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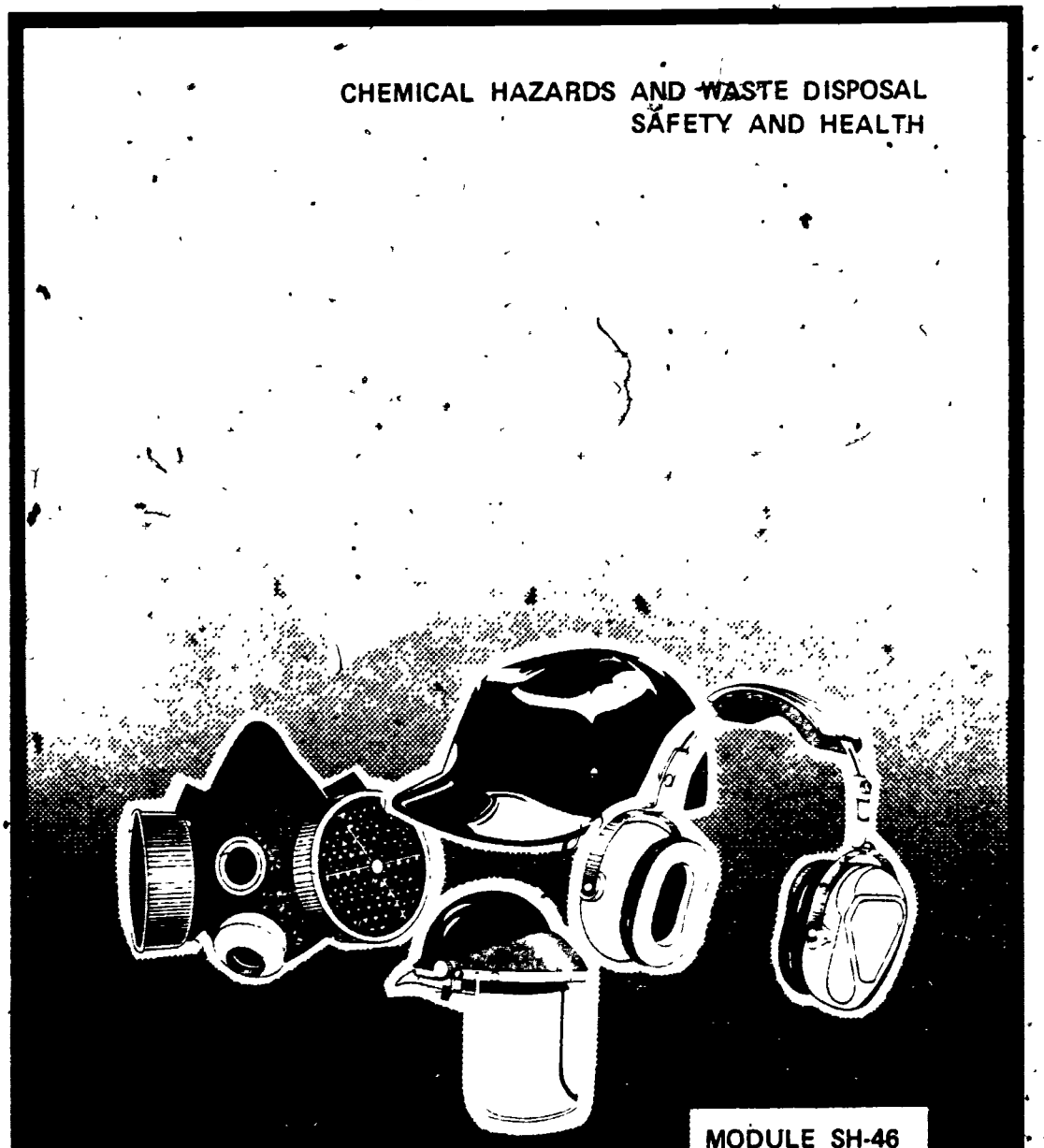
ABSTRACT

This student module on chemical hazards and waste disposal is one of 50 modules concerned with job safety and health. This module presents the principles of safe chemical handling and provides an overview of the hazards associated with different types of chemicals. Following the introduction, 13 objectives (each keyed to a page in the text) the student is expected to accomplish are listed (e.g., State the definition of a chemical hazard). 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)

SAFETY AND HEALTH

CHEMICAL HAZARDS AND WASTE DISPOSAL
SAFETY AND HEALTH



MODULE SH-46

ORD CENTER FOR OCCUPATIONAL RESEARCH AND DEVELOPMENT

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INTRODUCTION

Many industries manufacture or use chemical materials that can affect the health of employees. These may be encountered in the form of liquids, solids, gases, vapors, fumes, dusts or mists. In this module, many of the safety principles that are used when working with hazardous chemicals will be considered. Since there are so many hazardous chemicals, and since their number and types are constantly increasing, it would be impractical to attempt to include a discussion of all of them in this module. However, an attempt is made to cover basic information about handling and disposal of chemical substances.

Employees are not expected to know all the answers to the complex problems of chemical handling and waste disposal. However, certain aspects of safe chemical use depend ultimately on the conscientious attitude and careful procedures of individual workers. Attention to labeling, care in handling, proper use of personal protective equipment, cooperation with engineering controls, and good housekeeping are a few of the practices that must be carried out to prevent chemical accidents. The aim of this module is not to make chemists out of employees, but to educate future workers in the principles of safe chemical handling and to provide an overview of the hazards associated with different types of chemicals.

OBJECTIVES

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

1. State the definition of a chemical hazard. (Page 3)
2. Describe four major types of chemical hazards. (Page 3)
3. Describe the three major ways in which hazardous chemicals can enter the body. (Page 6)
4. Distinguish between acute and chronic poisoning and local and systemic effects on the human body. (Page 7)
5. Name six factors that determine whether exposure to a toxic substance constitutes a health hazard to an employee. (Page 10)

6. Identify ten approaches to protecting employees from a chemical hazard. (Page 12)
7. Describe two sources of information about hazardous chemicals. (Page 14)
8. Explain the importance of good housekeeping in controlling chemical hazards. (Page 16)
9. Describe how a properly designed ventilation system controls contamination by hazardous chemicals. (Page 18)
10. Describe the use of four types of personal protective equipment. (Page 22)
11. Describe the safe method of storing flammable liquids, corrosives, and toxic materials until they can be disposed of by trained personnel. (Page 28)
12. Discuss the factors that experts must consider in chemical waste management. (Page 29)
13. Identify the main hazards associated with eleven groups of chemicals. (Page 31)

OBJECTIVE 1: State the definition of a chemical hazard.

Chemicals are the basis of many ordinary items, such as cosmetics, synthetic fabrics, detergents and other cleaning agents, drugs, perfume, food additives, and plastics, to name a few. Many chemicals are normally harmless: sodium chloride (table salt), sodium bicarbonate (baking soda), 5% acetic acid solution (vinegar), and ascorbic acid (vitamin C). However, this term also includes certain materials that are very poisonous and can cause explosions, fires, or adverse health effects; examples of such hazardous materials are mercury, arsenic, ether, and sulfuric acid.

Chemical hazards may be defined as chemicals that may, unless dealt with carefully, cause injury or adverse health effects because of reactivity, instability, spontaneous decomposition, flammability or volatility.

ACTIVITY 1:*

State the definition of a chemical hazard.

_____

_____

OBJECTIVE 2: Describe four major types of chemical hazards.

Chemical hazards may be divided into four main types: toxic agents, corrosives, flammables, and reactives.

*Answers to Activities appear on page 31.

TOXIC AGENTS

Toxic chemicals are those gases, liquids, or solids that, through their chemical properties, can produce injurious or lethal effects upon contact with body cells. Poisonous chemicals may be absorbed through the skin, inhaled, or ingested (taken in by mouth).

The dangerous effects of toxic chemicals depend on a number of factors. Chief among these factors are the concentration encountered (the amount a person comes in contact with) and the length of exposure (how long a person is in contact with the substance). Some toxic agents strike a sudden and deadly blow, killing or making ill the victims of even brief exposures. Other poisons are less obvious, and many years of daily exposure may occur before ill effects become apparent. The health effects to those exposed to a hazardous chemical may be as minor as headaches, dizziness, or general weakness. Or it may be as serious as nausea, lowered blood pressure, seizure, or death.

Some vapors and gases give warning of their presence by their odor; ammonia is such a gas. Some, such as carbon monoxide, have no odor. Still others, such as hydrogen sulfide, initially have an easily detected "warning" odor; however, this odor may soon become unnoticeable because the chemical affects the victim's sense of smell. This can lead exposed persons to believe the hazard no longer exists, even while they are in the continued presence of a deadly concentration of the chemical.

Some toxic agents are present in the form of dusts. Materials associated with dust hazards in industry can be broadly divided into three groups:

- Dust hazards that, when inhaled, may pass from the lungs into the bloodstream, where they may be very harmful to various organs in the body. These chemicals include lead, mercury, and beryllium.
- Fiber-producing dusts, such as asbestos and free silica, that remain in the lungs for a lifetime. These fibers can make breathing very difficult and cause serious illnesses.
- The so-called nuisance dusts, which are primarily from wood, grain, and flour operations.

If not removed, these dusts can present a health hazard. Some are toxic and some can affect allergies in workers. Excessive dust makes good

housekeeping difficult and also increases the fire potential.

CORROSIVES

Three general types of chemicals may be grouped under the heading of corrosives; they are corrosives, sensitizers, and irritants. Corrosives are defined as causing visible or irreversible tissue damage on contact. In chemical terms, a corrosive implies the wearing away by chemical action, and includes both acids and bases. Some corrosives are also toxic or oxidizing (supportive of combustion) agents. However, most damage and injury occur to the respiratory tract from the breathing of corrosive vapors and from skin contact with the chemical. Examples of corrosives include acetyl bromide, ammonium hydroxide, sulfuric acid, and nitric acid.

FLAMMABLES

Flammable materials are materials that can easily catch on fire. Certain chemicals are capable of being easily ignited and burning with extreme rapidity. These chemical products can be either solid, liquid, or gas.

For example, liquids that catch on fire can be termed flammable or combustible. They are categorized by their ease of ignition. Flammable liquids are more easily ignited than combustible ones. Examples of common industrial flammables are gasoline; acetone, lacquer, and thinner.

REACTIVES

Reactives are substances that can explode if they are hit, dropped, heated, or mixed with the wrong chemical. Under certain conditions, reactives can be as dangerous as explosives. For example, ammonium nitrate is a reactive used in the making of fertilizers and dynamite.

ACTIVITY 2:

1. Choose the best answer.
   The effect of toxic agents depends primarily upon:
   a. Concentration and length of exposure.
   b. Concentration and warning odor.

c. Concentration and method of exposure (inhalation, ingestion, or absorption).

2. Fill in the blank.

a. Corrosives cause tissue damage to _____ and _____.

b. Flammable liquids are more easily ignited than _____ ones.

c. Reactives can _____ under certain conditions.

OBJECTIVE 3: Describe the three major ways in which hazardous chemicals can enter the body.

The three most common ways by which toxic chemicals enter the body are (1) inhalation (breathing), (2) ingestion (swallowing), and (3) absorption through the skin. Of these three routes of entry, the most common is absorption. However, the entry method causing the highest percentage of deaths is inhalation. Table 1 shows the disabling work injuries from toxic poisoning that occurred in California in a recent year.

TABLE 1. DISABLING WORK INJURIES - CALIFORNIA.

Contact Method	Total	Fatal	Non-Fatal
Inhalation	1203	23	1180
Absorption	4123	3	4120
Ingestion	145	2	143

Ingestion is sometimes encountered in industry where workers eat or smoke without washing, or where foods, candy, gum, or cigarettes are stored near where chemical materials are used. Some cases of lead and mercury poisoning have been traced to this route of entry into the body.

Skin absorption is a more hazardous route of entry than ingestion because it is not easily noticed and there is so much handling of products and chemicals in industrial activities.

Inhalation is an even more "hidden" hazard than ingestion or skin absorption because no visible physical contact between the worker and the chemical is required. Airborne gases, vapors, dusts, and mists travel freely with air currents in the work area, thus making the worker unaware of any harmful exposure.

ACTIVITY 3:

1. Which of the three routes of entry is the most common way for hazardous materials to enter the body?
   a. Inhalation.
   b. Absorption.
   c. Ingestion.
2. Which of the three routes of entry causes the highest percentage of deaths?
   a. Inhalation.
   b. Absorption.
   c. Ingestion.

OBJECTIVE 4: Distinguish between acute and chronic poisoning and local and systemic effects on the human body.

Poisoning may be acute or chronic. The difference between these is based on how long a person is exposed to the toxic substance.

Acute poisoning refers to the effects of a single exposure (or one of short duration) to a toxic substance. Usually, an incident of acute poisoning will result in one of three outcomes: death, permanent disability, or recovery. Carbon monoxide is a good example. If one is not killed by the gas, one may suffer permanent brain damage. However, if the exposure is not severe enough to cause either death or brain damage, one generally expects

essentially complete recovery. As applied to substances that are inhaled or absorbed, acute refers to a single exposure of a duration measured in seconds, minutes, or hours. As applied to substances that are ingested, acute refers generally to a single quantity or dose.

Chronic poisoning refers to the effects of many exposures to a toxic substance occurring over a long period of time. Each exposure, by itself, would normally be harmless. However, because exposures occur repeatedly, they become a serious health hazard. The level of toxicity slowly builds up within the victim's body and the symptoms are often difficult to detect. All carcinogens (cancer-causing substances), for example, are chronic poisons. As applied to substances that are inhaled or absorbed, chronic refers to prolonged or repeated exposures of a duration measured in days, months, or years. As applied to substances that are ingested, chronic refers generally to repeated doses over a period of days, months, or years.

Poisoning may also be local or systemic, depending on what areas of the body are affected by contact with the toxic substance.

Local poisoning means that the harmful effects of the toxic substance occurs only at the point or area of contact with the human body. The site of irritation or disease may include the skin or the mucous membranes of the eyes, nose, mouth, throat, and lungs. The harmful effects do not usually spread to other areas of the body.

Systemic poisoning means that the harmful effects of the toxic substance spread to other parts of the body beside the point or area with which it initially comes in contact. This presupposes that absorption into the bloodstream must take place. For example, contact with the liquid carbon tetrachloride could result in the skin becoming red, cracked, and dry. If carbon tetrachloride vapors are present, the eyes may burn and be irritated. However, because carbon tetrachloride is also absorbed into the bloodstream and carried to different areas of the body, it often causes serious damage to the liver.

Obviously, chemical poisoning may be acute local, acute systemic, chronic local, or chronic systemic. All of these types of poisoning should be of concern to the industrial worker.

No matter how posion enters the body, reactions may develop that change the way the body normally functions. Exactly how a human body will react is determined by many factors, the most important of which include the following:

- The amount of toxic material in the bloodstream, or in a specific organ (the concentration).
- Exactly how much an individual can take of a particular toxic chemical before it causes harm (the body's tolerance).
- How fast the body can eliminate the toxic substance or change it into something harmless - perhaps by giving prompt medical attention (the rate of recovery).

The body's tolerance and rate of recovery vary widely from one individual to another.

As mentioned earlier, a toxic chemical often enters the bloodstream. The effect it will have on the blood may include the following:

- A change in blood pressure.
- A change in the blood's composition.
- A change in the red blood cell count.
- A change in the blood circulation rate.
- A change in the coagulation (clotting ability) process.

It is also known that rapid cell destruction may occur in affected areas as well as a serious change in a person's breathing rate. Any or all of these changes may alter the proper functioning of organs such as the heart, brain, kidneys, liver, and lungs, or even result in death.

ACTIVITY 4:

An employee worked around beryllium residues very carelessly, her hands coming into contact with the toxic substance for five minutes. Within a few hours of exposure, this employee became unconscious and suffered kidney failure. However, within one month recovery was complete and ill effects were never suffered again. Based on this information, name the type of poisoning the worker had.

a. Acute local.

b. Acute systemic.
c. Chronic local.
d. Chronic systemic.

OBJECTIVE 5: Name six factors that determine whether exposure to a toxic substance constitutes a health hazard to an employee.

The single most important factor in determining whether or not illness will occur as the result of exposure to a specific chemical compound is dosage. When considering dosage, it should be noted that no chemical substance is completely safe and that few are entirely harmful. Usually harmless and even essential substances, such as water and salt, may cause illness or death if consumed in sufficient amounts. And even the most deadly of chemicals, such as arsenic is not harmful if the exposure is small enough, since the human body can presumably survive a dose of one molecule of anything.

Environmental concentration is the term used today by occupational safety specialists to refer to the amount (dosage) of a chemical substance that is present in a certain environment (or working area). Thus, the environmental concentration of a toxic substance is the most important factor in determining how dangerous that substance is.

However, in determining what exactly is "safe" when examining a working environment, other factors come into consideration. Besides the environmental concentration, five other factors determine whether exposure to a toxic substance contitutes a health hazard to an employee. All six factors are:

1. The concentration of the substance (environmental concentration).
2. The length of exposure.
3. The tolerance of the individual to that particular substance.
4. The general health of the individual exposed.
5. The way in which the substance is being used.
6. The protection the employee has.

Since it is practically impossible to have completely uncontaminated air in industrial operations, boundary limits have been set for toxic materials to prevent concentrations in the air that can cause bodily harm. These limits, called threshold limit values (TLV), have been established for toxic gases, vapors, mists, dusts, and fumes. They are sometimes also called maximum allowable concentrations (MAC). The term threshold limit values is the term adopted by the American Conference of Governmental Industrial Hygienists (ACGIH), while the term maximum allowable concentrations is used by the American National Standards Institute (ANSI). The two terms mean the same thing.

The threshold limit value is the greatest amount of a particular gas, vapor, mist, fume, or dust that can be present in the air without harming the average employee who is exposed for eight hours each workday. Gases and vapors usually have their TLV expressed in parts per million (PPM).

The TLV of toxic dust or mist usually is expressed in milligrams per cubic meter of air (mg/m^3). Table 2 shows examples of various chemical substances and their varied TLVs in 1974.

TABLE 2. THRESHOLD LIMIT VALUES.

Substance	ppm	mg/m^3
Osmium tetroxide	0.0002	0.002
Bromine	0.1	0.7
Hydrogen peroxide	1.0	1.4
Carbon monoxide	50.0	55.0
Ethyl Ether	400.0	1200.0
Carbon dioxide	5000.0	9000.0

Threshold limit values are used as guides in the control of health hazards. They should not be regarded as fine lines between safe and dangerous concentrations, because some individuals may suffer adverse effects even at exposure levels below those defined by the TLV.

It is important to note that most TLVs were originally set to avoid acute poisoning, with little regard for the chronic effects that a toxic

chemical may have on an individual exposed to it over a period of years. However, these safety standards are constantly being revised after further research and testing.

ACTIVITY 5:

Name six factors that determine whether exposure to a toxic substance constitutes a health hazard to an employee.

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____

OBJECTIVE 6: Identify ten approaches to protecting employees from a chemical hazard.

No single measure of control can guarantee the safe handling and disposal of hazardous materials. Safe use depends on a combination of many controls, applied to fit a specific hazardous situation.

Engineering and administrative controls should be the primary approach to chemical hazard control. Such controls may range from simple, general ventilation systems to local exhaust fans that expel a contaminant as it is generated (i.e., a vacuum duct that removes particles created by the action of a grinding wheel). Processes involving highly toxic materials may need to be enclosed entirely, and operations carried out by remote control.

Sometimes a less hazardous material can be substitued for one that is very toxic or flammable. Even when a hazardous chemical cannot be replaced effectively, the quantities of chemicals involved in a process can sometimes be limited. Restricting the number of persons who carry out high risk operations may also be possible. Plant operations can often be arranged so that

hazardous processes are separated from nonhazardous areas by walls, separate buildings, and distance.

Where engineering controls are not feasible or adequate, employees may need to wear personal protective equipment. Other methods of control include using adequate warning labels, employing routine and thorough good housekeeping procedures, and employee training.

One of the most important aspects of controlling chemical hazards is educating employees. Every worker who encounters these hazards should be made aware of their toxic vapors, flammable characteristics, or reactive or corrosive nature, as appropriate. The meaning of labels, the use of personal protective equipment, the reasoning behind engineering controls and the necessity for safe procedures should be taught as part of employee training. Re-education and follow-up are needed to keep employees informed of new hazards and prevent relaxing of control measures in the use of familiar ones. In a real sense, the success of all other control measures depends upon adequate employee education about chemical hazards.

ACTIVITY 6:

1. List six types of engineering or administrative controls.
   a. _____
   b. _____
   c. _____
   d. _____
   e. _____
   f. _____
2. Which one of the following approaches to controlling chemical hazards provides a key to all the others?
   a. Engineering controls.
   b. Personal protective equipment.
   c. Adequate labeling.
   d. Employee education.
   e. Good housekeeping.

OBJECTIVE 7: Describe two sources of information about hazardous chemicals.

Workers can generally obtain key information about a hazardous chemical from the manufacturer's label. All substances that are stored or used in an industrial setting should carry a label. Labels should be durable, noticeable, and easy to read. As a minimum, a label on a stored bottle or container of chemical material should describe:

1. Name of product.
2. Statement of hazards.
3. Warning or signal word.
4. Precautions for handling and storage.
5. Instructions in case of contact or exposure.

Some labels also give a date and point of origin. Figure 1 shows a typical hazardous chemical label.

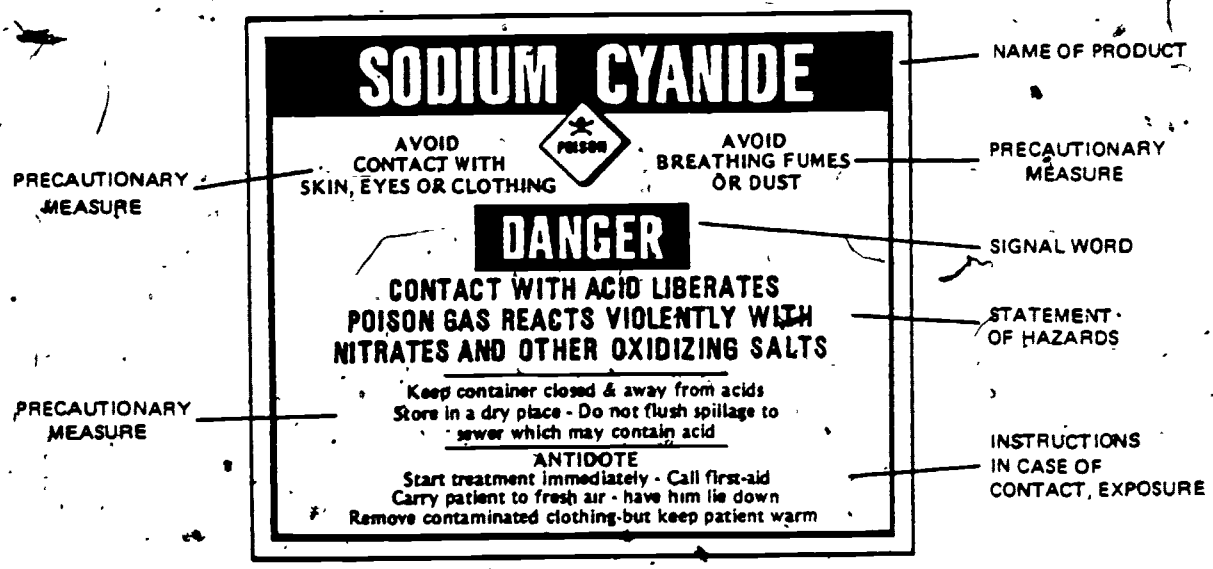


Figure 1. Typical hazardous chemical label.

"Stamp-labels" that indicate hazardous classification according to the Department of Transportation system are also used by manufacturers. Examples of these labels are shown in Figure 2.

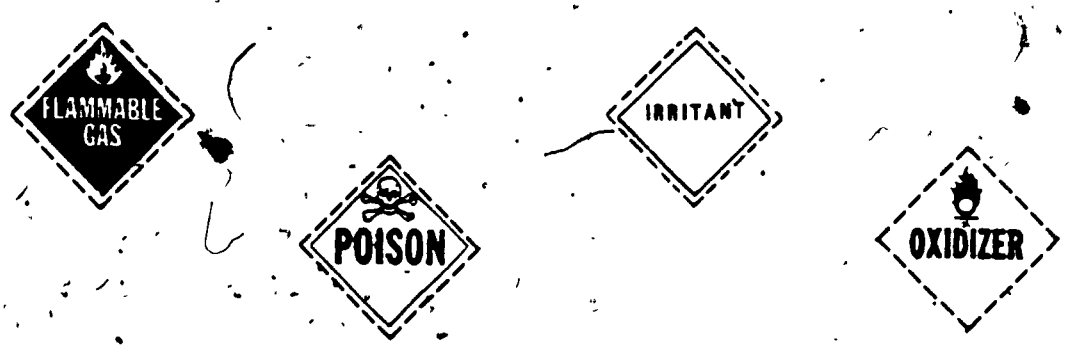


Figure 2. Examples of hazardous materials warning package labels.

If you work around hazardous materials, you need to be aware of the consequences of exposure. Reading the label and heeding its warning advice should become a habit with you, as routine as any other aspect of your job. However, it should be noted that labels do have limitations. Usually the cans or drums containing toxic materials carry a label giving a warning in general terms, but this warning may be misinterpreted. Many solvent labels, for instance, carry this warning: "Avoid prolonged exposure. Use with adequate ventilation." Before any material so marked is used, it is necessary to determine just how long is "prolonged" and just how much ventilation is "adequate." In other words, it is necessary to find out exactly what toxic substances the material contains, what the real hazards are, and what precautions must be taken. It may be that a safer material can be substituted.

The words "use adequate ventilation" are often seen on labels or in instructions. In general, a chemical so noted should be used only in a fume hood or in a facility with an exhaust fan in operation.

Signs that warn of real or potential hazards must be visible to all persons in a working area. "DANGER" signs must be used when an immediate hazard exists. "CAUTION" signs are to be used to warn against potential hazards or unsafe practices.

Signs that warn of real or potential hazards must be visible to all persons in a working area. "DANGER" signs must be used when an immediate hazard exists. "CAUTION" signs are to be used to warn against potential hazards or unsafe practices.

Above all, if one is working with chemicals or in an area where chemical hazards are present, and is unsure of labels, instructions, or practices, the person should ask a supervisor or specialized personnel before attempting to proceed. Failure to do this may be jeopardizing the safety of that worker and others.

Manufacturers make available Material Safety Data Sheets that contain information about the safe handling of chemical products. The safety offices of many companies keep the Material Safety Data Sheets on file; if they are not already at the workplace, they may be requested from the manufacturer.

ACTIVITY 7:

1. Name five kinds of information that should be included on a chemical label.
   a. _____
   b. _____
   c. _____
   d. _____
   e. _____
2. Manufacturers will provide _____ _____ _____ _____ that give information about safe handling of chemicals.

OBJECTIVE 8: Explain the importance of good housekeeping in controlling chemical hazards.

Proper housekeeping methods where chemicals are in use can reduce the potential for fire and control the risk of contamination. To reduce fire

hazards, all liquids and solids (especially oxidizing agents and flammables) must be kept in closed containers when not in use. Through improper handling and storage techniques, these chemicals may become contaminated and unwanted side reactions may occur. Such side reactions may be extremely dangerous.

Maintaining a clean and orderly workplace also reduces the danger of fires. Maintenance and operating practices should strive to control leakage and prevent the accidental escape of flammable or combustible liquids.

The materials used for cleaning can create hazards. Combustible sweeping compounds such as oil-treated sawdust can be a fire hazard. Floor coatings containing low flash point solvents can be dangerous if used near sources of ignition. All oily mops and rags must be stored in closed metal containers. Flammable material of any type should be kept only in places which are isolated by fire-resistant construction. Rubbish should be disposed of regularly.

Not only does good housekeeping contribute to a safer workplace by reducing the potential for fire, it also reduces accidents by controlling contamination. In dusty work areas, for example, where different types of dusts are present, vacuuming or wet brushing will prevent the dust from being redistributed in the air.

Spills and leaks of toxic materials must be decontaminated and/or cleaned up immediately - not only to prevent unnecessary exposure to workers near the spill but to keep it from spreading throughout the workplace. Spills and leaks that spread as airborne vapors or dusts and also as liquids or powders, may be tracked by trucks or shoes or be carried as contamination on clothing.

In summary, employees need to be informed about the chemicals with which they work and of required housekeeping procedures associated with them. They must know which chemicals, if mixed, are incompatible and may result in a hazardous reaction. Employees must know how to store the chemicals and which ones should be stored separately to preclude any violent reaction.

Employees must also know how to handle and dispose of the materials properly - which materials can be flushed down the drain and which need

special processing for proper disposal. Some chemical spills require separate or specialized equipment or procedures for proper cleanup. The supervisor and plant safety officer should always be consulted if there is a leak or spill of a hazardous chemical.

ACTIVITY 8:

Mark each statement True or False.

___ 1. Proper cleanup of spills require the same procedure for every hazardous chemical.

___ 2. All chemicals can be safely disposed of by flushing them down the drain.

___ 3. Good housekeeping is essential only because it can reduce fire hazards.

OBJECTIVE 9: Describe how a properly designed ventilation system controls contamination by hazardous chemicals.

Whenever materials are being handled or processed in the open, some of the materials or their byproducts may escape into the atmosphere. A few of the chemicals that are hazardous to human beings have already been mentioned. These materials may be in the form of dusts, gases, mists, or fumes. An industrial safety program strives to protect employees against breathing contaminated air of any type.

Natural ventilation is rarely adequate to control or remove all air contaminants from a work environment. Even those who work outdoors should not depend on natural breezes to protect them from inhaling harmful chemicals. Mechanical ventilation is usually employed to control air contaminants that are potential health hazards: either dilution ventilation, local exhaust ventilation, or both.

General dilution ventilation is based on the pulling of enough fresh air through the work area to dilute the contaminants to a lower, or

nonhazardous, level. Dilution ventilation requires a greater volume of air than does a local exhaust system.

General dilution ventilation is used for areas generating small amounts of hazardous substances. It may effectively be used in some flammable liquid storage areas or with low hazard potential substances.

For dilution ventilation to work properly, several points must be considered in its installation:

- Exhaust openings should be located as close as possible to the source producing the contaminant.
- The fresh air that is taken into the work space should first pass through the worker's breathing zone, then across the work space where the contamination is produced and into the exhaust system as rapidly as possible.
- Unless the exhausted air is discharged far away from the fresh air intake duct, the fresh air can become contaminated.

Figure 3 shows examples of a good and poor dilution ventilation systems.

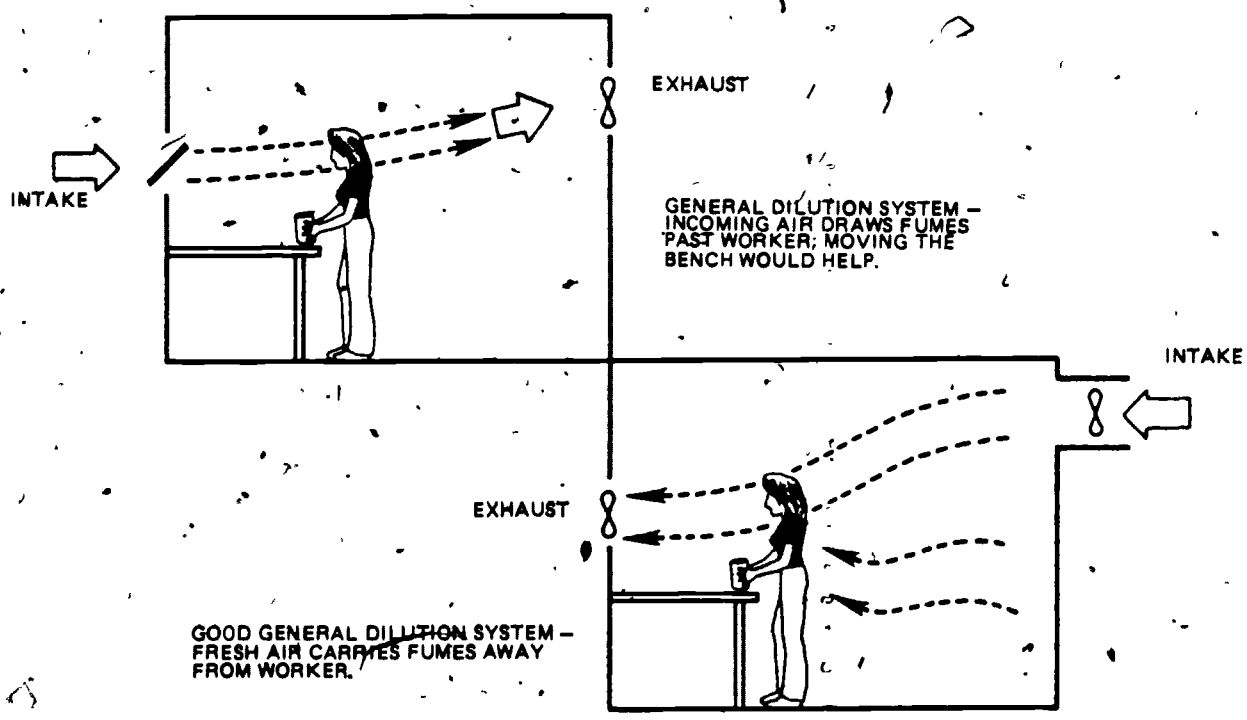


Figure 3. Good and poor general dilution ventilation systems.

Local exhaust ventilation removes the hazardous materials at or near their point of origin, thereby preventing them from circulating through the breathing zone of the worker or the entire work area.

Local exhaust systems are used wherever large amounts of air contaminants are produced or where a particularly hazardous substance is used. Some operations that usually require the use of local exhaust ventilation are welding, spray painting, and woodworking. Local exhaust is also needed when lead, mercury, asbestos, beryllium, and flammable materials are used.

Local exhaust ventilation can be provided by several types of equipment, including fixed enclosures (booths), freely movable hoods, and downdraft benches.

Many operations done in a fixed location can be provided with a fixed enclosure such as the one shown in Figure 4. This is a structure built

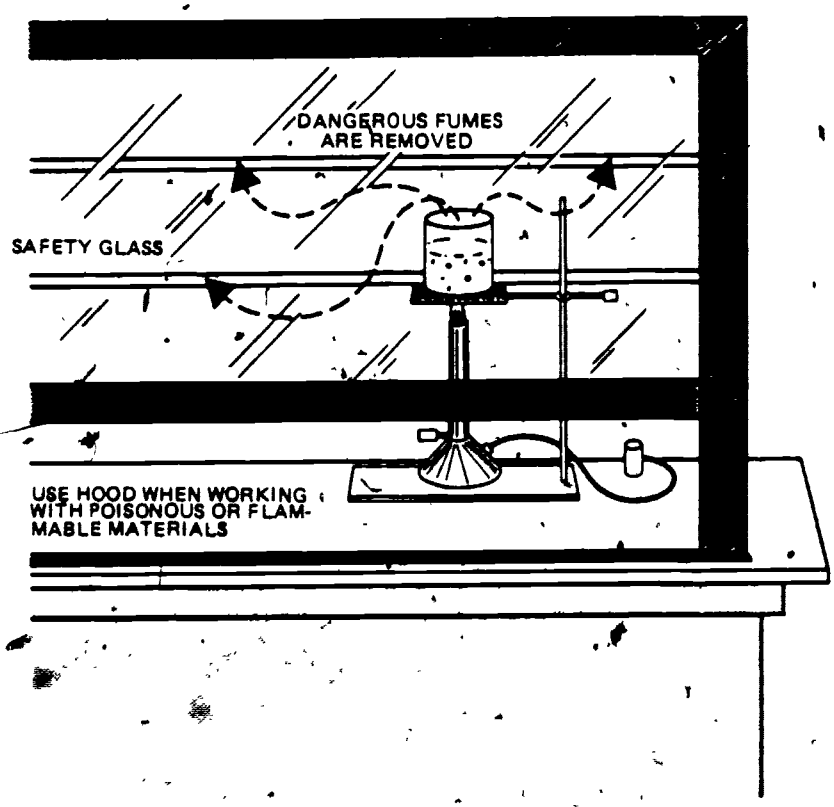


Figure 4. Laboratory type fume hood in fixed enclosure.

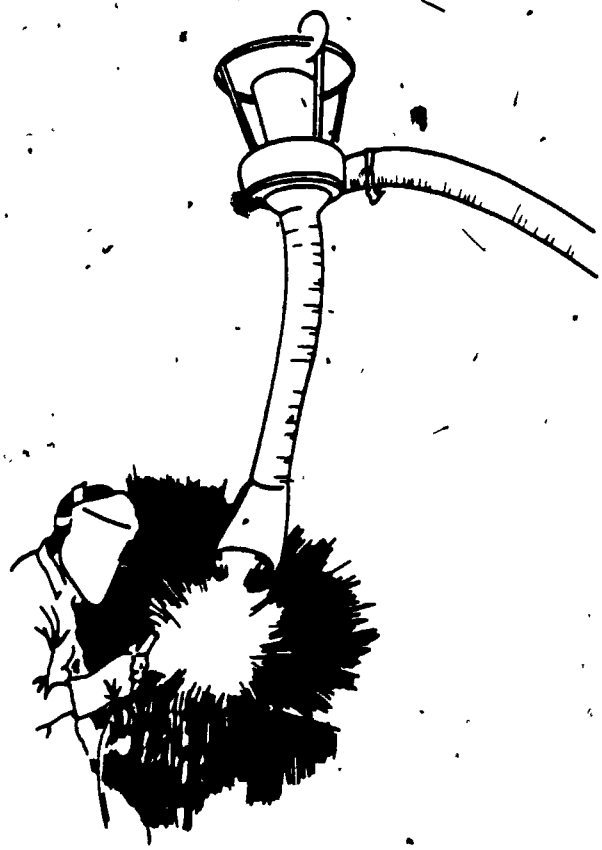


Figure 5. Movable hood.

around the operation which has a means for drawing air through the work area so that the work space is flushed continuously with fresh air.

A freely movable hood, attached to a fan, works by drawing air from the workplace and exhausts it outdoors. The hoods are normally constructed so that they can be moved into place by the worker (see Figure 5).

Another type of local exhaust ventilation is the down-draft bench or table that has an open grid as the work surface. Air is drawn downward through the grid into the duct work and then exhausted, preferably outdoors. This arrangement prevents the contaminants from rising into the person's breathing zone. However, for the bench to function properly, the work being done must not cover most of the work surface; the air flow into the exhaust system must be unblocked.

ACTIVITY 9:

Choose the best answer.

1. In a good general dilution system, the exhausted air should be discharged _____ the fresh air intake duct.
   a. directly in front of
   b. adjacent to
   c. far away from

2. Name three types of equipment that can provide local exhaust ventilation.

a. _____

b. _____

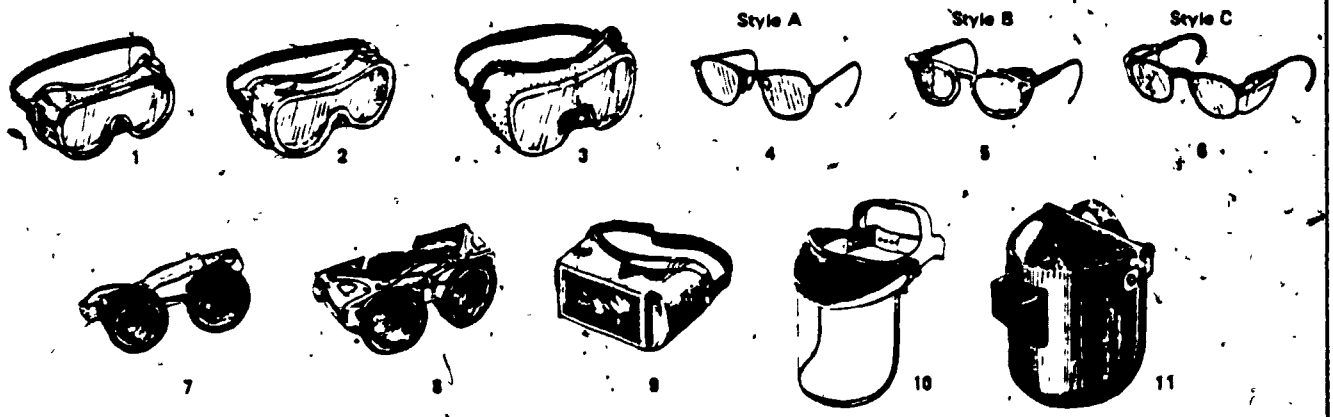
c. _____

OBJECTIVE 10: Describe the use of four types of personal protective equipment.

Perhaps one of the most important methods of protecting the employee is through the use of personal protective equipment (PPE). Personal protective equipment describes any device used to eliminate (or reduce the seriousness of) an accident. However, personal protective devices should never be considered the "first line of defense." Equipment of this nature should not be used in place of engineering controls such as substitution, isolation and ventilation. PPE must be of safe design and construction, appropriate for the work to be performed, and maintained in a sanitary and reliable condition. Even when personal protective equipment meets all these criteria, workers should not develop a false sense of security. Personal protective equipment can fail, and in the case of many chemical hazards, its failure means immediate exposure to the hazard.

The habit of using personal protective equipment for eye and face protection is especially important. Our eyes are valuable and irreplaceable, and unfortunately they can be injured easily by corrosives, dry chemicals, hot chemicals, or flying objects, such as debris from an explosion. Only protective eye wear of industrial quality, as specified by the American National Standard (Z87.1-1979) or the equivalent should be used. The American National Standard Institute (ANSI) standard covers such important features of protective eyewear as lens thickness, impact resistance, optical quality, and flame resistance of the frame. Proper eye protection should be selected on the basis of the kind and the degree of hazard. The ANSI Z87.1-1979 standard includes an eyewear selection chart, shown in Table 3.

TABLE 3. EYEWEAR SELECTION CHART (Z87.1-1979).



1 GOGGLES, Flexible Fitting, Regular Ventilation
2 GOGGLES, Flexible Fitting, Hooded Ventilation
3 GOGGLES, Cushioned Fitting, Rigid Body
*4 SPECTACLES, without Sideshields
5 SPECTACLES, Eyecup Type Sideshields
6 SPECTACLES, Semi-/Flat-Fold Sideshields
**7 WELDING GOGGLES, Eyecup Type, Tinted Lenses (Illustrated)
7A CHIPPING GOGGLES, Eyecup Type, Clear Safety Lenses (Not Illustrated)
**8 WELDING GOGGLES, Coverspec Type, Tinted Lenses (Illustrated)
8A CHIPPING GOGGLES, Coverspec Type, Clear Safety Lenses (Not Illustrated)
**9 WELDING GOGGLES, Coverspec Type, Tinted Plate Lens
10 FACE SHIELD, Plastic or Mesh Window (see caution note)
* 11 WELDING HELMET

*Non-sideshield spectacles are available for limited hazard use requiring only frontal protection.
**See Table A1, "Selection of Shade Numbers for Welding Filters," in Section A2 of the Appendix

APPLICATIONS

OPERATION	HAZARDS	PROTECTORS
ACETYLENE–BURNING ACETYLENE–CUTTING ACETYLENE–WELDING	SPARKS, HARMFUL RAYS, MOLTEN METAL, FLYING PARTICLES	7, 8, 9
CHEMICAL HANDLING	SPLASH, ACID BURNS, FUMES	2 (For severe exposure add 10)
CHIPPING	FLYING PARTICLES	1, 3, 4, 5, 6, 7A, 8A
ELECTRIC (ARC) WELDING	SPARKS, INTENSE RAYS, MOLTEN METAL	11 (In combination with 4, 5, 6, in tinted lenses, advisable)
FURNACE OPERATIONS	GLARE, HEAT, MOLTEN METAL	7, 8, 9 (For severe exposure add 10)
GRINDING–LIGHT	FLYING PARTICLES	1, 3, 5, 6 (For severe exposure add 10)
GRINDING–HEAVY	FLYING PARTICLES	1, 3, 7A, 8A (For severe exposure add 10)
LABORATORY	CHEMICAL SPLASH, GLASS BREAKAGE	2 (10 when in combination with 5, 6)
MACHINING	FLYING PARTICLES	1, 3, 5, 6 (For severe exposure add 10)
MOLTEN METALS	HEAT, GLARE, SPARKS, SPLASH	7, 8 (10 in combination with 5, 6, in tinted lenses)
SPOT WELDING	FLYING PARTICLES, SPARKS	1, 3, 4, 5, 6 (Tinted lenses advisable; for severe exposure add 10)

CAUTION:
- Face shields alone do not provide adequate protection.
- Plastic lenses are advised for protection against molten metal splash.
- Contact lenses, of themselves, do not provide eye protection in the industrial sense and shall not be worn in a hazardous environment without appropriate covering safety eyewear.

Most industrial laboratories and operations require that safety glasses be worn at all times in a situation where chemical hazards may be present. Violators of safety rules are often subject to dismissal. Contact lens use is restricted in many work settings where hazardous chemicals are used. If a person is splashed with a corrosive chemical, eyesight may be damaged by the time the contact lens is removed. Even protective safety goggles do not always protect contact lenses and the eyes.

Safety glasses provide only minimum eye protection; in some instances chemical splash goggles or a face shield should be worn. Face shields, which must be worn over goggles or safety glasses, are designed to provide added protection to the face against flying particles or hazardous chemical splashes or sprays. Acid-proof hoods are available to cover and protect the head, face, and neck, while leaving a "window" from which to see.

Figure 6. Emergency safety shower - eye wash.

In situations where potential explosives are being used, a shatterproof safety shield should be worn. This type of shield allows the user to see apparatus clearly and manipulate it by reaching around the sides of the shield while maintaining minimum personal exposure.

If a chemical, especially an acid, gets in the eye, the eye should be washed immediately. Suitable facilities for quick drenching or flushing of the eyes and body within the work area should be provided when a person may be exposed to corrosive material. Often, there is a combination eyewash fountain and safety shower available (Figure 6). Should chemicals touch a large portion of one's body, a safety shower should be used. (The ring on the shower is quickly pulled down to release large

amounts of water.) This wash should be continued for 15 minutes. If the action to wash off the chemicals with water is fast enough, chemical burns may be minimized. After the water rinsing, prompt medical attention should be sought. If clothing should catch fire, or if a corrosive chemical is spilled on the skin, every second counts in preventing severe burns. Because one may be confused and frightened at such a time, it is important that exact locations of safety showers and emergency equipment be noted before work in an area is begun.

Shop (laboratory) coats and aprons give general body protection. Frequently, they are used to safeguard one's clothes and body against grease and dirt. More specifically, they serve as protection from chemical and hot substances. Such coats and aprons are available in a wide variety of materials and styles, including resin-coated cloth, rubberized cloth, cotton duck, and vinyl plastic. If protective clothing or regular clothing becomes soaked with a toxic or corrosive material, the clothes should be removed immediately to prevent further exposure to the chemicals. An emergency shower should then be used to rinse off any remaining chemicals.

A variety of gloves are available to protect hands from burns, cuts, and poison contamination. Asbestos gloves (in good condition) or mittens are used to protect hands when handling hot objects. Latex surgeon-type gloves, which are tight fitting and flexible, provide protection against chemicals. Neoprene rubber and natural rubber gloves, which resist acids and most chemicals, are widely used in chemical operations.

For work on a construction site or in a production plant operation, a "hard hat" (helmet) and hard toe safety shoes are generally required. Rubber boots or shoes may be required for work around certain chemicals. These provide protection from falling objects for one's head and feet.

Under some hazardous conditions, respiratory protective equipment must be used by workers to enable them to breathe safely in the presence of hazards. Sometimes a supply of suitable respirators may need to be kept for emergency use. Respirators help to protect against harmful dusts, fumes, mists, gases, or vapors.

Respiratory protective devices fall into two broad categories. There are air-supplying respirators, which supply fresh air, and air-purifying

respirators (see Figure 7) which filter out impurities in the air. The respirators selected for use should be designed to protect against the specific hazards to which workers are exposed.

Figure 7. Workers wearing air-purifying chemical-cartridge respirators.

Problems can arise even when workers are using the proper equipment. For example, a person who wears safety goggles during certain hazardous work operations may remove them between times, hanging them about the neck on a cord or band until they are needed again. While hanging around the neck, the goggles are subject to contamination through rubbing against contaminated clothing. Thus when they are placed over the eyes again, a face burn can result from the contamination.

A person wearing safety goggles may receive a body splash of a corrosive chemical, step into a safety shower to wash off the chemical, but make

the mistake of removing the safety goggles before the shower starts. Thus some of the corrosive material enters the eyes.

Contamination can occur whenever personal protective equipment is handled improperly, as in the case of someone who wears rubber gloves to protect against skin absorption of a hazardous material, removes the gloves with the hand, and inadvertently rubs the eyes with the now contaminated hand.

In summary, personal protective equipment is effective when selected and used properly.

ACTIVITY 10:

Choose the best answer.

1. Personal protective equipment is considered -
   a. the first line of defense.
   b. foolproof protection.
   c. an important means of employee protection.
2. Contact lenses -
   a. provide some degree of eye protection.
   b. can increase the likelihood of damage by corrosive chemicals.
   c. should never be worn at the workplace.
3. Face shields -
   a. should be worn over safety goggles.
   b. may be worn in place of safety goggles.
   c. are more effective than safety goggles.
4. Respiratory protection -
   a. should be selected to suit the specific hazard.
   b. provides a supply of fresh air to the workers who wear them.
   c. filters out the contaminants in hazardous atmospheres.
5. Personal protective equipment is effective, subject to -

a. errors by users.
b. proper selection.
c. Both a and b.

OBJECTIVE 11: Describe the safe method of storing flammable liquids, corrosives, and toxic materials until they can be disposed of by trained personnel.

When working in an industrial situation, the handling, storage and waste disposal of toxic substances is essential if good health standards are to be maintained. All of these processes should come under the supervision of safety personnel.

Whenever handling containers of toxic and corrosive materials, a worker should do so carefully. If working with industrial drums, one should inspect it for leaks. Damaged drums may leak and, in an enclosed space, may cause dangerous concentrations of vapors and dusts.

Connections on all drums and pipes containing flammable liquids must be vapor and liquid tight. When flammable liquids are transferred from one container to another, they must be effectively bonded and grounded. This practice prevents electrical discharge (sparks) from the accumulation of static charge because of the transfer process.

Supplies of flammable liquids must be stored in approved fire-resistant safety containers. Storage cabinets must be marked: "FLAMMABLE - KEEP FIRE AWAY."

Corrosive materials often destroy their containers and get into the atmosphere of a storage area. Some of these substances can react with the atmosphere to cause explosions. Therefore, these materials should be stored in safety approved containers. They should be kept cool, but well above freezing. There should also be sufficient ventilation to prevent any building up of toxic fumes. As well as other hazardous substances, containers of corrosive materials should be carefully handled, kept closed, and properly labeled.

When dealing with toxic substances, it is even more important that all containers are sealed completely shut. It only takes a very small concentration of some toxic materials to prove very harmful to an unsuspecting victim.

In general, materials that are toxic or that can decompose into toxic substances when stored due to contact with heat, moisture, or acids should be stored in a cool, well-ventilated place, out of the direct rays of the sun, away from fire hazards, and should be inspected on a regular basis.

ACTIVITY 11:

Describe the safe method of storing flammable liquids, corrosives, and toxic materials until they can be disposed of by trained personnel.

OBJECTIVE 12: Discuss the factors that experts must consider in chemical waste management.

So many hazardous chemicals are widely used in today's society that the problem of chemical waste disposal has become exceedingly complex. Chemical engineers and other experts must consider not only the protection of plant workers who handle and transport chemicals, but also the safety and health of the surrounding communities. Contamination through improper disposal of chemical wastes can affect the water supply, soil conditions, and air quality to such an extent that sickness and even death can result. Besides the immediate effects of certain chemical waste dumping and spills, there are long-term biological and toxicological impacts to consider. What is the result when toxins enter the food chain? How long does it take a lake or stream to recover from severe contamination? What is the effect of chemical contamination on the agricultural capacity of a given area?

When scientists and engineers tackle the problems of chemical waste management, many factors must be considered. Many conditions can affect the chemicals being disposed: weather, soil characteristics, terrain, surrounding structures, debris, and nearby stored wastes. The flammability, explosibility, reactivity, and corrosive nature of the chemical or chemicals to be discarded must be thoroughly understood. Orderly waste disposal according to planned procedures present enough problems to challenge the experts; accidental spills or careless dumping require even more expertise to handle safely. Plant workers, homemakers, business employees, and other laypersons who come in contact with hazardous chemicals cannot be expected to know the answers to the complex problems of chemical wastes. However, employees reasonably can be expected to ask at least some of the right questions regarding chemical disposal.

As mentioned earlier in the module, in most aspects of chemical handling, the label is the employee's first source of information. However, the label may raise as many questions about storage and disposal as it answers - questions such as the following:

- When the label says, "Store in a cool, dry place," what is a cool, dry place? How cool is cool? How dry is dry?
- When the label says "Keep away from oxidizing materials," the worker may need to identify which materials in the surrounding area, if any, are classified as oxidizing.
- If the label has been removed or lost, employees need to find out what the material is and how it behaves.
- If the external packaging contains a warning label, but the individually packaged contents carry no hazard label, the employee needs to know why and what the precautions should be.
- When the chemical has been used, and the empty container is still around, employees need to ask about disposal procedures.

In cases where spills occur, employees should always inform the supervisor immediately. The proper procedures for cleanup may include evacuation of the area, the wearing of personal protective equipment, controlled burning, specialized absorbent materials and containers, and other steps that must be directed by a knowledgeable person. The consequences of attempting

to handle a spill without adequate knowledge or expertise can be disastrous.

ACTIVITY 12:

1. Name four environmental factors that experts must consider when planning chemical waste disposal.
   a. _____
   b. _____
   c. _____
   d. _____
2. Name four qualities of the chemical to be disposed that must be considered by experts in the planning of chemical waste disposal.
   a. _____
   b. _____
   c. _____
   d. _____

OBJECTIVE 13: Identify the main hazards associated with eleven groups of chemicals.

Chemicals are so widely used in manufacturing, construction, and domestic enterprises that it would be impossible to list all of the chemicals and their related hazards. However, the groups of chemicals discussed in this objective provide an overview of hazards in chemical manufacturing and use.

FIREWORKS AND PYROTECHNIC CHEMICALS

A substance of chief concern is still "black powder" that may be used for propellants, bursting charges, and primary mixtures. Other basic materials include: (1) combustible materials such as resins, gums, shellac, sulfur, flake aluminum, (2) oxidizing materials such as potassium chlorate, barium chlorate, (3) flame tinting material such as barium carbonate, sodium

oxalate, Paris green, (4) inert materials such as paraffin and lime.

The pyrotechnic and fireworks industry has many potential health and safety hazards. These potentials are often aggravated by careless handling, storage, and operational procedures. Fire and explosion are the most immediate dangers within the industry.

OXIDIZING SUBSTANCES

Some of the most frequently used oxidizing substances in the miscellaneous chemical products industry are copper chloride, sodium sulfide, stannous dichloride, iodine in potassium iodide, iodine in potassium hydroxide, sulfuric acid, hydrogen peroxide, potassium dichromate, chlorine in potassium hydroxide, nitric acid, ferric chloride, potassium iodate, perchloric acid. In both liquid and vapor form, oxidizing substances not only cause skin burns but are very irritating to the eyes, mucous membranes, and respiratory tract. The more highly toxic substances such as hydrofluoric acid (also used for metal treatment) are strongly corrosive, highly irritating, and poisonous. Nosebleed and sinus problems have been reported among workers exposed to very low levels of a fluoride or fluorine in the air.

In addition to the health aspects (corrosive to skin, etc.), oxidizing substances create a safety hazard because of their potential to ignite combustible materials. The peroxides of potassium and sodium react vigorously with water and release oxygen and much heat. If combustible materials are present when this reaction takes place, fire is likely to occur. Chlorates and inorganic nitrates are strongly oxidizing substances that can cause not only fire but also explosion when mixed with finely divided combustible material (certain dusty forms of floor sweepings).

WATER TREATMENT CHEMICALS

Some of the chemicals used in manufacturing water supply treatment materials are chlorine (the most used), diluted hydrazine, ammonia, sodium hydroxide, caustic alkalies, calcium hydroxide, chromic acid, sodium hypochlorite (a bronchial and skin irritant that can cause internal lesions if

ingested), certain complex organic chemicals, and hydrochloric acid. These substances are very corrosive.

Tribasic sodium phosphates, sodium hexametaphosphate, or other phosphate and sulfonate base detergents used in various water treatment chemicals may give rise to irritation of the skin and respiratory tract.

Other health considerations are the corrosive effects of acids and alkalies; respiratory irritation; narcotic effects of inhalation of many gaseous or volatile compounds; metabolic disturbances due to the absorption of certain complex organic chemicals; and a skin dermatitis condition known as "chrome holes" (skin ulcers most commonly found on hands and nose) that can be caused by chromic acid. These are only a few of the hazards that need to be controlled.

ORGANIC CHEMICALS AND SOLVENTS

Organic chemicals and solvents find wide application in industry. Most organic solvents have some effect on the central nervous system and the skin. The principal modes of exposure are inhalation of vapor and skin contact. Excessive solvent vapor inhalation may cause impairments that have no immediate discernible permanent effects on health - impairments such as lack of coordination and drowsiness - but that may increase the risk of accidents. In other cases, exposure may result in serious damage to bone marrow, blood, lungs, liver, kidney, and gastrointestinal tract. Management and employees should be aware of the hazards of the solvents used. There are eight classifications for industrial solvents:

- Hydrocarbons: All members of this group are flammable. Most have a narcotic effect and overexposure can lead to loss of muscular coordination, collapse, and unconsciousness. Chronic exposure to benzene may result in leukemia.
- Halogenated hydrocarbons: Although carbon tetrachloride and tetrachloroethane are dangerous to liver and kidneys and certain of the lower chlorinated napthalenes have an injurious effect on the liver, which may result in toxic jaundice, most solvents in this group have no chronic toxic effects.
- Alcohols: In general, on inhalation, their vapors produce mildly toxic effects (methyl alcohol may cause blindness if ingested), and because of their low flash point (which, for most, can be reached in a workroom) they constitute a fire hazard.

- Ethers: Ethers are highly flammable and possess strong narcotic properties, but for the most part, they are only mildly toxic.
- Glycol derivatives: Glycol derivatives are flammable, narcotic, and can have a toxic effect on the nervous system and blood.
- Esters: Esters may cause irritation of the eyes, nose, and upper respiratory tract; they are flammable.
- Ketones: Ketones are flammable. Because of the irritating effects on the nose, eyes, and upper respiratory tract, the vapors are not voluntarily inhaled.
- Miscellaneous solvents: These include the nitroparaffins, certain solvents of vegetable origin, and carbon disulfide, one of the most dangerous solvents used in industry. Carbon disulfide, which is highly flammable and highly toxic, can cause permanent damage to the central and peripheral nervous systems. Even the most inert solvents can dissolve the skin's natural protective barriers of fats and oils and leave the skin unprotected and subject to disabling dermatitis and potential infection. Skin contact with solvents may cause dermatitis that can range in severity from simple irritation to actual damage to the skin.

OILS

Oils and other similar products can clog the skin's pores and cause eruptions (sometimes severe) if good personal hygiene practices are not followed. These include washing of all exposed areas thoroughly and drying the area completely, changing work clothes after each shift, and cleaning the clothes as often as needed. Certain oils (for example, oils used for hydraulic fluids) may contain organophosphorous compounds that are considered highly toxic when ingested or inhaled.

Material safety data sheets or technical data should be obtained for lubricating and cutting oils since they may contain nitrosoamines that may be cancer-causing. Chlorinated cutting oils are recognized as a source of dermatitis.

FOUNDRY AND METAL TREATMENT CHEMICALS

Substances used in foundries and for metal treatment are many and varied; they include many types of earth, such as bentonite, talc, clay, silica flour, silica sand, and fluorspar, and various binders, such as derivatives of coal tar pitch or petroleum products. These materials, if not properly controlled, may give rise to undue exposure to free silica, which could

cause silicosis of the lung, and to coal tar pitch volatiles containing benzo [A] pryene (BaP), a known cancer-causing agent. Various types of binders (e.g., epoxy and other resins) give rise to skin problems.

Among the many compounds used for metal treatment are phosphates of iron, zinc, manganese, sodium, and ammonium. These agents, as well as the concentrated form of the phosphates, can cause severe, painful corrosive action on the skin and eyes. Chromic acid is a severe irritant to the skin and mucous membranes. Sodium hydroxide, potassium hydroxide, and trisodium phosphate are used for etching aluminum. Inhalation of these fumes and dusts can produce intense bronchial irritation and pulmonary edema, which should be treated by immediate hospitalization.

FLUXES AND BRAZING AND SOLDERING COMPOUNDS

Some of the more important ingredients for fluxes and brazing and soldering compounds are lead, antimony, tin, arsenic, nickel, cadmium, and chromium. With sufficient exposure, they are highly toxic and result in heavy metal poisoning, nervous disorders, lack of coordination, and other serious disorders.

DYE-PIGMENT CHEMICALS

Some inorganic dye-pigment chemicals contain chromates or hexalvalent chrome, lead compounds, oxides of metals (e.g., titanium, calcium), and similar toxic compounds that have hazards similar to those discussed above. Organic dyes, such as azo, and some other dyes produce cancer of the bladder and liver as well as other types of carcinomas.

SALT

Even in the manufacture of salt there are various hazards such as sunlight reflecting on the eyes that can result in some types of conjunctiva and perhaps even cataracts. The primary problem, however, is the development of various dermatitis problems such as atrophied scars, fissures, and other types of lesions. Again, a good personal hygiene program for employees is essential.

SOAPS AND DETERGENTS

Hazards involved in the soap industry include burns from hot operations and chemicals and skin diseases. Exposure to caustic substances is the most prevalant risk.

Allergies are commonly due to the coloring and perfume as well as the oils and rosin used in the industry. Once again, protective clothing, rubber gloves, aprons, boots, and face shields should be used.

Two excellent references can provide more information about specific hazardous chemicals; both issued by NIOSH (National Institute for Occupational Safety and Health), they are Occupational Safety and Health in Vocational Education by Frank Godbey, and Safety and Health for Industrial/Vocational Education.

ACTIVITY 13:

Fill in the blanks.

1. _____ and _____ are the most immediate dangers in the fireworks and pyrotechnic industry.
2. Oxidizing substances create a safety hazard because of their potential to _____ combustible materials, and a health hazard because they _____ the skin, eyes, and mucous membranes.
3. Some of the chemicals used in manufacturing water supply treatment materials (for example, chlorine, ammonia, and chromic acid) are very _____.
4. Most _____ _____ have some effect on the central nervous system and skin.
5. Some of the ingredients for fluxes and brazing and soldering compounds are lead, antimony, tin, arsenic, and cadmium. With sufficient exposure, they are _____ _____.
6. Allergies in the soap industry may be due to _____ and _____.

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ANSWERS TO ACTIVITIES

ACTIVITY 1

1. Chemical hazards are chemicals that may, unless dealt with carefully, cause injury or adverse health effects because of reactivity, instability, spontaneous decomposition, flammability, or volatility.

ACTIVITY 2

1. a.
2. a. Skin and respiratory tract.
   b. Combustible.
   c. Explode.

ACTIVITY 3

1. b.
2. a.

ACTIVITY 4

b.

ACTIVITY 5

1. Environmental concentration.
2. Length of exposure.
3. Tolerance of employee to that particular substance.
4. General health of employee exposed.
5. Way in which substance is being used.
6. Protection the employee has.

ACTIVITY 6

1. a. Substitution of a chemical.
   b. Reduction in quantities.
   c. Restriction of number of persons involved in hazardous operation.
   d. Separation of hazardous processes.
   e. General ventilation.
   f. Local ventilation.
2. d.

ACTIVITY 7

1. a. Name of product.
   b. Statement of hazards.
   c. Warning or signal word.
   d. Precautions for handling and storage.
   e. Instructions in case of contact or exposure.
2. Material Safety Data Sheets.

ACTIVITY 8

1. False.
2. False.
3. False.

ACTIVITY 9

1. c.

2. a. Fixed enclosure (booth).
   b. Freely movable hood.
   c. Down-draft benches.

ACTIVITY 10

1. c.
2. b.
3. a.
4. a.
5. c.

ACTIVITY 11

They should be stored individually in closed containers.

ACTIVITY 12

1. a. Soil characteristics.
   b. Terrain.
   c. Weather conditions.
   d. Surrounding structures, debris, other stored wastes.
2. a. Flammability.
   b. Explosibility.
   c. Reactivity.
   d. Corrosive nature.

ACTIVITY 13

1. Fire, explosion.
2. ignite, irritate.
3. corrosive.
4. organic solvents.
5. highly toxic.
6. perfumes, coloring.