetone, gasoline, ethyl alcohol, benzene, and lacquer thinner. There are three groups of Class I liquids and all of them are highly volatile and easy to ignite.

Class IA liquids are the most hazardous because they give off ignitable vapors even when the liquids are exposed to air temperatures below 73 degrees Fahrenheit (average room temperature). These liquids also have low boiling points — below 100 degrees Fahrenheit. Liquids with low boiling points are highly volatile; that is, they form vapors readily. The lower the boiling point of an ignitable liquid, the greater the hazard. Class IB liquids have low flash points (below 73 degrees Fahrenheit), but their boiling points are at or above 100 degrees Fahrenheit. Class IC liquids have somewhat higher flash points, at or above 73 degrees Fahrenheit with boiling points below 100 degrees Fahrenheit.

Class II liquids, such as kerosene, and Class III liquids such as heavy fuel oil and ethylene glycol (the main ingredient in some antifreeze compounds), are defined as combustible. These ignitable liquids have flash points at or above 100 degrees Fahrenheit; therefore, they do not ignite as readily as flammable liquids. However, any liquid that gives off ignitable vapors at any temperature must be respected — the possible consequences of carelessness are too grave to ignore.

Of course, a combustible liquid will produce ignitable vapor much more readily when it is heated to a temperature at or above its flash point. If a Class II or III liquid is sufficiently heated, it will become as hazardous as any Class I liquid and requires the same precautions as a flammable liquid.

For example, when red hot steel is dipped into high flash point quench oil, the oil is heated to several hundred degrees Fahrenheit. The resulting vapor becomes as readily ignitable as gasoline vapor.

Mixing flammable and combustible liquids is especially dangerous because the lower flash point liquid can act as a fuse to ignite the higher flash point liquid. For example, if even a small amount of gasoline is put into a tank of kerosene, the gasoline vapor can ignite, and raise the temperature of the kerosene to its ignition point.

Unfortunately, it may be hard to find out the hazard class of the particular liquid you are using or handling. Warning labels on containers of ignitable liquids may or may not specify the hazard class to which the liquid belongs. Properly marked exterior containers shipped in interstate commerce carry a red warning label when the contents have a flash point lower than 100 degrees Fahrenheit. But an individual container inside exterior packaging may not have a specific classification label. It may have only a general warning that the contents are ignitable and should not be used near an ignition source.

Never be tempted to use the odor of a liquid as a clue to its flammability or combustibility. Only a properly conducted flash point test can determine how much of a fire hazard the liquid might present under particular conditions. If you do not know what precautions to take, ask your supervisor or make a call to the safety office and have the information read to you from a Material Safety Data Sheet. Your employer should allow you to review Material Safety Data Sheets. These should be maintained for every potentially hazardous liquid used at your worksite. If specific fire hazard information is not on a container label, these sheets will provide sufficient information to enable you to use the liquid safely.

ACTIVITY 3:

(Choose the best answer from each pair.)

1. Liquids with low boiling points are:
   a. Highly volatile.
   b. Slow to form vapors.

2. Class I liquids have a flash point:
   a. Above 100 degrees Fahrenheit.
   b. Below 100 degrees Fahrenheit.
3. Class II liquids and Class III liquids:
   a. Can never become as hazardous as a Class I liquid.
   b. If heated, can become as hazardous as Class I liquids.
4. The liquids most complete information about precautions to take with specific liquids can be obtained by:
   a. Reviewing the label on the shipping container.
   b. Reviewing the Material Safety Data Sheet for the liquid in question.

OBJECTIVE 4: Identify 12 common ignition sources and precautions that may be taken regarding them.

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) come in contact with a spark (or other ignition source), an explosion and fire can result.

In the workplace, there are many possible ignition sources (Figure 3). Hot surfaces such as hot plates, electrical coils, and overheated bearings are one type of ignition source. Open flames such as pilot lights, bunsen burners, and smoking materials are another. Hot particles and embers from grinders and welding activities can travel through tiny cracks and holes to light combustible materials. Static electricity is the source of many fires and may be produced by rotating belts and machine parts, transferring of liquids, and electrical tools.

Pilot lights and smoking materials must be strictly prohibited near operations where flammable and combustible liquids are used. However, sometimes a piece of equipment which has hot surfaces or produces radiant heat is necessary to the operation. In these situations, such equipment including

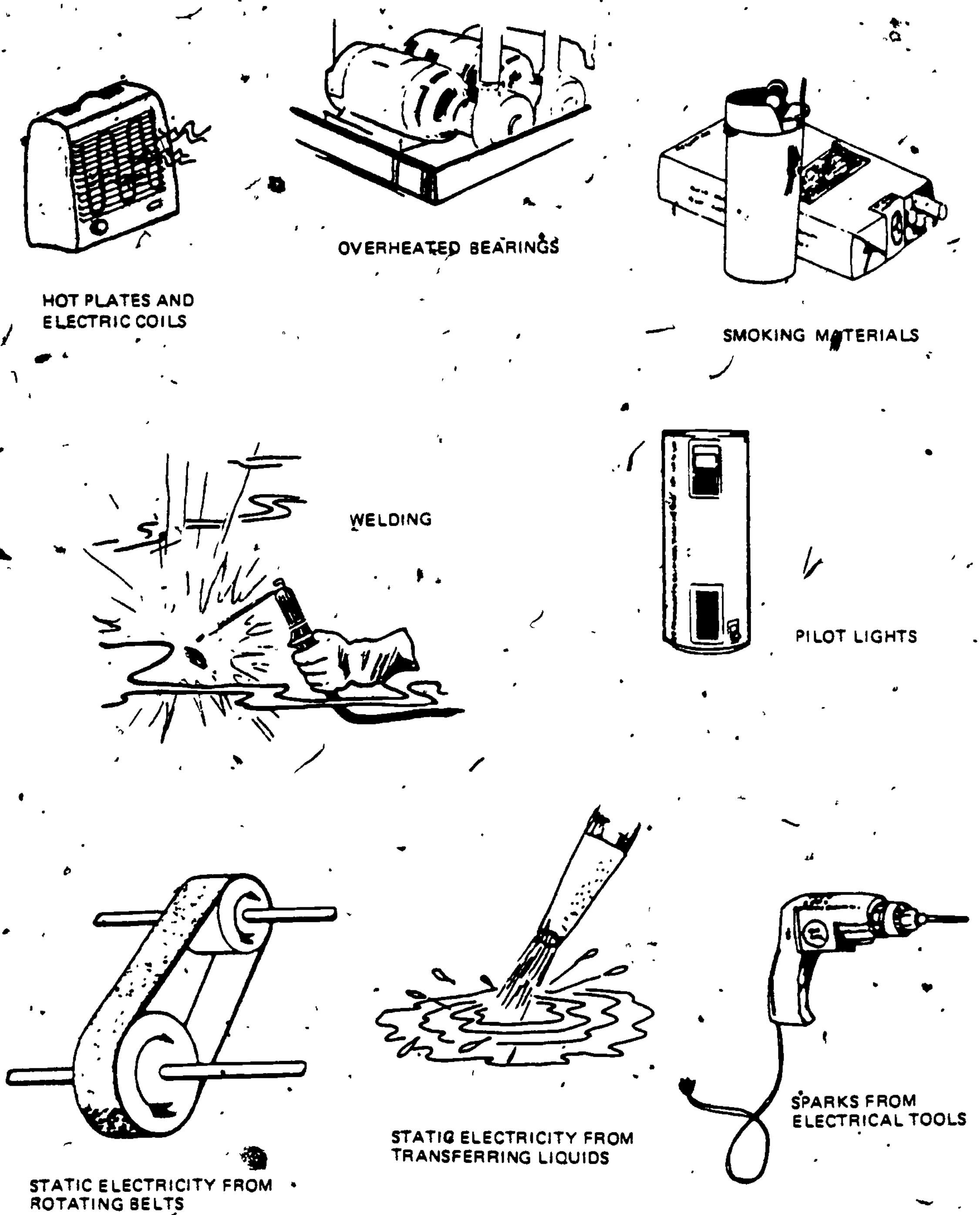

Figure 3. Common sources of ignition.

ovens, furnaces, or high-pressure steam lines must be designed or located to prevent contact with any ignitable liquids or ignitable vapor concentrations.

Room heating systems represent another possible source of ignition. As long as the surface temperature of steam or hot water systems remain below vapor ignition temperatures, they are considered safe. Gas-fired forced-air heaters are acceptable only if the heating unit is located outside the hazardous vapor area.

Before welding or torch cutting, workers should move out of the area where ignitable liquids are handled or used. If this is not feasible, ventilation should be adequate to prevent ignitable vapor from reaching concentrations at or above the lower flammable limits. Also, welding should always be done away from organic solvent degreasing operations not only to prevent a possible fire hazard, but also to prevent the formation of toxic substances such as phosgene.

Electricity is another ignition source which can create special problems wherever ignitable liquids are used. Ideally, of course, electrical devices or receptacles should be located outside fire-hazard areas.

As a precaution against electrical hazard, for example, lights should be installed on the outside wall of vapor-tight enclosures or rooms, providing illumination by shining through windows in the wall. Motors should be placed outside an enclosure for areas where ignitable vapors might be released, with drive shafts extending through the wall; openings for the shafts should be tightly sealed to prevent leakage of ignitable vapors. Switches and heaters should be installed only in fire-hazard-free areas.

Static charge creates a danger of fire and explosion where flammable liquids are being transferred from one container to another. Bonding and grounding, the precautions used to prevent the hazard of static discharge sparks, are explained in the next objective.

ACTIVITY 4:

List eight common ignition sources.

1. ________________
2. ________________
3. ________________

4. ______________________________
5. ______________________________
6. ______________________________
7. ______________________________
8. ______________________________

OBJECTIVE 5: Explain in a sentence or two the need for bonding and grounding where flammable liquids are poured, and the difference between the two terms.

Whenever Class I liquids — that is, flammable liquids with a flash point of less than 100 degrees Fahrenheit — are poured into containers, bonding and grounding are necessary.

The two terms, bonding and grounding, are sometimes used interchangeably. However, they are not the same. Bonding eliminates the electrical potential difference or ability to produce a spark between two conductive objects, such as two drum containers. These objects may or may not be grounded. Grounding eliminates the difference of a spark being generated between the earth (ground) and a conductive object. Once two objects are bonded together, a spark will not develop between the two objects; however, static electricity could develop enough energy to produce a spark between the bonded containers and the ground. Therefore, both bonding and grounding are necessary when transferring flammable liquids if the greatest measure of safety is to be met. Bonding and ground connections are shown in Figure 4. Whenever connecting bonding or grounding straps, always ensure that rust or corrosion have not interfered with a good connection. Another important consideration is to connect the bonding or grounding cable first to the container and then to the ground rod or bonding pipe. If done in this manner and a spark is generated, it will be generated at the farthest possible distance from the flammable material. More obvious but many times overlooked safeguards are to prohibit smoking in the area, to prohibit use of communication radios such as those used for citizen's band transmission and to ensure that vehicle engines are not running when transferring of flammable material is taking place. The use

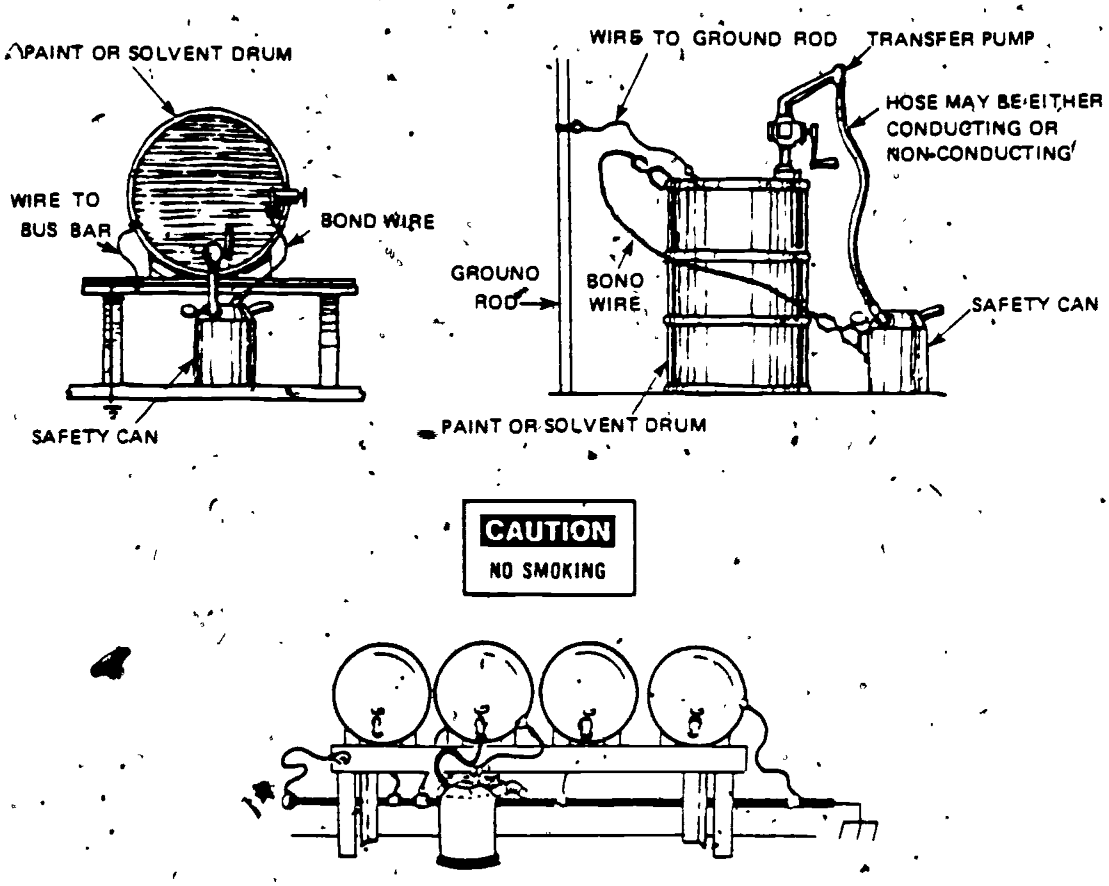

Figure 4. Examples of bonded and grounded containers.

of powered industrial trucks in areas where certain flammable and combustible material could be exposed to a spark is forbidden.

Static electricity is generated by the contact and separation of dissimilar material. When an individual walks across a carpet, touches a door handle, and receives a shock static electricity has been generated. The contact and separation of the shoes on the carpet builds up a static charge on the individual, and upon touching the metal door handle, the individual equalizes electrical potential via the spark. Now consider other conditions where a static charge can develop. Some ideas are belts, tires, liquid flow, and splashing liquid. All of these activities take place in industry. Belts drive shafts; liquid splashes into tanks; tires transfer equipment and materials; and liquid products flow in pipes. If charges build up and a spark occurs around an area where flammable vapors have accumulated, an explosion and fire could be the result.

ACTIVITY 5:

1. Explain the purpose of bonding: ____________

____

2. Explain the purpose of grounding: ____________

____

3. Where are grounding and bonding of liquid containers necessary? ____________

____

OBJECTIVE 6: Discuss the types of approved safety containers.

Flammable and combustible liquids are placed in a variety of containers. These vary from plastic milk cartons to approved safety cans, drums, tanks, and tank trucks. The plastic milk cartons or glass bottles often used by individuals to transport gasoline in automobiles for use in lawnmowers is extremely dangerous and in most states illegal. Placing gasoline in metal cans is an improvement over this practice, but an approved safety can is the best choice for storage of small amounts of flammable and combustible liquids (Figure 5).

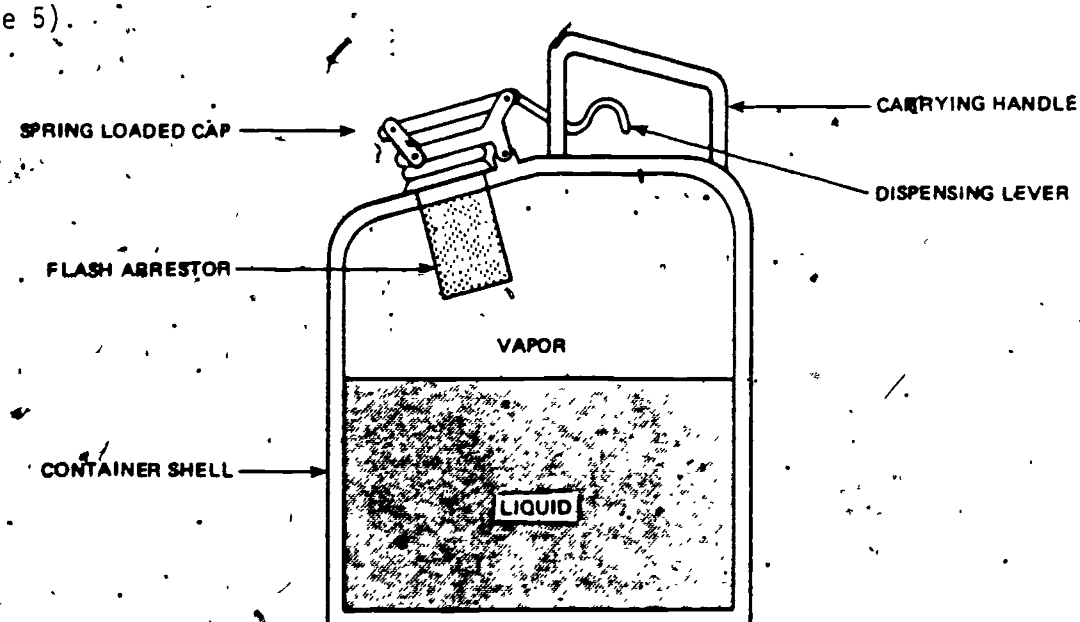

Figure 5. A typical safety can.

The safety can is designed to relieve internal pressure caused by temperature increases such as would occur in a fire. If gasoline is placed in a safety can early in the morning and is stored in the sun on a hot summer day, the pressure inside the can will increase. The liquid gasoline will increase in volume about 1% for each 14°F rise in temperature and vapors will be released (the increase in volume will cause a completely filled automobile gas tank to loose some on a hot summer day). The cap will then release this pressure by venting the vapors to the atmosphere. This action will alleviate the problem of the can rupturing and spilling gasoline, but if the vapors are vented into a non-ventilated enclosure such as the trunk of a car, dangerous concentrations of vapor could occur. This cap is designed so that liquid will not spill unless the dispensing lever is depressed or enough pressure is generated to force the cap open. A flash arrester for the spout of the safety can is designed to prevent a flashback from igniting can contents.

OSHA describes a safety can as an approved container, of not more than five gallons capacity, having a spring-closing lid and spout-cover and so designed that it will safely relieve internal pressure when subjected to fire exposure.

Barrels and drums of varying size (usually less then 60 gallons) are used to store and transport flammable and combustible liquids. To be acceptable for bulk liquids these containers must meet Department of Transportation (DOT) requirements. Apparently empty drums or tanks can be especially dangerous. Empty and near empty drums should be closed tightly and stored in a cool location.

Vehicles such as tank trucks, trailers, and semitrailers are used for transportation of flammable and combustible liquids. They are used to transport liquids to industries as well as petroleum products for consumer use. These trucks are regulated by either the Department of Transportation (DOT) or the Hazardous Materials Act of 1974.

Covered metal waste cans should be provided for oily or ignitable liquid soaked rags, and these should be emptied at least daily.

ACTIVITY 6:

1. What could be the result of a can of gasoline venting vapors into the closed truck of a car? ______

______

2. Name two types of containers that should not be used to transport gasoline.

a. ______

b. ______

OBJECTIVE 7: Describe the requirements associated with indoor storage of flammable and combustible liquids.

In a large, open room, a small quantity of flammable liquid may not produce ignitable or unhealthful levels of vapor except in the immediate vicinity of where the vapor is released. But regardless of the size of the room, an excess quantity of liquid could increase the likelihood of a fire or explosion; exposed to the air, large quantities may become a health hazard. No more ignitable liquid than you can use in one day or one shift should be stored near an industrial operation.

For bulk storage, containers must be placed in a separate, controlled area. This separation from source of ignition or fuel is important because even the best accident prevention systems can fail. If they do, a carefully designed storage area can mean the difference between a small, isolated fire and a major disaster. Isolating a fire and preventing its spread is the first fire-extinguishing goal, and proper storage facilities provide the primary means for containing a fire. But what makes a storage facility adequate?

The type of storage facility necessary to prevent a fire from spreading to other work areas depends on the quantity of ignitable liquids your employer must keep in storage; the extent of probable personal injury and property damage should fire protection systems fail; and whether explosions would be likely to occur if a fire did break out in the storage area.

There are two categories of storage facilities. One is inside storage located near a work area. It features specially designed rooms or cabinets.

The other category is the outside storage for large quantities of ignitable liquids. This requires separate buildings or specially enclosed open areas. To make it easier to understand when one storage area is preferable to another, the facilities will be discussed in size order — from the smallest to the largest.

INSIDE STORAGE CABINETS

Inside storage cabinets are used to hold up to 60 gallons of ignitable liquids with a flash point below 140 degrees Fahrenheit or as many as 120 gallons of liquids with a flash point at or above 140 degrees Fahrenheit.

Figure 6. Inside storage cabinet for flammable liquids.

When the flash point is not marked on a container, you should get it from the Material Safety Data Sheet prepared by the manufacturer of that liquid. Such information sheets should be kept on hand at your workplace so that they can be easily used.

A metal storage cabinet (see Figure 6) must be constructed entirely out of at least number 18 gage sheet iron. It must be double-walled, with a one-and-one-half-inch air space separating the walls. All joints must be riveted or welded tight. Doors should lock at the bottom, top, and middle. The doorsill must extend at least two inches above the bottom of the cabinet, to contain spills. All storage cabinets must be conspicuously marked or labeled, "FLAMMABLE — KEEP FIRE AWAY."

STORAGE ROOMS

How much ignitable liquid can be kept in a storage room is determined by the room's fire resistance rating, that is, by how well the materials used in walls, ceilings, and supporting members resist heat transmission for scientifically determined periods. In addition, load-supporting walls or columns must be able to sustain their rated load under fire conditions without breaking or buckling. As an example, a storage room having a one-hour fire resistance rating must keep its shape, and resist heating or unflamed surfaces, for a period of one hour. The size of a storage room with a one-hour fire resistance rating must not be larger than 150 square feet.

If a sprinkler system has been installed, up to five gallons of ignitable liquid per square foot can be stored in the room. Without a fire protection system, only two gallons per square foot can be stored.

A storage room with a two-hour fire resistance rating must not have floor space in excess of 500 square feet. Ten gallons of ignitable liquid per square foot can be stored in a room with a two-hour fire resistance rating if the room is equipped with a fire protection system. If the room has no sprinkler system, only four gallons per square foot can be stored.

Federal safety rules also regulate the stacking and placement of ignitable liquid containers. To prevent blocking of exits in inside storage rooms, a clean aisle at least three feet wide must be maintained. Stacking containers one on the other is prohibited if the containers have a capacity of over 30 gallons of flammable and combustible liquid.

A three-foot clearance is necessary between the top of stacked containers or shelving and the nearest beam, girder, or overhead fire protection system. If a fire breaks out, the three-foot clearance permits sprinklers to operate as designed, and damage to supporting members can be minimized. Stacked containers must be separated by pallets or dunnage (loose packing material) to provide stability and prevent stress on liquid container walls. If portable tanks are stored over one tier high, they must rest securely without dunnage.

Several construction criteria for an inside storage room have been established to ensure that any fire would be contained. The floor of a storage room must be liquid-tight to keep spills from escaping. To accomplish this, liquid-tight, noncombustible sills or ramps must lead into the storage room, where the floor must be lower than floors of adjacent rooms. Also, Class I liquids must never be stored in a basement, and should not even be stored in a building which has a basement; this is because vapors are heavier than air, and can settle and collect below ground level. All doorways and other inlet openings must have self-closing fire doors and dampers to automatically seal off the storage room in case of fire.

OUTSIDE STORAGE FACILITIES

Outside storage facilities for flammable and combustible liquids include separate warehouses or storage buildings, and restricted areas for bulk storage tanks. Large quantities of ignitable liquids can be kept on hand in separate storage facilities which generally may be located as close as 150 feet from other buildings. If the nearest wall of the storage facility has no windows, doors, vents, or other openings, and has a two-hour fire resistance rating, the distance may be 50 feet or less.

Bulk storage tanks up to 1100 gallons can be located next to a building if the building has one story only and is mainly used for ignitable liquid storage, or if the building's walls are masonry or concrete block with no opening within 10 feet of the storage area. The area surrounding aboveground storage tanks must be diked or provided with good drainage to prevent spills which could eventually reach nearby workplaces. Access to bulk storage areas whether outside or inside must be restricted to only authorized personnel to reduce the risk of any occurrence that could result in a fire or explosion.

ACTIVITY 7:

1. What kind of sign should be posted on the door of a cabinet containing flammable liquids?

   ____

2. How much clearance is required between the top of stacked containers or shelving and the nearest beam, girder, or overhead fire protection system?

   ____

3. Why should Class I liquids never be stored in a building that has a basement? __________

OBJECTIVE 8: Discuss the requirements necessary for service stations and refueling areas.

Service stations are the site of daily handling of flammable materials where certain handling of flammable materials where certain precautions should be routinely practiced.

Several obvious considerations should be observed in refueling areas. Engines of vehicles should be turned off and brakes set. Trucks delivering flammables must meet DOT standards. No open flames or smoking should be allowed and signs should be posted to this effect. Gasoline storage tanks should be buried underground. Completely trained and qualified individuals should be in charge of the operation.

OSHA has several specific requirements as outlined in 1910.106 (g) for service stations. One requirement is that an emergency power cutoff by clearly identified and easily accessible at a location remote from the dispensing device. The delivery hose nozzle valves must be manually held open during dispensing operations unless it is an automatic closing type with or without a hold open latch. The hold open latch is only allowed when an attendant is dispesing the flammable liquid.

Approved pumps taking suction through the top of the container or approved self-closing faucets are required when taking flammable liquids from drums and similar containers. Protection of the containers is also required.

ACTIVITY 8:

Discuss the requirements necessary for service station and refueling areas.

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________

OBJECTIVE 9: List at least six articles of protective equipment useful when working with flammables and combustibles.

Protective equipment is useful in protecting a person who handles flammable and combustible liquids. This equipment is designed to protect the body from the harmful effects of these liquids and their vapors.

Protective boots prevent penetration of the liquid through the skin. In addition to being water repellent, they should be designed to specifically repel the liquid being worked with. Protective gloves should also meet these criteria. Since the hands and feet are many times the most likely body parts to be exposed to an ignitable liquid, the selection and use of gloves and shoes should be done carefully.

Sometimes protective barrier creams are employed to prevent skin absorption of toxic or ignitable liquids. Since these liquids may remove the natural oils of the skin, a barrier cream is used to protect the skin. It must be applied completely over the area exposed and should be replaced as needed and then properly removed by following the vendor's or supplier's instructions.

At times, a chemical-proof suit is used to offer maximum protection when working with flammables or combustible liquids. Care must be exercised in selection and use of this equipment to ensure that it adequately protects against the flammable liquid of concern.

If the flammable liquid vapor poses a significant inhalation risk to the individual, a supplied air hose mask is used to offer protection against breathing harmful vapors. When this system is used, a safety harness with a lifeline may also be used to facilitate pulling an injured person from a confined space or hazardous location without jeopardizing other people.

Safety glasses or goggles should always be worn 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.

ACTIVITY 9:

List at least six articles of protective equipment which may be used when working with flammables and combustibles.

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________

OBJECTIVE 10: Describe fixed and portable fire fighting equipment for use with flammables and combustibles.

SPRINKLER SYSTEMS

Fixed firefighting systems consist of a variety of types, and water is most generally used in these systems. Automatic sprinkler systems are widely used as fixed fire extinguishing systems. They are efficient, effective, versatile, and dependable. Their relative cost is small compared to the cost of the facility they are meant to protect. These systems have a good success record with the few failures being attributed to maintenance errors such as closed water supply valves.

There are five basic types of automatic sprinkler systems. They are referred to as: wet pipe, dry pipe, preaction, deluge, and limited water supply. Four of these systems will be discussed.

The wet pipe system has been used most widely in industry. The complete system has water under pressure that is released when heat activates the sprinkler head. The only drawback in using a wet pipe system is that it is subject to freezing. Where the facility cannot be maintained at a temperature above freezing, a water soluble antifreeze such as glycerine may be used for small areas.

The dry pipe system is used when freezing is a problem. The water supply and valve are loacted in a heated area, and the piping system is filled with compressed air. As the heat from a fire activates the sprinkler head, the compressed air is released allowing water to run through the previously dry pipe. Because of the time it takes for the water to reach a sprinkler head, the fire may have spread, therefore activating more sprinkler heads. This slower activation of the extinguishing agent (water) could result in more damage than if a wet pipe system was used. Furthermore, any water that is left in the dry pipe could freeze and cancel the effectiveness of the system.

Preaction systems react faster than do dry pipe systems because a fire detector is used and is more sensitive to heat than the sprinkler head fuseable link. The sensor sends a signal to the water control valve which opens the valve, thereby allowing the water to move into the piping system. The water is ready to be discharged the instant a sprinkler head is activated.

Deluge systems are designed to wet down an entire area. Each sprinkler head does not activate independently to heat. A sensor is placed in the area of the sprinklers and when activated, the main valve opens, releasing water to open sprinklers throughout the system. This type of system is particularly useful where large quantities of flammables are stored because a fire could spread rapidly in such areas.

The automatic sprinkler system will not work if the sprinkler head is clogged or corroded. It is extremely important that the sprinkler heads be kept clean and protected. They must not be blocked by material being stacked near them. In areas where the sprinkler head is subject to overspray such as from paint spraying operations, the sprinkler head can be protected by placing a small paper bag over the sprinkler and held in place with a rubber band. The water pressure will burst the paper bag when it is activated. However, the paper bag must be replaced periodically depending upon the accumulation of overspray.

Carbon dioxide (CO_2) extinguishing systems are desirable where the fire can be extinguished by displacing the oxygen. This is useful where electrical equipment may present an electrical shock hazard if water is applied. Another advantage is that a carbon dioxide system does not damage the facility or products as does water. There are two considerations that must not be overlooked when one is using a fixed carbon dioxide extinguishing system. The first is that a warning device must be incorporated with its use to alert people in areas in which the system will be activated. Just as CO_2 displaces the oxygen available to the fire, it also displaces the oxygen needed for life. The second concern is that after the fire has been extinguished, fire fighters and workers might enter a location where the carbon dioxide has not dissipated enough to support life. Always ventilate the area and check oxygen levels before re-entering a confined area where carbon dioxide has been used.

Dry chemical systems function similarly to other piped systems providing for quick extinguishment of a fire. They, too, are useful where electrical equipment is present or where flammable liquids are stored. Unlike water, the extinguishing agent does not freeze or conduct electricity, and in addition, it is non-toxic. The dry chemical interrupts the chain reactions to extinguish the fire.

The automatic halon system functions much as dry chemicals, but it does not leave a residue. The halon is a colorless, odorless, nonconductive gas. It also extinguishes a fire by interrupting the chemical chain reaction necessary for fire to continue. Because of its properties, halon has found wide acceptance in electronic data processing computer operations and data storage facilities.

PORTABLE EXTINGUISHERS

Portable fire extinguishers are hand-operated and either carried by the individual or mounted on wheeled carts. They are useful in extinguishing a fire before it spreads and can be helpful in containing a fire before other firefighting methods are applied. Fire extinguishers are classified according to type and relative size of fire they can handle. The number preceding the letter designation for class of fire denotes the relative size fire that can be controlled with that extinguisher. The larger the number, the greater the capability. The number type and location of extinguishers in an area are determined by the occupancy and type of operations being conducted.

Class A extinguishers are used for control of fire in ordinary combustibles such as wood and paper products. The quenching or cooling effect of water is adequate for this type of fire.

Class B extinguishers are designed for use on flammable liquid or gas fires. They function by oxygen exclusion and interruption of the fire's chain reaction.

Class C extinguishers are designed for use around electrical equipment where the danger of electrical shock is a concern. Class C extinguishing agents are nonconductive. Usually Class C extinguishers are combined with capability to handle A and B fires since these types of fires are found in conjunction with the electrical shock hazards.

Class D fire extinguishers have been developed for special hazard protection involving combustible metals. Examples of these metals include aluminum, magnesium, sodium, and titanium. Those individuals involved in extinguishing metal fires need to be aware of the correct type and method of firefighting.

ACTIVITY 10:

Mark each statement True or False.

_____ 1. Many automatic sprinkler system failures are attributed to maintenance errors.

_____ 2. In a deluge system, each sprinkler head reacts or activates independently to heat.

_____ 3. Carbon dioxide extinguishing systems work by displacing oxygen.

_____ 4. Class C extinguishing agents are highly conductive.

OBJECTIVE 11: Discuss the hazards of flammable gases used for industrial purposes.

Gases used for industrial purposes are handled and stored either as liquids or as gases contained in high pressure cylinders. Gases that produce flammable mixtures with air or oxygen are common in industry. Some such gases are acetylene, ammonia, hydrogen, and liquefied petroleum gas (LPG).

ACETYLENE.

A common impression created by the word acetylene is that of oxy-acetylene welding and cutting; yet three quarters of the acetylene produced in this country is used for other purposes. It is used in the production of water-based paints, drycleaning solvents, Orlon, Lucite, and Plexiglas. Acetylene has the widest flammable range known. Under certain conditions it can form compounds with silver, mercury, or copper that explode spontaneously. An unstable compound, acetylene may explode even under low pressures.. The safe maximum pressure is 15 pounds per square inch (psi) for small diameter piping systems. Acetylene can be stored in cylinders at a pressure of 250 pounds per square inch (psi) at 70°F. The cylinders contain a porous material and acetone to absorb acetylene and create a stabilized condition.

AMMONIA

Ammonia is colorless, lighter than air, has a piercing odor, and is highly irritating to the eyes, skin, and respiratory tract. The National Institute for Occupational Safety and Health, (NIOSH) lists 81 occupations with potentially hazardous exposures to ammonia. They range from acetylene workers and farmers to tanners and wool scourers. The substance is widely used as a fertilizer and refrigerant.

Anhydrous ammonia is the pure dry gas. Liquid anhydrous ammonia is this gas compressed into a liquid. Ammonium hydroxide is gaseous ammonia dissolved in water. Anhydrous ammonia i- flammable; and though its flammable range is very high, ammonia fires and explosions are fairly common. The chief hazards of ammonia are freeze burns, severe eye injury, and death from inhalation of high concentrations.

HYDROGEN

Hydrogen, the lightest of all gases, is both colorless and odorless. Its flammable range is almost as wide as that of acetylene. A mixture of 10 to 65 percent in air will explode if ignited.

Some chemical reactions produce hydrogen as a byproduct. A lead-acid battery will produce hydrogen when being charged. Many electroplating processes also produce hydrogen. Some chemicals used to remove scale from the water side of boilers manufacture hydrogen. Whatever the operation, it is important to know whether hydrogen will be produced, and measures must be taken to prevent its accumulation and ignition. This is accomplished by proper ventilation and elimination of possible sources of ignition.

Storing hydrogen is difficult. This gas tries to escape through even the smallest opening in a pipe or container. Pipe threads and stems must be tight, because a high pressure hydrogen leak can ignite spontaneously, the cause being the friction of its own escape. All flammable gas leaks are dangerous and particularly so when, as in the case of hydrogen, they can be neither seen nor smelled.

OXYGEN

Although oxygen supports combustion, it does not burn. Oxygen is considered a hazardous element because flammable materials burn much faster in oxygen, and oxygen can quickly combine with other elements and compounds to produce spontaneous ignition. When oxygen comes into contact with oil, grease, or fuel oils, the result can be a sudden and violent fire. Employees involved in the handling of this gas must take every precaution to prevent the combination. Liquid oxygen can be equally dangerous if not handled properly. A burning cigarette dropped into liquid oxygen will produce a flame two feet high, and even shredded metal will burn if exposed to it. Open flames and smoking must never be allowed near oxygen storage areas.

LIQUEFIED PETROLEUM GAS

Liquefied petroleum gas (LPG) is a compressed or liquefied gas usually comprised of propane, some butane, and lesser quantities of other light hydrocarbons and impurities. LPG is used primarily as a fuel: as a fuel gas in industry for lift trucks, as a tractor fuel in agriculture, and as a cooking fuel in recreational vehicles, to name a few uses. LPG is also used in chemical processing.

LPG is stored under pressure in liquefied form, but converts into a gaseous state upon relief of the pressure. The vapor of LPG is highly flammable. Since LPG is heavier than air, and will accumulate in low-lying areas, adequate ventilation is important wherever it is used.

COMPRESSED GAS CYLINDERS

Compressed gas cylinders must be examined as soon as they are received. If there are any signs of damage or leakage, they must be moved to a safe, isolated area and returned to the supplier as soon as possible. The greatest care must be exercised in the handling of cylinders. They must never be dropped or banged against each other. Nothing should be allowed to fall on them. They must be stored upright in a safe, well ventilated area, away from any source of heat and away from electrical wiring. They must be secured in the upright position by chain, cable, or other suitable means to keep them from tumbling. Most cylinders are provided with a steel protective cap that screws on over the valve. Except when cylinders are in use, these caps should remain screwed down to the last thread.

When cylinders are moved, special hand trucks should be used. When in transit, the cylinders should be lashed to the cradles of the trucks in as near an upright position as possible.

Storage areas must be fire-resistant, clean, free of combustible materials, and well lighted. Cylinders of oxygen must never be stored near cylinders containing flammable gases. Empty cylinders must be marked MT and kept away from full ones. Full cylinders must be positively identified as to the gases they contain.

Improper handling of compressed gas cylinders can produce a hazard called "rocketing." If an accidental rupture occurs, or if a valve assembly is snapped off, a cylinder can blast its way through a concrete wall.

Occupational Safety and Health Administration (OSHA) standards require the employer to ensure that unloading operations are performed by reliable persons properly instructed. Employees should know the chemical and physical hazards with which they work, and must be thoroughly familiar with the types of personal protective equipment provided for their safety. They also should be instructed in first aid procedures.

ACTIVITY 11:

1. Name two ways in which gases used for industrial purposes may be handled and stored.
   a. ______________________________
   b. ______________________________
2. Pipe threads and stems should be tight where hydrogen gas is under pressure because ______________
   ____
3. Acetylene has the ______________ flammable range known.
4. When oxygen comes into contact with oil or grease, ______________ can result.

OBJECTIVE 12: Describe the hazards associated with plastics, textiles, and some combustible wastes.

Materials known as ordinary combustibles, such as wood, cellulose, paper, cloth, and rubber can provide fuel for fires. Wherever these materials are in use or storage, an adequate program of waste disposal should be in operation, and regular inspection should be made of the waste storage areas. In-plant housekeeping procedures should be firmly established to prevent any accumulation of waste and to ensure safe, clean work areas. External housekeeping should prevent accumulation of waste, brush, or high grass around the outside of buildings.

Burning plastics, such as nitrocellulose, polystyrene, cellulose, rayon, and polyvinyl chloride are especially dangerous because they produce large amounts of smoke and because their fumes are extremely toxic (poisonous).

Some textiles, including rayon, cellulose fibers, and cotton textiles are highly flammable. Combustible wastes such as oily rags and paint rags should be disposed of in closed approved metal containers. Combustible cleaning materials should be stored in approved metal containers.

ACTIVITY 12:

Name four types of combustible materials that are particularly hazardous.

1. ______________________
2. ______________________
3. ______________________
4. ______________________

OBJECTIVE 13: Describe two ways that dust explosions can be prevented.

Wherever material that will burn readily is present in powder form, a dust explosion hazard exists. Dust explosions are similar in several ways to gas or vapor explosions. To explode, a combustible dust must be mixed with air or oxygen and must be in flammable concentration when contacted by an ignition source.

Dust explosions tend to be even more destructive than gas explosions. The hazard potential is greater also because dusts are more likely to build up as a result of industrial activity. An explosion hazard can exist when seemingly little dust has accumulated. Any process that produces combustible dusts should be considered as a possible source of fire, explosion, or both.

Some of the more common potentially explosive dusts are listed in Table 2 below.

TABLE 2. SOME OF THE MORE COMMON POTENTIALLY EXPLOSIVE DUSTS

Type	Example
Carbon	Coal, peat, charcoal, coke, lampblack
Fertilizers	Bone meal, fish meal, blood flour
Food products and byproducts	Starches, sugars, flour, cocoa, powdered milk, grain dust
Metal powders	Aluminum, magnesium, zinc, iron
Resins, waxes, and soaps	Shellac, rosin, gum sodium resinate, soap powder, waxes
Spices, drugs, and insecticides	Cinnamon, pepper, gentian, pyrethrum, tea fluff
Wood, paper, tanning materials	Wood flour, wood dust, cellulose, cork, bark dust, wood extract
Miscellaneous	Hard rubber, sulfur, tobacco, many plastics

Dust explosions can be prevented in one of two ways:

- Explosive mixtures of dust and air can be prevented from forming (control of dust)
- Ignition of the mixtures can be prevented from occurring (control of ignition sources)

Control of dust may be accomplished in at least three ways. Wherever processes that generate dusts are localized, local exhaust systems can be used to minimize the hazard. Where possible, dust-producing operations should be enclosed or segregated from the general work area. Good housekeeping provides another method of dust control; vacuuming (with explosion proof vacuum cleaning equipment) and brushing away dust from floors and other surfaces can supplement the other two methods (enclosure and local exhaust).

Control of ignition sources is the other avenue of prevention of dust explosions. Ignition sources must be kept apart from areas where dust is generated. Control of open flames, friction sparks, static electricity, welding, and heated surfaces is necessary to prevent ignition of dusts. Only nonferrous (made of material other than iron) tools should be used in areas of dust exposure, and workers should wear shoes with nonferrous nails tacks.

ACTIVITY 13:

1. List three methods of dust control.
   a. ______________________
   b. ______________________
   c. ______________________
2. List five types of ignition sources that must be kept away from areas where dust is generated.
   a. ______________________
   b. ______________________
   c. ______________________
   d. ______________________
   e. ______________________

OBJECTIVE 14: Identify the classes of hazardous locations as defined by OSHA.

Almost every workplace contains materials or is made of materials that could provide fuel for a fire. However, some areas are far more hazardous than others because they contain flammable or combustible liquids, gases, or dusts. The Occupational Safety and Health Administration (OSHA) classified hazardous locations according to the presence of the various flammable and combustible materials. The OSHA classifications designate areas where the hazard potenial of flammable and combustible materials is serious enough that powered industrial trucks cannot be used in these areas. The classes provide a useful way of ordering the hazards of the various flammable and combustible materials.

CLASS I LOCATIONS

Class I locations are those in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitible mixtures. Class I locations are subdivided further.

Class I, Division I

This classification usually includes locations where volatile flammable liquids or liquefied flammable gases are transferred from one container to another. Interiors of spray booths and areas in the vicinity of spraying and painting operations where volatile flammable solvents are used are one example. Others include locations containing open tanks or vats of volatile flammable liquids, drying rooms or compartments for the evaporation of flammable solvents, and locations containing fat and oil extraction equipment using volatile flammable solvents. Additional examples include portions of cleaning and dyeing plants where flammable liquids are used, gas generator rooms and other portions of gas manufacturing plants where flammable gas may escape. In the same classification are inadequately ventilated pump rooms for flammable gas or for volatile flammable liquids and the interiors of refrigerators and freezers in which volatile flammable materials are stored in open, lightly stoppered, or easily ruptured containers. And finally, all other locations where ignitable concentrations of flammable vapors or gases are likely to occur in the course of normal operations are considered Class I, Division I.

Class I, Division 2

This classification usually includes locations where volatile, flammable liquids or flammable gases or vapors are used, but which would become hazardous only in case of an accident or of some unusual operating condition. The quantity of flammable material that might escape in case of an accident, the adequacy of ventilating equipment, the total area involved, and the record of the industry or business with respect to explosions or fires are all factors to be merit considered in determining the classification and extent of each location.

Piping without valves, checks, meters, and similar devices would not ordinarily introduce a hazardous condition even though used for flammable liquids or gases. Locations used for the storage of flammable liquids or liquefied or compressed gases in sealed containers would not normally be considered hazardous unless also subject to other hazardous conditions.

Electrical conduits and their associated enclosures separated from process fluids by a single seal or barrier are classed as a Divison 2 location if the outside of the conduit and enclosures is a nonhazardous location.

CLASS II LOCATIONS

Class II locations are those that are hazardous because of the presence of combustible dust. Class II locations include the following divisions.

Class II, Division 1

This classification may include areas of grain handling and processing plants, starch plants, sugar-pulverizing plants, malting plants, hay-grinding plants, coal pulverizing plants, and areas where metal dusts and powders are produced or processed. Other similar locations are those which contain dust producing machinery and equipment (except where the equipment is dust-tight or vented to the outside). These areas would have combustible dust in the air, under normal operating conditions, in quantities sufficient to produce explosive or ignitible mixtures. Combustible dusts which are electrically nonconductive include dusts produced in the handling and processing of grain and grain products. Some examples include pulverized sugar and cocoa, dried egg and milk powders, pulverized spices, starch and pastes, potato and woodflour, oil meal from beans and seed, dried hay, and other organic materials which may produce combustible dusts when processed or handled. Dusts containing magnesium or aluminum are particularly hazardous and the use of extreme caution is necessary to avoid ignition and explosion.

Class II, Division 2

This classification includes locations where dangerous concentrations of suspended dust would not be likely but where dust accumulations might form on or in the vicinity of electric equipment. These areas may contain equipment from which appreciable quantities of dust would escape under abnormal operating conditions or be adjacent to a Class II Division 1 location.

CLASS III LOCATIONS

Class III locations are those that are hazardous because of the presence of easily ignitable fibers or flyings but in which such fibers or flyings are not likely to be in suspension in the air in quantities sufficient to produce ignitable mixtures. Class III locations include the following categories.

Class III, Division 1

A Class III, Division 1 location is a location in which easily ignitable fibers or materials producing combustible flyings are handled, manufactured, or used.

Such locations usually include some parts of rayon, cotton, and other textile mills; combustible fiber manufacturing and processing plants; cotton gins and cotton-seed mills; flax-processing plants; clothing manufacturing plants; woodworking plants, and establishments; and industries involving similar hazardous processes or conditions.

Easily ignitable fibers and flyings include rayon, cotton (including cotton linters and cotton waste), sisal or henequen, sistle, jute, hemp, tow, cocoa fiber, oakum, baled waste kapok, Spanish moss, excelsior, and other mateirals of similar nature.

Class III, Division 2

A Class III, Division 2 location is a location in which easily ignitable fibers such as those cited above in Division 1 are stored or handled, except in the process of manufacture.

ACTIVITY 14:

1. Match the classes or the left with the materials on the right.

____CLASS I	a.	Combustible dusts
____CLASS II	b.	Flammable gases or liquids
____CLASS III	c.	Combustible fibers or flyings

2. Which of the following class of location is the most hazardous?
   a. CLASS I, Division 2
   b. CLASS III, Division 3
   c. CLASS I, Division 1
3. Give two examples of each of the following types of hazards:
   a. Combustible dusts-
   b. Flammable gases or liquids-
   c. Combustible fibers or flyings-

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ANSWERS TO ACTIVITIES

ACTIVITY 1

1. a. The lowest temperature at which a liquid releases enough vapor to support burning.
   b. Liquids having flash points below 100°F.
   c. Liquids having flash points above 100°F.
2. a. flammable b. common ignition sources

ACTIVITY 2

1. d
2. a. False b. True c. True

ACTIVITY 3

1. a
2. b
3. b
4. b

ACTIVITY 4

1. Hot plates and electric coils.
2. Overheated bearings
3. Smoking materials.
4. Welding.
5. Pilot lights.
6. Static electricity from rotating machine parts.
7. Static electricity from transferring liquids.
8. Sparks from electrical tools.

ACTIVITY 5

1. Bonding eliminates the electrical potential between two conductive objects.
2. Grounding eliminates the difference in electrical potential between the container(s) and the earth.
3. Wherever CLASS I liquids are poured into containers.

ACTIVITY 6

1. Dangerous concentrations of vapor could occur.
2. a. Plastic milk cartons.
   b. Glass bottles.

ACTIVITY 7

1. FLAMMABLE - KEEP FIRE AWAY.
2. 3 feet.
3. Vapors are heavier than air and can settle and collect below ground level.

ACTIVITY 8

1. Turn off engines.
2. Set brakes.
3. Have delivery trucks meet DOT regulations.
4. No smoking.
5. Trained people in charge.

ACTIVITY 9

a. Boots.
b. Barrier creams.
c. Body suit (slicker suit).
d. Supplied air hose mask.
e. Lifeline.
f. Goggles.
g. Face shield. (Any seven of these)

ACTIVITY 10

1. True
2. False.
3. True
4. False

ACTIVITY 11

1. a. Liquefied gases.
   b. Compressed gases.
2. Ignition can be caused by the friction of escaping hydrogen.
3. Widest.

4. Fire.

ACTIVITY 12

1. Plastics.
2. Some textiles.
3. Oily rags.
4. Combustible cleaning materials.

ACTIVITY 13

1. a. Local exhaust.
   b. Housekeeping (vacuuming, brushing).
   c. Enclosure of dust-producing area.
2. a. Open flames.
   b. Welding.
   c. Friction sparks.
   d. Static electricity.
   e. Heated surfaces.

ACTIVITY 14

1. b — I
   a — II
   c — III
2. C
3. a. Grain, starch, malt, hay, coal.
   b. Paint, solvents.
   c. Rayon, cotton, sisal, sisle, jute, hemp, tow, cocoa fiber, oakum, kopak, spanish moss, excelsior.