

Teamsters Emergency Response Training

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Introduction **Emergency Response Training** This manual is for use in two courses: ■ First Responders at the Awareness Level ■ First Responders at the Operations Level About Teamster Safety and Health Training About this course

Notes

This manual was prepared by the Hazardous Waste Worker Training Program of the International Brotherhood of Teamsters — the Teamsters Union.

It is designed for use in two types of first responder training courses in compliance with the OSHA Hazardous Waste Operations and Emergency Response (HAZWOPER) Standard [29 CFR 1910.120]:

(1) Course for first responders at the awareness level:

Workers who are likely to witness or discover a hazardous substance release and who have been trained to protect themselves by leaving the area and to initiate an emergency response by notifying the proper authorities. These workers may also isolate the area and deny access to others.

(2) Course for first responders at the operations level:

Workers who respond to a hazardous substance release or potential release in a defensive fashion, in order to contain the release from a safe distance, keep it from spreading, and prevent exposures. These workers may also isolate the area and deny access to others.

This manual was prepared under a grant from the National Institute of Environmental Health Sciences.

About this Manual

This manual can be used for two types of courses:

- (1)First responders at the awareness level.
- (2) First responders at
- the operations level.

In addition to **Emergency Response Training**, the Teamsters offer courses that meet federal and state requirements for **hazardous waste workers**, **radiological workers** and **hazardous materials transportation workers**. Teamster training is provided by certified, experienced instructors using effective adult education methods, real equipment, and realistic hands-on activities.

Teamster Training Centers have mobile units that can travel to local union halls, construction and remediation sites, government facilities or other locations to train workers. For more information, or to schedule a course, contact the Teamster NIEHS Worker Training Grants Office at:

IBT NIEHS Worker Training Grants Office 25 Louisiana Avenue, N.W. Washington, DC 20001 (202) 624-6963

About	the
Teams	ters

The International Brotherhood of Teamsters was founded in 1903. We now represent 1.4 million workers in the construction industry, the transportation industry, and in almost every other type of employment.

In 1973 the Teamsters established a Safety and Health Department. It was one of the first unions to do so. The Safety and Health Staff includes professionals in safety, industrial hygiene and adult education. You can reach the Teamsters Safety and Health Department at:

> IBT Safety and Health Department 25 Louisiana Avenue, N.W. Washington, DC 20001 (202) 624-6960

- (1) Upon completion of the course for **First Responders At The Awareness Level**, the student will have the skills and knowledge to respond safely and effectively if he or she witnesses or discovers a hazardous substance release. He or she will:
 - (a) know how to initiate the emergency response by notifying the proper authorities,
 - (b) know how to identify the substances involved,
 - (c) know how to recognize the potential safety and health hazards created by the release, and
 - (d) understand the importance of not attempting to stop, contain or clean up hazardous substances unless he or she has the proper training and equipment.
- (2) Upon completion of the course for **First Responders At The Operations Level**, the student will have the skills and knowledge to respond to a hazardous substance release or potential release in a defensive fashion, in order to contain the release from a safe distance, keep it from spreading, and prevent exposures. He or she will:
 - (a) know how to initiate the emergency response by notifying the proper authorities,
 - (b) know how to identify the substances involved in the release,
 - (c) know how to recognize the potential safety and health hazards created by the release,
 - (d) know how to contain the release from a safe distance, keep it from spreading and prevent exposures, and
 - (e) understand the importance of not attempting additional response procedures unless he or she has the proper training and equipment.

Course Objectives



Chapter 1 Learning Objectives

Upon completion of this chapter, the student will be able to DISCUSS the emergency response requirements of the OSHA HAZWOPER Standard, including the responsibilities and rights of employees and employers under this standard and other related laws and regulations.

The student will be able to SELECT the correct response from a group of responses which verifies his or her ability to:

- 1 IDENTIFY the types of training required before a worker may respond at various levels to a release of hazardous substances.
- 2 IDENTIFY the responsibilities and the limitations of (a) first responders at the awareness level, and (b) first responders at the operations level.
- 3 IDENTIFY the responsibilities and rights of employees and employers with regard to access to information under OSHA standards.
- 4 IDENTIFY the responsibilities and rights of employees and employers with regard to unsafe or unhealthy working conditions under OSHA standards and other labor laws.



This chapter discusses the laws and standards that apply to you and your employer with regard to hazardous materials (hazmat) emergencies. It describes the training requirements for emergency responders — which is why you are taking this course. This chapter also summarizes your rights to have a safe and healthy workplace, to participate in safety and health activities, and, as a last resort, to file a complaint about hazards.

Introduction to This Chapter

A Teamster driver pulled up to the diesel pump at a Midwestern freight barn to refuel. A worker at the pump noticed liquid dripping from the trailer. The supervisor told the driver to back up to the dock. He then told a dock hand to open the trailer and see what was leaking.

Does this scene sound familiar? What's leaking? Is it something wet, but harmless? Or is it a hazardous material? Is it safe to simply enter the trailer? Or could the dock hand be injured or made sick?

The liquid seemed to be coming from further inside, so the dock hand climbed between two pallets of drums to get a better look. A second later he staggered out, coughing heavily. The liquid was hydrofluoric acid, a strong corrosive that burns any tissue it contacts and whose vapor severely damages the respiratory system.

Was there a better way to handle this incident? Could they have determined beforehand what was in the trailer, and whether it was safe to enter? Did the dock hand have a right to safer procedures? Should all the people involved, including the supervisor, have had training in how to respond to a hazardous materials emergency?

This course will help you answer these questions.

Emergency Response

Government Agencies You Should Know

OSHA, the Occupational Safety and Health Administration. This federal agency enforces safety and health standards to protect workers on the job. In 23 states there are state safety and health agencies which do this job instead of federal OSHA.

DOT, the Department of Transportation. This federal agency enforces regulations for transportation by road, rail, airplane and water. DOT has regulations for hazardous materials in transportation. Most states have a state agency which also enforces transportation regulations.

EPA, the Environmental Protection Agency. This federal agency enforces regulations to protect the environment. Most states have a state agency which also enforces environmental regulations.

NIOSH, the National Institute for Occupational Safety and Health. This federal agency studies safety and health problems, makes recommendations for OSHA standards, and provides advice to workers and employers.

USCG, the U.S. Coast Guard. The Coast Guard enforces hazardous substance regulations with regard to spills and releases which may affect navigable waterways.

States which have their own Occupational Safety and Health Program							
Maryland	South Carolina						
Michigan	Tennessee						
Minnesota	Utah						
Nevada	Vermont						
New Mexico	Virginia						
New York*	Washington						
North Carolina	Wyoming						
Oregon							
T and NY only apply	to public employees						
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OSHAct, the Occupational Safety and Health Act. (Passed by Congress in 1970.) The OSHact created **OSHA**. The OSHAct says that every employer is required to do two things:

- 1. Provide to each of it's employees: "employment and a place of employment that are free from recognized hazards that are causing or are likely to cause death or serious physical harm."
- 2. Comply with all OSHA standards.

The OSHAct directs OSHA to:

- 1. Write standards to protect workers.
- 2. Listen to worker's complaints about unsafe or unhealthy conditions.
- 3. Conduct inspections and enforce OSHA standards.
- 4. Protect workers from retaliation if they report safety and health problems.

SARA, the Superfund Amendments and Reauthorization Act. (Passed by Congress in 1986.) Two parts of the law are important for this course:

- 1. SARA requires OSHA to write a special standard for hazardous waste and emergency response workers: the Hazardous Waste Operations and Emergency Response Standard, or HAZWOPER.
- 2. SARA requires businesses that handle or use hazardous substances to prepare emergency response plans. It also directs cities and towns to prepare community emergency response plans.

Laws You Should Know

OSHA Standards

The safety and health rules which OSHA writes to protect workers are called **OSHA Standards**. There are many OSHA standards that may apply to your job. For example: standards which limit the concentration of toxic substances in workplace air, standards for the safe operation of forklifts, or standards for electrical safety. OSHA standards have the force of law.

There is a special OSHA standard called "**Hazardous Waste Operations and Emergency Response**". If you take the first letters of these words you can spell the name **HAZWOPER**, which is what everyone calls this standard.

Each OSHA standard has a number which is called its **citation**. The citation helps you find the standard in a law book, and it makes it easy to refer to a particular standard. The citation for HAZWOPER is **29 CFR 1910.120**.

How the citations work.

CFR stands for "**Code of Federal Regulations**." This is a set of law books containing the rules and regulations of all the federal agencies.

29 is the number for the US Department of Labor. OSHA is part of the Department of Labor.

1910 is the number for OSHA safety and health standards for "General Industry."

.120 is the section of the general industry standards called Hazardous Waste Operations and Emergency Response - **HAZWOPER**.

The OSHA HAZWOPER Standard covers three categories of workers:

- 1. Workers engaged in emergency response.
- 2. Workers at hazardous waste treatment, storage and disposal facilities (TSD's).
- 3. Workers at hazardous waste clean-up sites.

This course is for certain workers in the emergency response category. HAZWOPER defines emergency response as:

A response effort by employees from outside the immediate release area or by other designated responders ... to an occurrence which results, or is likely to result, in an uncontrolled release of a hazardous substance.

Paragraph "q" of HAZWOPER is titled "Emergency Response to Hazardous Substance Releases."

This paragraph covers employers whose employees are engaged in emergency response no matter where it occurs.

Paragraph "q" has requirements for:

- 1. Emergency response plans and procedures.
- 2. Worker training.
- 3. Medical surveillance.

The HAZWOPER Standard

The citation for the emergency response provisions of HAZWOPER is 29 CFR 1910.120 (q). This paragraph covers emergency responders in any place, any situation.

Training for Emergency Responders

Paragraph q divides emergency response worker into five categories.

This manual is for:

- (1)First responders at the awareness level,
- &
- (2) First responders at the operations level.

Paragraph "q" lists five kinds of emergency responders:

- First responders at the awareness level are persons who are likely to witness or discover a hazardous substance release and who have been trained to initiate an emergency response sequence by notifying the proper authorities of the release. They take no further action beyond protecting themselves, notifying the authorities and keeping others away.
- 2. First responders at the operations level are persons who respond to releases or potential releases of hazardous substances as part of the initial response for the purpose of protecting nearby persons, property or the environment. They are trained to respond in a defensive fashion without actually trying to stop the release. Their function is to contain the release from a safe distance, keep it from spreading, and prevent exposures, and keep others away.
- 3. Hazardous materials technicians are individuals who respond to releases or potential releases for the purpose of stopping the release. They assume a more aggressive role than a first responder at the operations level. They will approach the point of release in order to plug, patch or otherwise stop the release of a hazardous substance.
- 4. Hazardous materials specialists are individuals who respond with and provide support to hazardous materials technicians. Their duties require a more directed or specific knowledge of the various substances they may be called upon to contain.
- 5. On scene incident commanders are individuals who assume control of the incident scene.

The materials in this manual are for awareness level and operations level first responders (1 and 2, above).

If hazardous materials are handled at your work site, and there is the possibility that a spill, leak or other accident could occur, then you need training.

HAZWOPER has different training requirements for different kinds of emergency responders.

You need to be trained as a **first responder at the awareness level** if:

- 1. You might be the person who discovers or witnesses a hazardous substance release, and
- Your only responsibility is to leave the area for your own protection and summon the proper authorities. You may also keep others away from the release area. Whom you summon depends on what it says in the emergency response plan (ERP) for your work site. It might be your supervisor, an on-site hazmat team, or an outside group such as the fire department.

You need to be trained as a **first responder at the operations level** if:

- 1. You might be part of the initial response to a release or threatened release of a hazardous substance,
- 2. You do not enter the hot zone around the release, and
- 3. You only respond in a defensive fashion without actually trying to stop the release. You work at a safe distance to contain the release, stop it from spreading, and prevent exposures to yourself and others. You may also keep others away from the release area.Your exact responsibilities depend on what it says in the emergency response plan (ERP) for your work site.

Training (continued)

OSHA Rights and Responsibilities

OSHA requires your employer to provide a safe and healthy workplace, and comply with OSHA standards.

As an employee, you have legal rights provided by OSHA and other federal laws, and you also have the responsibility to work in a safe manner in compliance with OSHA standards. Your OSHA rights include:

- 1. The right to a safe and healthy workplace.
- 2. The right to receive safety and health training.
 - A. Hazard communication training.
 - B. HAZWOPER emergency response training.
 - C. Respirator training (if applicable).
 - D. Confined space training (if applicable).

3. The right to information.

- A. Material safety data sheets (MSDS's).
- B. Copies of OSHA standards related to your work site.
- C. Your employer's Log and Summary of Occupational Injuries (the "OSHA 200 Log").
- D. Results of workplace monitoring and surveys.
- E. Your own medical records.
- F. Written safety and health programs, including the emergency response, hazard communication, and any other applicable safety and health programs.
- G. Copies of any OSHA citations.

4. The right to take part in safety and health activities.

- A. Point out hazards and suggest corrections.
- B. Discuss safety and health concerns with your fellow workers and your union representative.

5. The right to participate in OSHA inspections.

- A. You or your union representative participate in the opening and closing conferences.
- B. You or your union representative accompany the OSHA inspector during the inspection.
- C. Respond to questions from the OSHA inspector.

6. The right to file an OSHA complaint if a hazard exists.

- A. Have your name kept confidential by OSHA.
- B. Be told by OSHA of actions on your complaint.
- C. Be notified if your employer contests a citation.
- D. Object to an abatement period proposed by OSHA.
- 7. The right to refuse to do work which would expose you to imminent danger of death or serious injury.

(We discuss this right in more detail on the next page.)

8. The right to protection from retaliation or discrimination because of safety and health activities.

A. File a complaint with OSHA if you believe you have been discriminated against for discussing safety and health, pointing out hazards, filing an OSHA complaint, or refusing dangerous work.

Your OSHA Rights (continued)

The Right to Refuse Dangerous Work

Refusing work is tricky. If possible, always contact your shop steward or union representative first.

The NLRB protects "concerted action" action on behalf of more than one employee. As an employee, you are expected to do your job as directed by the supervisor. However, the law says that under certain conditions, you can't be disciplined for refusing dangerous work.

OSHA is supposed to protect you if you are disciplined or discharged for refusing dangerous work, but only if you can prove that <u>all</u> the following conditions were met:

- 1. You had a reasonable belief, based on what you knew at the time, that there was a real, imminent danger of death or serious injury, and
- 2. You asked the employer to eliminate the danger, and
- 3. You had no reasonable alternative, and
- 4. There wasn't time to get OSHA involved, and
- 5. You contacted OSHA within 30 days of when you were disciplined or discharged for this incident.

You also have the right under the **NLRB** (National Labor Relations Board) to take concerted action for safety.

If you feel you must refuse, always take all of these steps:

- 1. Don't act alone. Talk to others. Contact the union.
- 2. Make it clear that you are not being insubordinate. Point out the danger. Explain that you are willing to do the job if it can be done safely.
- 3. Offer to do other work.
- 4. Don't walk off the job. Don't leave the site unless ordered to do so by the supervisor.
- 5. Call OSHA at the first opportunity.

The Department of Transportation (DOT) has safety and hazardous materials (hazmat) regulations. DOT also has training requirements for hazmat workers who:

- 1. Load, unload or handle hazmat.
- 2. Operate a vehicle used to transport hazmat.
- 3. Prepare hazmat for transportation.
- 4. Are responsible for hazmat transportation safety.
- 5. Recondition or test hazmat packaging.
- DOT requires three kinds of training for hazmat workers:
 - 1. General awareness training. (Like HAZWOPER first responder awareness level training.)
 - 2. Function-specific training. (Specific safe practices that apply to the hazmat activities of your job.)
 - 3. Safety training. (Handling hazmat packages.)

In transportation related job sites it is often confusing whether OSHA standards or DOT regulations apply. The Teamsters follow the rule of thumb that says most truck driving related work is under DOT jurisdiction, while loading, unloading, and warehousing are covered by OSHA standards.

DOT will respond to safety complaints, but they may be slow to do so. You do not have the same rights to participate in DOT inspections as you do under OSHA. If you file a complaint with DOT, put it in writing, be specific, and cite the exact DOT regulation that's being violated. Keep a copy for your records. Be sure to also contact your union representative.

DOT Regulations and Training Requirements

The DOT training requirements are in 49 CFR 172 (H).

Review Questions

1. List the five types of emergency responders for which OSHA has special training requirements.



2. List the responsibilities of a first responder at the awareness level.

3. List the responsibilities of a first responder at the operations level.

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Review Questions (Continued)

- 4. True or false:
 - a. First responders at the awareness level should try to stop a leak before it creates a worse hazard.
 - b. Your responsibility as a first responder at the awareness level is to leave the immediate area of a spill or leak for your own protection, and report the incident to the supervisor or other authority as stated in the emergency response plan.
 - c. Your responsibility as a first responder at the operations level includes actively trying to stop a leak before it spreads and creates a worse hazard.
 - d. As a first responder at the operations level, you may be required to try to contain a spill or keep it from spreading, as long as you can do this from a safe distance without being exposed to hazardous materials.
- 5. List eight categories of safety and health rights which you have as an employee.



Review Questions (Continued)

6.	List seven types of safety and health information that you have a right to obtain.
7.	Describe the steps that you should take if you believe that a task which you have been instructed to perform is unsafe.

Chapter **2**

Health Hazards

Health hazards

Chemical forms

Routes of exposure

Acute and chronic effects

Exposure limits

Health effects of chemicals

Chapter 2 Learning Objectives

Upon completion of this chapter, the student will be able to DISCUSS the potential health hazards of exposure to hazardous substances.

The student will be able to SELECT the correct response from a group of responses which verifies his or her ability to:

- 1 IDENTIFY at least four examples of "acute" health effects and four examples and "chronic" health effects.
- 2 IDENTIFY five chemical routes of entry.
- 3 SELECT the proper definition for each of the following chemical forms:
 - a. Solid e. Particulate
 - b. Liquid f. Fume
 - c. Gas g. Fiber
 - d. Vapor h. Mist
- 4 SELECT the proper definition for:
 - a. OSHA e. REL
 - b. NIOSH f. STEL
 - c. ACGIH g. ppm
 - d. PEL h. mg/m³
- 5 SELECT the proper definition for:
 - a. Local effect d. Cancer
 - b. Systemic effect e. Latency period
 - c. Target organ

There are many ways hazardous chemicals can affect you. You might get a rash, feel sick or become dizzy. Your liver, lungs or other organs might be damaged. Your ability to have children might be affected. You might get cancer. The effect depends on the chemical, how much you absorb, and your own state of health.

Asphyxiants prevent the body from getting or using oxygen, causing dizziness, unconsciousness or death.

Simple Asphyxiants are gases that displace oxygen in the air. They may not be toxic in themselves, but if they take the place of oxygen, then the air cannot support life. Examples of simple asphyxiants include nitrogen, helium, methane and carbon dioxide.

Chemical Asphyxiants interfere with the way the body uses oxygen. Cyanide compounds prevent cells from using oxygen. Carbon monoxide gas combines with hemoglobin, and prevents it from bringing oxygen to the body. Hydrogen sulfide gas affects the nerves that control breathing, causing you to stop breathing.

Corrosives cause burning and destruction of any tissue they contact. They can cause permanent eye damage or blindness. They burn the skin, mouth, nose, esophagus, stomach, and lungs. Examples include sulfuric acid, nitric acid, hydrofluoric acid, and sodium hydroxide (lye).

Irritants cause redness, swelling, itching or burning of the eyes and skin. If inhaled, they cause coughing, or difficulty breathing. Examples include ammonia, weak concentrations of acid gases like chlorine, solvents, turpentine, and dilute solutions of corrosives.

Sensitizers cause some people to become "sensitized", and react to even a very small exposure. They suffer asthma-like symptoms, or skin irritation. Examples are formaldehyde, nickel, and toluene-di-isocyanide (TDI).

Chemicals and Your Health

Chemicals and Your Health, (continued)

Both men and women can be affected by reproductive hazards. **Neurotoxins** affect nerves. Some affect the brain (central nervous system) causing dizziness, nausea, headaches, poor coordination, or behavior changes. Some examples are lead, mercury, and solvents like toluene, alcohol, and carbon disulfide. Others affect nerves that go to other parts of the body (peripheral nervous system) causing numbness, tingling, weakness or tremors. Examples are lead, arsenic, mercury, and hexane. Many chemicals affect both central and peripheral nerves.

Kidney toxins (nephrotoxins) damage the kidneys, and may cause kidney failure. Examples include lead, cadmium, mercury, methyl alcohol, and chlorinated solvents like carbon tetrachloride and chloroform.

Liver toxins (hepatotoxins) can cause hepatitis, cirrhosis, or liver failure. Examples include ethyl alcohol, PCB's, and chlorinated solvents like chloroform and carbon tetra-chloride. Vinyl chloride can cause liver cancer.

Respiratory toxins damage the lungs and airways. Corrosives and irritants can cause burning. Ozone and phosgene gas cause fluid to collect in the lungs (edema). Asbestos and silica dust cause scarring of the lungs. Asbestos, arsenic and tobacco smoke can cause lung cancer.

Blood toxins (hematopoietic toxins) affect the blood, or the organs that make blood cells. Arsine and phosphine gas kill red blood cells. Benzene and lead cause anemia. Benzene can also cause leukemia (blood cancer).

Reproductive toxins affect your ability to conceive, or give birth to normal, healthy children. Possible effects include low sperm count, deformed sperm, impotence, menstrual irregularities, infertility, miscarriage, low birth weight and birth defects. Examples include lead, DBCP (a pesticide which is banned in the United States, but is still manufactured for export), ethyl alcohol, ethylene oxide, cellosolve, mercury and PCB's.

Health Effects of Hazardous Chemicals

ASPHYXIANTS

deprive the body of oxygen. Gasses like: **CARBON-DIOXIDE** and **NITROGEN** can displace the air in an enclosed space. Poison gases like **CARBON-MONOXIDE** and **HYDROGEN-SULFIDE** can poison the body so that it cannot use oxygen.

LIVER TOXINS

cause cirrhosis and hepatitis. Examples: carbon-tetrachloride, ether, certain pesticides and alcohol.

KIDNEY TOXINS

cause kidney damage and kidney failure. Examples: LEAD, CADMIUM, MERCURY, ALCOHOL, CARBON-TETRACHLORIDE.

IRRITANTS

cause irritation of the skin, eyes or respiratory tract. Examples: AMMONIA and ACID GASES like CHLORINE.

SENSITIZERS

cause allergic reactions. Examples: то (тоциеле-diisocyanate), formaldehyde.

NEUROTOXINS

affect the brain and nerves. They can cause numbness, poor coordination, memory loss, depression or psychiatric effects. Examples: LEAD, MERCURY, ORGANIC SOLVENTS, PESTICIDES and CARBON-DISULFIDE.

RESPIRATORY TOXINS

damage the lungs and airways. Examples: LEAD, CADMIUM, MERCURY, ALCOHOL, and CARBON-TETRACHLORIDE.

REPRODUCTIVE HAZARDS

increase the risk of birth defects, miscarriages or decreased sperm count. Examples: LEAD, MERCURY, CERTAIN PESTICIDES and ALCOHOL. Also IONIZING RADIATION from RADIOACTIVE MATERIALS CAN cause reproductive effects.

CARCINOGENS

increase the risk of cancer. Examples: BENZENE (leukemia), ASBESTOS (lung), VINYL-CHLORIDE (liver), and BENZIDINE (bladder). Also IONIZING RADIATION from RADIOACTIVE MATERIALS CAN CAUSE many types of cancer.

CORROSIVES

cause severe chemical burns. Examples: caustic soda (LYE) and acids such as sulfuric, hydrofluoric and nitric.

Cancer

Cancer is the uncontrolled growth of abnormal cells that interfere with the way your body is supposed to work.

Many chemicals increase your risk of getting cancer. These chemicals are called carcinogens. Your body contains trillions of living cells. There are hundreds of different types, each with special functions to perform in order to maintain a healthy, living body.

Cancer is the uncontrolled growth of abnormal cells. In other words, cancer is what happens when some cells begin to "misbehave", and enough of these "cancer" cells grow so that they cause a problem.

For example, the normal cells in your lungs form a structure which expands and contracts as you breathe. Some cells form the air passages, others are specialized cells that let oxygen pass into your blood. If some cells in your lung cease to perform their proper function, and instead grow into a mass that interferes with the passage of air or the normal expansion and contraction, then this mass of cells is called lung cancer.

Because there are many different kinds of cells in the body, there are many different kinds of cancer: liver cancer, lung cancer, breast cancer, leukemia (blood cancer), bladder cancer, skin cancer, and so forth.

Why do cells "go bad" and become cancer cells? We don't know all the details. We do know that some cancers are more likely if the person is exposed to certain chemicals. For example, insulation and shipyard workers who were exposed to asbestos fibers are much more likely than other people to get lung cancer, or a rare cancer called mesothelioma. Smokers have a much greater chance of getting lung cancer than nonsmokers.

Workers exposed to benzene have an increased risk of leukemia. Those exposed to benzidine have an increased risk of bladder cancer. Those exposed to vinyl chloride have an increased risk of liver cancer. Workers exposed to chromium have an increased risk of lung cancer. Chemicals that increase your risk of cancer are called carcinogens.

Just because you're exposed to a carcinogen doesn't mean you'll get cancer. There are many steps involved, and most of the time they don't all happen:

The chemical has to reach the cells in the target organ.

The cells have to be changed by the chemical, but not damaged so badly that they die.

The damage has to go unrepaired.

Enough cancer cells have to grow so that they interfere with normal functioning.

Most of the time exposure to a carcinogen doesn't cause cancer to develop.

However, the more you are exposed, the more likely it becomes that all the bad steps will occur, and a cancer will grow. It's like buying lottery tickets. If you just buy one ticket you might win, but probably not. If you buy many, many tickets, then your chances of winning increase. Not everyone who smokes will get lung cancer. But of the people who do smoke, more of these will get lung cancer than people who don't smoke. In the cancer lottery, we want to buy as few tickets as possible.

Not all chemicals cause cancer, but some do. We need to identify carcinogens in the workplace, and keep our exposure to these as low as possible. Remember that very few chemicals have actually been studied to see if they are carcinogens . There may be other cancer causing chemicals we don't know about. This is another reason to keep all chemical exposures as low as possible. Cancer (continued)

To decrease your risk, keep your exposure as low as possible.

Chemical Forms

Many chemicals can exist in different form, depending on the conditions.

In terms of air monitoring and respirator selection, gases and vapors are the same thing. Part of recognizing chemical hazards is knowing what forms chemicals have. Are they solid, liquid or gas? Do they break up into dusts or fibers? Do they evaporate? Chemicals take the form of either solids, liquids or gases.

Solids keep their size and shape, unless they're broken into smaller pieces. Solids are things like a stone, a piece of wood, or ice. Some solids break into extremely small pieces called dusts, powders, or fibers. These are often more hazardous because we can inhale them.

Liquids flow, like water. They keep the same size (volume), but change shape to fit their container.

Gases have no definite size or shape. They expand to fill the space available. If they leak, they disperse in all directions.

Many chemicals change form, depending on the conditions. Water is an example. If it's cold enough, water is a solid called ice. If we heat it, it melts and becomes liquid. Water can evaporate slowly to become a gas (water vapor). Water also becomes a gas more quickly if we heat it, causing it to boil.

Vapor is the word for a gas that e**vapor**ates from a liquid or solid. It turns into a gas and escapes into the air. For example, paint thinner is a liquid. We smell it because some of the liquid evaporates to form a gas, called solvent vapor, which gets into our noses. When a vapor touches a cool surface, it can condense back into a liquid.

A "gas" is something that's normally in the form of a gas. A "vapor" is something which is usually liquid or solid, but has evaporated. With respect to monitoring instruments and respirators, gases and vapors are the same thing. They behave like the other gases in the

air. If released, they diffuse (spread out) into the space available.

Dust or **powder** is a solid material that has been ground into small pieces. You can see dust in the beam of a movie projector, or when you shine a flash light in a dark room. Because dust floats in the air, it can be inhaled.

Fibers are small solid pieces that float in the air. Fibers are like dusts or powders, except that the individual pieces are much longer than they are wide. For some chemicals, this arrow-like shape makes it easier for them to get deep into the lungs. An example is asbestos fibers.

Fumes are extremely small solid particles formed in hot processes like fire, welding, and diesels. Fume isn't vapor, although people say "fume" when they mean "vapor". You smell gasoline vapor, not gasoline fumes. This distinction is important because we use a different kind of filter to trap solid particles like fume than to trap gases and vapors. Respirator labels use these words to mean different things. If you don't know the difference, you may pick the wrong respirator and not be protected.

Mists and **Sprays** are tiny droplets that float in the air, and can settle on clothing or bare skin, or be inhaled.

Particulate means any liquid or solid in a form small enough to float. (Dust, powder, fiber, fume, mist, spray.)

Smoke from combustion or welding is a mixture of chemicals including gases, vapors and particulates.

Air contaminants are hazardous chemicals in a form that is small enough stay in the air and be inhaled. There are only two ways this can happen. The chemical must either be (1) a gas or (2) a particulate.

Oxygen deficiency is a shortage of the oxygen we need to live. It causes simple asphyxiation. We include it in a list of airborne hazards because, as with contaminants, we use respirators and ventilation for protection.

Chemical Forms (continued)

Fume is a tiny solid particulate. It's not vapor.

Airborne Hazards

1. Gases / Vapors

2. Particulates (dust, powder, fiber, fume, mist, spray)

- 3. Oxygen deficiency
- 4. A combination of the above

Routes of Entry

In order for a hazardous material to affect your health, it has to get into or on your body. The different ways that chemicals do this are called **routes of entry.**

- 1. Inhalation is breathing-in a hazardous material. It may damage the lungs, and it may be absorbed in the blood and carried to other parts of your body.
- 2. Skin or eye contact is when a hazardous material gets on your skin or in your eye.
- **3. Skin absorption** is when a hazardous material gets on your skin and soaks through. It then enters the blood and is carried to other parts of your body.
- **4. Ingestion** is when you accidentally swallow a material. This might happen if the material gets on your hands, and then on the sandwich you eat for lunch.
- **5. Injection** is when a sharp object punctures the skin, allowing a chemical or infectious agent to enter.

Chemicals can use more than one route of entry. For example, if you handle a leaking container of solvent, you may get some on your hands. It can irritate your skin. It can also soak through, into your blood, and reach your liver or other organs. It can also evaporate and you will inhale it. The solvent affects you by skin contact, skin absorption, and inhalation.




If a chemical causes damage at the place where it comes in contact with your body, this is called a **local effect**. For example, if acid spills on your hand, the skin burn is a local effect. When you inhale ammonia, the irritation in your nose, throat and airways is a local effect.

If a chemical is absorbed — by whatever route of entry — and travels through your system to damage another organ, this is called a **systemic effect**. For example, suppose that you inhale solvent vapors and start to feel dizzy. The solvent has been absorbed through the lungs, traveled in the bloodstream and caused an effect in your brain. Another example might be a chemical that soaks through your skin and then causes damage to your liver.

Many chemicals produce both local and systemic effects. For example, inhaling a solvent might irritate the nose and lungs. This is a local effect: it happens where the chemical comes in contact with your body. But the solvent will also be absorbed in the lungs and carried by the blood to the liver, kidneys and brain. Damage to these other organs is a systemic effect.

In any case, the organs that a chemical affects are called **target organs**.

Local and Systemic Effects

Short Term and Long Term Effects

Acute = short term Chronic = long term

Latency Periods: Average Years After Exposure for Cancer to Appear						
Asbestos	33 yrs					
Arsenic:	25 yrs					
Benzene	10 yrs					
Benzidine	16 yrs					
Chromates	21 yrs					
Napthylamine	22 yrs					
Vinyl chloride	15 yrs					

Some chemicals cause effects that occur right away. If acid gets in your eye, it causes a painful burn immediately. If you inhale ammonia vapor, you cough and feel irritation in your nose and airways right away. This is called a **short-tern effect** or **acute effect**.

If you breathe small amounts of asbestos fibers you won't even notice them. There are no acute effects. But if you inhale asbestos month after month, year after year, you greatly increase your chances of getting lung cancer. This is a **long-term effect** or **chronic effect**.

It may take many years between the time you were exposed and when symptoms begin to appear. This is called the **latency period**. For some diseases, like cancer, the latency period can be twenty, thirty or more years.

The same chemical can cause both kinds of effects. For example, toluene is a chemical used in paints and solvents, and in the cement for plastic models. Inhale toluene and you can get dizzy or "high", and feel respiratory irritation. Toluene can also dry and irritate the skin. These are acute effects. However, if you are exposed again and again, toluene will damage your liver and destroy brain cells. These are chronic effects.

We usually notice acute effects. For example, acid burns and we feel it almost immediately. Just one whiff of ammonia vapor can make you cough. These effects can warn us to take precautions.

Unfortunately, you usually won't notice chronic effects until it's too late, because they happen slowly and it takes a long time to develop symptoms. You have to learn the possible chronic effects of the chemicals you work with. Then you will know that you must be careful, and what precautions to take, even if the materials don't cause any immediate effects. How much exposure is too much? This depends on the chemical, how healthy you are, and what other chemicals you're exposed to. **The best policy is to keep any exposure as low as possible**.

Several organizations and government agencies set limits for common chemicals. The idea is that most people will not be harmed if their exposure is kept below the limit. For example, the OSHA limit for toluene is 100 ppm. OSHA assumes that for most people, this amount in the air at work will not cause health problems.

An exposure limit is based on information from animal experiments and on information about the effects that workers experience in industries that use the chemical.

Exposure limits are listed on MSDS's (material safety data sheets). In an emergency, the safety officer may use exposure limits to decide what type of personal protective equipment is required. If you suffer health effects, the limits might be used to decide whether the effects were caused by the chemicals you worked with.

Most limits are only for the amount of a chemical in the air. They only deal with the inhalation route of entry. Most limits are set for day-long, low level exposures in normal industrial settings, not emergency situations.

In a factory, the amount of a chemical in the air changes during the day, depending on what's going on. For example, if someone is painting, there will be a higher level of solvent vapor than when the paint cans are closed and the products are dry. Most exposure limits are based on the **average** exposure. The actual concentration will sometimes be above the average, sometimes less. The average is called the **Time-Weighted-Average** or **TWA**. "Time-weighted"

Exposure Limits

The best policy is to keep any exposure as low as possible.

Most limits are set for normal work exposures, not emergencies.

8-hour TWA = The average exposure to a chemical over an 8 hour work day.

Exposure Limits (continued)

just means that it's the average over a period of time. Usually it's based on an eight hour day, so it's an **8-hour TWA**.

A few chemicals have a **Short Term Exposure Limit**, or **STEL**. These chemicals are so irritating that even if the average concentration were low, the times when the concentration goes above the average would cause problems. A STEL is a limit you should only be exposed to for fifteen minutes or less, and for no more than four fifteen minute periods a shift, at least one hour apart.

Some chemicals have a **Ceiling Limit** or C. This means that the concentration in the air must never go above this limit, even for a few minutes.

Some limits say the word **Skin**. This reminds you that the liquid or solid form of the chemical can be absorbed through the skin. This is not an exposure limit for the skin. It's just a warning to avoid skin exposure.

What Does PPM Mean?

Air is a mixture of individual molecules of nitrogen (78%), oxygen (21%) and other gases and vapors (1%). Each breath contains many millions of molecules.

Suppose we could count the molecules as we inhaled them. By the time we got to one million, we whould have counted about 210,000 oxygen molecules, about 780,000 nitrogen molecules, and about 10,000 molecules of other gases and vapors. Out of one million molecules we have 210,000 oxygen molecules. One way to say this is that we have 210,000 parts per million (ppm) of oxygen. "Ppm" means how many of one kind of molecule are in a mixture of one million molecules.



With a big number like the number of oxygen molecules it's easier to just say 21%. However, for hazardous chemicals, a much smaller concentration can be harmful. Consider benzene. The OSHA PEL is 1 ppm. This means that OSHA has determined that even if only one out of every million molecules we breathe is a benzene molecule, we may be absorbing enough benzene to damage our health. The American Conference of Governmental Industrial Hygienists (ACGIH) is a professional association of industrial hygienists. Their limits are called Threshold Limit Values or TLV's. They are only recommendations, and are not legally binding.

The federal Occupational Safety and Health Administration (OSHA), or in some states, the state safety and health agency, sets legally binding limits called Permissible Exposure Limits or PEL's.

Another federal agency called the **National Institute for Occupational Safety and Health (NIOSH)** makes recommendations about limits. These are called **Recommended Exposure Limits** or **REL's**.

The TLV, PEL and REL are often the same. For example, xylene has an 8-hr TWA of 100 ppm in all three systems.

Sometimes the limits are different. For example, carbon disulfide: TLV = 10 ppm, PEL = 4 ppm, and REL = 1 ppm.

For formaldehyde, the OSHA PEL is 1 ppm TWA with a STEL of 2 ppm. NIOSH and ACGIH, however, have not set a REL or TLV. This is because formaldehyde is a carcinogen, and both NIOSH and ACGIH take the position that you can't set a valid limit since theoretically any exposure increases your cancer risk somewhat.

Which is the "right" limit? The fact that one organization has a lower limit means there are health professionals who believe greater protection is required. You or your union representative should insist on control measures that keep your exposure below the lowest limit. It is better to err on the side of caution.

Always keep exposures as low as possible.

Who Sets the Limits?

Exposure Limits

ACGIH TLV Recommendation of a private orgaization

OSHA PEL Legally binding standard of a government agency

NIOSH REL Recommendation of a government agency

Always keep exposures as low as possible.

Can We Trust the Limits?

The limits are not perfect. Many limits have been lowered over the years as we discover that even smaller amounts of some chemicals can be harmful. The best practice is to try to keep exposures as low as possible, lower than the limits if we can. Here are some of the reasons to be wary of the limits for chemical exposure:

* The information behind the limit might not be good. There may only be a few animal studies, or very limited information about the real health effects in workers.

* Often a chemical causes more than one effect. However, the limit may be based on preventing only one effect. For example, the OSHA PEL for formaldehyde (TWA, 1 ppm; STEL, 2 ppm) will protect most workers from respiratory irritation, but these limits don't necessarily prevent an excess risk of nasal cancer.

* Some of us may be more affected by a chemical than other people. For us the limit may not be low enough. In fact, the ACGIH says that its TLV's are believed to protect "nearly all workers", but not all.

* Limits don't take into account the effects of the other chemicals a worker is exposed to. The combined effect may be more serious than the individual effects.

* Almost all limits are based on the amount of chemical in the air. This ignores other routes of entry. Many chemicals are absorbed easily through the skin. The proper respirator may keep your exposure to solvent vapors below the PEL or TLV, but if you're not wearing the right gloves and clothing, you may have an even greater exposure if the liquid gets on your skin.

* There are over one hundred thousand chemicals that have been used in the United States. But there are PEL's, REL's and TLV's for only about 600. For most chemicals there is no exposure limit.

How do you know what chemicals you are exposed to? How do you know how much you're exposed to? How do you know if your exposure is lower than the limit?

There are instruments for monitoring some chemicals in the air. For some chemicals there are tests to see how much is in your body. There are also clues to indicate exposure even if you don't have special instruments. You may be able to smell a chemical or feel an acute effect like itching skin or watery eyes. There may also be clues in your work environment to indicate exposure.

Odor. If you can smell it, you are inhaling it. The **odor threshold** of a chemical is the lowest amount most people can smell. If this is well below the exposure limit, then the chemical has **good warning properties**. If you can smell less than what it takes to harm you, then you will be warned before exposure rises to a dangerous level.

Many chemicals don't have good warning properties. The amount needed for smell is higher than the exposure limit. Others have no smell, like carbon monoxide, or they numb your sense of smell, like hydrogen sulfide.

Taste. Never taste something that might be a hazardous chemical. However, if you inhale a chemical or accidentally get some in your mouth, it may have a particular taste that warns you you're being exposed.

Particles in your respiratory system. Your nose and airways have mucous which traps particulates and removes them when you cough or blow your nose. If your mucous is an unusual color or has visible particles in it, then you have inhaled particulates. What you see are particles that were large enough to be trapped. There may be smaller ones that made it deep into your lungs. Particulates this small are too small to see. This is why for particulate contamination, like asbestos fibers, people say, "It's what you can't see that hurts you."

Are You Exposed?

Are You Exposed? (continued)

Acute symptoms. Many chemicals cause an acute effect, like irritation. One whiff of ammonia will warn you it's there. Other acute symptoms such as dizziness, nausea or headache may also warn you of exposure. Unfortunately, it's easy to ignore these symptoms, or to assume that you're just getting a cold or the flue.

Spills or leaks. Leaking drums or pools of liquid indicate a hazard. Chemicals may be evaporating into the air. Don't walk through spilled material, or get it on your bare skin.

Visible material in the air. If you see visible clouds of vapor or particulates, there is probably a serious exposure problem. Remember, however, that most gases and vapors are invisible, and that often the most dangerous particulates are too small to see.

Settled dust. If there is chemical dust on the ground or other surfaces, it probably got there by settling out of the air. This means that there are particulates in the air that you could inhale. It is likely that if you walk through the area, or use equipment, you will send more of the settled dust back into the air, increasing the inhalation hazard. Remember also that if dust settles on the ground, it can also settle on your clothes, on your hair, and on any food that you bring into the work place.

Does your nose really know?

It's important to recognize the warning signs of chemical exposure, like odor, or acute symptoms. But what if there are no signs? Can you forget about exposures? Many chemicals have no smell, taste, or acute symptoms. Some people can't smell certain chemicals. Some chemicals numb your sense of smell. Many air contaminants are invisible. There may be contamination on the things you handle, without there being enough to see or feel. Use the common sense clues we've discussed as warning signs. But never assume you're not exposed just because you don't see or feel any warning signs. Some hazardous materials are **radioactive**. They give off **ionizing radiation** that can cause adverse health effects. The effects we're most worried about with radiation are the increased risk of cancer and the increased risk of reproductive problems.

Radioactive materials can be solids, liquids or gasses. These **materials** can get into or on our bodies by the same routes of entry we've discussed. If they get into or on our body, then we will be exposed to the **radiation** they give off.

But there's another, special problem with radioactive materials. Some materials give off a form of radiation called gamma radiation that can pass right through many substances, including wood, paper, plastic, glass and sheet metal. It can also pass right into our bodies, like an x-ray. Materials that give off gamma radiation can be hazardous even if the material doesn't get into or on your body. These materials can be hazardous even if the routes of entry we talked about are blocked.

This is the reason there are special packaging, loading and shielding requirements for radioactive materials that give off gamma radiation. Even if you have no contact with the material, the radiation it gives off may be harmful.



Health Effects of Radioactive Materials

Review Questions

1. Give four examples of **acute** health effects.

_ _ _ _ _ _ _ _ _ _ _ 2. Give four examples of **chronic** health effects. _ _ _ _ _ _ _ _ _ _ _ _ _ 3. Identify five **routes of entry** by which chemicals can get into or on your body. _ 4. True or false: a. Exposure to a carcinogen always causes cancer. b. The best policy is to keep all chemical exposures as low as possible.

5.	Define each of these chemical forms:							
	Solid:							
	Gas [.]							
	Vapor:							
	Particulate:							
	Fume:							
	Fiber:							

Review Questions (Continued)

Review Questions (Continued)

	O S H A :
	NIOSH:
	ACGIH:
	PEL:
	REL:
	STEL:
	ppm:
	mg/m ³ :
7.	Define each of these terms:
	Local effect:
	Systemic effect:
	Target organ:
	Cancer:
	Latency period

6. Write out the meaning of each abbreviation:

Chapter 3 **Safety Hazards** Fire hazards Bonding and grounding Fire extinguishers Chemical incompatibility Confined space hazards

Chapter 3 Learning Objectives

Upon completion of this chapter, the student will be able to DISCUSS the potential safety hazards related to hazardous substances.

The student will be able to SELECT the correct response from a group of responses which verifies his or her ability to:

- IDENTIFY three special safety hazards related to hazardous substances.
- 2 SELECT the proper definition or example for:
 - a. Combustion e. Flammable
 - b. Explosion f. LEL
 - c. Flash point g. UEL
 - d. Combustible h. Flammable range
- IDENTIFY the four components of the fire pyramid.
- 4 EXPLAIN the purpose of and procedure for:
 - a. Bonding containers of flammable liquids.
 - b. Grounding containers of flammable liquids.
- 5 IDENTIFY four incompatible chemical combinations and the potential hazardous results of these combinations.
- 6 DESCRIBE four different types of fire extinguishers and the types of fires they are used for.

Many materials are hazardous because they burn easily. **Combustion** is the technical name for burning. It is the chemical reaction between fuel and oxygen which gives off heat and light.

A **Fire** is a form of combustion that takes place relatively slowly. Some fire produce flames. Others may just smolder more slowly.

An explosion of combustible materials is a form of combustion that happens very quickly, releasing heat and pressure in a fraction of a second. This kind of explosion is a super fast fire.

A material which can act as a fuel (that is, can burn) is **combustible**. If a material won't burn under normal conditions, it's **non-combustible**.

Some liquids which burn have a different name: flammable. A **flammable** liquid is a liquid which gives off enough vapors under normal conditions that a small ignition source (like a spark) will cause the vapors to burn or explode.

Four things are necessary for fire to happen: There must be (1) **fuel**, (2) **oxygen**, (3) an **ignition source** (heat) to start the process, and (4) a **chain reaction** to keep the fire going.



Fire and Explosion

Combustion is the chemical reaction between fuel and oxygen which gives off heat and light.

An explosion is a super fast fire.

The fire pyramid has four components. If any one of these is missing, the fire won't happen.

Fire and Explosion (continued)

The chain reaction is what keeps the fire going. It's also what makes an explosion happen. An **ignition source** is a match, a spark of static electricity, an electric current, lightning, a welding torch, friction, etc. It's anything hot enough to start the fuel burning.

The lowest temperature that the ignition source can be and still start a particular fuel burning is called the **ignition temperature** of the fuel. It's different for different fuels.

In order for the fire to continue, the heat created by the part of the fuel which starts burning first has to spread to more of the fuel, causing it to burn. This produces more heat, which starts more fuel burning, which creates more heat, and so on. This is the **chain reaction**.

Try to start a "2x4" on fire using a match. You have fuel, oxygen, and an ignition source. You won't be able to keep a fire going because the heat from the initial reaction (where the match flame touches the wood) is absorbed by the wood and dissipated. There isn't enough heat to keep a chain reaction going.

Suppose that gasoline has evaporated into a closed room from a leaking tank. The vapor consists of individual molecules of gasoline mixed with oxygen in the air. A tiny spark could start a few molecules burning. This creates a little more heat which burns the surrounding molecules, which makes more heat, which starts more molecules burning, and so on. This chain reaction happens so fast that it seems like all the vapor burned at once. This is an example of an explosion of a flammable substance in the air.

To have an explosion in the air, there has to be the right mixture of fuel and oxygen. Suppose just one teaspoon of gasoline evaporates in the room. The fuel molecules will spread out so far from each other that a chain reaction won't happen, and there will be no fire or explosion. This mixture of fuel and air is too **lean** to burn.

It's also possible to have so many fuel molecules that there isn't enough oxygen to go around. In this case the mixture is too **rich** to burn.

When you adjust a carburetor, you are applying this principle. The carburetor has to make a mixture of gasoline vapor and air that will explode in the cylinder when set off by the spark plug.

The **lower explosive limit** (**LEL**) is the smallest concentration of fuel molecules in the air that will sustain a chain reaction and explode in the air. The LEL is different for different chemicals. For gasoline it's 1.4%. At least 1.4% of the molecules in the air have to be gasoline in order to start a fire or explosion.

The **upper explosive limit** (**UEL**) is the greatest concentration of fuel molecules that will explode. For gasoline the UEL is 7.6%. With more than this concentration, gasoline can't burn or explode in the air.

The **explosive range** is all the concentrations between the LEL and the UEL. In this range, an ignition source such as a spark with enough heat could set off an explosion.

If there's a release of flammable vapor into the air, we want to be certain that the concentration is far below the LEL. This is because conditions could change. More fuel could evaporate, or the concentration could be greater as we move deeper into a confined space or closer to the source of the fuel. Also, the instrument we use to measure the concentration might not be accurate Fire and Explosion (continued)

The LEL is sometimes called the LFL or "lower flammable limit.".

The UEL is sometimes called the UFL or "upper flammable limit.".

The explosive range is sometimes called the "flammable range.".

OSHA requires the concentration to be less than 10% of the LEL in order for workers to remain in the area.

Fire and Explosion (continued)

The only safe condition is to be far below the LEL.

The FLASH POINT is the lowest temperature of a liquid at which it gives off enough vapor so that a spark will set off a fire or explosion. OSHA requires the concentration to be less than 10% of the LEL in order for workers to remain in the area. A prudent safety and health program might establish an even lower **action level** (the point at which you leave). Ventilation is used to lower the concentration below the



action level.

If the concentration is above the UEL, theoretically there can't be an explosion. However, ventilation or air mixing could lower the concentration into the explosive range. The only safe condition is to be far below the LEL.

Liquids evaporate more easily as they get warmer, and they evaporate less if they are colder. The **flash point** is the lowest temperature of a liquid at which it evaporates enough molecules so that a spark will set off a fire or explosion. Another way of saying this is that the flash point is the lowest temperature of the liquid at which an LEL concentration is created above its surface. A low flash point indicates how dangerous a material is. Consider gasoline. It's flash point is minus 45° F. Anytime liquid gasoline is warmer than minus 45°, there will be enough vapor to have a fire or explosion. This means that in any situation (except maybe at the South Pole) liquid gasoline creates enough vapor to burn or explode.

Consider diesel fuel. It's flash point is around 130°. Diesel fuel is not as easy to start burning as gasoline.

A **flammable liquid** is one which has a flash point low enough so that under normal conditions there's enough vapor that a spark will set off a fire or explosion.

A **combustible liquid** is one which has a flash point higher than the temperatures we consider normal. This means that under normal conditions there won't be enough vapor for a spark to set off a fire or explosion.

What's normal temperature? This is confusing because there are two systems in use. One is the **NFPA** (National Fire Protection Association) classification. According to the NFPA, if the flash point is below 100° F, the material is considered flammable. If the flash point is 100° or above (up to 200°), it's combustible. The idea is that most of the time the temperature doesn't get above 100°, so it isn't hot enough for an NFPA combustible liquid to give off enough vapor to burn or explode. But it's often hot enough for an NFPA flammable liquid to reach its flash point and create a fire or explosion hazard.

DOT uses a different cutoff. DOT considers a liquid flammable if it has a flash point under 141°. A DOT combustible liquid has a flash point greater than 141° and less than 200°.

The idea behind both systems is that we need to be more careful with flammable liquids because an ignition source such as a spark could cause a fire or explosion.

DOT recognizes that it's normal for liquids to get hotter than 100°. This could happen in a tanker on a sunny day, in drums in a sealed trailer in the sun, or on a warm day in Tucson. Liquids with a flash point up to 141° are labeled and placarded **flammable liquid** because under normal conditions it may get this warm.

Fire and Explosion (continued)

NFPA FLAMMABLE LIQUID has a flash point under 100°.

NFPA COMBUSTIBLE LIQUID has a flash point of 100° to 200°.

A DOT FLAMMABLE LIQUID has a flash point under 141°.

A DOT COMBUSTIBLE LIQUID has a flash point more than 141° and less than 200°.

Fires and Fire Extinguishers

We have been talking mostly about fires caused by flammable and combustible liquids. Many solids also burn, especially cellulose based materials such as paper and wood. There are also certain metals which can react rapidly enough with oxygen that they produce a fire.

The first line of defense against fire is often the portable fire extinguisher. There are different types of extinguishers for different types of fires. Using the wrong type might be ineffective, or worse. For example, using water on an oil fire will spread the fire because the burning oil can float on top of the water. The heat could also cause the water to boil with explosive force, blowing burning oil in all directions.

If there is any possibility that you might be expected to use a fire extinguisher, then you should have special training which goes beyond the scope of this course for first responders at the awareness and operations levels.



Туре

Fires of cellulose fuels (wood, paper, cotton, etc.). Water is an effective extinguisher, as are dry chemical agents.

Туре

Fires of flammable or combustible liquids. Water is not a safe extinguisher; it can spread the fire. Use dry chemical agents, carbon dioxide or halon.

Туре

Fires in electrical systems. Water conducts electricity, making the situation worse, or creating a shock hazard. Use dry chemical agents, carbon dioxide or halon.



Fires of combustible metals such as magnesium or sodium. Water and common extinguishing agents react with these, making the fire worse. Use special fire fighting materials for combustible metals. Because a tiny spark can ignite the vapors, it is essential to prevent all sparks when handling flammable liquids.

Static electricity is produced when dissimilar materials rub together. Friction transfers electrons from one object to the other. If the extra electrons have no way to leave their new home, they just sit there. That's why it's called static electricity.

A spark occurs when the object with the extra electrons gets close to another object that can conduct electricity. The electrons jump through the air to the conductor. When you walk across a nylon carpet wearing rubber soles, electrons transfer from the carpet to your shoes. When your are about to touch a door knob, the electrons rush through your body, and jump to the knob.

When liquid flows through a hose, or pours out of a container, friction causes electrons to transfer from the liquid to the container. When the spout touches another container, there could be a spark which ignites the vapors coming from the liquid.

Bonding is connecting a good conductor (such as a copper wire) between two containers so that any extra electrons on one container can flow easily to the other container without causing a spark.

Grounding is connecting a good conductor (such as a copper wire) between a container and the earth. This prevents a spark from jumping between the container and a metal object that is in contact with the earth.

Not just any old wire will do. Use heavy gauge copper wire with special connectors that are designed for this purpose. These connectors are either clamps with sharp pointed screws, or special heavy duty clips. The connector has to make a good contact with the container, piercing through the rust or paint.

Bonding and Grounding



BONDING: connecting a good conductor between two containers to prevent a spark.



Chemical Incompatibility

Incompatible chemicals are combinations of chemicals that undergo dangerous reactions if they mix with each other. **Incompatible chemicals** are combinations of chemicals that undergo dangerous reactions if they mix with each other. The effects of these reactions are:

- Production of heat and pressure;
- Fire and explosion;
- Formation of toxic gases and vapors; or
- Formation of flammable gases and vapors.

Some chemicals are dangerous if they simply contact water, air, or common substances like wood and paper.

Because of the extreme danger which incompatible chemicals create, a great deal of effort must be put into analyzing hazardous substances and keeping them separate. This includes the creation of segregated staging areas for chemical storage. It is also why the DOT has special rules about chemical segregation during transportation.

While you are not expected to be a chemist, there are some deadly combinations you can remember:

- Never mix acids and bases. They react violently.
- Never mix cyanide compounds with acids. This creates deadly hydrogen cyanide gas.
- Never let strong oxidizers contact flammables or combustibles. Fire or explosion could follow.
- Never put water on materials that react violently with water, like magnesium or sodium metal.

Oxidizers are chemicals that release oxygen when they react with other chemicals. This can cause the other chemical to burn or to explode. Examples are chlorine gas, chlorates, swimming pool chlorine, ozone, nitrates, concentrated hydrogen peroxide, and sulfuric and nitric acids. Keep oxidizers away from flammables and combustibles, including oils and greases.

Corrosives are chemicals that corrode (eat into) other substances. They can cause serious, painful burns to skin, and permanent eye damage. Many corrosives react with metals, so they can't be put in standard drums. A corrosive can eat through the metal of another container, releasing the contents and possibly causing a dangerous chemical reaction.

Acids and **bases** are two general kinds of corrosives. While they are similar in that they both corrode many other substances, they must never be mixed, and should be stored separately. Acids and bases react violently together.

The **pH scale** is a way of measuring the strength of an acid or base solution in water. The scale runs from "0" to "14", with "7" in the middle. "7" is neutral, neither acidic nor basic. "7" is the pH of pure water.

If the pH is less than "7", it's an acid. If the pH is more than "7", it's a base. The further the number gets from "7", the stronger (more corrosive) the solution is.

Chemical Incompatibility (continued)

Some chemicals, like sulfuric acid are both corrosives and oxidizers.

Never let acids and bases mix. Store them separately.





Hazardous waste workers often have to enter and work in confined spaces. Some examples are storage tanks, sump pits, manholes and tanker trailers.

These things can make confined spaces dangerous:

- Not designed for continuous worker occupancy.
- Poor natural ventilation.
- Difficult to get in and out.
- Hazardous atmospheres like air contaminants, flammable gases and vapors, or oxygen deficiency.
- Other hazards like moving machinery, electricity, engulfment hazards, liquids or high temperatures.



More than half of the workers who perish in confined space accidents are would-be rescuers who lack the necessary training and equipment. Confined Spaces

Any safety or health hazard could be present in a confined space. An accident or chemical exposure is often much worse because it occurred in a confined space.

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Review Questions

1.	Lis sub	t thi stanc	ree ces.	safe	ety	haz	ard	S O	f h	aza	rdo	us
					_				· ·			·
2.	Define each of the following:											
	Con	nbus	tion:									
	Exp	losio	n:									
	<u> </u>											
	Flas	sh Po	int: _									
	C	0	m 	b 	u 	S	t	i	b		e	:
	Flar	nmat	ole: _					· · · · · ·				
	L E	L :	-									

UEL: Flammable range: 3. List the four components of the fire pyramid. 4. What is the purpose of: Bonding containers of flammable liquids: _ _ _ _ _ _ _ _ Grounding containers of flammable liquids: True or false: 5. a. Bonding is just another name for grounding. b. Flammable and combustible are two different words for the same thing. c. No matter what the type of fire, any type of fire

Review Questions (Continued)

Review Questions (Continued)

extinguisher is better than nothing.

- d. The flash point is the temperature of a liquid at which the liquid gives off enough vapors so that a spark near the surface of the liquid will cause and explosion.
- 6. Identify four incompatible chemical combinations and state the potential hazardous results of each combination.



7. List four types of fire extinguishers and state the type of fire that each should be used for.

Chapter 4

Identifying Hazardous Materials

The OSHA HAZCOM Standard

Chemical container labels

Material safety data sheets (MSDS's)

DOT placards, labels and markings

Shipping papers

Types of containers and packages

Resources for information about chemicals

Chapter 4 Learning Objectives

Upon completion of this chapter, the student will be able to USE several sources of information in order to identify hazardous materials and hazardous substances, and obtain information about those materials and substances.

The student will be able to SELECT the correct response from a group of responses which verifies his or her ability to:

- 1 IDENTIFY a hazardous material using placards, labels and markings.
- 2 IDENTIFY hazardous materials using shipping papers and manifests.
- 3 IDENTIFY various types of vehicles, containers, vessels, packages drums and tanks.
- 4 IDENTIFY conditions which indicate that a container is damaged or unstable.
- 5 IDENTIFY health hazards, safety hazards, and proper protective measures for specific hazardous materials or substances using:
 - a. NIOSH Pocket Guide to Chemical Hazards
 - b. Material Safety Data Sheets (MSDS's)
 - c. DOT North American Emergency Response Guidebook
- 6 IDENTIFY degrees of chemical hazard using the NFPA Hazard Identification System.

The OSHA Hazard Communication Standard, or HAZCOM (29 CFR 1910.1200) requires employers to:

- 1. Have a written HAZCOM program to inform workers of chemical hazards.
- 2. Have a Material Safety Data Sheet (MSDS) for each hazardous chemical in the workplace, and make these MSDS's available to workers.
- 3. Make certain that all containers of hazardous chemicals are clearly labeled.
- 4. Maintain an up-to-date list of hazardous chemicals in the workplace and make this list available to workers.
- 5. Provide training to workers about:
 - A. The Hazard Communication Standard.
 - B. The employer's HAZCOM program.
 - C. The operations or locations in the workplace where hazardous chemicals are present.
 - D. What hazardous chemicals are present.
 - E. How to use MSDS's.
 - F. How to interpret chemical labels.
 - G. How to detect the presence of chemicals.
 - H. The health and safety hazards of the chemicals.
 - I. Safe work practices, protective equipment and emergency procedures for the chemicals.

The OSHA HAZCOM Standard

HAZCOM requires your employer to tell you the "what, where and how" of the hazardous chemicals in your work place.

HAZCOM Chemical Labels

The HAZCOM Standard requires manufacturers and importers of hazardous chemicals to put labels on the containers in which the chemicals are packaged. These HAZCOM labels must include:

- 1. Name of the product.
- 2. Name, address and phone number of the manufacturer or importer.
- 3. Hazards of the product, including:
 - A precautionary word, such as DANGER, CAUTION or WARNING.
 - The physical hazards of the product.
 - The health hazards of the chemical.
 - The target organs which the chemical may affect.
 - Precautions and protective equipment.
 - Emergency first aid information.



Atmospheric Pressure Tanker Trailer End View The label may include a **CAS number**, which is a unique "social security" number for each chemical. This is helpful because most chemicals have more than one name. If you look in another information source you can be sure that you are getting information about the right chemical if you verify the CAS number.

The label might also include a **UN/NA identification number**, which is the DOT number for the chemical, or for the group of chemicals it belongs to.

There are generally two reasons for chemicals to be in your workplace:

- Chemicals passing through your work place: If you work in the transportation industry, then there are chemicals that are just being transported, not actually used. The HAZCOM labels may be hidden by other packaging. For example, containers may be inside other boxes.
- Chemicals used in your work place: All chemicals used in your workplace must be labeled so you can read the label. For example: lubricants, paints and solvents used to maintain equipment. Also, chemicals used in making a product at your work place.

If you transfer a chemical to a **secondary container**, HAZCOM requires the secondary container to be labeled also. For example, suppose there is a properly labeled 30 gallon drum of turpentine in the hazmat storage shed. You fill a one-quart can and take it to the paint room. This one-quart secondary container also needs a label. A common way to comply with this requirement is to fill out an HMIS label as described on the next page.

There is an exception: If the contents of the smaller container will only be used by one worker during one shift, then it doesn't have to be labeled.

HAZCOM Chemical Labels (continued)

If the smaller container is only used by one worker during one shift, then it doesn't have to be labeled.

HMIS Labels

One way to label secondary containers is to fill in a **Hazardous Materials Identification System (HMIS)** label using the appropriate hazard and protection codes.





A **material safety data sheet (MSDS)** is prepared by the chemical manufacturer or importer for each hazardous substance. It contains detailed information about the substance, its hazards, and precautions.

Your employer is required to have a MSDS for every hazardous chemical used at your workplace. It is not required to have MSDS's for substances that are only in transportation in the workplace, but are not being used. MSDS's must be available to all workers on all shifts.

Twelve types of information must be on the MSDS:

- 1. The identity of the chemical.
- 2. Physical and chemical characteristics.
- 3. Physical hazards (fire, explosion, reactivity).
- **4. Health hazards** (signs and symptoms of exposure, medical conditions aggravated by exposure).
- 5. Routes of entry.
- 6. Exposure limits (OSHA PEL, ACGIH TLV, etc.).
- 7. Whether the chemical is a carcinogen.
- 8. Precautions for safe handling.
- **9. Control measures** (engineering controls, work practices and personal protective equipment).
- 10. Emergency and first aid procedures.
- **11.** Date the MSDS was prepared.
- 12. Name, address and phone number of the manufacturer of importer.

Material Safety Data Sheet (MSDS)

See the next two pages for an example MSDS.

MATERIAL SAFETY DATA SHEET

PRODUCT NAME: ABC Solvent

ADC Solvent								
SECTION MANUFACT ABC Chemical Products.	URER INFORMATIO Inc.	N Emer	aency Telepl	none Number	:			
2 Canary Street			1 - 800 123	3 - 1234				
Somewhere, MA 12345			Date Prepared: April 10, 1					
SECTION II HAZARDOL	IS INGREDIENTS							
Common name	OSHA PEL (STEL)		ACGIH	NIOSH	%			
Acetone	Acetone 750 ppm (1000)			Same	20			
Ethylene Glycol	50 ppm ceiling		Same	Same	3			
Methyl Ethyl Ketone	Methyl Ethyl Ketone 200 ppm (300)			Same	21/2			
Xvlene	ane 100 ppm (150)			Same	6			
Inert Ingredients (Non-Hazardous)				001110	68½			
Boiling Doint:	125°E	Snoci	fic Gravity (v	$v_{ator} = 1$	0.79			
Vapar Prossura:	ling Point: 125°F		Specific Gravity (water – T).					
Vapor Pressure:		Fuerd	ig Point.		-150°F			
vapor Density (air = 1).	1.1	Evaporation Rate			4 5			
Solubility in water:		(Butyl Alcohol = 1):			4.5			
Appearance and odor:	Clear liquid, solvent		dor.					
SECTION IV FIRE AND E	EXPLOSION HAZAR	D DAT	Ą					
Flash Point:	5°F (open cup)							
Flammable Range: LEL 1.5%			UEL 9.5%					
Extinguishing Media:	NFPA Class B Extir	Extinguisher						
Special Fire-Fighting Proc	cedures:	Water Class	r spray may l B extinguisł	be ineffective ner (CO ₂ , dry	. Use NFPA chemical).			
Explosion Hazards:	Closed container m	ay exp	lode if heate	ed.	,			
SECTION V REACTIVIT	Y DATA							
Explosive								
Avoid heat, open flame. e	lectrical equipment.							
Incompatibility:	Oxidizers							
Hazardous Decomposition	n Products:	Carbo	on Monoxide	. Carbon Diox	kide			
Hazardous Polymerization	n:Will not occur			,				
MATERIAL SAFETY DATA SHEET (page 2)

SECTION VI HEALTH HAZARD DATA Routes of Entry: X Inhalation X Skin contact X Skin absorption X Ingestion Eye, nose and throat irritation. Acute Health Effects: Central nervous system (dizziness). Skin irritation. Chronic Health Effects: No chronic effects reported. Target Organs: CNS, Respiratory system, Eyes, Skin. Carcinogenicity: NTP IARC OSHA Not reported Not reported Not Reported Signs and Symptoms of Exposure: Eye, nose, throat, lung, skin irritation. Dizziness. Medical Conditions Aggravated By: Asthma Emergency & First Aid: Vapors inhalation: Remove to fresh air. Call physician. Eyes: Flush with running water for at least 15 minutes. Skin: Wash with water. Ingestion: Do not induce vomiting. Call physician. SECTION VII PRECAUTIONS FOR SAFE HANDLING AND USE In case of material release or spill: Remove all sources of ignition. Avoid breathing vapors. Ventilate. Waste Disposal: Dispose in accordance with state and federal regulations. Handling and Storage: Do not store over 110°F. Store as NFPA Class 1A flammable liquid. Other Precautions: Bond containers when pouring. Use with adequate ventilation. SECTION VIII CONTROL MEASURES Respiratory Protection: NIOSH/MSHA Approved Pressure Demand SCBA or Airline. Ventilation Use local exhaust ventilation. Ventilate and test confined space before entry. All ventilation equipment must be explosion proof. Protective Gloves: Butyl rubber. Eye Protection: Chemical splash goggles. Protective Clothing: Splash apron. Work/Hygiene Practices: Do not eat, drink or smoke in areas where used.

DOT Placards, Labels and Markings

The **US Department of Transportation (DOT)** also has requirements for placards, labels and markings on hazardous materials in transportation.

DOT regulations divide hazardous materials into nine hazard classifications. Some of the classifications are divided into divisions. There are DOT placards and labels for each of these classes and divisions.

	DOT Ha	zard Classes and Divisions
Class 1	Division 1.1	Explosives (with a mass explosion hazard)
Class 1	Division 1.2	Explosives (with a projection hazard)
Class 1	Division 1.3	Explosives (with predominately a fire hazard)
Class 1	Division 1.4	Explosives (with no significant blast hazard)
Class 1	Division 1.5	Very insensitive explosives, blasting agents
Class 1	Division 1.6	Extremely insensitive detonating substances
Class 2	Division 2.1	Flammable gas
Class 2	Division 2.2	Non-flammable compressed gas
Class 2	Division 2.3	Poisonous gas
Class 3		Flammable and combustible liquid
Class 4	Division 4.1	Flammable solid
Class 4	Division 4.2	Spontaneously combustible material
Class 4	Division 4.3	Dangerous when wet
Class 5	Division 5.1	Oxidizer
Class 5	Division 5.2	Organic peroxide
Class 6	Division 6.1	Poisonous materials
Class 6	Division 6.2	Infectious substance (etiologic agent)
Class 7		Radioactive material
Class 8		Corrosive material
Class 9		Miscellaneous hazardous material



DOT Placards, Labels and Markings (continued)

There may be an **identification number marking** on a vehicle which shows the UN/NA identification number of the hazardous material. This may be in a separate rectangle, or it may be on the placard in place of the class/division name:



Atmospheric Pressure Tanker Trailer End View

DOT labels are attached to the packaging of a hazardous material (box, drum, etc.). They look like small placards:



The North American Emergency Response Guidebook (ERG) is designed by DOT to provide information that can be used to identify hazardous materials and make decisions about emergency response and evacuation during the initial response to a hazardous materials incident. The book is also useful in non-emergency situations to identify materials from their UN/NA number and to prepare for emergencies. The ERG has four main sections. The pages of each section are color coded:

- Yellow: List of UN/NA identification numbers giving the chemical name and guide for each. The United Nations ID Number (UN) or the North American ID Number (NA) is a four digit number assigned to each hazardous material or, in some cases, to a group of hazardous materials.
- Blue: List of chemical names giving the UN/NA identification number and guide for each.
- Orange: Guides which give a brief summary of the hazards involved, and the procedures to take if a hazmat emergency occurs.
- Green: Table of initial isolation and protective action distances for materials that are highlighted in the yellow and blue sections. This section also contains a list of chemicals that react with water.

There is also an instruction section, a summary of protective equipment, a glossary, and a list of emergency response phone numbers in the United States, Canada and Mexico.

Hazardous materials transportation workers are required to have training in how to use the ERG. A copy should be available in your vehicle or workplace.

DOT Emergency Response Guidebook



NIOSH Pocket Guide	The NIOSH Pocket Guide to Chemical Hazards describes more than 600 chemicals. These are all the chemicals for which OSHA has a PEL, plus some others for which NIOSH has recommends a standard.
	You can obtain a free copy of the NIOSH Pocket Guide by calling NIOSH at (800) 356-4674 [(800) 35 NIOSH].
	Look up a chemical in alphabetical order along the left edge of the even numbered pages. Four chemicals are listed on each even numbered page. The information stretches in a row across that page and onto the adjoining odd numbered page. A sample is reproduced below.

In order to pack a lot of information into one book, the NIOSH Pocket Guide uses many abbreviations. These are all explained in the front part of the book.

Chemical name, shucture/formula, CAS and RTECS nos, and DOT ID and guide Nos.	Synonyms, Trade names, and conversion tectors	Exposure limits (TMA unless noted otherwise)	IDLH	Physical description White odoriess	Chemical and ph properties MW, BP, SOL, FL.P, IP, Sp. G, frammability	VP, FRZ UEL, LEL	Incompatabilities and reactivities	Measurement method (See Table 1)
Titanium Dioxide TiO ₁ 13463-67-7 XR2275000	Rutile Tranium colde Tranium percolde	NIOSH Ca See Appendix A OSHA 15 mg/m ²	Ca [5000 mg/m ³]	White odoriesa powder	MW. 79.9 IIP: 4532- 5432 *F Sot Insoluble FL P: NA IP: NA Sp. G. 4.26 Noncombutble Sol	VP Omm (Approx) MLT: 3328- 3362 % UEL: NA LEL: NA	None reported	Pilber; Acid; AAS; II(3); [#S385]
o-Tolidine Cl.,H.,N. 119-93-7 DD 125000	4,4'-Diamino-3,3'-dimethyl biphnyl; Diaminoditolyl; 3,3'-Dimethylenzidine; 3,3'-Dimethyl-4,4'-diphnyl- diamine; 3,3'-Toldime [CH_JNH_JC_JH_C_H_JNH_JCH_]	NIOSH Ca See Appendix A See Appendix C C 0.02 mg/m ¹ [80 min] [80 min] [Skin] OSHA See Appendix A	Ca [N.D.]	White to reddish crystals or powder (Note: Darkens on exposure to air, Often used in paste or well cake form. Used as a basis for many dyes.)	MW.212.3 BP: 572.4F Sot 0.1% FL.P: ? IP: ? Sp. G. ? Combustible solid	VP.? MLT: 264 *F UEL: ?	Strong celdizers	Filer; water; HPLC?UVD III [#5013, Dyes]
Toluene C,H,CH, 108-58-3 X85250000	Methyl benzene; Methyl benzol Phenyl methane Toluol 1 ppm = 3.83 mg/m ²	NICISH 100 ppm (315 mg/m ²) 8T 160 ppm (560 MGAV ²) CSH4 200 ppm C 300 ppm 500 ppm (10-min max	500 ppm x peak)	Coloriesis liquid with a sweet, pungent benzene- like odor.	MW, 92.1 BP: 232 P Sot (74 P) 0.07% FL P: 40 P IP: 5.52 eV Sp. G. 0.57 Class IB Flammable	VP: 21 mm PR2: -139 PF UEL: 7.1% LEL: 1.1%	Strong oxidizers	Cher; CS; GCFD; III (#1500 Hydro- carbone]
Toluenediamine CH,C,H,INH,J, 25378-45-8 95-80-7 (2,4-TDA) X89645000 X89625000 (2,4-TDA) 1709 53	Diamineotoluene Methylphenylene diamine; TDA Tolylenediamine	NIOSH Ca (all isomers) See Appendix A OSHA none	C# [N.D.]	Coloriess to brown needle-shaped crystais or powder (Note: Tends to darken on storage & exposure to all. Properties given are for 2,4-TDA.]	MW: 122.2 BP: 558 % Sol: Soluble FL P: 300 % IIP: 7 8p. G: 1.05 (Liquid Combustible Solid	VP: (234 F): 1 mm MLT:210 °F UEL: ? LEL: ? I at 212 °F)	None reported	Imp; Reagent; HPLC/UVD III III III6518]

The Guide gives an **immediately dangerous to life or health (IDLH)** level for many chemicals. This is the airborne concentration which "is likely to cause death or immediate or delayed permanent adverse health effects or prevent escape from such environment."

If NIOSH considers a chemical to be a carcinogen, you will find "Ca" written in the IDLH column. NIOSH believes that any exposure to a carcinogen increases your risk of cancer, which is a permanent adverse effect. Therefore, no other IDLH value is listed for carcinogens.

If you can't find the chemical you're looking for, try looking in the "Synonym and Trade Name Index", the "CAS Number Index", or the "DOT ID Number Index" at the back of the book. These indexes give the page on which the chemical is listed

NIOSH Pocket Guide (continued)

Personal protection and sanitation (See Table 3)		Recommendations for respirator		Health	Health hazards			
		concentration for use (MUC) See Table 4	Route	Symptoms (See Table 5)	Fin (See	st Aid Table 6)	Target Organ (See Table 6	
Skin: EYES: Wash skin Remove: Change:	N.R. N.R. N.R. Daily	NIOSH 8: SCBAF PO, PP/SAF PO, PP, ASCBA Escape: HEF/SCBAE	Inh	Lung 18. (carc)	Breath:	Resp. support	Resp. sys. [In animals: Jung tumor	
[Titanium d	ladde							
Skin:	Prevent skin contact	NIOSH	Inh	lmit eyes, nose	Eye	Irr. immed	Eyes, resp	
sys. Eyes: Wash skin: Remove:	Prevent eye contact When contam/Daily When wet or contam	8: SCBAF PD. PP/SAF PD. PP. ASCBA Escape: GMPOVHEF/SCBAE	Abs Ing Con	In animals: liver, kidney damage: [carc]	Skin: Breath Swallov:	Scap flush immed Resp. support Medical attention	liver, kidneyr [in animals liver, bladide	
6. Change:	Daily					immed	mammery	
gland Provide:	Eyewash, Quick drench						tumors]	
[o-Tolidine]								
Skin: Eyes Wash skin: Remove: Change:	Prevent skin contact Prevent eye contact When contam When set (famm) N.R.	NICSH 500 ppm: CCROWPAPROWGWFOW SAISGBAF § SCBAP: PD PPISAF PD /PP ASCBA Escape: GMFOVHEP/SCBAE	Inh Abs Ing Con	Inti eyes, nose, fig. week, cont, euph, dizz, head, dilated pupils, lac, nec musc fig. Insorn, pres, denn, liver, kidney damage	Eye: Skin: Breath Swallow:	lin, immed Soap wash prompt Resp. support Medical attention immed	Eyes, skin, resp sys, CP liver, kidneyr	
[Toluene]								
Skin: Eyes: Washiskin: Remove: stastion	Prevent skin contact Prevent eye contact When contern/Daily When wet (famm) In extension	NIOSH X: SCEAF FO, PP/SAF FO, PP, ASCEA Escape: GMFOVHEF/SCEAE	inh Abs Ing Con	Imt eyes, skin, nose, throat, dem, ataxis, tacar, nau, vomit, convuls, resp depres; methemo, cyan, he	Eye: Skin: Breath: ed	in: immed Water flush immed Resp. support Swallow:	Eyes, skin, resp sys, C\ liver, CNS Medical	
Change: Provide:	Daily Eyevash, Quick drench			fig, dizz, biluleh akin, liver inj: [card]		immed	liver, skin & mæmmery	

NFPA Hazard Identification System

The NFPA Hazard Identification System is intended to provide information to fire fighters during an emergency.

The higher the number, the greater the hazard. "4" is the most extreme hazard.

The NFPA label does not identfy the chemical, the specific health effects, or the manufacturer. The **NFPA Hazard Identification System** is intended to provide information to fire fighters in an emergency. You will find the diamond shaped NFPA labels on containers, storage tanks, doors and walls.

Numbers from 0 to 4 in the three top diamonds indicate how dangerous the material is in terms of fire hazard, health hazard and chemical reactivity. "0" means no hazard. "4" means the most severe hazard. The bottom diamond is for special information, such as "radioactive", or "water reactive".



In the example, the health hazard rating of "2" indicates an extreme acute health hazard. The fire rating of "4" means extremely flammable. The reactivity rating of "3" means that the material may explode. The "w" with a line through it indicates that the material reacts dangerously with water, so don't use water to fight a fire here. The complete definitions of the hazard ratings are found on the next page.

The NFPA label does not identify the chemical. It does not give specific health effects. It also does not identify the manufacturer. These are all things which OSHA requires on product labels.

NFPA Hazard Identification System									
Health Hazard Color Code: Blue	Flammability Color Code: Red	Reactivity (Stability) Color Code: Yellow							
4 Materials which on very short exposure could cause death or major residual injury even though prompt medical treatment was given.	A Materials which will rapidly or completely vaporize at atmospheric pressure and normal ambient temperature, or which are readily dispersed in air and which will burn readily.	Aterials which in themselves are readily capable of detonation or of explosive decomposition or reaction at normal temperatures and pressures.							
Materials which on short exposure could cause serious temporary or residual injury even though prompt medical treatment was given.	3 Liquids and solids that can be ignited under almost all ambient temperature conditions.	3 Materials which in them- selves are capable of detonation or explosive reaction but require a strong initiating source or which must be heated under confinement before initiation, or which react explosively with water.							
2 Materials which on exposure could cause temporary incapacitation or possible residual injury unless prompt medical treatment is given.	2 Materials that must be moderately heated or exposed to relatively high ambient temperatures before ignition can occur.	2 Materials which in themselves are normally unstable and readily undergo violent chemical change but do not detonate. Also materials which may react violently with water or which may form potentially explosive mixtures with water.							
Materials which on exposure would cause irritation but only minor injury if no treatment is given.	2 Materials that must be pre-heated before ignition can occur.	1 materials which in themselves are normally stable, but which can become unstable at elevated temperatures and pressures or which may react with water with some release of energy but not violently.							
Materials which on exposure would offer no hazard beyond that of ordinary combustible material.	Materials that will not burn.	O Materials which in themselves are normally stable, even under fire exposure conditions and which are not reactive with water.							

DOT Shipping Papers

In the transportation industry there are **shipping papers** required by DOT which list information about hazardous materials that are being transported. For each hazardous material the shipping papers include:

- 1. The proper shipping name, as listed in the DOT Hazardous Materials Table 49 CFR 172.101.
- 2. The DOT hazard class and division number.
- 3. The four digit UN/NA identification number.
- **4.** The packing group number. This is an additional DOT hazard specification for some materials.
- 5. An emergency phone number.
- 6. The total quantity of each hazardous material.
- 7. "RQ" (reportable quantity). This means that a spill from this shipment must be reported to the National Response Center.
- 8. The shippers certification statement. This attests to the correctness of the above information.

No. Packages	НМ	Kind of Package, Description of Articles, Special Marks, amd Exceptions	Weight	Rate	Check
10 DM.	Х	Flammable Solid, n.o.s. (Calcium	3,085 lbs.		
		Resonate), 4.1, UN 1325, PG III			
1 Cyl.	Х	Nitrogen, compressed, 2.2, UN 1066	800 lbs.		
1 DM.	RQ	Toluene, 3, UN 1294, PG II	1000 lbs.		

Hazardous waste has a special shipping paper called a **Uniform Hazardous Waste Manifest (UHWM)**.



PI-		int on home /Form desir	and for use on el	ile (12-nilch) tuneuriter	.1						Form	Annound	OMB No.	2050-0039
Ĩ	UNIFORM HAZARDOUS 1. Generator ID Number 2. Page 1 of 3. Emergency Response Phone 4. Manifest Tracking Number								2000-000					
11	S. Generator's Name and Malling Address Generator's Site Address (If different Itan								en melling addres	33)				
							I			-				
	6. Tre	anoporter 1 Company Nan	e							U.S. EPA ID N	lumber			
	7. Te	eroporter 2 Company Nan	ie .							U.S. EPAID N	lumber			
	8. De	esignated Facility Name ar	nd Sile Address							U.S. EPAID N	iumber			
	Facil	lb/s Phone:								I				
	99. HM	9b. U.S. DOT Descript and Packing Group (F	kon (Including Proper arry()	Shipping Name, Hazard (Class, ID Number,			10. Contail No.	ners Type	11. Total Quantity	12. Unit WL/Vol.	13.	Waste Code	5
18		1.												
ERAT														
GEN		2.												
		,												
		Î.												
	⊢	4.												
11	14.8	Special Handling Instruction	15 and Additional Info	ormation										
	15.	GENERATOR'S/OFFERO marked and labeled place Exporter, I certify that the I certify that the waste min	R'8 CERTIFICATIO rded, and are in all r contents of this cons imization statement	DN: I hereby declare that it respects in proper conditional signment conform to the te identified in 40 CFR 262.3	the contents of this in for transport acc arris of the attache 27(a) (if I arria larg	s consignment cording to appl ed EPA Acknow be quantity per	are fully a icable inter viedgment neratori or	nd accurately de mational and nati of Consent. (b) (If I am a sma	scribed above ional governm ill quantity get	e by the proper shi vental regulations. nerator) is true.	ipping name . If export sh	e, and are cle lipment and l	am the Prim	aged, ary
	Gene	ension's Offenor's Printed Ty	ged Name			8	mane						nan Day	168
F	98. in	niemational Shipments	Π			1								
Ī	Trens	sporter signature (for expo	rts only/c	60.8.	L	_] Export from	0.8.	Port of en Date leavi	ng U.S.:					
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Chemical Tanker Trucks



High Pressure Chemical Tanker End View



Atmospheric Pressure Tanker Trailer End View



High Pressure Liquified Gas Tanker End View



High Pressure Chemical Tanker Side View



Atmospheric Pressure Tanker Trailer Side View



High Pressure Liquified Gas Tanker Side View

Pressurized cylinders



Open top and closed top drums



Horizontal Storage Tanks May contain almost any kind of chemical. Tanks, Cylinders and Drums

Review Questions

1. List the five requirements of the OSHA Hazard Communication Standard (HAZCOM).



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3. What are the four main sections of the DOT North American Emergency Response Guidebook.



- 4. True or false:
 - a. An NFPA label has four parts.
 - b. An NFPA label identifies the chemical.
- 5. What does it mean if "Ca" is found in the IDLH column of the NIOSH Pocket Guide ?
- 6. What does it mean if "RQ" is listed on the shipping papers for a hazardous material?

7. True or false:

- a. An MSDS must indicate whether the chemical is a carcinogen.
- b. Only supervisors are required by law to be able to look at an MSDS during working hours.
- c. An MSDS usually does not state the routes of entry for the chemical.
- d. If a chemical container is being transported, then it is possible that it's HAZCOM label will be hidden by the packaging.
- e. A CAS number is unique (each chemical has a different CAS number).
- f. It is possible for more than one chemical to have the same UN/NA number.

Review Questions (Continued)

Notes

Chapter 5

Respiratory Protection

First responders and respirators

Respiratory hazards

Air purifying respirators

Atmosphere supplying respirators

How much protection do respirators provide

Medical fitness for wearing a respirator

Choosing the right respirator

Chapter 5 Learning Objectives

Upon completion of this chapter, the student will be able to DISCUSS the types of respirators required when responding to chemical releases, the dangers and limitations of using respirators, and how to choose the proper respirator for a particular situation.

The student will be able to SELECT the correct response from a group of responses which verifies his or her ability to:

- DESCRIBE three categories of airborne hazards.
- DESCRIBE the three basic types of respirators (APR, atmosphere supplying and rebreather).
- 3 SELECT the proper definition or example for:
 - a. APR d. PAPR
 - b. SAR e. HEPA
 - c. IDLH f. SCBA
- 4 IDENTIFY the limitations of:
 - a. Air purifying respirators.
 - b. Self contained breathing apparatus.
 - c. Supplied air respirators.
- 5 DESCRIBE the difference between:
 - a. Qualitative fit test.
 - c. Quantitative fit test.
- 6 DESCRIBE the factors to consider in choosing the correct respirator for a particular situation.

Workers wear respirators:

- 1. To protect the respiratory system from air contaminants.
- 2. To provide oxygen in oxygen deficient atmospheres.



The respiratory system includes the lungs, and the passages through which air gets to the lungs, beginning with the nose and mouth.

There are two reasons to protect the respiratory system from air contaminants:

- **1. To prevent injury to the respiratory system**. For example, the burning caused by inhaling acid mists.
- 2. To prevent the entry of chemicals into the body by way of the respiratory system which could affect other parts of the body. For example, dizziness or unconsciousness caused by inhaling solvent vapors.

Review: Health Effects

There are different **routes of entry**, (ways chemicals can get into or on the body). The purpose of respiratory protection is to block the inhalation route of entry.

There are **local effects** and **systemic effects**. Another way of saying item 1, above, is to prevent local effects to the respiratory system. Another way of saying item 2, is to prevent systemic effects of chemicals that enter through the respiratory

The Purpose of Respiratory Protection

Respirators and First Responders

First responders at the awareness level and at the operations level **may not wear respirators** except for escape purposes. These first responders do not have the necessary training to wear respirators safely as part of the response to a chemical release.

Why are we discussing respirators in this course? We introduce respirators so you will understand that:

- Respirators are serious equipment. It's dangerous to wear a respirator without proper training.
- Respirators have important limitations. Respirators are only good for certain conditions.
- The air in the area around a chemical release may be unsafe to breathe without a respirator. This is one of the reasons you, as an awareness level or operations level first responder, are not allowed in the immediate area of the release.
- If you use the wrong respirator in a particular situation, the results could be fatal.

Review: The HAZWOPER Standard

First responders at the awareness level are persons likely to witness or discover a hazardous substance release. They leave the area for their own safety and notify the proper authorities. They do not participate in stopping or controlling the release. They may also isolate the area and keep others away.

First responders at the operations level respond only in a defensive fashion without actually trying to stop the release. Their function is to contain the release from a safe distance, keep it from spreading, and prevent exposures. They may also isolate the area and keep others away.

Awareness level and Operations level responders do not enter the area where exposure is likely, and they do not wear respirators as part of the response. The air we breathe is a mixture of gases. It contains 21% oxygen and 78% nitrogen. That adds up to 99%. The other 1% of the air contains several other gases, including some gases and vapors that are harmful. We need about 21% oxygen to function normally.



There are also various kinds of **particulates** (very small solid or liquid particles) floating in the air. These include dusts, powders, mists, pollen, etc. Many are harmful.

The harmful gases, vapors and particulates in the air are called air contaminants. If you inhale them, they may cause irritation, disease or even death.

Toxic gases, vapors or particulates are often released during a hazardous substance emergency. In a fire or in a confined space, the amount of oxygen in the air may also decrease.

There are many different respirators. Choosing the right respirator depends on whether there is enough oxygen in the air, whether we know what the contaminants are, and whether we know how much of each contaminant is present.

The Air We Breathe

Because of air contaminants, and the danger of oxygen deficiency, respirators may be required. This is one of the reasons that first responders at the awareness level and operations level are not allowed in the hot zone.

Air Contaminants	Respirators protect the respiratory system from air contaminants . For something to be an air contaminant, it must be small enough to stay in the air and to be inhaled .
	If you toss a piece of chalk up in the air, it will fall immediately. It's too big to float, and too big to inhale. The piece of chalk is not an air contaminant. If you put chalk dust in the air, it will float for awhile, possibly long enough to get to your nose and mouth. Particulates like chalk dust are small enough to inhale. They can be air contaminants.
The word "vapor" is in the middle of the word "evaporate".	When a gas escapes from a cylinder, or when a liquid evaporates and forms a vapor, individual molecules of the chemical become part of the air. Remember that gases and vapors behave the same in the air. "Gas" and "vapor" are really two different words for the same thing.
	Gas and vapor molecules are as small as the molecules of oxygen and nitrogen that make up most of the air. They stay in the air, and can be inhaled. Gases and vapors can be air contaminants.
	All air contaminants fit in one of these two categories:
"Fume" means a tiny particulate that condenses from a hot	 Small particulates floating in the air. This category includes solids like dusts, powders, fibers, and fumes; and liquids like mists, sprays and fogs.
process, like welding fume. "Fume" is <u>not</u> another word for vapor.	2. Gas or vapor molecules which become part of the air itself. This category includes gases like carbon monoxide or hydrogen sulfide, and vapors like toluene or gasoline that evaporate from liquids.
	Some respirators, called APR's, work by cleaning the air. There are different kinds of APR's for particulates, and for gases/vapors. You need to know what the contaminants are so you can choose the right APR.

Our bodies are designed to breathe air that contains approximately 21% oxygen. If the level of oxygen drops below this amount, adverse health effects can occur. Too much oxygen is also unsafe because things burn or explode much more easily when there's extra oxygen.

Oxygen and Health

Too Much

23¹/₂% Oxygen enriched. Not necessarily bad for your heath. However, increased risk of fire and explosion.

Just Right

21% Normal level of oxygen. Our bodies are designed for this amount.

Too Little

- **19½%** The lowest level OSHA allows. Reactions and coordination begin to be impaired. This is a safety hazard.
- **16%** Breathing is more difficult. Judgement is impaired.
- **14%** Breathing is much more difficult. You tire very quickly from any exertion. Judgement is severely affected.
- **6%** Death. A few minutes of gasping for breath at this amount is fatal.

Some respirators only clean the air. Others provide a separate supply of air. If there's less than $19\frac{1}{2}$ % oxygen, you must have the kind of respirator that supplies air.

Oxygen Deficiency

19½ % Oxygen is the lowest level OSHA allows. Below this you must have a respirator that supplies breathing air.

You Need a Respirator When ...

If you are an awareness or operations level first responder, you are not allowed in the hot area where an emergency has created these conditions. These are **three** hazardous conditions of the air that require respiratory protection:

- 1. **Particulates**. Tiny pieces that float in the air. Solid particulates: dust, powder, fiber and fume. Liquid particulates: mist, spray and fog.
- 2. Gases and vapors. Individual molecules that become part of the air itself.
- **3. Oxygen deficiency**. Too little oxygen can cause serious adverse effects, including death. The lowest level you are allowed to breathe is 191/2%.

Remember that you may often encounter a **combination** of the three conditions above.

Types of Respirators

There are two basic types of respirators used in emergency response work:

- 1. Air Purifying Respirators (APR's). With these you breath the dirty air around you. The respirator has filters or cartridges that try to clean that air before you inhale it. APR's do not supply oxygen.
- 2. Atmosphere supplying respirators. These provide a separate, clean air supply from a cylinder on your back (SCBA), or through an airline from a cylinder or compressor. In an oxygen deficient atmosphere you must have an atmosphere supplying respirator.

With an **air purifying respirator** or **APR**, the air you breathe is the air around you. It starts out contaminated, and you depend on the filters or cartridges in the APR to catch the contaminants before you breath them in.

As you inhale, the air pressure inside the APR goes down. We call this **negative pressure** because it's lower than the air pressure around you. Air always moves from higher to lower pressure. When you inhale, the atmosphere around you pushes air into the respirator.

Unfortunately, if the respirator doesn't fit your face almost perfectly, some dirty air will get in around the edge of the respirator, skipping the filters or cartridges.

The filters or cartridges are supposed to trap air contaminants. Unfortunately there are many chemicals for which there is no filter or cartridge that works.

There are several styles of air purifying respirator. Here are the ones that might be used by hazardous materials specialists and technicians (not first responders):

- Full-face APR. The face piece covers the chin, mouth, nose and eyes. There are dual filters or cartridges.
- Half-face APR. The face piece covers the chin, mouth and nose, but not the eyes. These use the same dual filters and cartridges as the full-face APR.
- Powered air purifying respirator (PAPR). This has a fan which blows air through the filters or cartridges. There are conflicting claims about whether this provides more protection than a regular APR. PAPR's come in full-face and hood style.
- Gas mask. This is a full-face APR with a large cartridge called a canister. They are used in the military, but are not very common in civilian emergency response.

Air Purifying Respirators (APR's)

Escape

There is a style of APR with a chemical cartridge, a mouthpiece and a nose-plug. In the event of a chemical release, you are supposed to put the mouthpiece in your mouth, clip your nose, and run like crazy upwind. The only advantage is that it's cheap. It's not really what you want in a life-threatening situation. Later we will discuss escape atmosphere supplying respirators, which provide much greater protection.

Styles of APR That Are Not For Emergency

There are other styles of APR's that may be appropriate in normal industrial or hospital settings where the concentrations of air contaminants are known and controlled. These APR's are not for emergency response.

- Dust mask or surgical style mask. The material the mask is made of acts as the filter. Some have an exhalation valve to help prevent the mask from soaking up moisture from your breath. Never use the variety that has only one rubber band; it won't seal very well against your face. Some varieties have a label that says they provide no health protection. Obviously, these are worthless. Some are not NIOSH approved. Never use these either. Do not use any dust or surgical style mask for emergency response.
- Quarter-face APR. The face piece only covers the mouth and nose. This type often leaks around the edge. In a normal, controlled industrial setting, it's always better to use a half-face APR; it will seal better to your face. Never use a quarter-face APR for emergency response.

If an APR doesn't fit your face very closely, dirty air will be sucked in at the edges. Everyone's face is different. You may have to try several different sizes, models and manufacturers, to find one that fits your face. Fullface respirators provide a better fit than half-face ones because the full-face seals around the outside of your face. The half-face goes over the bridge of the nose, the hardest place to seal.

If you have the correct filters or cartridges installed, then fit is the single most important factor that determines how much protection a respirator provides. In order to know if a respirator fits you properly, you have to take a fit test. There are two kinds of fit tests:

- 1. Qualitative fit test. In this test you are exposed to a smelly, tasty or irritating substance while you wear the respirator. If it fits adequately, you won't sense the test chemical. The substances used are banana oil (smells like bananas), saccharin (tastes sweet), and irritant smoke (burning sensation). This is called a "qualitative" test because it gives you an idea of the quality of the fit. It seems to fit; or it doesn't. The test doesn't measure exactly how well it fits.
- 2. Quantitative fit test. This test does measure exactly how well the respirator fits. A special instrument measures the amount of a test chemical in the air around you, and uses a probe to measure how much of the chemical has gotten inside the respirator. If the test chemical in the air has a concentration of 1,000 ppm, and the probe inside the mask measures 10 ppm, then the air in the mask is 100 times cleaner than the air outside. This is called a **fit factor** of 100.

It is impossible to get a proper fit unless you are clean shaven. Facial hair prevents the respirator from sealing against your skin. It will leak, and you will be exposed to contaminants. You have to shave to wear a respirator.

How It Fits Is Important

Fit is the single most important factor that determines how much protection a respirator provides.

Qualitative → Quality. Does the respirator seem to fit your face adequately?

Quantitative → Quantity. Measures exactly how well the respirator fits. Provides an exact fit factor for this respirator on your face.

OSHA requires you to be clean-shaven to wear a respirator that has a tight seal between the respirator and your face.

Limitations of APR's

Unless you can say "yes" to <u>all</u> of these conditions, then it's unsafe to enter the area with an APR. You need greater protection than an APR can provide.

IDLH: the concentration of contaminant that is immediately dangerous to life or health. To safely use an APR, all of these must be true:

- You are properly trained to use the APR.
- You are medically approved to wear the APR.
- You are fit-tested with the same make, model and size APR you will wear.
- You know there is at least 19½% oxygen in the air. APR's don't supply oxygen!
- You know the identity of the contaminants. Otherwise you can't pick the right cartridge or filter.
- You know the concentration of the contaminants. Otherwise you don't know if the respirator is rated for this concentration.
- You know that the concentration is not above the IDLH level (immediately dangerous to life or health). If the filters or cartridges stop working, you will be exposed to an IDLH level. No APR is rated for IDLH conditions.
- You have filters or cartridges approved for those contaminants at those concentrations.

How long can you use the cartridges of filters?

One of the most important questions about APR's is How long do the cartridges or filters last? When do they have to be changed? The answer is not simple. It depends on how much contaminant there is in the air, and how hard the person is working. OSHA says that for filters, you can use them until you sense increased breathing resistance, which means that the filters are getting clogged. However, this doesn't apply to chemical vapor cartridges, because there is no increase in resistance as the cartridge gets used up. For cartridges, OSHA requires the employer to use a change schedule that is based on the air concentration and work level, or use cartridges that have an **end of service life indicator (ESLI)**. Atmosphere supplying respirators provide you with a clean source of air. You're not breathing the dirty air around you. There are two styles:

- 1. Self contained breathing apparatus (SCBA). This is the most common respirator for emergency response. The air comes from a high pressure cylinder on your back. There are half-hour and one-hour cylinders. These usually last less than the stated time. Don't worry, there's an air gauge and a low level alarm. The SCBA has a full face-piece.
- 2. Air line respirator (also called a supplied air respirator or SAR). This supplies clean air through a high pressure hose from a storage cylinder or air compressor. You can keep working without having to leave the hot zone to change cylinders. There's a danger, however, that the air hose could be cut or kinked, stopping the air. For this reason, you must have a 5-minute SCBA escape cylinder which you can turn on if the hose fails. Air line respirators for emergency response have a full face piece.

No respirator is perfect. No respirator provides absolute protection. However, an SCBA, or an air line respirator with an escape cylinder, provide the greatest amount of respiratory protection available. The only thing better would be to eliminate the hazards so that you don't need a respirator.

In many emergency response situations, it is not possible to know what contaminants are present, or in what concentrations. Even if measurements are taken, the situation may change. To survive requires the greatest amount of protection. This is why SCBA's are the most common respirator used by hazmat teams. This is also why SCBA's should always be used for confined space entry, unless you have tested and proven that no respiratory hazard can occur in the space. Atmosphere Supplying Respirators

SCBA, and the air line respirator with escape cylinder, provide the greatest amount of respiratory protection available.

Atmosphere Supplying Respirators (continued)

Grade D Breathing Air								
Oxygen:	19	1⁄2 – 231⁄2%						
Hydrocarbor	าร:	<5mg/m ³						
Carbon mon	ioxid	e <20ppm						
Carbon diox	ide:							
<1000ppm								

Atmosphere supplying respirators have regulators that control the flow of air into the face-piece. They must be operated in either the **full-flow** mode or in the **pressure-demand** mode. Full-flow means that enough air for breathing is always flowing in, even though you actually take one breath at a time. Pressure-demand means that a small amount of air is always flowing in, but when you start to inhale (demand), the regulator lets more air in so there's enough to breathe.

Both the full-flow and the pressure-demand mode maintain **positive pressure** in the face-piece. This means that if there is a leak around the face-piece, most likely clean air will leak out, rather than dirty air leaking in. This is the reason that these respirators provide so much greater protection than APR's. It is the reason that atmosphere supplying respirators are generally preferred for response activities.

The air for atmosphere supplying respirators has to be clean. It should be tested periodically to assure that it meets the specifications for Grade D breathing air.

Escape

Escape SCBA's are better than escape APR's. These are small SCBA's for escape in case a chemical emergency occurs. They are not for response activities. These usually have a five minute cylinder and either a plastic hood or a face-piece. Escape SCBA's are superior to the escape APR's we discussed earlier. To safely use an air supplying respirator <u>all</u> of the following must be true:

- You are trained to use the air supplying respirator.
- You are medically approved to wear the air supplying respirator.
- You are fit-tested with the same make, model and size respirator that you will wear.
- You use only a Grade D or better air supply.

In addition, if you are using an air line respirator:

- You have no more than 300 feet of air hose.
- You have an escape cylinder.

Atmosphere supplying respirators provide much greater protection against contaminants than APR's do. Because they supply air, these respirators can be used in oxygen deficient atmospheres. However, atmosphere supplying respirators do have limitations:

- SCBA's are heavy. Cylinders can weigh 25-35 pounds. This is a lot of extra weight to carry while you're working.
- Air line respirator hoses may limit your movement. The hose may be awkward to handle, and may get caught or damaged.

Limitations of Atmosphere Supplying Respirators

OSHA requires fittesting for any respirator that has a tight fitting seal against your face. This includes most types of SCBA and airline respirator.

NIOSH Approval

The National Institute for Occupational Safety and Health (NIOSH) has standards for testing and certifying respirators. Never use a respirator unless it, or its package, is labeled with the NIOSH TC (testing and certification) number. Respirators are certified only for use with their own parts. Never try to use filters, valves or other parts from one respirator on another respirator with a different TC number.

Protection Factors

NIOSH Protection Factors	on
Quarter-face APR:	5
Half-face APR:	10
Full-face APR:	50
PAPR:	50
Air line with escape cylinder: 10,000	
SCBA: 10,	000
Air line without escape cylinder:2,	000

NIOSH has assigned **protection factors** to different styles of respirators. The protection factor means how much cleaner the air inside the respirator is than the contaminated air outside. For example, if the protection factor is 10, this means the air inside the respirator is ten times cleaner than outside. If the outside air has 1000 ppm of a contaminant, then the air inside — the air you actually breathe — ought to be 100 ppm.

Protection factors come from quantitative tests NIOSH did using respirators on mannequins. If you pass a qualitative fit test, you can assume that the respirator gives you at least the protection measured on the NIOSH mannequin. Notice the high factors for atmosphere supplying respirators. Notice also the difference an escape cylinder makes to the air line respirator.

It's possible that a respirator fits you better than the NIOSH mannequin. The only way to know this would be to take a quantitative fit test. This would give you the actual fit factor for that respirator on your face.

The assumed protection measured by NIOSH is called the **protection factor**. The actual protection measures on your face is called the **fit factor**. You must be medically fit for the type of respirator you wear. You need a medical evaluation by a physician or other licensed health care professional who understands the strain that respirator use involves. If you have heart, circulation or lung problems, the extra effort it takes to breathe through a respirator, or the extra work to carry an SCBA cylinder or drag a hose may be dangerous or even deadly. The following physical and psychological problems may be associated with respirator use:

- More effort to breathe, especially with APR's.
- Extra weight to carry, especially with SCBA's.
- Impaired visibility with full-face respirators.
- Difficulty communicating.
- Heat stress.
- Possible claustrophobia.
- Discomfort.
- Can't use regular glasses with full-face respirators.
- Clean shave required for proper respirator fit.
- Scars or missing dentures may affect respirator face piece seal.

If you wear a full face respirator and also wear glasses, then you need a "spectacle kit". This is a special set of frames which clips inside the face piece. Respirator makers sell spectacle kits. Your optometrist puts in the prescription lenses.

Medical Fitness to Wear a Respirator

Choosing the Right Respirator

To choose the right respirator you have to know:

- Is the area a confined space?
- Is there at least 19½% oxygen?
- Do you know what contaminants are in the air?
- Do you know the concentration of the contaminants?
- Is the concentration above the IDLH?
- How much protection is required for these contaminants?
- Is there a correct APR filter or cartridge available?

SCBA or Air Line with Escape Required ...

Use an SCBA or an air line respirator with an escape cylinder if <u>any</u> of these conditions is present. An SCBA or an air line respirator with escape cylinder is always required in these situations:

- * Confined space entry (unless you have tested and proven that no respiratory hazard can occur).
- * Oxygen level less than 19¹/₂%.
- * Unknown contaminants.
- * IDLH concentrations of contaminants.
- * Unknown concentrations of contaminants.
- ^{*} Contaminants or concentrations for which no APR filter or cartridge is available.

In emergency response, it's often impossible to know what contaminants are present, or in what amounts. Even if measurements are taken, the situation may change. To survive requires the greatest protection. This is why SCBA's are the most common respirators used by hazmat teams. It's also why SCBA's are used for confined space entry, unless you have tested and proven that no respiratory hazard can occur.

APR's are usually not appropriate for emergency response activities. **APR's can only be used when**:

- * There is at least $19\frac{1}{2}$ % oxygen.
- * There will be no confined space entry.
- * The contaminants are known.
- * The concentrations are known.
- * There are no IDLH concentrations.
- * There is a correct APR filter or cartridge available.

If it's possibile that the situation might change for the worse — a leak might get bigger or a fire might start — then you won't know what the contaminants or concentrations are. Don't rely on an APR.

Look at the manufacturer's selection chart to see what filters or cartridges are available, and what contaminants and concentration levels they can handle. This information, as well as the NIOSH TC number, is also printed on the filter or cartridge itself.

For particulates, the best APR filter is called a **HEPA** filter. This stands for high efficiency particulate air filter. It is also called a "100" filter.

Choosing the Right Respirator (continued)

Use an APR <u>only</u> if <u>all</u> of these are true.

Review Questions

- 1. List three hazardous conditions in the air that might require that you wear a respirator.
- 2. List the two basic types of respirators.
- 3. With an air purifying respirator (APR), the air you breathe comes from:
- 4. With an atmosphere supplying respirator (SCBA or airline), the air you breathe comes from:
- 5. Fill in the blanks:
 - a. Normal air contains _____ percent oxygen.
 - b. The danger of excess oxygen is that it increases the risk of _____.
 - c. The lowest oxygen level allowed by OSHA is _____ percent.
 - d. Awareness level and operations level responders are ______ trained to wear a respirator as part of an emergency response.
6. What is the difference between a qualitative and a quantitative respirator fit test?

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Review Questions (Continued)

7. List eight conditions that must all be true in order to wear an air purifying respirator.

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Review Questions (Continued)

9. W	rite the definition of each of the following:
a.	APR
b.	SAR
С	. PAPR
d	IDLH
e.	HEPA
f.	SCBA
g.	ESLI

Chapter 6

Protective Clothing

Protective clothing types and materials

Chemical protective clothing and heat stress

Permeation, penetration and degradation

Levels of protection

Inspecting protective clothing

Selecting protective clothing

Wearing protective clothing

Chapter 6 Learning Objectives

Upon completion of this chapter, the student will be able to DISCUSS the types of protective clothing required when responding to releases of chemical substances, and how to choose the proper clothing for a particular situation.

The student will be able to SELECT the correct response from a group of responses which verifies his or her ability to:

- 1 DEFINE the following:
 - a. Permeation d. Liquid-protective
 - b. Penetration e. Vapor-protective
 - c. Degradation
- 2 DESCRIBE four types of heat stress and their symptoms, and DESCRIBE methods for preventing heat stress at work.
- 3 IDENTIFY the type of protective clothing and respiratory protection used in each of the four levels of protection (Level A, B, C, and D).

You may think that you have a pretty tough skin, but it's not designed to endure all the chemical and physical abuse that it's exposed to in the workplace, like sunburn, cuts, scrapes, burns and chemical exposures. Skin is the site of three routes of entry for chemical exposures: skin contact, skin absorption and injection.

The type of protective clothing that is intended to protect you from **skin contact** and **skin absorption** is called **chemical protective clothing**, or **CPC**. Although we will briefly discuss other types of protective clothing, this chapter is mainly about CPC.

CPC is intended to keep chemicals from touching your skin. In this chapter we will discuss different kinds of CPC, the limitations and dangers of wearing CPC, and how to pick the right CPC for a particular situation.

It's often easy to ignore skin exposures. We think, "I'll just wash it off later". Remember, that in addition to damaging the skin itself, chemicals that are absorbed through the skin are carried to every part of the body where they might damage other organs, affect the nerves, cause cancer or cause reproductive effects.

Review: Routes of Entry

Skin is the location of three of the five routes of entry:

- Skin or eye contact is when a hazardous material gets on your skin or in the eye.
- Skin absorption is when a hazardous material gets on your skin, soaks through, enters the blood and is carried to other parts of your body.

Protecting Your Hide

Just checking: What are the other two routes of entry?

Types of Protective Clothing

Examples of CPC

There are many types of protective clothing. These include hard hats to protect the head from bumps and from small, falling objects. Safety glasses to protect the eyes from flying pieces. Chemical goggles and face shields to protect the eyes from chemical splashes. Safety shoes and boots to protect the feet from cuts and punctures, and from being crushed. Stainless steel mesh gloves to protect the hands from cuts. Leather gloves to protect the hands from abrasion. And many others.

In this chapter we focus on chemical protective clothing (CPC) which is designed to prevent or decrease the tendency of chemicals to touch your skin.

There are many types of CPC. They cover different parts of the body; they have different kinds of closures (zippers, etc.); and they may or may not have room inside for other protective equipment. Here are some examples:

- Two piece chemical splash suits.
- One piece chemical splash suits.
- Encapsulating chemical suits.
- Vapor resistant totally encapsulating suits.
- Chemical resistant gloves.
- Chemical resistant boots.

There are several things to consider in selecting the right chemical protective clothing (CPC):

- Chemical resistance. Since we wear CPC to keep chemicals away from our bodies, we need to know how well the CPC resists chemicals. We discuss chemical resistance on the next two pages.
- Strength. How strong is the material? Will it tear easily? Will the seams split? Will the zipper get stuck or break?
- Heat, cold and sunlight. Will the material become brittle or crack if exposed to cold weather or to sunlight? Will it deteriorate in heat? Will changes in temperature affect its chemical resistance?
- Use with respirators. Can you wear the CPC with the type of respirator you'll use?
- Cleaning. Can the CPC be properly cleaned and decontaminated? In some cases it is more practical to use single-use disposable CPC.
- Size and Comfort. Does the CPC come in the right size to fit you comfortably? Does its size and flexibility allow full range of motion?
- Cost. Your employer is required to provide adequate protection, not cut corners on CPC. Nevertheless, cost is always a consideration. Employers need to realize that although they might save money initially by buying a less expensive CPC, they may lose in the long run. Inadequate CPC does not last as long, and it may increase injuries and illnesses of workers.

Select CPC on the basis of manufacturers' specifications and selection charts, and on information from other reference books.

Selection of Chemical Protective Clothing

Chemical Resistant Materials

CPC manufacturers use several different chemical resistant materials. The table below describes the most common materials. Don't use this table to select CPC. Use the manufacturer's selection chart or other references that list the specific chemicals you're dealing with.

CPC Materials									
Material	Good For	Limitations							
Natural rubber	Good for some bases, some alcohols and dilute acids. Inexpensive.	Poor for organic chemicals. Dries out with age. Some people allergic to natural rubber.							
Neoprene	Good for many bases and some organic chemicals.	Poor for gasoline, toluene and many other organic chemicals.							
Nitrile	Good for many organic chemicals, and dilute acids and bases.	Less acid resistance than PVC. Poor for chlorinated solvents.							
Polyurethane	Good for many petroleum products and alcohols, dilute acids and bases, PCP's.	Poor for many organic chemicals, gets stiff in cold weather.							
Polyvinyl chloride (PVC)	Good for many alcohols, and petroleum products.	Poor for acids and bases.							
Polyvinyl alcohol (PVA)	Good for many acids, bases, peroxides and some organic chemicals.	Poor for chlorinated solvents and many other organic chemicals.							
	Good for many organic solvents.	Degrades in water. Very expensive.							

There are several terms you should know in order to understand what can go wrong with CPC when it gets in contact with chemicals:

- **Degradation**. Visible, gross damage to the material such as blistering, cracking, swelling or dissolving.
- Penetration. Chemicals leaking through seams, stitching or zippers.
- Permiation. Chemicals soaking into and through the material.
- Breakthrough time. The time it takes before enough permeation occurs so that the chemical can be measured (in the laboratory) on the other side.

In order to limit penetration, the seams of some CPC are sealed with special tapes or chemical sealants. Some CPC has special self sealing zippers and/or seals which close over zippers. Gloves and boots are usually molded without seams in order to prevent penetration.

The manufacturers provide CPC selection charts which list different CPC materials, and different common industrial chemicals. The charts indicate how well the materials resist degradation by each listed chemical.

CPC selection charts also list breakthrough times (which may range from a few minutes to several hours, or indefinitely) for each CPC material and listed chemical.

Finally, the charts list the permeation rate for each CPC material and listed chemical, once breakthrough occurs.

There is a standard test procedure, but each manufacturer does its own testing. They often get different results. The information for the same CPC material and chemical may differ on different charts.

Degradation, Penetration, Permeation,

Gloves and Boots

Hands and feet are the parts that most often come into contact with chemicals. There are gloves and boots made from the CPC materials described on page 100. As with other CPC, we need to match the material to the chemical exposure. Gloves and boots are usually molded without seams, so there is little chance of penetration. We also want materials that resist degradation and permeation.

We often wear more than one layer in order to:

- Increase chemical resistance. We might be exposed to more than one chemical at the same time with different breakthrough times and permeation rates. Some manufacturers make single gloves which have multiple layers of different materials.
- Protect a more expensive garments from cuts or degradation. It is common to wear tough, inexpensive (or disposable) outer boots and gloves to protect the gloves, boots or suit underneath.
- Provide greater comfort. It is also common to wear cotton inner gloves or liners to separate the skin from uncomfortable rubber or plastic glove materials.

Unfortunately, multiple gloves reduce dexterity. Boot covers may have less traction, causing a slip hazard.

Gloves and boots don't protect forever. Sooner or later they will degrade, or they will reach their breakthrough time and significant permeation will occur. Once chemicals get through a glove, the fact that they are trapped inside may increase skin damage and skin absorption, making the exposure worse than if no glove were worn. Consult the glove selection chart. Use the breakthrough time for the glove material and chemical exposure in order to know how long to use the gloves. Then put on new gloves before permeation can occur. CPC can be uncomfortable and even dangerous to wear. Here are some of the important problems and limitations of CPC:

- * Choose the right CPC. Your protective clothing has to match the chemicals and conditions in which you wear it. You need to know what you'll be exposed to, and whether your CPC has sufficient resistance to degradation, penetration and permeation. Picking the wrong suit gives a false sense of security, and may result in harmful or deadly exposure.
- * Wear CPC correctly. You need to know exactly how to wear the particular type of CPC you are using. Do the cuffs need to be taped? Do you need more than one layer of gloves and boots? Can you wear your respirator at the same time?
- * CPC wears out. CPC doesn't last forever. Is it in good condition? Is it worn out? Does the zipper work?
- * **CPC gets contaminated**. If your CPC was worn before, was it properly decontaminated? If not, you may be exposed to chemical residues.
- * CPC is uncomfortable. It's, hot and sweaty inside CPC. Your dexterity, agility and sense of balance may be affected. CPC may also affect your ability to see and to hear or be heard.
- * **CPC is not fire proof**. There are special heat resistant suits that offer limited protection from heat and flame. However, most CPC provides no protection, and may in fact burn easily.
- * **CPC can be deadly**. Wearing CPC is not just uncomfortable, it can be life threatening if you experience heat stress. This problem is so important that we devote the next three pages to heat stress.

Limitations of Protective Clothing

CPC Can Cause Heat

Heat stress is one of the most deadly hazards in the work place. It can occur if you're working strenuously in a hot environment. Heat stress can also occur in a mild or even cool environment, if you are wearing chemical protective clothing.

We wear CPC for protection from harmful chemical exposures. These garments are designed to keep chemicals *outside*. Unfortunately, they also keep heat *inside*. Most importantly, protective clothing traps sweat *inside*, and prevents it from evaporating. Sweating alone doesn't cool the body. It's the *evaporation* of sweat that cools. When sweat evaporates it changes from a liquid to a vapor and takes a lot of heat along with it. If it can't evaporate, it can't cool. **Your body might over heat**.

You need to think carefully about what protective clothing you wear. If you're wearing heavier or more protective clothing than you need, you may be creating a new hazard: heat stress. Even under moderate or cool working conditions, it's possible to suffer heat stress if you're inside protective clothing that interferes with your body's ability to cool itself.

Your body tries to maintain its temperature close to 99°F. Under heat stress conditions the body might not be able to cool itself. Heat exhaustion or heat stroke occur. Heat stroke is a serious medical emergency. Almost half of all people who experience heat stroke die as a result.

It's important to recognize the signs of heat stress so that preventive action is taken *before* heat exhaustion or heat stroke occur. Preventive action means adequate rest breaks in a cool area, drinking plenty of water, and not working harder than your fitness allows. There are four effects caused by heat stress conditions: Heat rash, heat cramps, heat exhaustion and heat stroke. One effect can signal that a more serious effect is likely if the person continues to work under heat stress conditions.

Heat rash is an itchy rash that occurs when the skin becomes swollen and plugs the sweat glands. This is not life-threatening, but it indicates that heat stress conditions might be present.

Heat cramps are painful muscle cramps caused when sweating has diminished the fluids in your body so that not enough is available to hard working muscles. This also is not a life threatening condition, but it is a sign that you are working under heat stress conditions. If you suffer heat cramps, stop working and rest in a cool, shaded area. Drink water.

Heat exhaustion makes you feel worn-out and nauseous. There's heavy sweating. You may have rapid, shallow breathing, and you may feel dizzy, or you might faint. Stop work. Rest in a cool place. Drink water. Summon medical assistance since heat exhaustion can develop into heat stroke.

Heat stroke is a serious medical emergency. Call emergency medical help immediately if a fellow worker suffers heat stroke. Without rapid attention this condition is often fatal. Symptoms of heat stroke include hot, dry, red skin. There is little or no sweating, even though the person may have been sweating profusely just moments before. The person's temperature may rise to 105°F or more. Half of all heat stroke victims die. Get help immediately.

Learn to recognize the signs and symptoms of heat stress in yourself and in you fellow workers. Sometimes we don't notice what's happening to ourselves. If your buddy looks like they're having a hard time, getting too red, sweating too much, or acting dizzy or uncoordinated, don't be afraid to say something. You might be saving their life.

Heat Stress (continued)

Heat Stress (continued)

Your body cannot acclimatize to impermeable CPC. Here are some of the ways to prevent heat stress:

Rest shelters. Provide cool, shaded rest shelters. Air conditioning is even better.

Drink plenty of water. Sweating cools the body, but it also robs the body of fluids it needs. Drink enough to replace what you lose in sweat. Drink regularly; don't wait until you feel thirsty. Most people don't feel thirsty until they've already started to become dehydrated.

Keep fit. The healthier you are, the more resistant your body is to heat stress conditions.

Acclimatization. If you are healthy, and not wearing impermeable protective clothing, then you may become used to working in hot conditions. This takes several days, so take it easy at first.

If you are wearing protective clothing, and your sweat can't evaporate, then it's possible to suffer heat stress no matter how physically fit you are, no matter how "used to it" you think you are. Your body cannot acclimatize to impermeable CPC. You have to use safe work practices including regular, adequate rest periods.

You can monitor yourself for heat stress. Take your pulse when you begin a break. If your heart rate is more than 110 beats per minute, then you should consider shortening your next work period, or working less vigorously. To take your pulse, touch the inner arm lightly just above the wrist. Count the beats for 15 seconds and multiply by 4 to get beats per minute. There are many possible combinations of CPC and respirator. However, it is standard to talk of just four basic sets. These are called **Level A**, **Level B**, **Level C** and **Level D**. See the chart, below.

Level D is just a technical term for regular work clothes: no CPC, no respirator.

The respirator is the same for Level A and Level B. However, Level A requires a fully encapsulating suit with special seals that keep vapors and gases from getting in. This is not for respiratory protection - you already have the best respirator. It is only necessary if there is an air contaminant (such as nerve gas) whose vapor is toxic when absorbed through the skin.

The CPC is the same for Level B and Level C.

On the next three pages we describe Level A, Level B and Level C in more detail.

Levels of Protection

Level	Respirator	Protective Clothing (CPC)
Level A	SCBA - or - SAR with escape bottle	Totally encapsulated vapor protective suit
Level B	SCBA - or - SAR with escape bottle	Liquid protective suit
Level C	Air purifying respirator (APR)	Liquid protective suit
Level D	None	Coveralls or other normal work clothes

Level C



Level C:

 Air Purifying Respirator.

(The lowest level of respiratory protection.)

- Liquid protective suit. (Good skin protection: prevents most skin contact with solids or liquids; allows skin contact with air contaminants.)
- Usually not good for emergency response.

- Air purifying respirator (APR). *Full-face* preferred. Use Level C only if conditions are safe for APR's.
- Liquid protective suit. One or two piece suit, with or without hood, reusable or disposable.
- Chemical resistant gloves. (Additional inner and/ or outer gloves optional.)
- Chemical resistant safety boots. (Boot covers optional.)
- **Hard hat**. Worn inside or outside of hood.
- Optional: Radio, face shield, cloth coveralls under suit.

Level C protects the skin against splashes and spills of liquid and solid chemicals. It doesn't seal completely, so chemicals might get in at the neck. It doesn't prevent air contaminants from reaching skin through suit openings.

Level C provides some respiratory protection, but only within the limitations of the air purifying respirator.

Use level C only if you know:

- Skin contact with air contaminants is not hazardous.
- There is at least 19½% oxygen.
- All chemicals and air concentrations are known.
- All chemicals have good warning properties.
- There are no IDLH concentrations.

Since you usually don't know all these things, Level C is usually not appropriate for emergency response.

- SCBA or SAR. Full-face. The best respirator available.
- Liquid protective suit. One or two piece suit, with or without hood, reusable or disposable.
- Chemical resistant gloves. (Additional inner and/ or outer gloves optional.)
- Chemical resistant safety boots. (Boot covers optional.)
- **Hard hat**. Worn inside or outside of hood.
- Optional: Radio, face shield, cloth coveralls under suit.

Level B provides skin protection against splashes and spills of liquid and solid chemicals that may get on the suit. It doesn't seal completely, so chemicals might get in at neck. It doesn't prevent air contaminants from reaching skin through openings or through suit material.

Level B provides the best respiratory protection.

Use level B when:

- Skin contact with air contaminants is not hazardous.
- There is less than $19\frac{1}{2}\%$ oxygen.
- The air contaminants are unknown; or they have bad warning properties; or there are IDLH concentrations; or there is no APR filter or cartridge suitable for these chemicals at these concentrations.

Level B is the most common level of protection used by hazmat teams for emergency response.

Level B



Level B:

SCBA or SAR w/ escape.

(The best available respiratory protection.)

 Liquid protective suit. (Good skin protection: prevents most skin contact with solids or liquids; allows skin contact with air contaminants.)

Level A



Level A:

SCBA or SAR w/ escape.

(The best available respiratory protection.)

Vapor protective suit. (The best available skin protection: prevents skin contact with air contaminants.)

- SCBA or SAR. Full-face. The best respirator available. SCBA worn inside of suit. SAR airline enters suit through air tight fitting.
- Vapor protective suit. One piece fully encapsulating suit, with or without hood, reusable or disposable.
- Chemical resistant gloves are part of the suit. May also wear additional inner and/or outer gloves.
- Chemical resistant boots are part of the suit. May also wear outer safety boots or boot covers.
- Hard hat. Worn inside of suit.
- Optional: Radio, cloth coveralls under suit.

Level A provides skin protection against splashes and spills of liquid and solid chemicals that may get on the suit. It seals completely, so chemicals cannot get in at neck. It prevents air contaminants from reaching skin through openings or through suit material.

Level A provides the best available respiratory protection.

Use level A when:

Skin contact with air contaminants is hazardous.

Level A protects in these situations also:

- There is less than $19\frac{1}{2}\%$ oxygen.
- The air contaminants are unknown; or they have bad warning properties; or there are IDLH concentrations; or there is no APR filter or cartridge suitable for these chemicals at these concentrations.

CPC should be inspected *before* it is used. Inspect it when it's received from the supplier, and periodically during storage so that you know it's ready. Check for:

- Tears, holes and cuts.
- Evidence of contamination.
- Damaged zippers, seals or valves.

Do not use CPC that is damaged or contaminated.

After CPC is used, it must be either:

- Thoroughly decontaminated before it is stored; or
- Properly disposed of. Contaminated CPC is considered a hazardous waste.

It's difficult to thoroughly decontaminate CPC. You might not be able to see or feel chemicals that have soaked into the CPC material.

After decontamination, make sure CPC is dry. Then store in a cool, dry place according to the maker's directions.

With Level C or Level B, it's common practice to tape the joints between the gloves and the sleeves, and between the boots and the pants. This prevents solid or liquid chemicals from splashing or running inside the CPC. **Tape does not make the suit vapor resistant**. **Tape does not change Level B CPC into Level A**.

Leave tabs so that it's easy to remove the tape.

Don't assume that CPC is decontaminated just because there's no discoloration or odor.

Taping

CPC: Some Things to Remember

Your health and safety — and perhaps your life — may depend on your CPC. You need to pick the right CPC. You need to inspect it. You need to use it correctly.

- CPC must match the chemicals to which you are exposed. Use the manufacturer's selection charts or other references to choose the best CPC for the job.
- No CPC provides perfect protection against all hazards.
- Heat stress is a real danger when wearing CPC. Learn to recognize the signs of heat stress in yourself, and in your co-workers.
- CPC creates its own hazards. CPC can interfere with your ability to see, or to communicate. CPC may make it more difficult to move, walk, to use tools or to pick things up.
- Inspect CPC before you have to use it.
- Do not use CPC that is damaged or contaminated.
- Use the buddy system. If the job is hazardous enough to require CPC, then it's hazardous to require you and your co-workers to look out for each other.

1.	Define each of the following terms:
	Permeation:
	Penetration:
	Degradation:
	Liquid protective:
	Vapor protective:
2.	List four types of heat stress.

Review Questions

Review Questions (Continued)

3. List three ways to prevent heat stress.



4. List the components of Level C.



5. List the components of Level B.

Chapter **7**

Air Monitoring

Direct reading instruments vs. sampling for laboratory analysis

Limitations of direct reading instruments

Proper use of direct reading instruments

Calibration and maintenance

Chapter 7 Learning Objectives

Upon completion of this chapter, the student will be able to DISCUSS the types of direct reading monitoring equipment used to assess the hazards of chemical releases.

The student will be able to SELECT the correct response from a group of responses which verifies his or her ability to:

- 1 DEFINE "direct reading" and "sampling for laboratory analysis".
- 2 LIST four chemical substances for which direct reading instruments are available.
- 3 LIST three limitations of direct reading instruments.
- 4 DESCRIBE each of the following:
 - a. Combustible gas meter.
 - b. Colorimetric indicator tubes.
 - c. Oxygen meter.
 - d. Multigas meter.
 - e. Photo ionization detector (PID).
- 5 EXPLAIN the importance of:
 - a. Proper, regular calibration of instruments.
 - b. Proper maintenance and storage of instruments.

In an emergency we need to know what's in the air:

- 1. Are there flammable chemicals? Is their concentration high enough to cause a fire or explosion hazard?
- 2. Are there toxic chemicals? Is the concentration above the PEL? Is it above the IDLH level?
- 3. Is the oxygen level between $19\frac{1}{2}\%$ and $23\frac{1}{2}\%$?

There are instruments to help answer these questions. We divide the instruments into two general categories:

- Sampling instruments. These collect a sample of the air, or a sample of the contaminants in the air. The sample is analyzed later in a laboratory.
- Direct reading instruments. These monitor something in the air right now. They provide "real time" information.

Sampling and Direct

Sampling: Provides more accurate information about more chemicals. But you have to wait for the results.

Direct reading: Less accurate, measures fewer chemicals. But you get the information right away.

Sampling Instruments and Direct Reading Instruments Compared

Sampling Instruments	Direct Reading Instruments
\checkmark Have to wait for laboratory analysis.	✓ "Real time" information, right now.
 Can measure more different chemicals. 	 ✓ Can only measure certain chemicals.
✓ Generally more accurate.	✓ Generally less accurate.
 Can measure smaller levels (less than 1 ppm or even ppb). 	 Generally cannot measure very small levels (not less than a few ppm).
✓ Generally more expensive.	✓ Generally less expensive.
 ✓ Generally requires more training. 	✓ Generally requires less training.

Direct Reading Instruments

In an emergency situation, there isn't time to wait for results to come back from a laboratory. We need information right now. This is why direct reading instruments are so important.

If you've ever watched *Star Trek* then you've seen the ultimate direct reading instrument, the *tricorder*. It's a device that identifies and measures just about everything. Unfortunately, it's only imaginary. The real instruments available to us are much less sophisticated.

We will discuss five types of direct reading instruments that are available and commonly used:

- Oxygen meter (O_2 meter).
- Combustible gas indicator (CGI).
- Photoionization detector (PID).
- Multigas meter.
- Colorimetric indicator tubes.

The first four instruments listed above are electronic devices. Each has a **sensor** that reacts to the presence of a particular substance in the air, and a **display** which tells what the measurement is. The display on older instruments is a dial with a needle. Newer models have digital displays, like a calculator. Both kinds are acceptable. Some people prefer the dial display, because it's easier to notice if the reading is changing.

The last kind of instrument listed above is a glass tube in which a chemical reaction takes place which changes color to provide information about the concentration of air contaminants. Recall from Chapter 5 that the oxygen level should be between $19\frac{1}{2}$ % and $23\frac{1}{2}$ %. Too little oxygen is a health hazard. Too much is a safety hazard since things burn or explode much more easily if there's extra oxygen.

The **Oxygen meter** or O_2 meter directly measures the percent of oxygen in the air. Oxygen meters are essential for safe confined space entry if there is any possibility that fire, chemical reaction, purging or biological growth has reduced the oxygen concentration.

The oxygen meter is the most easy of all instruments to calibrate. Simply measure the oxygen level outside. The meter should read 21%. If it does, the meter is calibrated. If it's just a few points off, adjust the calibration control till the meter reads 21%. If it's more than a few points off, the sensor may not be working properly. Don't use the meter until it is checked by a technician.

Oxygen meters have these limitations:

- The reading can be affected by changes in temperature and atmospheric pressure.
- Some sensors are affected by other gases besides oxygen and may give an erroneous reading.



Oxygen Meter

Combustible Gas Indicator

The **combustible gas indicator** or **CGI** is used to determine whether there is an explosion hazard in the air. The meter needs to be calibrated with a sample gas that has a known concentration of a flammable gas.

Recall that it takes at least a certain minimum amount of a flammable vapor or gas in order for their to be an explosion. This minimum level is called the **lower explosive limit (LEL)**. Recall also that you should never work in an area where the concentration is greater than 10% of the LEL. Staying below 10% allows a wide margin of error in case conditions change. The CGI tells who what percentage of the LEL is present. The meter reads from 0 to 100% LEL.

The CGI has several limitations:

- Requires accurate calibration with certified calibration gases.
- Does not tell you what gas or vapor is in the air, only whether there is an explosion hazard.
- Gives different readings with different gases.
- Reads low if there is oxygen deficiency. Always measure the oxygen level first.



Colorimetric indicator tubes are glass tubes that contain special chemicals that change color if they are exposed to certain air contaminants. A hand operated or battery driven pump pulls a measured amount of air through the tube. If you are using an ammonia tube, for example, and there is ammonia vapor in the air, then the contents of the tube will change from yellow to purple, beginning at the end where the air comes in. The longer the purple stain, the greater the concentration.

These tubes are used extensively, but they have many limitations:

- Not very accurate. The best you can count on is plus or minus 25%.
- They are only available for certain chemicals.
- They may be affected by other chemicals and give a false reading. If the presence of another chemical gives an inaccurately high reading, it's called a positive interference. If it causes too low a reading, it's called a negative interference.
- Temperature and humidity also affect the result.
- Each tube can only be used once.
- Tubes have a limited shelf life.

Colorimetric Indicator Tubes



Photo Ionization Meter

The **photo ionization detector (PID)** uses ultraviolet light and a special light sensitive detector to measure the amount of vapors and gases in the air. It is extremely sensitive to some chemicals, and can detect concentrations as low as 1 ppm. However, it won't tell you what the chemical is. There are many chemicals that it cannot detect.

The PID has several limitations:

- The sensors have a limited shelf life.
- They are only available for certain chemicals.
- Temperature and humidity may affect the result.



There are many types of multigas meters available. They usually combine an oxygen sensor and LEL sensor with one or more other sensors that can detect a specific chemical such as carbon monoxide or hydrogen sulfide.

These meters require careful calibration for each of the sensors. Oxygen calibration is easy, as with the oxygen meter. The LEL sensor and the other sensors require special calibration gases.

Most multigas meters have audible alarms that are set to go off at $19\frac{1}{2}$ % oxygen, 10% LEL, and a specific action level for the other sensors.

Multigas meters have several limitations:



Multigas Meter

What the Data Means

Monitoring can be extremely important, but it has limitations. No monitoring equipment is perfect. No results are 100% accurate. You need to know how much faith you can put in monitoring results, what they mean, and what they don't mean.

- Conditions change. At its best, monitoring only tells you what's happening at a specific time and place. It doesn't tell you what the situation will be later, or what it will be somewhere else. This is one of the reasons for repeated or continuous monitoring, especially during confined space entry.
- Monitoring only measures some things. At best, monitoring measures the contaminant or condition the instrument is designed to measure. There may be other contaminants. Because you measure for one thing, and don't find it, doesn't mean that there aren't other contaminants that may be even more harmful. This is why you must take care to make sure that the type of monitoring you do is appropriate for the contaminants or conditions that may be present.
- Monitoring equipment is inaccurate. There are many reasons that monitoring equipment may give inaccurate results. This may be a fact of the way the equipment is designed. For example, colorimetric indicator tubes are only expected to read ±25%. If an instrument is not calibrated to the same contaminants that are measured, then its reading will probably be inaccurate. Electronic devices rely on batteries, which can wear down, and on sensors and other components that may change with wear, or with mishandling.

In an emergency response situation we need to monitor for the contaminants and conditions that might be present. If we know what's there, then it is easier to determine what kind of monitoring to due. For example, if a gasoline storage tank is leaking, we would monitor for a possible explosive atmosphere using a combustible gas indicator (CGI) calibrated to gasoline vapor.

If we don't know what's there, then its much more difficult to determine what do. At a minimum, we should measure for these four categories, unless we know for sure that one or more of them is not present:

- **1. Oxygen level**. This must always be monitored in any confined space entry, and in any other situation where fire, chemical reaction or purging may have depleted the oxygen level.
- **2. LEL**. Whenever a liquid is spilled, a CGI should be used to determine whether an explosion hazard exists, unless you know for certain that the liquid is not flammable or combustible.
- **3. Toxics**. This is difficult, since there are so many thousands of toxic contaminants. The more you can determine from labels, shipping papers and other records about the identity of the contaminants, the easier it will be to pick what to measure for.
- **4. Ionizing radiation**. Radiation is the easiest of all conditions to monitor. It is not necessary if radioactive materials have not been used or handled at the site.

The emergency response plan must include specific action levels for each of the four conditions listed above. The action level is the point at which you take action. What action? This is simple: get out. If you're not already in, then stay out. Action levels must be at least as protective as those in the box at the side of this page.

Monitoring in an Emergency

Action Levels

Oxygen: No less than 19½% No more than 23½%

LEL: no more than 10% LEL

Toxics: no more than 50% PEL

Ionizing radiation:no more than2.5 millirem per

Calibration and Maintenance



Your life or health may depend on the accuracy of monitoring equipment. Instruments are worthless unless you know that they are functioning properly. This means regular inspection and servicing, proper storage, and being calibrated to the contaminant or condition they will measure.

There should be a designated person trained to inspect and calibrate the equipment regularly, and to assure that it is stored properly. Internal adjustments or other specialized service should be done by a qualified technician, usually at the manufacturer or distributor. Keep careful records of all service.

Each person who uses an instrument should be trained to make field adjustments as needed, and to recognize obvious signs of malfunctioning.

It is all too common to loose the instructions, and to then make mistakes in operation. Make at least one extra copy. For example, the instruction sheets that come in each box of colorimetric indicator tubes have a knack for getting lost. Keep copies in a binder.

Calibration must be done with a calibration gas or source that matches the contaminant or condition that will be measured. Keep a calibration record. Ideally this is a bound book in which you record the serial number of the instrument, and the date, time, method and result of the calibration.

At a minimum, calibrate each instrument when it arrives new, after servicing, after batteries are changed, after dropping or other mishandling, and if a long time has passed since the last use.

The best practice is to calibrate before each use. This is easy with many instruments including the oxygen meter, CGI, radiation survey meter, and sound level meter. 1. Define "direct reading instruments."

2. Define "sampling instruments". _ _ . 3. List four substances for which direct reading instruments are available.

Review Questions

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-		
4. T	he safe range of oxyger	n concentration is:
_	percent to	percent.
5. Li in	ist four limitations o ndicator:	f the combustible gas
_		
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_		
_		
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6. Li	ist two limitations of the	oxygen meter:
_		
7. Li	ist six limitations of colo	rimetric indicator tubes:
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Chapter 8 Learning Objectives

Upon completion of this chapter, the student will be able to DISCUSS the proper procedures which a first responder at the operations level should follow in order to contain a hazardous substance release from a safe distance, keep it from spreading and prevent exposures.

The student will be able to SELECT the correct response from a group of responses which verifies his or her ability to:

- 1 IDENTIFY the procedures which a first responder at the awareness level is qualified to carry out, including the limitations on what the first responder is allowed to do.
- 2 IDENTIFY the procedures which a first responder at the operations level is qualified to carry out, including the limitations on what the first responder is allowed to do.
- 3 DESCRIBE specific spill response procedures:
 - a. Basic control d. Blocking
 - b. Containment e. Diking
 - c. Confinement f. Using sorbents

In general there are four kinds of hazardous substance releases. The emergency response plan (ERP) should address each of these that might be possible at the site.

- 1. Air release. This means the release of gas, vapor or particulate matter into the air. The released substance may spread into the rest of the building (if it is indoors) or be blown into the surrounding community (if it is, or gets outside). Gas leaks usually occur at valves and fittings. Vapor results from the evaporation of liquid that has been released. Damage to a container may cause the release of powdered substances.
- 2. Ground or land release. If the material spills on the ground, it may or may not soak in, depending on the surface. Hazardous materials that are stored and handled in paved areas, are easier to control.
- 3. Release into surface water. If a tank, pipe or other container leaks into a stream or lake, the material can pollute a wide area, possibly poisoning wildlife and contaminating drinking water supplies.
- 4. Release into groundwater. Hazardous substances that soak down into the groundwater are perhaps the most difficult to control and to clean up. It often takes many years to flush contaminants from groundwater. In the meantime, the drinking water supply may be unusable.

Spills and Releases

Assessing the Risk

The first step in an emergency response is assessing the situation. What's going on? What are the risks? This means answering the following questions as quickly and accurately as possible:

- What hazardous substances are involved in the release? This information is obtained from labels, shipping papers and other documentation as described in Chapter 4 of this manual.
- Where is the release? Where is it coming from? This may seem obvious, but not always. It may be difficult to tell what's leaking, or where, if the release is from one of many pipes located close together, or from inside a trailer loaded with many different goods.
- How much material is involved? This also may be obvious, as when one drum is leaking, or one tank or cylinder. However, if it's hard to tell exactly where the release originates, it will also be difficult to judge how much material potentially may be involved.
- What is the area of the release like? Is the area easily accessible? Are there other goods or equipment that need to be moved? What is the surface like? Is it paved? Is it dirt? Is there a slope? Are there sewers or drains that could be contaminated?
- What other hazards are present? Is there a heat or ignition source that could set off an explosion? Are there other, incompatible chemicals that could react dangerously?
- What damage could the release cause before it is controlled? Could the release endanger the community? Could hazardous substances enter a stream, or soak into groundwater? The priority is to protect life, the environment and property.

By now you should be clear about what you can and cannot do as a first responder. This issue is so important, however, that we will review it here. You are risking your life and your health if you attempt response activities for which you are untrained and unequipped.

1) First responders at the awareness level

You are someone who is likely to witness or discover a hazardous substance release and who has been trained to initiate an emergency response by notifying the proper authorities.

Your only responsibility is to leave the area for your own protection and summon the proper authorities. You may also isolate the area and keep others away.

Whom you summon depends on what it says in the emergency response plan (ERP) for your work site. It might be your supervisor, an on-site hazmat team, or an outside group such as the fire department.

(2) First responders at the operations level:

You are someone who responds to a hazardous substance release or potential release in a defensive fashion, in order to contain the release from a safe distance, keep it from spreading, and prevent exposures. You may also isolate the area and keep others away.

You do not actually try to stop the release. You work at a safe distance to contain the release. Your exact responsibilities depend on what it says in the emergency response plan (ERP) for your work site.

You do not enter the hot zone around the release. You do not wear level A, B, or C protective clothing and respirators.

What First Responders Can Do

Spill Containment Equipment

Several kinds of equipment and supplies are available to control and contain spills, and keep them from spreading. The emergency response plan (ERP) should specify what supplies and equipment are required for the situations anticipated in the plan, and should specify what quantities are to be maintained at hand.

1. Soaking up spills. There are many kinds of pads, pillows and booms made of materials that can soak up liquids. The technical term for this equipment is "sorbent." Sometimes these are made of natural materials such as hay, cellulose, or cotton. They may contain mineral products such as vermiculite. There are specialized sorbents that only soak up oils, but leave water behind. Others have the reverse property.

Sorbents are often easy to use. Simply spread them on or around the spill. It is important to add to, or replace the sorbent as it becomes saturated. An important problem that arises with sorbents is that the contaminated sorbent has to be disposed of properly as a hazardous waste.

2. Chemical reactions. Other chemicals may be effective in neutralizing a spilled hazardous substances. An example would be using sodium bicarbonate (baking soda) to neutralize an acid spill.

Chemicals should only be used under the careful supervision of someone who is trained in their safe use. While the results of the chemical reaction may be a less hazardous substance, it is possible that the reaction itself may create dangerous heat, explosion or splashing.

3. Vacuuming spills. It is sometimes possible to contain or clean up spilled material by vacuuming. Again, this should only be done under the supervision of someone who is trained to use this equipment and who knows what specific type of vacuum is appropriate. Never use an ordinary vacuum on liquids. This could create an electrocution hazard, and will probably damage the vacuum. There are special vacuums for liquids.

An ordinary vacuum may create a more hazardous situation by spreading fine dust from its exhaust. An ordinary vacuum filter is too course to trap small particulates like asbestos fibers or metal oxide fumes. Particulates should only be vacuumed with a special vacuum containing a HEPA (high efficiency particulate air) filter.

Hazmat response companies have special vacuum trucks that designed to take in large quantities of hazardous substances and transport them safely.

4. Controlling vapors. In some cases it is possible to spread special foams on the surface of spilled liquids to control evaporation.

Spill Containment Equipment (continued)

In an emergency situation it is not safe to work alone. Despite the emphasis that is given to advance planning, accidents and the unexpected can occur. If you are injured or overcome, you need someone there to help, or to summon assistance. Your coworker will also tell you if you're showing signs of heat stress, or warn you of other hazards that you might not have noticed.

The Buddy System

Confinement: Blocking and Diking

Confinement means taking steps to keep a spilled material from spreading. Confinement activities may be carried out by a first responder at the operations level, as long as the responder can maintain a safe distance from the source of the spill, and is not exposed to toxic substances.

Blocking means covering sewers, drains and outlets to prevent spilled materials from running in. This is especially important if material entering the drain could contaminate water supplies or damage wastewater treatment plants. There are many ways to do this.

One method is to cover a sewer or other opening with plastic and then weighting it down with sand. Sorbents can be placed in front of the sewer to catch liquids as they approach.

Another method is to cover the sewer or drain with sorbent pads or pillows. If the sorbents become saturated, however, then liquid will leak through.

There are also special products designed to cover sewers and drains. These include pads containing a foam plastic that molds itself to the holes or slots in the sewer cover.

Diking means placing a barrier that prevents the flow of spilled materials. This may be a long pile of sand or dirt. It might be a wall of sand-filled plastic bags. It may be a sorbent boom. In many cases it is possible to control a hazardous substance release by closing a valve, or turning off a pump or other piece of equipment. If this can be done safely, without hazardous exposure, then it is something that a first responder at the operations level my undertake.

Operations level responders may move other equipment or materials away from the scene of the release. They may turn off or remove sources of ignition such as motors.

Operations level responders may also do activities related to the response such as roping off the area, and keeping others away.

Controlling the Release

Plugging Leaks

There are many ways to plug leaks in drums, tanks and pipes. We will describe some of these here. However, these are methods to stop leaks and are beyond the duties of a first responder at the operations level.

A small hole in a drum can often be plugged with a cone-shaped wooden plug. There are special putties and epoxies that are also used. Make sure that the plug material is compatible with the hazardous substance which is leaking. There are also various kinds of rubber stoppers and screw-in fittings. There are pads and clamps for sealing leaking pipes. Many of these devices are available from hardware or plumbing suppliers. The hazmat technician should have a box of plugs and stoppers available for stopping small leaks.

There are also several types of rubber or plastic belts, some of which are inflatable, for wrapping around leaking drums and pipes.

Once a leaking drum is plugged it should be transferred to an over-pack drum. The extra space inside the overpack should be filled with sorbent.

Remember, first responders at the operations level do not actually try to stop leaks. They do not enter the hot zone around the release, and they do not wear level A, B or C protective clothing and respirators. The emergency response plan (ERP) should include an inventory of the supplies and equipment that are to be on hand for emergency response. These should not be "borrowed" for other purposes. They should be maintained, ready for emergency use. A typical emergency response inventory might include:

- 1. Protective clothing. Splash shields and chemical resistant goggles. Protective gloves and boots. Protective clothing. All equipment appropriate to the situations anticipated in the ERP. They should be stored in a clean, dry locker, and inspected regularly.
- 2. Respirators. These should be stored in a clean, dry cabinet. They should be inspected regularly so that they are ready for use. The pressure in SCBA cylinders should be checked on a regular schedule. A bottle that appears to be leaking should be checked by a qualified technician. SCBA cylinders also have to be hydro tested every three years (for composite cylinders) or five years (for solid steel or aluminum).
- **3. Safety equipment**. This include fire extinguishers which must be inspected annually. Also eyewash stations (portable or fixed) and any other safety equipment specified in the ERP.
- 4. Monitoring equipment. At a minimum, an oxygen meter and CGI. There should be some way to measure toxics. Some or all of these may be combined in a multigas meter. If radioactive materials might be present, there should be a radiation survey meter.
- **5. Spill control equipment**. The types of equipment and supplies described previously in this chapter.
- 6. Decon equipment. All necessary supplies and equipment for setting up the decon line as described in Chapter 9.

Emergency Response Kit

Review Questions

- 1. List four types of spills and releases of hazardous materials.
- _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ 2. List the responsibilities of a first responder at the awareness level. _ 3. List the responsibilities of a first responder at the operations level. _

5. What does blocking mean? _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ 6. What does diking mean? _ _ _ _ _ _ _ _ _ a. First responders at the awareness level do not actually try to stop leaks. b. First responders at the operations level do not actually try to stop leaks. c. First responders at the awareness and at the operations level do not enter the hot zone around the release.

4. List six questions that need to be answered in order to assess the risk caused by a hazardous materials

Review Questions (Continued)

7. True or false:

release.

Notes

Chapter 9 **Decontamination** Preventing contamination Decontamination methods Equipment and supplies **Decontamination lines** Vehicle decontamination Emergency decontamination

Chapter 9 Learning Objectives

Upon completion of this chapter, the student will be able to DISCUSS the proper procedures to decontaminate protective clothing and equipment, response equipment and tools, vehicles, and other surfaces that may be contaminated.

The student will be able to SELECT the correct response from a group of responses which verifies his or her ability to:

- 1 IDENTIFY five reasons why decontamination is important.
- 2 IDENTIFY two types of contamination.
- 3 IDENTIFY the four common methods used in decontamination.
- 4 DESCRIBE the layout of a Level C decontamination line.
- DESCRIBE the general procedures for deontaminating vehicles.

Decontamination is the process of cleaning, removing or neutralizing hazardous substances that have gotten onto protective clothing, tools, equipment or vehicles used on the job. Decontamination also means cleaning your hands, arms or other parts of your body that have come into contact with hazardous substances.

Decontamination is important in order to:

- Reduce your chemical exposure.
- Reduce the exposure of other workers.
- Reduce the exposure of your family and the public.
- Reduce the chance of fire, explosion or reaction by limiting the spread and release of chemicals.
- Reduce costs by allowing clothing, tools, equipment and vehicles to be safely used again.
- Reduce waste. Reduce the amount of contaminated items that must be disposed of as hazardous waste.

Chemicals on your hands or other parts of your body have more time to irritate your skin or be absorbed if you don't remove them. It's important to do this in a way that does not increase your exposure to harmful solvents or cleaners that aren't designed for safe skin contact.

Chemicals have more time to soak through your protective clothing if they are not removed properly. Chemicals left on protective clothing or on respirators can cause more exposure when you use them again.

Chemicals on clothing, tools, equipment and vehicles will be tracked to other places. They may contaminate your work site or the community, and cause exposures to fellow workers, your family, or the public.

Decon Is Important

Preventing Contamination

One of the most important aspects of decontamination is to **prevent or limit contamination**, so there's less decontamination to do. This means less chance of exposure, less chance of fire or chemical reaction, less mess to clean, and less waste to dispose of.

You need standard operating procedures, good work practices and proper tools and equipment to do routine and emergency work in the cleanest manner possible.

Use good work practices to limit chemical contact:

- Don't walk through contaminated areas.
- Don't step or kneel in puddles or spills.
- Never touch, sniff or taste a chemical to determine what it is.
- Use proper equipment to handle hazardous materials.
- Where possible, cover tools and equipment with disposable plastic or tape.

Use protective clothing properly:

- Make sure you have the right protective clothing for the chemicals you may be handling.
- Make sure protective clothing is properly sealed.
- Wear outer boots and gloves.
- Avoid broken pallets, metal or glass that could tear or puncture your boots or clothing.

There are two types of contamination:

- 1. Chemicals on the surface of clothing, tools, and equipment.
- 2. Chemicals that have soaked in, or become imbedded in clothing, tools and equipment.

Chemicals that are soaked in (permeated) are the most difficult to detect, and the most difficult to remove. It might not be possible or cost effective to remove chemicals that have permeated protective clothing. This is one reason that disposable garments might be worn.

Types of Contamination

There are four general methods of decontamination:

- **1. Physical removal**. This includes scrubbing, scraping, washing and rinsing.
- **2. Chemical removal.** This uses other chemicals to neutralize or inactivate contamination.
- **3. Evaporation**. This means allowing time for chemicals to evaporate out. The process is sometimes aided by careful heating.
- 4. Using disposable clothing and equipment. This can eliminate the need for some decontamination, but it creates an additional disposal problem.

Proper decontamination methods must be part of the safety and health plan. The plan must anticipate what chemicals will be involved, and what protective clothing, tools, equipment and resources are needed.

Types of Decontamination

Decon Solutions	The most com is scrubbing v solution . Thi added. Washi The clothing i	t common decon method for protective clothing bing with a warm (not hot) water-based decon n . This is water with some type of detergent Vashing is followed by rinsing with lots of water. hing is then air dried.							
	The more yo Unfortunately which may h waste.	u wash and rinse, the cleaner it gets. , you also generate more waste water ave to be disposed of as hazardous							
	Protective clothing must be completely dry be is stored. Moisture usually causes very unple odors, and may promote the growth of biol contamination.								
	The right decon solution depends on the chem involved. Below are some example of some commused decon solutions.								
Comn	non Decon Sol	utions and Their Uses							
Decon Solution A : 5% sodium carbor 5% trisodium phos	nate. phate.	Used for : Inorganic acids. Some organic solvents. PCB's.							
Decon Solution B: 10% calcium hypor	chlorite.	Used for : Some pesticides. Some heavy metals. PCB's. Inorganic contamination.							
Decon Solution C: 5% trisodium phos	phate.	Used for : Oily, greasy contamination. Some organic solvents. PCB's.							
Decon Solution D:		Used for:							
Dilute hydrochloric (1 pint in 10 gallon	acid. s of water.)	Inorganic acids. Bases.							
	- 1	64 -							

Decontamination requires the proper equipment and supplies:

- Drop cloths and plastic sheeting. These are used to catch contamination and rinse water, and direct it to waste water collection containers.
- Waste water collection containers. Drums, tanks, "kiddy pools", etc. to catch the runoff from decon.
- Decon solutions. These were described on the previous page.
- Running water and decon shower. This is to rinse protective clothing before it is doffed.
- Collection containers. Metal or plastic containers in which to place gloves, boots, clothing, hard hats, etc.
- Adsorbents. Towels and pads to wipe off contaminants.
- Brushes. Soft-bristled brushes to wash and scrub.
- Towels. Paper towels for drying clothing and equipment after it is rinsed.
- Personal Shower. Workers should shower before changing into clean work or street clothes.
- Lockers. To store your clean clothes to wear home. Never wear contaminated clothing home. You will expose your family and friends to chemical hazards.
- Storage cabinets. For storing decon supplies. Also for storing protective clothing and equipment after it has been properly decontaminated and dried.

Decon Equipment

Decon Plans

Decontamination is important. It has to be done correctly, or there will be more contamination and more chemical exposure. This means careful advance preparation.

Decontamination has to be part of the Emergency Response Plan. This part of the plan must include:

- Types of contamination that might be present.
- Safe work practices to prevent or limit contamination.
- Proper use of tools and equipment.
- Selection of protective clothing.
- Decon supplies and equipment.
- Layout of the decontamination area (the decon line).
- Personnel assigments for decon activities.
- Protective clothing and respirators for decon workers.
- Determining if decon has been done adequately.
- Proper disposal of contaminated clothing, tools and equipment.
- Proper treatment and disposal of waste water.

Decontamination is carried out in an orderly, well planned process in a designated decontamination area or **decon line**. Only persons who are directly involved in decontamination should be at the decon line.

The decon line always moves from the most contaminated condition toward the clean area; never in the opposite direction. The decon line starts in or near the contaminated area and ends in the clean area.

Contaminated workers and equipment move through the line getting cleaner, and doffing clothing at **stations** along the way. Decon workers are assigned to help at the stations. They have the protective clothing and equipment required for the exposures they might face at their station. When other workers and equipment have been decontaminated, then the decon workers themselves go through the line, starting at their own station.

There are many ways to arrange the decon line. Some lines have only a few stations. Others have as many as nineteen stations. The decon line includes these kinds of activities, in order, and often at different stations:

- Equipment drop.
- Initial rinse.
- Decon shower, wash and rinse.
- Outer boot and glove removal.
- Respirator removal or exchange.
- Protective clothing removal.
- Personal shower and clothes change.

See the next page for an example decon line.

Decon Lines and Stations

Example Decon Line



Decontamination must be carried out in a safe and healthy manner in order to protect the people involved, and to assure that the decontamination is effective.

- Allow enough time for a thorough, safe decon. Don't rush. If you are using SCBA's this means starting decontamination before your alarm bell signals that you are low on air.
- Make sure that there are enough decon workers to assist at each station.
- Be careful about slips and falls. Plastic sheeting used to contain runoff is slippery when wet.
- Provide hand-holds and benches for workers to use while doffing (removing) clothing and equipment.
- Use decon solutions that are compatible with the chemicals involved, and with the protective clothing.
- Doff (remove) clothing in the proper order.
- Do not touch the outer surface of clothing, boots or gloves with bare skin.
- Properly treat and/or dispose of waste water.
- Properly dispose of trash, including clothing and equipment that cannot be decontaminated.
- Allow only required, trained workers on the decon line.
- Keep personal showers, change areas and locker rooms clean and sanitary.
- Follow the decon plan.

Safety and Health Precautions During Decon

Vehicle Decon

The principles we have discussed apply in general to all decontamination procedures. However, there are some special considerations for the decontamination of vehicles and heavy equipment:

- Keep vehicles and heavy equipment from getting contaminated in the first place. Don't drive through spills or contaminated areas.
- If vehicles must be used near contaminated areas, consider covering the wheels, and other exposed parts with tape and plastic sheeting.
- Provide sturdy platforms or other means to safely get at all parts without having to climb on the vehicle.
- Decon workers must have the right protective clothing, respirators and eye protection.
- Be careful when using pressurized sprayers.
- Use decon solutions that are compatible with the chemicals involved, and with the vehicle's paint.
- Provide a means to collect runoff water.
- Usually start at the top and work down.
- Use long handled brushes to get at all parts.
- Pay special attention to the under carriage and other parts where contamination might not be noticed.
- Plan a method to determine that decon is complete. This may include taking surface wipe samples..
- Properly treat and dispose of all waste water.

The Emergency Response Plan must include procedures for persons who are both **injured and contaminated**. The first priority is always to save human life and prevent illness or injury.

Providing first aid or moving a contaminated person causes exposure risks to the responders. However, there may be cases where medical attention cannot wait for full or even partial decontamination. Examples might include severe bleeding, cardiac arrest or heat stroke.

In other cases, it may be life threatening if the person is not decontaminated immediately. For example, if a person is lying in a pool of acid or caustic material.

There are ways to speed up the decon procedure if necessary. For example, protective clothing might be cut away, rather than washed. Emergency medical technicians (EMT's) and other medical personnel should be trained in how to treat contaminated victims, and how to use their own protective clothing and equipment.

Remember that an injured or unconscious person wearing protective clothing might also be suffering the effects of heat stress. Heat stress is dangerous. Its most extreme form, heat stroke, is a life-threatening condition. Rapid medical attention is essential if there is the possibility of heat stroke.

The Emergency Response Plan must include a prior understanding with the ambulance service and hospital to deal with the possibility of a chemically contaminated patient. These services exist to provide care, but they do not want to see their expensive equipment and facilities contaminated. Make arrangements in advance.

Emergency Decon

Review Questions

1. List the five reasons why decontamination is important.



- 4. True or false:
 - a. Chemicals that have soaked into protective clothing are the easiest to detect and remove.
 - b. Proper decon must be part of the safety and health plan.
- 5. List, in order, the stations in a seven station decon line:

	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_
	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	—	_	_	_
	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_
	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_
	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_
	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_
6.	Li he	st eav	se vy	eve eq	en Jui	sp prr	ec ner	cia nt (l c de	con	nsio	de	rat	ior	าร	fo _	r ۱	/eł	nic	le _	ar _	nd
	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_
	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_

Review Questions

Notes

Chapter 10 **Emergency Response Plans** Types of emergencies Contents of the emergency response plan Incident command system Emergency alarms and communication Emergency drills

Chapter 10 Learning Objectives

Upon completion of this chapter, the student will be able to DISCUSS the requirements of an emergency spill response plan.

The student will be able to SELECT the correct response from a group of responses which verifies his or her ability to:

- 1 IDENTIFY seven types of hazardous substance emergencies that might occur.
- 2 IDENTIFY the required contents of an emergency response plan.
- 3 DESCRIBE the basic parts of an incident command system (ICS).
- 4 DESCRIBE four types of alarm systems that can be used to warn of hazardous substance releases.
- 5 DESCRIBE the importance and function of emergency drills and rehearsals.
- 6 Describe the three zone system for controlling access to the site of a hazardous materials incident.

If an emergency occurs, properly trained personnel have to act fast. It's too late to decide who's in charge, what equipment is needed or who's going to do what. These decisions have to be made in advance, so that when the need arises, the response can start immediately.

OSHA requires every employer whose employees are engaged in emergency response, no matter where it occurs, to have an **Emergency Response Plan** or **ERP**.

Why A Plan ?

When an emergency happens, it's too late to figure out what to do. Advance planning is crucial, and it's the law

The Emergency Response Plan has to work for the kinds of emergencies that could happen at your facility. Your employer has to figure out in advance what could go wrong, so that the plan can deal with it. Here are seven of the most common hazardous substance emergencies:

- 1. Spills of liquids or solids.
- 2. Escape of gases and vapors.
- 3. Fire.
- 4. Hazardous reaction of incompatible chemicals.
- 5. Contamination or poisoning of workers.
- 6. Faulty chemical handling or processing equipment.
- 7. Natural disasters such as lightning, hurricane, earthquake or flood which could result in a hazardous substance release.

If these or any other hazardous substance emergency could happen, then it must be included in the Plan.

What Could Go Wrong ?

Emergency Response Plans

General requirements for ERP's. The Emergency Response Plan shall be:

- 1. In writing.
- 2. Available for inspection and photocopying by employees, their representatives, and by OSHA.
- 3. Cover all anticipated emergencies.

What OSHA Says about Emergency Response Plans

29 CFR 1910.120 (q) (1) Emergency response plan. An emergency response plan shall be developed and implemented to handle anticipated emergencies prior to the commencement of emergency response operations. The plan shall be in writing and available for inspection and copying by employees, their representatives and OSHA personnel. Employers who will evacuate their employees from the workplace when an emergency occurs, and who do not permit any of their employees to assist in handling the emergency, are exempt from the requirements of this paragraph if they provide an emergency action plan in accordance with §1910.38 (a) of this part.

29 CFR 1910.120 (q) (2) Elements of an emergency response plan. The employer shall develop an emergency response plan for emergencies which shall address, as a minimum, the following to the extent that they are not addressed elsewhere:

(i) Pre-emergency planning and coordination with outside parties.

(ii) Personnel roles, lines of authority, training, and communication.

- (iii) Emergency recognition and prevention.
- (iv) Safe distances and places of refuge.
- (v) Site security and control.
- (vi) Evacuation routes and procedures.
- (vii) Decontamination.

(viii)Emergency medical treatment and first aid.

(ix) Emergency alerting and response procedures.

(x) Critique of response and follow-up.

(xi) PPE and emergency equipment.

(xii)Emergency response organizations may use the local emergency response plan or the state emergency response plan or both, as part of their emergency response plan to avoid duplication. Those items of the emergency response plan that are being properly addressed by the SARA Title II plans may be otherwise kept together for the employer and employee's use. **Content of the ERP**. The Emergency Response Plan shall include:

- 1. Planning and coordination with outside agencies such as the fire department, the police, and the local hospital.
- 2. Job descriptions, lines of authority, training requirements and communication methods. In other words, who does what. This is called the Incident Command System (ICS).
- 3. How to recognize and prevent emergencies.
- 4. Safe distances and places of refuge.
- 5. Site security and control.
- 6. Evacuation routes and procedures. This includes rally points and accounting for all personnel.
- 7. Decontamination procedures.
- 8. Emergency medical treatment and first aid.
- 9. Emergency alarms.
- 10. Evaluation and follow-up after an emergency has occurred.
- 11. Personal protective equipment (PPE) and other emergency equipment and supplies.
- 12. Procedures to report incidents to local, state or federal officials.

Emergency Response Plans

Incident Command System (ICS)

The Incident Commander is in charge. The actual person filling this role may change during the response as more experienced personnel arrive on the scene. The Emergency Response Plan tells who will do what. One person is in charge. Everyone else has specific, defined responsibilities. OSHA calls this the **Incident Command System** or **ICS**.

The person in charge is called the **Incident Commander (IC)**. It is possible for the actual person serving as IC to change during the response. For example, when a spill occurs, a supervisor who is only trained at the operations level might take charge of situation by calling the local fire department's Hazmat Team and overseeing workers who isolate the area. When the Hazmat Team arrives, its leader, who has more training and experience, takes over as Incident Commander. This is just an example. The Emergency Response Plan will state who serves as Incident Commander, and when that role passes to another person.

All persons who participate in emergency response are part of the ICS. In a large facility, or on a hazmat team, these might include the personnel shown on the organization chart below. This is just one example. The actual ICS and its personnel depend on the specific facility or organization.


Incident Commander. In charge of all aspects of the response, although specific responsibilities are delegated to other personnel. Establishes a command post. Coordinates the work of other officers and team leaders.

Safety Officer. Assures implementation of the safety and health aspects of the ERP. Interprets monitoring results. Determines what protective equipment and respirators are required. Coordinates with emergency medical personnel.

Security Officer. Establishes security perimeter and controlled access points. Coordinates with police and fire departments. Coordinates evacuation if necessary.

Operations Officer. Carries out the orders of the IC. Supervises the team leaders.

Entry Team Leader. Supervises the team that enters the hot zone to stop the hazardous substance release or clean up released substances. There is also an entry team leader for confined space entry.

Entry Team Members. Workers who enter the hot zone to stop a hazardous substance release or clean up released substances. There are also entry team members for confined space entry.

Decontamination Team Leader. Sets up and supervises the decontamination line.

Decontamination Team Members. Work on the decontamination line.

Support Team Leader. Sets up and supervises support activities.

Support Team Members. Carry out support activities.

What They Do

Depending on the type of facility or organization, one or more of these roles may be filled by the same person.

Entry team members must have training as hazmat detentions or hazmat specialists. Operations and awareness level first responders do not enter the hot zone.

Three Zone Plan

The usual practice in emergency response (and in hazardous waste clean-up operations) is to divide the work area into three zones as shown on the opposite page. The purpose of the zones is to control the activities and the personnel in each zone. The way in which zones are established will be specified in the ERP.

Exclusion zone or hot zone. This is the area immediately surrounding the hazardous substance release. This is the zone where contact with the hazardous substance is possible. It is where action is taken to stop the release, and it is where clean-up will happen. Generally protective clothing and respirators will be required in this zone. (Level C, B or A, depending on the conditions.) Only personnel with hazmat technician, hazmat specialist, or greater training are permitted in the hot zone.

Contaminant reduction zone (CRZ). This zone surrounds the hot zone. It is a transition area between the contaminated area of the hot zone and the clean area of the support zone. It's purpose is to reduce the possibility of contaminations reaching clean areas.

Support zone. This is the clean area where support activities take place such as storage of supplies and equipment. The command post is located here.

Hot line. This is the border around the hot zone.

Contamination control line. This is the border around the contamination reduction zone.

Contamination reduction corridor (CRC). This is the passage connecting the support zone to the hot zone, passing through the CRZ. The decon line is located here.

Access control points. Access to the different zones is allowed only at designated, controlled points.



Three Zone Plan

Communication and Alarms

During an emergency response it is essential that all personnel be able to communicate quickly and accurately. Information has to move, and be understood, so that decisions can be made quickly and accurately.

The ERP should include all communications methods and equipment. This includes:

- Initial reporting of the incident. Whom does the first responder (who discovers and incident) notify? How does the responder do this? Is there a phone, radio or intercom ready for this purpose? Is the number posted?
- Communication among the response workers. How does communication happen within the incident command system (ICS)? How does the incident commander (IC) communicate with the other members of the ICS, including the team leaders. How do the team leaders and members communicate? Do they use radios? Is there a system of hand signals?
- Communication with outside agencies. There need to be prior arrangements for contacting the police, fire department, ambulance service, hospital, outside hazmat team, etc.
- Emergency signals and alarms. If a worker is injured during the response activities, or if the release suddenly becomes more serious, how is this information transmitted quickly. If personnel need to be evacuated, what is the emergency signal?

There is no standardized system of alarms, or of hand signals. What is important is that signals and alarms be easy to understand and remember, and that all personnel know what they are and what they mean. In an emergency response situation, it is essential that all personnel know what they are supposed to do, and that they work in an efficient, coordinated manner, as set out in the emergency response plan. The only way to assure this is through **emergency drills**. Just as special teams in football practice their plays in order to execute them properly, so too, emergency responders must practice their response activities.

There are many types of emergency drills. The simplest is the **fire drill** or **evacuation drill**. This assures that all personnel at the facility know what the alarm sounds like, know where to exit the facility, and where their rendezvous point is.

Emergency response personnel should have regular **functional drills**. This means practicing specific tasks that they would perform, depending on their level of training. For first responders at the operations level, for example, this might mean practicing control techniques such as blocking and diking.

The most complete test of emergency preparedness is a **full-scale drill**. A simulated incident is created. All emergency response personnel participate, acting as if they are responding to a real incident. This may include the participation of outside responders, such as the fire department or outside hazmat team.

Another valuable way to prepare is the **tabletop drill**. Participants discuss how they would respond to a particular situation. It is often helpful to use models, drawings and maps.

After any drill, all of the people involved must take the time to **discuss** and **evaluate** what worked well, what went wrong, and what should be done differently the next time. An advantage of drills is that they allow you to learn from your mistakes.

Emergency Drills

Review Questions

1. List the seven types of emergencies involving hazardous materials.



- 4. True or false:
 - a. A first responder at the operations level can never serve as the incident commander.
 - b. One person can fill more than one role in the ICS.
- 3. In the space below, draw a plan of a hazardous materials emergency site. Label the different zones, lines, corridors and access points.

Review Questions

Notes



Notes

ACGIH (ACGIH) American Conference of Governmental Industrial Hygienists. This is the organization that establishes the **TLV**'s.

Acute effect. A harmful effect on the body following a short exposure to a chemical or physical agent. An acute effect generally occurs immediately after exposure or within a few hours.

Additive effect. A biological response to exposure to more than one chemical that is the sum of the effects of the individual chemicals.

Attendant. An individual stationed outside a confined space who monitors the authorized entrants and who performs all attendant's duties assigned in the employer's confined space program.

Biological hazard. An organism or the product of an organism that poses a health threat to humans or animals.

Carcinogen. A chemical or physical agent that can cause cancer.

Ceiling limit. The concentration of an air contaminant that should never be exceeded, even for a moment. Written as **TLV-C** (Threshold Limit Value-Ceiling).

Central Nervous System. The system in the body made up of the brain and the spinal cord. It is often referred to as the **CNS**.

Chemical Name. The scientific name of a chemical. For example, "benzene" and "3,3'dimethylbenzidine" are chemical names.

Chronic effect. An adverse effect on the body which occurs after a long term exposure to a chemical or physical agent such as a carcinogen. A chronic effect or disease may not show up for many years after exposure.

Combustible. Any material, chemical, solid, liquid or gas, that can burn. A **DOT Combustible Liquid** is a liquid with a flashpoint above 140°F. Combustible liquids do not ignite as easily as **Flammable Liquids**. However thay can ignite under certain circumstances, and must be handled with caution.

Command post. The centralized base of operations established near the site of a hazmat incident.

Concentration. The amount of a chemical (gas, vapor or particulate) in the air. For example, 5ppm of acetone is 5 parts of acetone in every 1,000,000 parts of air.

Contamination reduction corridor. A designated area within the contamination reduction zone where decontamination takes place.

Contamination reduction zone. The area between the exclusion zone and the support zone.

Control line. Line between the contamination reduction zone and support zone.

Corrosive. A substance that can eat away another substance. Corrosive substances such as acids and alkalis (caustics) can severly burn or damage the skin and eyes.

Dermatitis. Inflammation of the skin, such as redness, rash, dryness or cracking, blisters, swelling or pain.

Engineering controls. Prevention of worker exposures to contaminants by means of work process controls, mechanical equipment or ventilation, rather than by requiring workers to wear protective equipment (**PPE**). OSHA regulations require that exposure to airbourne contaminants be reduced by engineering controls wherever possible, rather than by the use of respirators.

Evaporation. The process by which a liquid changes into a vapor and mixes with the surrounding air.

Exclusion zone. The contaminated area. Also called the **Hot Zone**.

Explosive material. A material that can react rapidly resulting in a sudden and violent release of energy.

Flammable. A liquid (defined by DOT) that has a flash point below 141°F. A flammable liquid ignites easily at normal temperatures in the presence of a spark or other ignition source.

Hazard class. A group of materials that, as designated by the DOT, share

a common major hazardous property such as flammability, corrosivity or radioactivity.

Hot line. The boundary line around the exclusion zone.

Inflammation. A condition of the body, or part of the body, characterized by swelling, redness, pain or heat.

Ingestion. The process of taking a substance into the body through the mouth and the digestive system.

Inhalation. The process of breathing something into the lungs.

Latent period. The time between when a chemical exposure occurs and when a disease or other health effect occurs.

Local Effect. A chemical action that takes place at the point where the chemical comes into contact with the body.

Lower explosive limit. The lowest concentration of a gas or vapor in air that can explode. Commonly called **LEL**.

mg/m³ Milligrams of contaminant per cubic meter of air. This is a way of measuring the concentration of a contaminant in the air.

Mutagen. A substance which can cause changes (usually adverse) in the genetic material of a cell. If the change occurs in a sperm or an egg, the damage can be passed on to the offspring. The change is called a **mutation**.

Odor Threshold. The lowest concentration of a substance at which a person can begin to detect the characteristic odor of the substance.

Organic compound. A chemical that contains carbon. Volatile organic compounds vaporize easily at room temperature. They are found in many industrial and household materials.

Oxidation. The process of combining oxygen with another substance. Examples include combustion and the rusting of iron.

Oxidizer. A substance that provides oxygen in a chemical reaction and supports combustion.

Oxygen deficient atmosphere. An atmosphere having less than 19.5 % available oxygen by volume. Normal air contains about 21% oxygen by volume.

Oxygen enriched atmosphere. An atmosphere with more than 23.5% oxygen by volume.

Parts per million or PPM. A way of expressing the concentration of a contaminant. The ratio the amount of the contaminant to the total amount of air or water.

Permissible exposure limit. The maximum exposure to a chemical allowed by OSHA. Commonly called the PEL. Most PEL's are time weighted averages (TWA). Some are short term exposure limits (STEL), while others are ceiling limits (C).

Personal protective equipment. Clothing and devises worn by workers to protect against hazards in the environment, including respirators, safety glasses, protective clothing, etc. The common abbreviation is **PPE**.

Poison. A chemical that is able to produce an adverse health reaction even when only a small amount gets into or on the body.

Protection factor. A term used to identify the amount of leakage, and thus the effectiveness of a respirator to protect the worker from exposure to contaminants. It is determined in a laboratory by dividing the concentration of a contaminant outside the respirator face piece by the concentration inside the face piece.

Reactivity. The susceptibility of a substance to have a chemical reaction that may result in an explosion, fire or corrosive emission. The condition that causes the reaction, such as heating or dropping the material, is usually specified as «conditions to avoid» on the MSDS.

Sensitizer. A substance that may not cause any harmful reaction in a person following the initial exposures, but after repeated exposures the person may develop an allergic response.

Short term exposure limit. The maximum average exposure to an air contaminant that is allowed by OSHA during a 15 minute period. Only four such exposures are permitted in an 8 hour work day, and they must each be at least 50 minutes apart. Commonly known as the STEL. Only some chemicals have STEL's.

Solvent. Liquid capable of dissolving other substances.

Support zone. The uncontaminated area where workers shouldn't be exposed to hazardous conditions. The clean area.

Synergistic effect The biological response to an exposure to two or more chemicals which is greater than the sum of the effects of the individual chemicals.

Systemic effect. An effect which takes place in a part of the body that is different from the point at which the chemical first comes in contact with the body. For example, some pesticides are absorbed through the skin (the point of contact), but affect the nervous system (the site of action).

Teratogen. A substance that causes birth defects or other anomolies in the offspring.

Threshold limit value. A chemical exposure limit recommended by the ACGIH. Commonly called the **TLV**. A TLV is not always the same value as the OSHA PEL. The TLV's are recommendations only. They do not have the force of law.

Time weighted average. The average concentration of an air contaminant during a period of time, usually 8 hours. The common abreviation is **TWA**.

Trade Name. The commercial name which a company uses for its chemical products, either for advertising purposes or to keep the actual ingredients secret. For example, «Stripeze®» is a trade name.

Upper Explosive Limit. The greatest concentration of a gas or vapor in air that can explode. Commonly called **UEL**.

Volatile. A liquid that has the ability to evaporate quickly or easily.