IUOE National Training Fund

National HAZMAT Program

CONSTRUCTION INDUSTRY OUTREACH TRAINING

30-Hour

Instructor Guide

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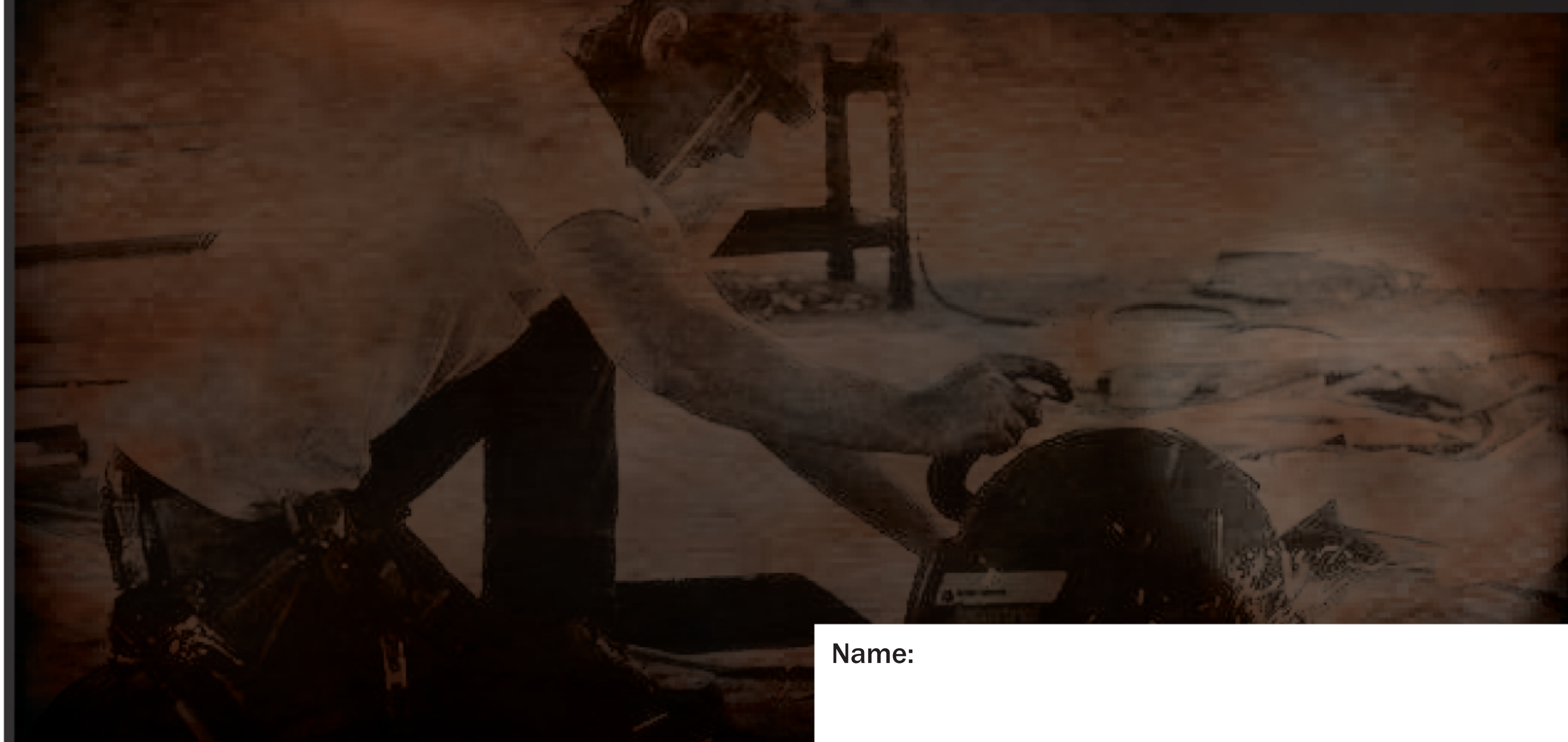

Name:

(304) 253-8674 • hazmat@iuoehazmat.org • www.iuoehazmat.org

IUOE National Training Fund
National HAZMAT Program
1293 Airport Road
Beaver, WV 25813
(304) 253-8674
Fax (304) 253-7758
hazmat@iuoehazmat.org
www.iuoehazmat.org

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- It is not the intent of the content developers to provide compliance-based training in this presentation, the intent is to address hazard awareness in the construction industry, and to recognize the overlapping hazards present in many construction workplaces.
- It should NOT be assumed that the suggestions, comments, or recommendations contained herein constitute a thorough review of the applicable standards, nor should discussion of "issues" or "concerns" be construed as a prioritization of hazards or possible controls. Where opinions ("best practices") have been expressed, it is important to remember that safety issues in general and construction jobsites specifically will require a great deal of site- or hazard-specificity – a "one size fits all" approach is not recommended, nor will it likely be very effective.

To: Users of IUOE National Training Fund Programs

The IUOE National Training Fund -- National HAZMAT Program offers a broad spectrum of safety and health training, as well as training support to other users of the National HAZMAT Program's resources. The National HAZMAT Program has available, at ***no cost***, the following:

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The IUOE National Training Fund encourages all workers to take advantage of the National HAZMAT Program's services to assist you to be employable, competitive, and safe in the workplace.

Sincerely,

Jeffrey R. Vincent
Executive Director,
IUOE National Training Fund

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- Proper PPE use
- Heat stress monitoring and prevention

Presentation and Materials

- Allow 60 minutes to present this chapter.
- Use Personal Protective and Lifesaving Equipment PowerPoint slides.
- Use Review Questions at the end of the chapter to facilitate discussion.
- Use 30-Hour Construction Outreach course manual.

Module 1

Personal Protective And Lifesaving Equipment

OSHA: 29 CFR 1926 Subpart E – CIO 201-301-302-202

Lesson Outline

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Overview

Your personal protective equipment (PPE) might be all that stands between you and an exposure or situation that could be very hazardous to you. Knowing how to put on, use, and take off your PPE will ensure that you get the most out of it. This chapter will teach you how to use and take care of your PPE and to understand its limits.

Objectives

After completing this chapter, you should be able to:

Know

- Cite problems with using overprotective PPE.
- Describe ways chemicals enter your body.
- Define permeation, degradation, and penetration in relation to chemical protective clothing.
- State the minimum level of protection needed for working with unidentified hazards.
- Name factors that can cause heat stress and ways to monitor it.

Apply

- Explain considerations used to select chemical protective clothing.
- Develop a plan to prevent heat stress.

Analyze

- Determine the appropriate level of PPE ensemble to wear based on the situation at hand.

Personal Protective Equipment

Figure 1.1 Safety goggles offer important protection.

When you enter a construction site containing hazardous waste or other potential hazards, protecting your own health and well-being is your first concern. That's why you may need to wear personal protective equipment (PPE) and protective clothing. You want to be shielded from chemical, physical, or biological hazards that might be present at the site. PPE is necessary when engineering controls or administrative controls aren't feasible or haven't worked.

Appropriate PPE for the hazards present should protect your respiratory system, skin, eyes, face, hands, feet, head, body, and hearing. That means you might wear some combination of respirators, gloves, protective suits, boots, hard hats, safety glasses, and ear plugs. But it's important to remember that wearing PPE does not guarantee protection against all hazards. That's impossible. However, when chosen, used, and cared for properly, PPE should offer you the kind of protection you'll need.

You might think that the best answer is to overprotect yourself. That has drawbacks, though. You might want to wear a protective suit when one isn't warranted. You could needlessly face heat stress, for instance, or physical and psychological stress, impaired vision and movement, and decreased ability to communicate. A simple rule of thumb is that the more protection you use, the more risks you face yourself. The key is to know what PPE is proper for the hazard you'll face.

PPE Program

A written PPE program guides you as an operating engineer to know what PPE is appropriate for the hazard you face. A solid PPE program identifies the hazards at the site, provides medical and environmental monitoring, and training on the selection, use, maintenance, and decontamination of your PPE. The program fulfills two basic objectives: protect you as the wearer from safety and health hazards, and protect you from incorrect use or malfunction of the PPE. The following table shows the corresponding OSHA standards for each area of the program.

Type of Protection	Regulation
General	29 CFR 1926.28 29 CFR 1926 Subpart E
Eye and Face	29 CFR 1926.102
Noise Exposure	29 CFR 1926.101
Respiratory	29 CFR 1926.103
Head	29 CFR 1926.100
Foot	29 CFR 1926.96
Electrical Protective Devices	29 CFR 1910.137

Table 1.1

The PPE program isn't static either. It should be reviewed every year or if questions come up about whether it's working. The review should include a survey of each site to ensure compliance with regulations, the number of person-hours that workers wear PPE, accident and illness experience, levels of exposure, and adequacy of equipment selection, operational guidelines, decontamination, training, and recordkeeping. You as an employee also have a right to see the results of the evaluation. The evaluation should also be presented to top management to ensure changes can be made if needed.

Who Pays for PPE?

OSHA requires employers to provide and to pay for personal protective equipment required by the company for workers to do their jobs safely and in compliance with OSHA standards. Where equipment is very personal in nature and is usable by workers off the job, the matter of payment may be left to labor-management negotiations.

Examples of PPE that would not normally be used away from the worksite include, but are not limited to, welding gloves, wire mesh gloves, respirators, hard hats, laser or ultraviolet radiation protection glasses, face shields, and specialty foot protection, such as metatarsal shoes.

Examples of PPE that is personal in nature and often used away from the worksite include nonspecialty safety glasses, safety shoes, and cold weather outerwear worn by construction workers. However, shoes or outerwear subject to contamination by carcinogens or other toxic or hazardous substances that cannot be safely worn off site must be paid for by the employer.

Failure of the employer to pay for PPE that is not personal and not used away from the job is a violation.

OSHA Requirements

OSHA through its personal protective equipment standard (29 CFR 1926 Subpart E) outlines the protection required for your body as well as for specific situations. Here are highlights of each of those sections:

Criteria for Personal Protective Equipment

- PPE must be provided and maintained.
- The employer must ensure that when you provide your own PPE that it's adequate, properly maintained, and sanitary.
- The employer must provide PPE at no cost to you except for safety-toe protective footwear, prescription safety eyewear, metatarsal guards, and everyday work clothing.

Occupational Foot Protection

- Safety-toe footwear shall meet the requirements and specifications in American National Standard for Men's Safety-Toe Footwear, Z41.1-1967.

Head Protection

- When you work in areas where there is a possible danger of head injury from impact, or from falling or flying objects, or from electrical shock and burns, you shall be protected by protective helmets.
- Helmets must meet ANSI specifications contained Z89.1-1969.
- Helmets for the head protection of people exposed to high voltage electrical shock and burns shall meet the specifications contained in ANSI Z89.2-1971.

Hearing Protection

- When it's not feasible to reduce the noise levels or duration of exposures, ear protective devices shall be provided and used.
- Ear protective devices inserted in the ear shall be fitted or determined individually by competent persons.
- Plain cotton is not an acceptable protective device.

Eye and Face Protection

- You shall be provided with eye and face protection equipment when machines or operations present potential eye or face injury from physical, chemical, or radiation agents. The protection must meet ANSI Z87.1-1968 and the equipment must be kept clean and working.
- If you require corrective lenses, you must be protected by spectacles whose protective lenses provide optical correction, by goggles that can be worn over corrective spectacles without disturbing the adjustment of the spectacles, or by goggles that incorporate corrective lenses mounted behind the protective lenses.
- See the tables in Subpart E for the specific protection to be chosen for the hazard faced *(http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10665)*.

Respiratory Protection

The regulations are extensive in this section, but they require the employer to provide proper, fitted, working respiratory protection to you when conditions warrant.

Safety Belts, Lifelines, and Lanyards

- Lifelines, safety belts, and lanyards shall be used only for employee safeguarding. Any lifeline, safety belt, or lanyard actually subjected to in-service loading, as distinguished from static load testing, shall be immediately removed from service and shall not be used again for employee safeguarding.
- Lifelines shall be secured above the point of operation to an anchorage or structural member capable of supporting a minimum dead weight of 5,400 pounds.
- Lifelines used on rock-scaling operations, or in areas where the lifeline may be subjected to cutting or abrasion, shall be a minimum of ⅞-inch wire core manila rope. For all other lifeline applications a minimum of ¾-inch manila or equivalent, with a minimum breaking strength of 5,400 pounds, shall be used.
- Safety belt lanyard shall be a minimum of ½-inch nylon, or equivalent, with a maximum length to provide for a fall of no greater than six feet. The rope shall have a nominal breaking strength of 5,400 pounds.
- All safety belt and lanyard hardware shall be drop forged or pressed steel, cadmium plated and the surface shall be smooth and free of sharp edges.
- All safety belt and lanyard hardware, except rivets, shall be capable of withstanding a tensile loading of 4,000 pounds without cracking, breaking, or taking a permanent deformation.

Safety Nets

- Safety nets shall be provided when workplaces are more than 25 feet above the ground or water surface, or other surfaces where the use of ladders, scaffolds, catch platforms, temporary floors, safety lines, or safety belts is impractical.
- Where safety net protection is required by this part, operations shall not be undertaken until the net is in place and has been tested.
- Nets shall extend 8 feet beyond the edge of the work surface where employees are exposed and shall be installed as close under the work surface as practical but in no case more than 25 feet below such work surface. Nets shall be hung with sufficient clearance to prevent user’s contact with the surfaces or structures below. Such clearances shall be determined by impact load testing.
- Forged steel safety hooks or shackles shall be used to fasten the net to its supports.

Working over or near Water

- If you’re working over or near water, where the danger of drowning exists, you shall be provided with U.S. Coast Guard-approved life jacket or buoyant work vests.
- Before and after each use the buoyant work vests or life preservers shall be inspected for defects.
- Ring buoys with at least 90 feet of line shall be provided and readily available for emergency rescue operations. Distance between ring buoys shall not exceed 200 feet.
- At least one lifesaving skiff shall be immediately available at locations where you are working over or adjacent to water.

Chemical Protective Clothing and Accessories

Figure 1.2 Protective gloves.

The most common route for a chemical to enter your body is for you to inhale it. Another common route of exposure is absorption through the skin. Being exposed via the skin can be just as dangerous as breathing in a harmful contaminant. For instance, some chemicals burn or irritate your skin. Perhaps even more frightening are the ones you absorb without any pain or redness to indicate you've been exposed. Some of these chemicals are so dangerous once they've been absorbed that they can damage vital organs, such as your liver or your central nervous system. Bad news, indeed. To protect against that type of exposure, you might wear chemical protective clothing (CPC).

Knowing the concentration and form of the chemical you're working with is critical in determining what CPC you should wear. Some materials protect against a chemical in a low concentration for a long time, yet those same materials might deteriorate quickly if they are exposed to high concentrations of the chemical. You also want to know the clothing material type and thickness and manufacturing method to determine the proper CPC. Because CPC comes in a variety of materials that offer a wide range of protection, the appropriate clothing material depends on the chemicals present and the work to be done.

No *one* material can protect against all chemicals.

The following tables highlight the types of PPE typically used to protect the various parts of your body.

Full Body

Type of Clothing	Description	Type of Protection	Use Considerations
Fully encapsulating suit	One-piece garment. Boots and gloves may be integral, attached and replaceable, or separate.	Protects against splashes, dust, gases, and vapors.	• Does not allow body heat to escape. • May contribute to heat stress in wearer, particularly if worn in conjunction with a closed-circuit SCBA; a cooling garment may be needed. • Impairs worker mobility, vision, and communication.
Nonencapsulating suit (splash suit)	Jacket, hood, pants, or bib overalls, and one-piece coveralls.	Protects against splashes, dust, and other materials but not against gases and vapors. Does not protect parts of head or neck.	• Do not use where gas-tight or pervasive splashing protection is required. • May contribute to heat stress in wearer. • Tape-seal connections between pant cuffs and boots and between gloves and sleeves
Aprons, leggings, and sleeve protectors	Fully sleeved and gloved apron. Separate coverings for arms and legs. Commonly worn over nonencapsulating suit.	Provide additional splash protection of chest, forearms, and legs.	• Whenever possible, should be used over a nonencapsulating suit (instead of using a fully encapsulating suit) to minimize potential for heat stress. • Useful for sampling, labeling, and analysis operations. • Should be used only when there is a low probability of total body contact with contaminants.

Table 1.2 (continued on next page)

Type of Clothing	Description	Type of Protection	Use Considerations
Firefighters' protective clothing	Gloves, helmet, running or bunker coat, running or bunker pants (NFPA No. 1971, 1972, 1973), and boots.	Protects against heat, hot water, and some particles. Does not protect against gases and vapors, or chemical permeation or degradation. NFPA Standard No. 1971 specified that a garment consist of an outer shell, an inner liner, and a vapor barrier with a minimum water penetration of 25 lbs/in2 (1.8 kg/cm2) to prevent the passage of hot water.	• Decontamination is difficult. • Primarily for structural firefighting. • Should not be worn in areas where protection against gases, vapors, chemical splashes, or permeation is required.
Proximity garment (approach suit)	One- or two-piece overgarment with boot covers, gloves, and hood of aluminized nylon or cotton fabric. Normally worn over other protective clothing, such as chemical protective clothing, firefighters' bunker gear, or flame-retardant coveralls.	Protects against brief exposure to radiant heat. Does not protect against chemical permeation or degradation. Can be custom manufactured to protect against some chemical contaminants.	• Auxiliary cooling and an SCBA should be used if the wearer may be exposed to a toxic atmosphere or needs more than two or three minutes of protection.
Blast and fragmentation suit	Blast and fragmentation vests and clothing, bomb blankets, and bomb carriers.	Provides some protection against very small detonations. Bomb blankets and baskets can help redirect a blast.	• Does not provide hearing protection. • Provides limited chemical protection.

Table 1.2 (continued on next page)

Type of Clothing	Description	Type of Protection	Use Considerations
Radiation contamination protective suit	Various types of protective clothing designed to prevent contamination of the body by radioactive particles.	Protects against alpha and beta particles. Does NOT protect against gamma radiation.	• Designed to prevent skin contamination. • If radiation is detected on site, consult an experienced radiation expert and evacuate personnel until the radiation hazard has been evaluated.
Flame-/Fire- retardant coveralls	Normally worn as an undergarment.	Provide protection from flash fires.	• Add bulk. • May exacerbate heat stress problems. • Impair mobility.
Flotation gear	Life jackets or work vests. (Commonly worn underneath chemical protective clothing to prevent flotation gear degradation by chemicals.)	Adds 15.5 to 25 lbs (7 to 11.3 kg) of buoyancy to personnel working in or around water.	• Adds bulk and restricts mobility. • Must meet USCG standards (46 CFR 160).
Cooling garment	One of three methods: (1) A pump circulates cool, dry air throughout the suit or portions of it via an air line. Cooling may be enhanced by use of a vortex cooler, refrigeration coils, or a heat exchanger. (2) A jacket or vest having pockets into which packets of ice are inserted. (3) A pump circulates chilled water from a water/ice reservoir and through circulating tubes, which cover part of the body (generally the upper torso only).	Removes excess heat generated by worker activity, the equipment, or the environment.	• Pumps circulating cool air require 10 to 20 ft3 (0.3 to 0.6 m3) of respirable air per minute, so they are often uneconomical for use at a waste site. • Jackets or vests pose ice storage and recharge problems. • Pumps circulating chilled water pose ice storage problems. The pump and battery add bulk and weight.

Table 1.2

Head

Type of Clothing	Description	Type of Protection	Use Considerations
Safety helmet (hardhat)	For example, a hard plastic or rubber helmet.	Protects the head from blows. Provides no chemical protection.	• Helmet shall meet OSHA standard 29 CFR 1926.100.
Helmet liner		Insulates against cold. Does not protect against chemical splashes.	
Hood	Commonly worn with a helmet.	Protects against chemical splashes, particulates, and rain. Gives thermal protection.	
Protective hair covering		Protects against chemical contamination of hair. Prevents the entanglement of hair in machinery or equipment. Prevents hair from interfering with vision and with the functioning of respiratory protective devices.	• Particularly important for workers with long hair.

Table 1.3

Eyes and Face

Type of Clothing	Description	Type of Protection	Use Considerations
Face shield	Full-face coverage, eight-inch minimum.	Protects against chemical splashes. Does not protect adequately against projectiles.	• • Must be suitably supported to prevent them from shifting and exposing portions of the face or obscuring vision. • • Provides limited eye protection.
Splash hood		Protects against chemical splashes. Does not protect adequately against projectiles.	• • Must be suitably supported to prevent them from shifting and exposing portions of the face or obscuring vision. • • Provides limited eye protection.
Safety glasses		Protect eyes against large particles and projectiles.	• • If lasers are used to survey a site, workers should wear special protective lenses. • • Must have side shields.
Goggles		Depending on their construction, goggles can protect against vaporized chemicals, splashes, large particles, and projectiles (if constructed with impact-resistant lenses).	
Sweatbands		Prevent sweat-induced eye irritation and vision impairment.	

Table 1.4

Ears

Type of Clothing	Description	Type of Protection	Use Considerations
Ear plugs and muffs	Full-face coverage, eight-inch minimum.	Protect against physiological damage and psychological disturbance. Limited to no chemical protection.	• Must comply with OSHA regulation 29 CFR 1910.95. • Can interfere with communication. • Use of ear plugs should be carefully reviewed by a health and safety professional because chemical contaminants could be introduced into the ear.
Headphones	Radio headset with throat microphone.	Provide some hearing protection while enabling communication. Limited to no chemical protection.	• Highly desirable, particularly if emergency conditions arise.

Table 1.5

Hands and Arms

Type of Clothing	Description	Type of Protection	Use Considerations
Gloves and sleeves	May be integral, attached, or separate from other protective clothing.	Protect hands and arms from chemical contact.	• Wear jacket cuffs over glove cuffs to prevent liquid from entering the glove. • Tape-seal gloves to sleeves to provide additional protection.
Overgloves		Provide supplemental protection to the wearer and protect more expensive undergarments from abrasions, tears, and contamination.	
Disposable gloves		Should be used whenever possible to reduce decontamination needs.	

Table 1.6

Feet

Type of Clothing	Description	Type of Protection	Use Considerations
Safety boots	Boots constructed of chemical-resistant material.	Protect feet from contact with chemicals.	
	Boots constructed with some steel materials (e.g., toes, shanks, insoles).	Protect feet from compression, crushing, or puncture by falling, moving, or sharp objects.	• All boots must at least meet the specifications required under OSHA 29 CFR 1926.96. • Should provide good traction.
	Boots constructed from nonconductive, spark-resistant materials or coatings.	Protect the wearer against electrical hazards and prevent ignition of combustible gases or vapors.	
Disposable shoe or boot covers	Made of a variety of materials. Slip over the shoe or boot.	Protect safety boots from contamination. Protect feet from contact with chemicals.	• Covers may be disposed of after use, facilitating decontamination.

Table 1.7

General

Type of Clothing	Description	Type of Protection	Use Considerations
Knife		Allows a person in a fully encapsulating suit to cut his or her way out of the suit in the event of an emergency or equipment failure.	• Should be carried and used with caution to avoid puncturing the suit.
Flashlight or lantern		Enhances visibility in buildings, enclosed spaces, and the dark.	• Must be intrinsically safe or explosionproof for use in combustible atmospheres • Sealing the flashlight in a plastic bag facilitates decontamination. • Only electrical equipment approved as intrinsically safe, or approved for the class and group of hazard as defined in Article 500 of the National Electrical Code may be used.
Personal Dosimeter		Measures worker exposure to ionizing radiation and to certain chemicals.	• To estimate actual body exposure, the dosimeter should be placed inside the fully encapsulating suit.
Personal locator beacon	Operated by sound, radio, or light.	Enables emergency personnel to locate victim.	• Must be intrinsically safe.
Two-way radio		Enables field workers to communicate with personnel in the support zone.	• Must be intrinsically safe. • Sealing the radio in a plastic bag facilitates decontamination.

Table 1.8 (Continued on next page)

Type of Clothing	Description	Type of Protection	Use Considerations
Safety belts, harnesses, and lifeline		Enable personnel to work in elevated areas or enter confined areas and prevent falls. Belts may be used to carry tools and equipment.	• • Must be constructed of spark-free hardware and chemical-resistant materials to provide proper protection. • • Must meet OSHA standards in 29 CFR 1926.104.

Table 1.8

Selection of Chemical Protective Clothing

Choosing the chemical protective clothing for the job at hand is a complex task. People with training and experience should be in charge of PPE selection. The most appropriate clothing material and accessories will depend on the hazards you'll be exposed to and the job you have to accomplish. Regardless, the employer is responsible under OSHA regulations for ensuring that the PPE necessary to protect you from injury or illness is adequate and of safe design and construction for the work you perform. As you've read, chemical protective clothing isn't foolproof, but ideally, the clothing chosen resists permeation, degradation, and penetration.

Figure 1.3 Some situations may require a full suit of protective clothing.

Permeation, Degradation, and Penetration

When a chemical dissolves and passes through material, that's **permeation**. The permeation rate is the time it takes to do this. Although CPC provides a barrier, some chemicals can eventually work their way through—and sometimes you may not even be able to detect the permeation by simply looking at the clothing.

When the fabric loses its effectiveness as a barrier because chemicals have broken it down, that's **degradation**. Often you can tell when the material has degraded. It might be puckered, brittle, or eroded. Chemicals, sunlight, and high temperatures all cause degradation.

Penetration is when chemicals pass through zippers, stitched seams, pinholes, or other openings in the material.

Five major factors affect the rate of permeation, degradation, and penetration:

- Contact time
- Concentration
- Temperature
- Size of contaminant materials
- Physical state of the wastes

When mixed, chemicals can work even quicker on your CPC. Even small amounts of a chemical that are permeating quickly may provide a path that speeds up the permeation of other chemicals.

Other Considerations in CPC Selection

Besides permeation, degradation, and penetration, several other factors must be considered in selecting the appropriate CPC. The following factors affect not only chemical resistance, but your ability to perform the required task:

- Heat transfer. How much heat does the fabric retain? How much does it interfere with your body's cooling mechanisms?
- Durability. Can the material withstand the physical stress of the task at hand? Will it resist tears, punctures, and scrapes? Can it stand up to repeated contamination and decontamination?
- Flexibility. Does the CPC interfere with your ability to perform assigned tasks, such as putting on gloves?
- Temperature effects. Will the material maintain its protective and flexible characteristics in extreme heat or cold?
- Ease of decontamination. Are decontamination procedures available on site? Will the material pose any decontamination problems? Should you use disposable clothing? Can you use splash and over-covering suits?
- Compatibility with other equipment. Does the clothing restrict the use of another necessary piece of protective equipment, such as suits that restrict hardhat use in an area requiring a hardhat?
- Duration of use. Can you complete the required task before chemical breakthrough occurs or degradation becomes significant?
- Special conditions. Fire, explosion, heat, and radiation require special PPE. This equipment might be used with the CPC or it might protect you from the chemical adequately itself.

Respiratory Protection


Figure 1.4 Respiratory protection is often a necessary piece of equipment.

Respirators are devices that protect you from inhaling harmful substances in the form of airborne vapors, gases, dust, fog, fumes, mist, smoke, or spray. Some respirators also protect you from breathing air with dangerously low levels of oxygen. Your employer is required to provide you with respirators when conditions warrant them. OSHA's hierarchy of controls says that the employer first must try to protect you through engineering control methods, such as enclosure or confinement of the operation, general and local ventilation, and substitution of less toxic materials. If those methods aren't feasible, then you receive a respirator.

Respirators fall into two categories, air purifying or atmosphere supplying. The type you use depends on the situation at your job site. No matter which type you use, it must meet design and manufacturing criteria set by the National Institute of Occupational Safety and Health (NIOSH).

Air Purifying Respirators

Air purifying respirators remove contaminants from the air. This is usually the type you would use at a construction site. They use filters or sorbents to remove harmful substances from the air before you breathe it. They range from simple disposable masks to sophisticated devices. If the concentration of particulates in the air is low, you can wear a particulate filter air purifying respirator for a long time without having to change the filter. Air purifying respirators don't supply oxygen, though, so you don't wear them when oxygen levels are low (oxygen content below 19.5 percent by volume) or when the atmosphere is immediately dangerous to your life or health (IDLH) (possible death, irreversible adverse health effects, impaired ability to escape danger).

Atmosphere Supplying Respirators

Atmosphere supplying respirators provide clean air from a source other than the surrounding contaminated work atmosphere. They include supplied air respirators (SAR) and self-contained breathing apparatus (SCBA).

SARs supply air from a fixed source located some distance away from you through an air line hose. Sometimes you'll hear them called air line respirators. SCBAs supply air from a source you carry. With SARs you don't have to worry about breakthrough times, change schedules, or end of service life indicators for airborne toxic materials. Those are factors you must consider with air purifying respirators. When the concentration of contaminants in the air is high, you get better protection from an atmosphere supplying respirator.

Types of Airflow

Air purifying respirators are further organized by the type of airflow they supply to the facepiece. There are three types:

- Negative pressure respirators draw air into the facepiece when you inhale. Their main disadvantage is that if a leak develops, you inhale contaminated air.
- Continuous flow respirators receive a continuous flow of air into the facepiece. They don't guarantee positive pressure at all times, so there's a chance you can inhale contaminants through a break in the seal. Some SARs and all powered air purifying respirators (PAPR) fall into this category.
- Positive pressure/Pressure demand respirators maintain a positive pressure in the facepiece whether you're breathing in or out. They have a pressure regulator and an exhalation valve to maintain the positive pressure. Even if a leak develops, the regulator keeps you from inhaling contaminated air.

The type of respirator you wear depends on a number of factors: toxicity and concentration of the contaminant and the hazardous material, the amount of oxygen present, the nature and extent of the hazard, work rate, area to be covered, mobility, work requirements and conditions, and limitations and characteristics of the available respirators. The site's health and safety plan should analyze these factors.

Your employer will decide which type of respirator is appropriate for you. The employer will use the assigned protection factors in making the choice based on the exposure limit of a contaminant and the level of contaminant in the workplace. The respirator must be NIOSH certified and follow the OSHA respiratory standard (29 CFR 1910.134). Approval numbers are clearly written on all approved respiratory equipment. NIOSH periodically publishes its Certified Equipment List of all approved respirators and components at *http://www.cdc.gov/niosh/npptl/topics/respirators/CEL/*.

When Not to Use APRs

While air purifying respirators are appropriate in some instances, there are common situations when you should avoid them:

- The atmosphere in the contaminated area is oxygen deficient.
- There's an immediate danger to life or health.
- The contaminant is above the maximum use level or concentration the APR is rated for.
- The possibility of unknown contaminants exists.
- The remaining service life of the air purifying respirator is not known, the APR has no end of service indicator, or the employer has no program for changing canisters or cartridges.

Fit Testing

Before your employer asks you to wear a respirator, you must undergo a medical evaluation to make certain you are physically capable of wearing a respirator. Then the respirator must be fit tested to make certain you wear a proper facepiece that fits comfortably and effectively. A physician or other licensed healthcare profession must perform the medical evaluation using a questionnaire or examination. Follow-up exams may be necessary. None of this is at any cost to you; the employer is responsible for the exam, fit testing, and training.

Fit testing must be performed before you're required to use any respirator with negative or positive pressure, tight-fitting facepiece, or when a different facepiece from one you've been fit for is used. Fit testing also must be completed annually. In addition, if you or the person responsible for the respirator protection program notices changes in your physical condition that would affect the respirator fit, such as scarring, dental changes, cosmetic surgery, or an obvious change in body weight, then fit testing must be completed again.

The employer is required to offer enough respirator models and sizes for you to choose one with the best fit.

Selection of Ensembles

You now know about the different kinds of protection you have available to you. And you know how well they'll work for what you face. You also understand respiratory protection. Now it's time to gear up. Picking the equipment and clothing you'll wear to fully protect yourself in a hazardous waste operation is not unlike checking the weather forecast and deciding what you'll wear outside work—you want to make certain you're going to be warm enough or cool enough, but you don't want to overdo it one way or the other.

When dealing with hazardous materials, you want to create an ensemble that fully protects you from the hazards you'll face while minimizing the drawbacks of the PPE itself. For example, before you choose to wear a fully encapsulating suit, which you've learned limits your mobility and puts you in danger of heat stress, make certain the hazards you'll face call for that level of protection. The level of PPE needed is established through air monitoring. The respiratory protection you need is what determines the level of protection.

It's also important to continually reevaluate your ensemble. As you learn more about the site you're working and the hazards you face, you might want to either upgrade or downgrade your level of protection as long as the site safety officer and field team leader agree.

Here are some reasons to upgrade your protection or consult the safety officer or field team leader:

- Known or suspected presence of hazards to the skin.
- Occurrence or likely occurrence of gas or vapor emission.
- Change in work task that will increase your contact or potential contact with hazardous materials.
- Your own belief that your PPE or CPC is inadequate.

Here are some reasons you might downgrade your protection or consult the safety officer or field team leader:

- New information shows the situation is not as hazardous as first thought.
- The site conditions change, lessening the hazard.
- Change in work task that will lessen your contact or potential contact with hazardous materials.

The Environmental Protection Agency (EPA) as well as 29 CFR 1910.120 Appendix B in the OSHA regulations offers some guidelines for selecting your ensemble. The EPA lists four levels of protection, ranging from A (the most protection) to D (the least). The levels are a good starting point, but you have to tailor your final ensemble according to the situation you face. The illustration and tables starting on the next page summarize the EPA guidelines.

Typically, your employer will want to avoid Level A protection if it isn't necessary because it is very expensive and also difficult on you wearing that kind of ensemble. If you're facing an unknown situation, at a minimum you will wear Level B protection. Most workers like yourself will likely never wear Level A protection, but you might wear Level B if you're involved in hazardous waste operations. Typically, though, in your normal work at a construction site, Level D is all you'll don.

Take special note of the hardhat too in the tables. It's a big issue if your hardhat doesn't fit correctly, and you might have to tape it on. Hardhats can be especially helpful under Level A protection because the hat helps hold up your hood, making it easier for you to see. On the other hand, hardhats can be a problem for Level B and C ensembles because sometimes they don't fit correctly under some suits.

Figure 1.5 The four levels of protection in personal protective equipment.

Level A

Equipment

RECOMMENDED:

- Pressure-demand, full facepiece SCBA or pressure-demand-supplied air respirator with escape SCBA.
- Fully encapsulating, chemical-resistant suit.
- Inner chemical-resistant gloves.
- Chemical-resistant safety boots/shoes.
- Two-way radio communications.

OPTIONAL:

- Cooling unit.
- Coveralls.
- Long cotton underwear.
- Hardhat.
- Disposable gloves and boot covers.

Protection Provided

The highest available level of respiratory, skin and eye protection.

When to Use

- The chemical substance has been identified and requires the highest level of protection for skin, eyes, and the respiratory system, based on either:
  - Measured (or potential for) high concentration of atmospheric vapors, gases, or particulates.
  - Site operations and work functions involving a high potential for splash, immersion, or exposure to unexpected vapors, gases, or particulates of materials that are harmful to skin or capable of being absorbed through the intact skin.
- Substances with a high degree of hazard to the skin are known or suspected to be present, and skin contact is possible.
- Operations must be conducted in confined, poorly ventilated areas until the absence of conditions requiring Level A protection is determined.

Limits

Fully encapsulating suit material must be compatible with the substances involved.

Level B

Equipment

RECOMMENDED:

- Pressure-demand, full facepiece SCBA or pressure-demand supplied air respirator with escape SCBA.
- Chemical-resistant clothing (overalls and long-sleeved jacket; hooded, one- or two-piece chemical splash suit; disposable chemical-resistant one-piece suit).
- Inner and outer chemical-resistant gloves.
- Chemical-resistant safety boots/
- shoes.
- Hardhat.
- Two-way radio communications.

OPTIONAL:

- Coveralls.
- Disposable boot covers.
- Face shield.
- Long cotton underwear.

Protection Provided

- The same level of respiratory protection but less skin protection than Level A.
- It is the minimum level recommended for initial site entries until the hazards have been further identified.

When to Use

- The type and atmospheric concentration of substances have been identified and require a high level of respiratory protection, but less skin protection. This involves atmospheres:
  - With IDLH concentrations of specific substances that do not represent a severe skin hazard.
  - That do not meet the criteria for use of air-purifying respirators.
- Atmosphere contains less than 19.5 percent oxygen.
- Presence of incompletely identified vapors or gases is indicated by direct-reading organic vapor detection instrument, but vapors and gases are not suspected of containing high levels of chemicals harmful to skim or capable of being absorbed through the intact skin.

Limits

- Use only when the vapor or gases present are not suspected of containing high concentrations of chemicals that are harmful to skin or capable of being absorbed through the intact skin.
- Use only when it is highly unlikely that the work being done will generate either high concentrations of vapors, gases, or particulates, or splashes of material that will affect exposed skin.

Level C

Equipment

RECOMMENDED:

- Full-facepiece, air-purifying, canister-equipped respirator.
- Chemical-resistant clothing (overalls and long-sleeved jacket; hooded, one- or two-piece chemical splash suit; disposable chemical-resistant one-piece suit).
- Inner and outer chemical-resistant gloves.
- Chemical-resistant safety boots/shoes.
- Hardhat.
- Two-way radio communications.

OPTIONAL:

- Coveralls.
- Disposable boot covers.
- Face shield.
- Escape mask.
- Long cotton underwear.

Protection Provided

The same level of skin protection as level B, but a lower level of respiratory protection.

When to Use

- The atmospheric contaminants, liquid splashes, or other direct contact will not adversely affect any exposed skin.
- The types of air contaminants have been identified, concentrations measured, and a canister is available that can remove the contaminant.
- All criteria for the use of air-purifying respirators are met.

Limits

- Atmospheric concentration of chemicals must not exceed IDLH levels.
- The atmosphere must contain at least 19.5 percent oxygen.

Level D

Equipment

RECOMMENDED:
- Coveralls.
- Safety boots/shoes.
- Safety glasses or chemical splash goggles.
- Hardhat.

OPTIONAL:
- Gloves.
- Escape mask.
- Face shield.

Protection Provided

- No respiratory protection.
- Minimal skin protection.

When to Use

- The atmosphere contains no known hazard.
- Work functions preclude splashes, immersion, or the potential for unexpected inhalation of or contact with hazardous levels of any chemicals.

Limits

- This level should not be worn in the exclusion zone.
- The atmosphere must contain at least 19.5 percent oxygen.

Proper PPE Use

Follow manufacturer's instructions regarding PPE use.

A hammer is a great tool for pounding a nail into a board. Doesn't work quite as well for sawing that same board, does it? The same goes for your PPE. It's only effective if you use it for the task it was intended for. Proper use of your personal protective equipment considers a number of factors: training, work mission duration, personal use, fit testing, donning, in-use monitoring, doffing, inspection, storage, and maintenance.

Training

OSHA requires that you receive training in the PPE you will don. The benefits of training are numerous:

- You become familiar with your equipment and CPC in a safe situation.
- You build your confidence in using PPE.
- You learn the PPE's capabilities and limitations.
- You make the overall operations more efficient when you can work efficiently in your PPE.
- Knowing how to use the PPE correctly can reduce maintenance costs for the PPE.

Figure 1.6 A worker dons chemical protective clothing with some help.

Training should take place before you use the PPE in a hazardous environment. It should be repeated annually.

Work Mission Duration

Before starting work in your PPE, determine how long your mission will take. Several factors play a role in mission length:

- How long will your air supply last given the rate you'll work at, your fitness, your body size, and your breathing patterns?
- How much permeation and penetration of your ensemble can be expected given the hazardous materials you'll deal with?
- How much will the surrounding temperature affect both you and the integrity of your ensemble? Extreme heat and cold take more of a toll.
- How long will your supply of coolant last under stressful heat conditions?

Personal Use Factors

Some of your own personal features also play a role in your safety. For instance, facial hair and long hair can impede a proper fit to a respirator or they can impair your vision. If you wear glasses, they might get in the way of a proper fit to your PPE, or they might fog up. They also can allow excessive contaminant penetration. Same for contact lenses. And of course, you don't want to chew gum or tobacco when you're wearing a respirator.

Donning

A routine for putting on the different levels of PPE, especially fully encapsulating suits and self-contained breathing apparatus, should be established and practiced periodically. Once you have the equipment on, check the fit. If it's too small, you might tear something. If it's too large, you might snag it on something and you might not be able to move as dexterously. If the fit's poor, you should be provided better fitting clothing.

In-use Monitoring

You must understand everything about the CPC and PPE you're wearing, especially if it's a fully encapsulating ensemble, which can lead to suffocation if misused. If you're having problems while wearing the ensemble, let your supervisor know. For instance, you might notice degradation in the ensemble, an unusual odor, skin irritation, unusual residues, discomfort, rapid pulse, nausea, chest pain, difficulty breathing, fatigue, interference with your vision or communication, or restriction in your movement. Don't take chances of something developing into a more serious problem. Report your concern.

Doffing

In the same way you do when donning your equipment, you also should establish a routine for taking it off and practice it. Your primary concern is preventing the transfer of contaminants from the work area to your body, the decontamination assistants, and others. So, doff your PPE only after you've been through decontamination. Throughout the doffing procedure both you and any assistants should avoid any contact with the outside surface of your suit.

During doffing always assume PPE is contaminated. Don't do everything right all day and then contaminate yourself going through the decontamination line!

Inspection

The personal protective equipment should be inspected at various times to ensure it's still effective. A solid PPE inspection program features five different inspections:

- Inspection and operational testing of equipment received from the factory or distributor.
- Inspection of equipment as it is issued to workers.
- Inspection after use or training and before maintenance.
- Periodic inspection of stored equipment.
- Periodic inspection when a question arises concerning the appropriateness of the selected equipment, or when problems with similar equipment arise.

Protective suits usually have a shelf life of 4-5 years. Follow the manufacturer's guidelines for the suit.

Storage

Clothing and respirators can't be stored just anywhere. They need a place that limits exposure to dust, moisture, sunlight, damaging chemicals, extreme temperatures, and impact. Storage procedures must be in place. Often equipment fails because it hasn't been stored properly. Here are some guidelines:

- Potentially contaminated clothing should be stored in an area separate from street clothing.
- Potentially contaminated clothing should be stored in a well-ventilated area, with good air flow around each item, if possible.
- Different types and materials of clothing and gloves should be stored separately to prevent issuing the wrong material by mistake.
- Protective clothing should be folded or hung in accordance with manufacturers' recommendations.

Maintenance and Repair

Only people properly trained in the manufacturer's recommended procedures should handle maintenance and repair of chemical protective clothing or other PPE.

Heat Stress

Probably the most dangerous consequence of wearing PPE is heat stress. It is one of the most common (and potentially serious) illnesses at hazardous waste sites. You must be aware of it at all times and monitor yourself to make certain you're not experiencing it. Heat stress can result in simple fatigue and progress to serious illness or death.

A number of factors can cause heat stress: environmental conditions, clothing, workload, and your own individual characteristics. Factors that might predispose you to heat stress include lack of physical fitness, lack of acclimatization, age, dehydration, obesity, alcohol and drug use, infection, sunburn, diarrhea, and chronic disease.

The amount and type of PPE you wear directly affect your chances of heat stress. PPE adds weight and bulk, severely reduces your body's access to normal heat exchange mechanisms (evaporation, convection, and radiation), and makes you expend more energy. That's why when selecting PPE you should carefully weigh the benefit of each item in relation to its potential for increasing the risk of heat stress.

Monitoring Heat Stress

Because the incidence of heat stress depends on a variety of factors, all workers, even those not wearing protective equipment, should be monitored.

If workers are wearing permeable clothing (e.g., standard cotton or synthetic work clothes), follow recommendations for monitoring requirements and suggested work/rest schedules in the current American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values for Heat Stress. If the actual clothing worn differs from the ACGIH standard ensemble in insulation value and/or wind and vapor permeability, change the monitoring requirements and work/rest schedules accordingly.

For workers wearing semipermeable or impermeable encapsulating ensembles, the ACGIH standard cannot be used. For these situations workers should be monitored when the temperature in the work area is above 70 degrees Fahrenheit.

According to NIOSH, to monitor the worker, measure:

- **Heart rate.** Count the radial pulse during a 30-second period as early as possible in the rest period.
    - If the heart rate exceeds 110 beats per minute at the beginning of the rest period, shorten the next work cycle by one-third and keep the rest period the same.
    - If the heart rate still exceeds 110 beats per minute at the next rest period, shorten the following work cycle by one-third.
- **Oral temperature.** Use a clinical thermometer (three minutes under the tongue) or similar device to measure the oral temperature at the end of the work period (before drinking).
    - If oral temperature exceeds 99.6°F (37.6°C), shorten the next work cycle by one-third without changing the rest period.
    - If oral temperature still exceeds 99.6°F (37.6°C) at the beginning of the next rest period, shorten the following work cycle by one-third.
    - Do not permit a worker to wear a semipermeable or impermeable garment when his/her oral temperature exceeds 100.6°F (38.1°C).
- **Body water loss,** if possible. Measure weight on a scale accurate to ±0.25 lb at the beginning and end of each work day to see if enough fluids are being taken to prevent dehydration. Weights should be taken while the employee wears similar clothing or, ideally, is nude. The body water loss should not exceed 1.5 percent total body weight loss in a work day.

Prevention

As with most things involving hazardous waste operations, preventive measures and proper training are the best defenses against heat stress. Preventing heat stress is particularly important because once someone suffers from heat stroke or heat exhaustion, that person may be predisposed to additional heat injuries. To avoid heat stress, management should take the following steps:

- Adjust work schedules:
    - Modify work/rest schedules according to monitoring requirements.
    - Mandate work slowdowns as needed.
    - Rotate personnel. Alternate job functions to minimize overstress or overexertion at one task.
    - Add additional personnel to work teams.
    - Perform work during cooler hours of the day if possible or at night if adequate lighting can be provided.
- Provide shelter (air-conditioned, if possible) or shaded areas to protect personnel during rest periods.
- Maintain workers' body fluids at normal levels. This is necessary to ensure that the cardiovascular system functions adequately. Daily fluid intake must approximately equal the amount of water lost in sweat, i.e., 8 fluid ounces (0.23 liters) of water must be ingested for approximately every 8 ounces (0.23 kg) of weight lost. The normal thirst mechanism is not sensitive enough to ensure that enough water will be drunk to replace lost sweat. When heavy sweating occurs, encourage the worker to drink more. The following strategies may be useful:
    - Maintain water temperature at 50° to 60°F (10° to 15.6°C).
    - Provide small disposable cups that hold about 4 ounces (0.1 liter).
    - Have workers drink 16 ounces (0.5 liters) of fluid (preferably water or dilute drinks) before beginning work.
    - Urge workers to drink a cup or two every 15 to 20 minutes, or at each monitoring break. A total of 1 to 1.6 gallons (4 to 6 liters) of fluid per day are recommended, but more may be necessary to maintain body weight.
    - Weigh workers before and after work to determine if fluid replacement is adequate.
- Encourage workers to maintain an optimal level of physical fitness.

- Provide cooling devices to aid natural body heat exchange during prolonged work or severe heat exposure. Cooling devices include:
  - Field showers or hose-down areas to reduce body temperature and/or to cool off protective clothing.
    - Cooling jackets, vests, or suits.
  - Train workers to recognize and treat heat stress.

Glossary

air purifying respirator (APR)—device that protects you from breathing in contaminated air by removing contaminants either through filters or sorbents.

atmosphere supplying respirator—device that protects you from breathing in contaminated air by providing you clean air from a source other than the surrounding contaminated work atmosphere. They include supplied air respirators (SAR) and self-contained breathing apparatus (SCBA).

chemical protective clothing—clothing worn to protect you against being contaminated by chemicals when working with them.

continuous flow respirator—receives a continuous flow of air into the facepiece.

degradation—when a fabric loses its effectiveness as a barrier because chemicals have broken it down.

doffing—a routine for putting on the different levels of PPE.

donning—a routine for putting on the different levels of PPE.

fit testing—process of fitting a respirator to your face to ensure effective protection.

heat stress—potentially dangerous situation in which the body overheats.

negative pressure respirator—draws air into the facepiece when you inhale.

penetration—when chemicals pass through zippers, stitched seams, pinholes, or other openings in the material.

permeation—when a chemical dissolves and passes through material.

personal protective equipment—any type of clothing or equipment designed to protect you against hazardous materials or other dangers on the job site.

positive pressure/pressure demand respirator—maintains a positive pressure in the facepiece whether you're breathing in or out.

self-contained breathing apparatus (SCBA)—type of atmosphere supplying respirator that supplies air from a source you carry.

supplied air respirator (SAR)—type of atmosphere supplying respirator that supplies air from a fixed source located some distance away from you through an air line hose. Sometimes called air line respirator.

Review Questions

1. Cite at least two drawbacks to overprotecting yourself with more PPE than is needed for the hazard.

Drawbacks may include heat stress, physical and/or psychological stress, impaired vision, impaired movement, and decreased communication capabilities.

2. What is the most common route for chemicals to get into your body?

Inhaling is the common way of ingesting a chemical.

3. State a second route of chemical exposure.

Another common exposure route is through your skin.

4. Match the terms permeation, degradation, and penetration with their definitions for chemical protective clothing purposes.

Permeation	When a chemical passes through various openings in the materials.
Degradation	When a chemical dissolves and passes through the materials.
Penetration	When chemicals break down the fabric so it is less effective as a barrier.

Permeation is when a chemical dissolves and passes through the materials.
Degradation is when chemicals break down the fabric so it is less effective as a barrier.
Penetration is when a chemical passes through various openings in the material.

5. What is the main difference between how air purifying respirators and atmosphere supplying respirators work?

APRs remove contaminants from the air, while atmosphere supplying respirators provide clean air from a source other than the surrounding contaminated work atmosphere.

6. What is the difference between Level A and Level B ensembles in the protection provided?

Levels A and B provide the same level of respiratory protection; however, Level B has less skin protection because the back of the neck may not be fully covered.

7. Is the following statement true or false? The level of PPE you wear is determined by the respiratory protection needed.

True. The level of PPE needed is established through air monitoring. The respiratory protection you need is what determines the level of protection.

8. What is the minimum level of protection you would wear in a situation having unknown conditions?

If you are facing an unknown situation, at a minimum you will wear Level B protection.

9. Which ensemble level(s) does not use a respirator?

Only Level D has no respirator.

10. List nine factors that must be considered to ensure the proper use of PPE.

The nine factors include training, work mission duration, personal use, fit testing, donning, in-use monitoring, doffing, inspection, storage, and maintenance.

11. Is the following statement true or false? All workers, even those not wearing protective equipment, should be monitored for heat stress.

True. All workers should be monitored for heat stress because the incidence of heat stress depends on a variety of factors and is one of the most common illnesses at hazardous waste sites.

12. List three monitoring measurements used to detect heat stress.

Measurements of heart rate, oral temperature, and body water loss can be used to monitor heat stress.

13. What steps would you include if you were to construct a plan to prevent heat stress?

Prevention steps covered in this chapter include adjust work schedules, provide appropriate shelter areas, encourage and provide ways for workers to maintain proper body fluids, encourage workers to stay physically fit, provide cooling devices, and train workers to recognize and treat heat stress.

Other Resources

OSHA Fact Sheet: Personal Protective Equipment
http://www.osha.gov/OshDoc/data_General_Facts/ppe-factsheet.pdf

OSHA Home Page: Personal Protective Equipment
http://www.osha.gov/SLTC/personalprotectiveequipment/index.html

eMedicine Health: Personal Protective Equipment
http://www.emedicinehealth.com/personal_protective_equipment/article_em.htm

NIOSH: Protective Clothing and Ensembles
http://www.cdc.gov/niosh/npptl/topics/protclothing/

OSHA Technical Manual: Chemical Protective Clothing
http://www.osha.gov/dts/osta/otm/otm_viii/otm_viii_1.html

Occupational Health and Safety: ISEA vs. ISO: Apparel Standards Examined
http://www.ohsonline.com/articles/45044/

Canadian Centre for Occupational Health and Safety: Designing an Effective PPE Program
http://www.ccohs.ca/oshanswers/prevention/ppe/designin.html

OSHA QuickCard: Heat Stress
http://www.osha.gov/Publications/osha3154.pdf

OSHA: Heat Stress
http://www.osha.gov/SLTC/heatstress/index.html
NIOSH: Heat Stress
http://www.cdc.gov/niosh/topics/heatstress/

The Center to Protect Workers' Rights: Heat Stress in Construction
http://www.cpwr.com/hazpdfs/hazheat.pdf

University of California: Tips for Coping with Heat Stress
http://news.ucanr.org/newsstorymain.cfm?story=691

OSHA Respiratory Protection Booklet
http://www.osha.gov/Publications/OSHA3079/osha3079.html

OSHA QUICKCARD – Respirators
http://www.osha.gov/OshDoc/data_Hurricane_Facts/respirators.pdf

OSHA Respiratory Protection eTool
http://www.osha.gov/SLTC/etools/respiratory/index.html

Instructor Lesson Plan

Health Hazards in Construction

OSHA: 29 CFR 1926.50 Subpart D – CIO 219-319-359

Key Concepts

- Occupational health hazards are potentially part of every type of construction work.
- Contaminants have adverse health effects; effects range from mild irritations to disability and death.
- Each contaminant can produce conditions that have specific symptoms.
- Recognizing the symptoms and early warning signs of occupational illnesses can help in getting early treatment.
- The severity of some illnesses or conditions can be lessened by quick first aid.
- There are work practices that can greatly reduce your risk of adverse health effects because of an on-the-job contamination.
- Workplace control measures can reduce or eliminate the health risks associated with some occupational contaminants.

Presentation and Materials

- Use Health Hazards in Construction PowerPoint® slides.
- Use Review Questions at the end of the chapter to facilitate discussion.
- Encourage individual input concerning experiences with contaminants and personal protective equipment.
- Use 30-Hour Construction Outreach course manual.

Module 2

Health Hazards in Construction

OSHA: 29 CFR 1926.50 Subpart D – CIO 219-319-359

Lesson Outline

Health Hazards in Construction

Air Monitoring

Asbestos

Asphalt Fumes

Cold Stress

Diesel Exhaust

Dust

Heat Stress

Lead

Mold

Noise

Silica

Other Resources

Overview

As a construction worker and operating engineer, you are at risk of exposure to various health hazards that can result in injury, illness, disability, or even death. This chapter provides an introduction to how air is monitored at the job site to determine the amount of airborne contaminants. It also provides a general overview of various health hazards to which construction workers might be exposed.

Objectives

After completing this chapter, you should be able to:

Know

- List major occupational contaminants and the jobs that produce the most contaminant and, therefore, the most risk.
- Describe the importance of using recommended work practices to reduce or eliminate your exposure to health risks.
- Be aware of the health effects of each contaminant.
- State the controls that could be implemented to reduce exposure risk for the hazards discussed in this unit.
- Be able to recognize symptoms of occupational-related illnesses covered in this unit.

Apply

- Use terms appropriate to the information about health hazards to communicate information.
- Choose work practices that will reduce the health risk of each hazard.

Analyze

- Choose personal protection needs based on job site conditions.
- Compare and contrast the significance of short-term health consequences to long-term consequences to contaminant exposure and how this impacts work practices and medical surveillance responsibilities.
- Assess potential health conditions and implement appropriate immediate first aid treatment.

Health Hazards in Construction

Your work in construction is probably dynamic, diverse, and constantly changing. Most likely you often change job site environments and conditions. Of course, that puts you at risk of exposure to a wide variety of health hazards.

Figure 2.1 Plaster dust is a health hazard.

Each job faces its own health hazards. Drywall installers breathe plaster dust, carry heavy loads, and hold awkward postures. Electricians work near heavy metals in solder fumes and asbestos dust. Pipefitters might inhale lead fumes and particles, welding fumes, or asbestos dust. Roofers might be exposed to asphalt fumes while rock drillers and excavation machine operators contend with silica dust, vibration, and noise. Any workers who need to wear personal protective equipment (PPE) to control their exposure to chemical or biological hazards are at risk for heat stress.

Figure 2.2 An air hammer exposes the operator to silica dust, vibration, and noise.

Asbestos, lead, dust, silica, asphalt, and diesel fuel are a sampling of the chemical hazards found in construction work. Physical hazards include cold and heat stress and noise. Mold is an example of a biological hazard found in construction. This chapter will give you an overview of the health effects, control, and safe work practices for each of these hazards.

Air Monitoring

Occupational Safety and Health (OSHA) standard 1910.120 requires that airborne contaminants in the workplace are not only identified, but quantified. Air quality monitoring is an essential part of maintaining a healthy and safe environment on the job. Failure to conduct air sampling or to implement control measures can result in endangering workers' health and can lead to costly OSHA citations and fines.

Figure 2.3 Air monitoring instruments.

Figure 2.4 Indoor air monitoring.

Respiratory hazards occur in many operations. Here is a sampling of work that usually involves airborne contaminants:

- Painting
- Stripping and solvent-based dipping
- Varnishing or staining
- Abrasive blasting and surface preparation
- Welding, brazing, and cutting
- Bake-finishing
- Mold packing
- Adhesive application
- Concrete sawing
- Demolition
- Asbestos removal
- Lead removal

You can see that monitoring for the many and varied airborne contaminants is specific to the job. OSHA regulations set permissible exposure limits (PELs) for each type of contaminant. Refer to the specific standard to find out the exact limit exposure and the exact recommendations that regulate that contaminant.

In general, you can expect the following OSHA regulations in regard to each contaminant. OSHA regulations provide for:

- Permissible exposure limits, which are airborne concentrations of chemicals to which workers may be exposed to day after day for a lifetime. They are measured in parts per million (ppm) or milligrams per cubic meter (mg/m3). The lower the PEL, the more dangerous the chemical.
- Implementation and use of engineering controls and work practices to reduce employee exposure.
- A written compliance program to ensure that exposures are at or below the time-weighted average (TWA). This average refers to concentrations of airborne toxic materials weighted for a certain time duration, usually eight hours.
- Air monitoring systems and programs, including initial monitoring, sampling and testing, and periodic monitoring schedules.
- Training programs that provide you information about the contaminant, control measures, personal protective equipment, and any necessary worker testing.
- Medical surveillance for negative health effects.
- PPE, including goggles, masks, or clothing depending on the type of contaminant.

Case Report

OSHA cited and fined a Syracuse, NY, contractor $57,000 for exposing employees to asbestos-related health hazards. The contractor had failed to monitor the employees' exposure to asbestos even though monitoring records alleged that it had been done. The company was cited for six willful and serious violations.

The OSHA inspection of the site also found that the contractor had failed to collect short-term air sampling, keep accurate monitoring records, notify employees of sampling results, or have an employee training program.

http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=NEWS_RELEASES&p_id=14080

Monitoring Instruments and Methods

Figure 2.5 Low flow personal sample pump.

Direct-reading monitors are available only for a few specific substances, but other methods can determine approximate levels of concentration for other pollutants. Some methods give exact amounts, while others give approximate concentrations.

Here are some examples of monitoring instruments and methods:

- **Combustible gas indicators**—measure combustible gases and vapor concentrations.
- **Flame ionization detectors**—measure organic vapor concentrations.
- **Gamma radiation survey instruments**—measure levels of radiation.
- **Direct-reading colorimetric indicator tubes**—measure concentrations of specific gases and vapors.
- **Direct-reading gas monitors**—detect the presence of a gas and can also measure the concentration, depending on the instrument.
- **Collection plates and millipore filters**—collect airborne particulate matter for measurement and testing.

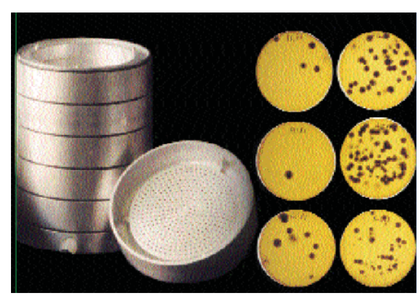


Figure 2.6 Filters and plates for measuring air particulates.

Figure 2.7 Field sampling rotameter.

Monitoring programs should be selected after a thorough inspection and study of the site, the contaminants likely to be present, and environmental conditions. General site monitoring, perimeter monitoring, periodic monitoring, and personnel monitoring are components of the overall program that depend on the specific contaminant. On-site conditions that might affect testing include temperature, wind speed, humidity, and rainfall.

Airborne contaminants can present a significant threat to your health and safety. Identification and quantification of these contaminants through air monitoring is essential.

Case Report

The Lakehead Blacktop and Materials Company received serious citations and fines for safety violations after an accident claimed the lives of four people. The workers were overcome by toxic fumes after going down in a manhole at the company's landfill. The workers had not been wearing personal hydrogen sulfide monitors on their safety vests.

One worker had gone down to perform repairs and was overcome by the fumes. His brother, also on the job, heard his brother gasping for air, went down to help him, and was overcome. Two other workers also died trying to help the men out of the manhole.

https://secure.forumcomm.com/superior/articles/index

Definitions

airborne particulates—small particles in the air that can cause negative health effects when inhaled

failure to abate—a violation that has not been corrected; this violation can result in fines of up to $7,000 per day.

permissible exposure limits (PELs)—airborne concentrations of chemicals to which workers may be exposed day after day for a lifetime. They are measured in parts per million (ppm) or milligrams per cubic meter (mg/m3). The lower the PEL, the more dangerous the chemical.

repeat violation—a violation of a standard that occurs again after the company has been previously cited or fined; repeated violations can result in fines of up to $70,000.
serious violation—a violation or condition that presents a substantial chance for death or serious physical harm.

time-weighted average—concentrations of airborne toxic materials weighted for a certain time duration, usually eight hours.

willful violation—A violation that the employer intentionally and knowingly commits; willful violations carry penalties of $5,000 to $70,000.

Review Questions

1. Name some examples of work that usually produces airborne contaminants.

- *Abrasive blasting and surface preparation*
- *Welding, brazing, and cutting*
- *Bake-finishing*
- *Mold packing*
- *Adhesive application*
- *Concrete sawing*
- *Demolition*
- *Asbestos removal*
- *Lead removal*
- *Painting*
- *Stripping, varnishing*

2. Does your job have airborne contaminants? Discuss with others in your training session the type of contaminant at your workplace and some of the health and safety strategies you must use to protect yourself.

Answers will vary

Asbestos

Asbestos poses a significant health hazard to the estimated 1.3 million construction workers who are exposed to asbestos on the job. Heaviest exposures occur when construction or general contracting jobs call for the removal of asbestos during renovations or demolitions. Other industries manufacture asbestos for their products, such as textiles, insulations, and automotive brakes and clutches.

Figure 2.8 Asbestos fibers.

Asbestos is a mineral fiber mined from the earth. It is composed mainly of six minerals: chrysolite, amosite, crocidolite, anthophyllite, tremolite, and actinolite. All types of asbestos minerals are known to be highly toxic because of their tendency to break into tiny fibers, which enter the body by inhalation or ingestion and can cause a variety of debilitating or fatal conditions. Many uses of asbestos have been banned in numerous countries since the mid-1980s.

Figure 2.9 Fibers on asbestos rock

Having a good working knowledge of asbestos risks and the standards that regulate the handling of asbestos will let you protect yourself and avoid the negative consequences to your health that can occur from asbestos exposure.

Standards

OSHA has three standards to protect workers from exposure to asbestos in the workplace. The three standards refer to the type of workplace environment.

- 29 CFR 1926.1101—asbestos in construction work, including repair, renovation, and demolition.
- 29 CFR 1915.1001—asbestos in shipyard work
- 29 CFR 1910.1001—asbestos in general industry, such as automotive work, thermal systems insulation, and surfacing materials.

Each standard has different requirements for different types of work performed.

Case Report

A New Jersey building firm received 21 serious and 2 willful OSHA violations for failure to protect employees from exposure to asbestos. A furnace blast spewed asbestos throughout the structure, endangering employees.

OSHA citations stated that the "employer willfully violated OSHA standards by failing to use engineering controls or work practices in all operations involving asbestos, failing to train employees who perform housekeeping operations, and failing to institute a training program for all employees performing Class I through IV asbestos work."

http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=NEWS_RELEASES&p_id=1691

Classification of Asbestos Risk

OSHA classifies asbestos risk depending on the type of work:

Figure 2.10 Safe removal of asbestos-containing materials

- Class I: This is the most potentially hazardous class of asbestos job. It involves the removal of thermal insulation and surfacing asbestos-containing materials.
- Class II: This class includes the removal of asbestos-containing materials that are NOT insulation materials, such as flooring and roofing materials.
- Class III: This class involves asbestos-containing materials that are disturbed in the process of the work.
- Class IV: Risks in this class are associated with the cleanup of asbestos-containing wastes.

Health Effects

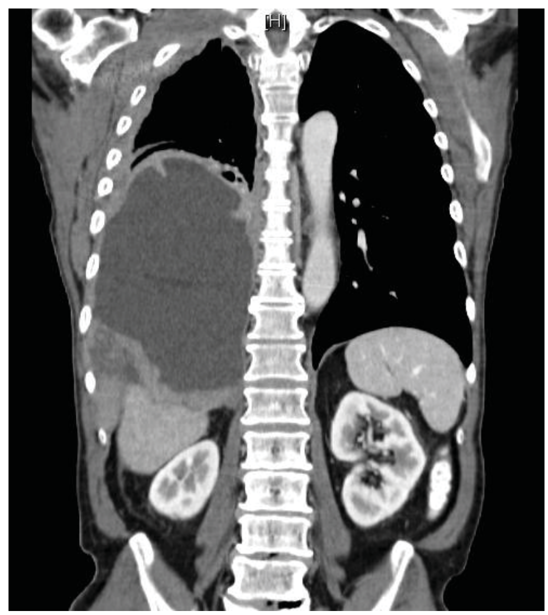


Figure 2.11 Large mesothelioma tumor of the right lung (left side of image) on a CT scan.

Asbestos is a known carcinogen. When asbestos fibers are inhaled or ingested, they become embedded in body tissues and increase the risk of both lung cancer and mesothelioma, a cancer of the thin lining surrounding the lung or abdominal cavity.

Exposure to asbestos can have no immediate negative health effects, but cancer can show up years later. Some studies have also suggested that exposure to asbestos can increase the incidence of cancer of stomach, intestines, esophagus, pancreas, and kidneys, but this has not been proven yet. Asbestosis, a scarring of the lungs develops 7-30 years after exposure and progresses to disability and death.

Early identification and treatment can extend the survival of an individual and improve the quality of life, but learning how to reduce the risks of asbestos in work environments and prevent the development of cancers is the optimal goal of the OSHA standards and requirements for employers and employees.

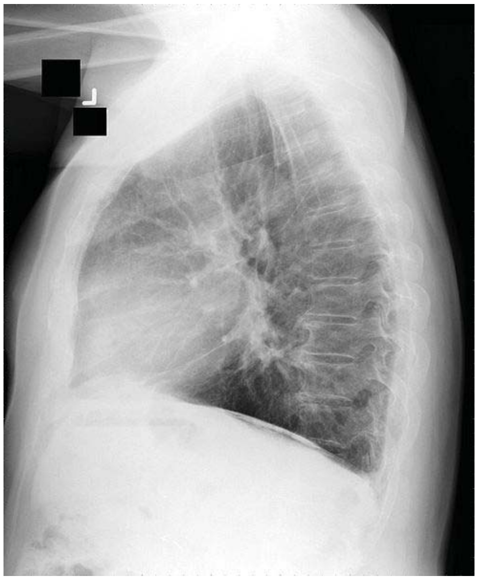


Figure 2.12 Asbestosis X-ray of a retired pipefitter showing plaque infusion in the lungs.

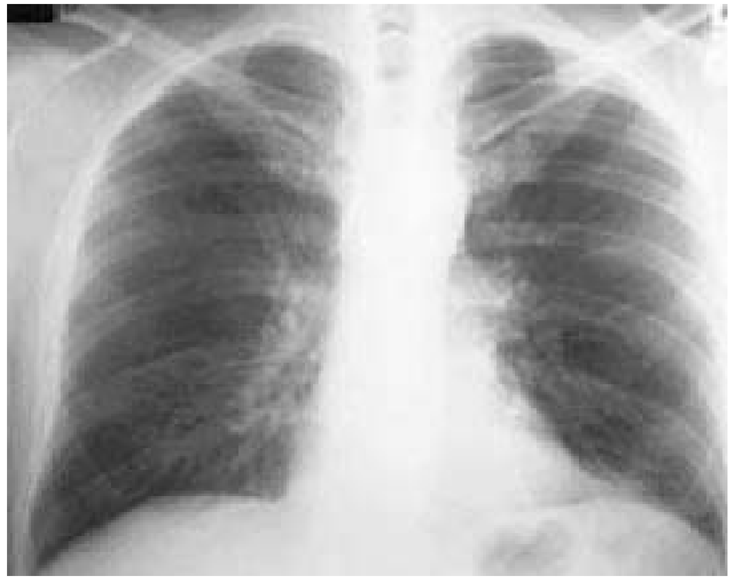


Figure 2.13 Normal chest X-ray. Note the much clearer appearance of the lungs.

Permissible Exposure Limits

OSHA has defined two exposure limit provisions for asbestos:

- **Time-weighted average.** No employee should be exposed to an airborne concentration of asbestos in excess of 0.1 fiber per cubic centimeter (1 f/cc) as averaged over an eight-hour TWA day.
- **Excursion limit.** No employee should be exposed to an airborne concentration of asbestos in excess of 0.1 fiber per cubic centimeter (1 f/cc) as averaged over a sampling period of 30 minutes.

Regulations

In addition to the PELs, OSHA also has a number of specific recommendations for work that involves handling asbestos. These recommendations are divided into separate categories. Read the following OSHA categories for asbestos work regulations and some examples of provisions under that category. Were you aware of these requirements for the safe handling of asbestos?

Exposure Monitoring

- Employers must perform initial monitoring for all employees who are or are expected to be exposed to airborne asbestos at or above the PEL unless the monitoring results conducted after March 31, 1992, meet all other standards or if the data demonstrates that asbestos is not capable of being released at that job in concentrations at or above the PEL. See OSHA guidelines for specifics.

Medical Surveillance

- The employer must provide medical surveillance for all employees who are or will be exposed to concentrations of asbestos at or above the PEL and/or EL. All medical exams and procedures must be performed by a licensed physician. All exams will be provided at no cost to the employee. The examinations must be made available yearly.
- Upon termination of employment, the employer must provide an ending medical exam to the employee within 30 days before or after the date of termination unless the employee has been examined within the last year.
- The employer must provide the physician a copy of the OSHA standard. The physician provides a written report to the employer, and the employee receives a copy of the report within 30 days.

Recordkeeping

- The employer must keep an accurate record of all exposure measurements for 30 years.
- The employer must maintain an accurate record for each employee for the time of employment plus 30 years.

Regulated Areas

- A regulated area must be established wherever airborne concentrations of asbestos exceed the PEL and/or EL. Only authorized personnel are to be allowed inside the regulated areas, and all authorized personnel are required to wear an appropriate respirator.
- No smoking, eating, drinking, chewing tobacco or gum, or applying cosmetics is permitted in a regulated area.

Control

- Use local exhaust ventilation and dust collection systems.
- If local exhaust cannot be used, use personal protective equipment and NIOSH-approved respiratory protection.
- Work with asbestos in a wet state to prevent the worst fiber exposure.
- Do not remove cement, mortar, grout, plaster, or other materials containing asbestos from cartons without wetting.
- Communicate all information on the health and safety hazards of asbestos to workers in accordance to the OSHA Hazard Communication Standard, 29 CFR 1910.1200.

Work Practices

There are quite a few general work practices covered under the OSHA standard for working with asbestos in construction. Consider the following recommendations to ensure a safe work environment for you and your coworkers.

- If your clothing becomes contaminated with asbestos, wash and change clothes as soon as possible.
- Do not take contaminated clothing home. Family members could be exposed to asbestos.
- Use a vacuum with a high efficiency particulate air (HEPA) filter or a wet method to reduce asbestos dust during cleanup.
- Use a respirator in all situations where work practice controls are not yet sufficient to reduce exposure to or below the PEL and/or EL.
- Make sure your respirator fits properly and that you have chosen the proper respirator for your work needs.
- Wear protective clothing, such as coveralls, head coverings, gloves, and foot coverings. Vented goggles or face shields may also be needed.
- The employer must provide clean protective clothing and equipment at least weekly.
- Change rooms and lockers must have separate facilities—one for storing contaminated clothes and one for your street clothing.
- Shower at the end of the shift and do not leave the work area wearing any contaminated clothing.
- Keep all surfaces in the work environment as free of asbestos dust or waste as possible.

Effective management of worker health protection issues and regulations that are designed to address and remediate worker safety risks have reduced the numbers of job-related health injuries and illnesses.

Case Report

A Georgia-based company was cited and fined $44,800 by OSHA for the "willful failure to protect employees working about asbestos." The employer refused to provide respiratory protection and outer clothing to employees even after sampling confirmed the presence of asbestos.

http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=NEWS_RELEASES&p_id=10689

Testing

Levels of asbestos can be measured in urine, feces, mucus, or lung washings. Tissue samplings can confirm higher than average levels of exposure, but cannot predict the future health effects of the exposure.

A complete medical history, physical examination, and diagnostic tests are needed to assess asbestos-related disease. Chest X-rays, lung function tests, and CAT scans can identify lung disease caused by asbestos exposure.

Definitions

asbestos—a mineral fiber mined from the earth composed mainly of six minerals: chrysolite, amosite, crocidolite, anthophyllite, tremolite, and actinolite.

asbestosis—a scarring of the lungs that can develop 7-30 years after asbestos exposure and progress to disability and death.

carcinogen—anything that causes cancer.

HEPA filters (High Efficiency Particulate Air filters)—filters that can remove 99.97 percent of airborne particles 0.3 μm (micrometers) in diameter. These particles are the most difficult to filter and are the most penetrating (to human tissue) particle size.

mesothelioma—a cancer of the thin lining surrounding the lung or abdominal cavity.

permissible exposure limits (PELs)—airborne concentrations of chemicals to which workers may be exposed day after day for a lifetime. They are measured in parts per million (ppm) or milligrams per cubic meter (mg/m3). The lower the PEL, the more dangerous the chemical.

Review Questions

1. Why is asbestos such a health hazard to workers?

All types of asbestos minerals are known to be highly toxic because of their tendency to break into tiny fibers that enter the body by inhalation or ingestion and cause a variety of debilitating or fatal conditions.

2. If you want to find out something about the OSHA standard for your asbestos work, why might you have to look at three different OSHA standards?

OSHA has three standards for three types of work environments.

- ***Construction** (including repair, renovation, and demolition)—29 CFR 1926.1101*
- ***Shipyard asbestos work**—29 CFR 1915.1001*
- ***General industry** (including automotive work, thermal insulation, surfacing materials)—29 CFR 1910.1001*

3. Describe the seriousness of the health hazards of working with asbestos.

Asbestos is a known carcinogen. When asbestos fibers are inhaled or ingested, they become embedded in body tissues and increase the risk of both lung cancer and mesothelioma. Exposure to asbestos can have no immediate negative health effects, but cancer can show up years after the exposure. Some studies have also suggested that exposure to asbestos can also increase the incidence of cancer of the stomach, intestines, esophagus, pancreas, and kidneys, but this has not been proven yet. Asbestosis, a scarring of the lungs develops 7-30 years after exposure and progresses to disability and death.

4. How does OSHA classify the job risk of working with asbestos?

The risk is classified according to the level of risk of exposure in the job:

Class of Risk	Type of Work
Class I	Removal of thermal insulation and surfacing asbestos-containing materials.
Class II	Removal of asbestos-containing materials that are NOT insulation materials, such as flooring and roofing materials.
Class III	Work where asbestos materials are disturbed in the process of the work.
Class IV	Cleanup of asbestos-containing wastes

5. List as many work practices as you can that could limit your exposure to asbestos and keep you safer from asbestos health hazards.

- *If your clothing becomes contaminated with asbestos, wash and change clothes as soon as possible.*
- *Do not take contaminated clothing home. Family members could be exposed to asbestos.*
- *Use a vacuum with a HEPA filter or a wet method to reduce asbestos dust during cleanup.*
- *Use a respirator in all situations where work practice controls are not yet sufficient to reduce exposure to or below the PEL and/or EL.*
- *Make sure your respirator fits properly and that you have chosen the proper respirator for your work needs.*
- *Wear protective clothing, such as coveralls, head coverings, gloves, and foot coverings, and perhaps vented goggles or face shields.*
- *The employer must provide clean protective clothing and equipment at least weekly.*
- *Change rooms and lockers must have separate facilities—one for storing contaminated clothes and one for worker street clothing.*
- *Shower at the end of the shift and do not leave the work area wearing any contaminated clothing.*
- *Keep all surfaces in the work environment as free of asbestos dust or waste as possible.*

Asphalt Fumes

Figure 2.14 Asphalt concrete layer for a new road under construction

Over one-half million workers are exposed to asphalt fumes during construction work such as road paving, roofing, and siding and in the production of the asphalt products. Many health effects have been linked to asphalt exposure, but some of these effects have not been proven. Health and safety regulatory agencies are quick to say that more studies are essential to keep workers safe.

Asphalt is a dark brown to black, cement-like semi-solid or solid made from the distillation of crude oil during petroleum refining. Three types of asphalt are: paving asphalts, roofing asphalts, and asphalt-based paints. Most asphalt in the United States is used for paving and roofing. Much less (about 1 percent) is used for waterproofing, damp-proofing, insulation, paints, or other products. Most asphalt workers do paving or roofing jobs.

Health Effects

Workers are at risk from asphalt fumes and through direct contact with asphalt products. Although some of the health effects have not been scientifically proven, certain symptoms have been repeatedly linked to asphalt exposure in construction workers.

Short-term symptoms that are also usually short-lived include the following:

- Eye irritation
- Nose and throat irritation
- Headache and dizziness
- Nausea and vomiting
- Coughing, wheezing, shortness of breath
- Rashes and acne-like lesions
- Stomach pain
- Decreased appetite
- Fatigue
- Severe burns

Figure 2.15 Second degree burn.

Here are some chronic or long-term health effects of exposure to asphalt fumes:

- Irritation of the eyes
- Unconsciousness
- Thermal burns to the skin and eyes
- Irritation of the respiratory tract and nausea
- Lung, stomach, and skin cancers

Figure 2.16 Scald burn.

Note: Extracts of certain asphalt products have been shown to cause cancer in animals.

Case Report

A Bellefontaine, OH, company was fined $7,500 for five serious violations for failure to provide safety training that could have prevented a fatal accident. Workers sealing cracks in asphalt used a tar kettle to heat solid tar above 350 degrees. Water was added to oil in a thermal jacket and led to the release of hot steam and oil that exploded due to the propane burners. The employee died of severe burns.

http://www.osha.gov/SLTC/asphaltfumes/standards.html

Regulations

Currently, there are no specific OSHA standards for asphalt fumes. Asphalt hazards are addressed in the individual standards for the construction industries, such as PPE.

An exposure assessment must be performed before choosing the correct measures of control for work safety. Options for controls include:

- **Engineering controls.** Heating systems maintain a constant temperature; emissions vent and exhaust systems get rid of fumes from the headspace inside the kettle.
- **Administrative actions.** Examples include substituting low-fuming asphalt and limiting worker exposure time.
- **PPE.** Masks and clothing may help.

Occupational Exposure

Exposures vary considerably between different types of asphalt work and different job assignments. Asphalt-related jobs primarily include those associated with road construction and roofing. Asphalt fume contamination at a work site may affect not only those working directly with the material, but also those in the vicinity of the work. The size of the contaminated area may be affected by factors such as asphalt temperature, outside air temperature, wind velocity, and wind direction.

Figure 2.17 Road paving exposes workers to asphalt fumes.

Case Report

OSHA fined a Gulfport, MS, company $71,500 after a fatal accident involving an asphalt emulsion. An assistant plant manager was attempting to cut with an acetylene torch a hole in a tank containing asphalt. The 16-foot high, 10,000 gallon tank exploded, and the worker was killed.

http://www.osha.gov/SLTC/asphaltfumes/standards.html

Work Practices

There are workplace practices that can result in a much safer environment for you and your coworkers when working with asphalt and asphalt products. Consider the following safe workplace practices. Were you aware of the measures that could allow you to avoid injuries on the job?

- Use local exhaust ventilation at the site of the fume release or wear an appropriate respirator.
- Wear protective work clothing and gloves.
- Wash thoroughly and immediately after exposure to asphalt.
- Post hazard warnings in the work area and communicate safety issues to workers according to the OSHA Hazard Communication standard, 29 CFR 1910.1200.
- Make health and safety hazard information a part of worker training.
- Conduct appropriate air monitoring at the work site.
- If clothing has been contaminated by asphalt fumes or particulate matter, change your clothes after a work shift and launder them.
- Do not eat, drink, smoke, or apply cosmetics where asphalt fumes are present.
- Provide eyewash stations close to the work area.
- Provide shower facilities for emergency exposures to hot asphalt.
- Wear indirect-bent, impact- and splash-resistant goggles when working with liquids; do not wear contact lenses.

Note: If you are wearing appropriate personal protection and you can still smell or taste asphalt or if you have any breathing problems or eye irritations, leave the area immediately. Check your respirator for a safe seal and replace the filter or cartridge.

Case Report

A Framington, MA, company was fined $52,000 for multiple serious and willful violations that resulted in an explosion of an asphalt tank that killed a worker.

http://www.osha.gov/SLTC/asphaltfumes/standards.html

Definitions

asphalt—a dark brown to black, cement-like semisolid or solid made from the distillation of crude oil during petroleum refining.

failure to abate—a violation that has not been corrected; this violation can result in fines of up to $7,000 per day.

permissible exposure limits (PELs)—airborne concentrations of chemicals to which workers may be exposed day after day for a lifetime. They are measured in parts per million (ppm) or milligrams per cubic meter (mg/m3). The lower the PEL, the more dangerous the chemical.

repeat violation—a violation of a standard that occurs again after it has been previously cited or fined; repeat violations can result in fines of up to $70,000.

serious violation—a violation or condition that presents a substantial chance for death or serious physical harm.

time-weighted average—concentrations of airborne toxic materials weighted for a certain time duration, usually eight hours.

willful violation—a violation that the employer intentionally and knowingly commits; willful violations carry penalties of $5,000 to $70,000.

Review Questions

1. How is asphalt made, and what are three types of asphalt?

Asphalt is made from the distillation of crude oil during petroleum refining. Three types of asphalt are paving asphalts, roofing asphalts, and asphalt-based paints.

2. Name some short-term effects of asphalt exposure.

- *Eye irritation*
- *Nose and throat irritation*
- *Headache and dizziness*
- *Nausea and vomiting*
- *Coughing, wheezing, shortness of breath*
- *Rashes and acne-like lesions*
- *Stomach pain*
- *Decreased appetite*
- *Severe burns*

3. Name some possible long-term effects of working with asphalt.

- *Unconsciousness*
- *Thermal burns to the skin and eyes*
- *Irritation of the respiratory tract and nausea*
- *Lung, stomach, and skin cancers*

4. List as many work practices as you can that could limit your exposure to asphalt and keep you safe from asphalt health hazards.

- *Use local exhaust ventilation at the site of fume release or wear an appropriate respirator.*
- *Wear protective work clothing and gloves.*
- *Wash thoroughly and immediately after exposure to asphalt.*
- *Post hazard warnings in the work area and communicate safety issues to workers according to the OSHA Hazard Communication standard, 29 CFR 1910.1200.*
- *Make health and safety hazard information a part of worker training.*
- *Conduct appropriate air monitoring at the work site.*
- *If clothing has been contaminated by asphalt fumes or particulate matter, change your clothes after a work shift and launder them.*
- *Do not eat, drink, smoke, or apply cosmetics where asphalt fumes are present.*
- *Provide eyewash stations close to the work area.*
- *Provide shower facilities for emergency exposures to hot asphalt.*
- *Wear indirect-bent, impact- and splash-resistant goggles when working with liquids; do not wear contact lenses.*

Cold Stress

Many construction workers have to work in cold and freezing temperatures. Construction or demolition work at emergency response sites or recovery sites also often involve adverse temperature environments. Prolonged exposure to cold temperatures can cause serious health problems. Workers who take certain medications; have illnesses such as diabetes, high blood pressure, or heart disease; or who are in poor physical condition face an even greater risk of adverse effects.

Figure 2.18 If you want to avoid cold stress, don't do this.

Occupational Exposure

Cold stress injuries and illnesses just don't happen to workers in Alaska or Northern Michigan. Workers in places where seasons change are more likely to suffer cold-related health issues because they are not as accustomed to dealing with very cold temperatures. If the body has not adjusted to the different temperatures and the worker is not properly prepared for a sudden change in the weather, serious health conditions can occur.

Cold stress results when the body is unable to warm itself. Four factors contribute to cold stress conditions:

- Cold air temperature
- Wind chill
- Air humidity
- Contact with cold water

Wind chill is the effect of the wind speed on how cold the air actually feels. For example, if you were working in air temperatures of 40 degrees Fahrenheit and the wind speed was 35 miles per hour, you would feel like you were working in air temperatures of 11 degrees F. You would have to make sure you dressed in the proper protective clothing in order to avoid cold stress illnesses.

When your body cannot warm itself adequately under adverse temperatures, blood flow begins to shift from your hands, feet, arms, and legs to your "core" (chest and abdomen). This puts your skin and extremities in greater risk of frostbite and hypothermia.

Health Risks of Cold Stress

Hypothermia, frostbite, trench foot, and chilblains are major health risks of cold stress. The following descriptions of each condition show you what symptoms to look for. Remember, damage to tissues from extreme cold can be permanent.

Frostbite

Frostbite happens when the skin freezes and loses water. Frostbite usually occurs at temperatures of 30 degrees F or lower, but wind chills can allow frostbite to occur at above freezing temperatures. Frostbite usually affects body extremities because blood flow has already been directed to the core body organs. Symptoms of frostbite include:

- Stinging or aching of hands or feet followed by numbness.
- Red skin , then purple, then white.
- Blisters.

Permanent damage can result from frostbite if not treated immediately. Follow these steps if you are in danger of frostbite:

- Contact medical personnel.
- Do not rub the affected areas.
- Move to a warm area.
- Wrap the area and do not let the area get cold again. Warming and recooling will cause severe tissue damage.
- Check skin for cuts. If the frostbitten area is already numb, you may not know the skin is broken. Open skin can become infected and can lead to gangrene. Amputation may be required.

Figure 2.19 Early stage of frostbitten fingers.

Hypothermia

Hypothermia (meaning low heat) occurs when the body loses heat faster than it can be replaced. At core body temperatures below the normal 98.6 degrees F, you will have recognizable symptoms:

- Loss of coordination
- Slurred speech
- Possible inability to stand or walk

At a body temperature of 85 degrees F, you might become unconscious; at 78 degrees, you might die.

Certain medications can affect the body's ability to maintain normal temperatures. Antidepressants, sedatives, and tranquilizers are a few of the medicines that can make it harder for the body to produce heat.

Follow these steps if you are in danger of hypothermia:

- Contact medical personnel.
- For mild hypothermia get to a warm area and try to stay active.
- Remove any wet clothing and get dry clothes or blankets.
- Drink warm (not hot) drinks; avoid caffeine.

Trench Foot

Trench foot occurs after prolonged exposure to damp, unsanitary, cold conditions. It was a particular problem of soldiers in the trenches during the World Wars and in Vietnam. Here are trench foot symptoms:

Figure 2:20 Trench foot.

- Feet become numb and then turn red or blue.
- Feet feel tingling or itchy.
- Feet swell as the condition worsens.
- Blisters and open sores form and lead to fungal infections, called jungle rot.
- Skin tissue dies and falls off.

Follow these steps if you are in danger of trench foot:

- Contact medical personnel.
- Thoroughly clean and dry the feet.
- Put on clean, dry socks daily.
- Treat the affected part by applying warm packs or soaking in warm water (102 to 110 degrees F) for approximately five minutes daily.
- Do not wear socks when sleeping or resting.
- Obtain medical assistance as soon as possible.

Chilblains

Chilblains are ulcers that form from exposure to cold and humidity. They are often confused with frostbite and trench foot, but they can indicate more serious medical conditions.

Figure 2.21 Chilblains affected toes.

Here are symptoms of chilblains:

- Ulceration of the fingers or toes
- Red nose
- Skin redness
- Toe and finger skin inflammation
- Earlobe inflammation
- Itchy skin

Follow these steps if you are in danger of chilblains:

- Seek medical care
- Keep area warm and do not scratch
- Use anti-itch creams, such as calamine lotion

Work Practices for Avoiding Cold Stress Injuries

Thirty percent of body heat is lost through your head.

- Always be prepared for weather changes if there is a potential for cold exposure.
- Always have appropriate clothing and personal protective equipment on cold job sites.
- Drink plenty of liquids, but avoid caffeine and alcohol.
- Watch out for coworkers' symptoms of cold stress illnesses.
- Eat high calorie foods to maintain energy reserves.
- Be aware of wind chill factors and dress accordingly.
- Be aware that surface temperatures also affect the temperatures of your tools. At lower temperatures you will start to have limited circulation to hands, wrists, and arms and will likely have more injuries.
- Dress with several thermal layers.
- Use radiant heaters and shield work areas from drafts or winds to reduce wind chills.

Definitions

chilblains—ulcers that form from exposure to cold and humidity.

frostbite—injury after excessive exposure to extreme cold, sometimes progressing from initial redness to gangrene.

hypothermia—dangerous medical condition in which the body's temperature drops below that required for normal body functions.

trench foot—a medical condition caused by prolonged exposure of the feet to damp, unsanitary, and cold conditions above the freezing point; also called immersion foot.

wind chill—the temperature felt by the body from a combination of air temperature and wind speed

Review Questions

1. What other factors besides air temperature affect whether or not you develop a cold stress illness?

High winds, air humidity, and contact with cold water can increase the likelihood that cold stress conditions can occur. Also, workers who take certain medications; have illnesses such as diabetes, high blood pressure, or heart disease; or who are in poor physical condition face an even greater risk.

2. Describe the symptoms you would look for in the following cold stress conditions and then describe the treatment for each:

a. Frostbite

Frostbite*—Symptoms include stinging or aching hands or feet followed by numbness; skin turning red, purple, or white; and blistering skin.*

Frostbite must be treated immediately, or permanent damage or death can occur. Contact medical personnel immediately, do not rub the affected areas, move to a warm area, and wrap the area so it does not get cold again. Check the skin for cuts because open skin can become infected and lead to gangrene.

b. Hypothermia

Hypothermia*—Symptoms to look for are loss of coordination, slurred speech, inability to stand or walk, and a body temperature lower than normal.*

Treatment for hypothermia includes getting to a warm area, trying to stay active, and removing any wet clothing and replacing with dry, warm clothes. Get medical help as soon as possible; severe hypothermia can lead to death.

c. Trench foot

***Trench foot**—Symptoms to look for are feet becoming numb and then turning red or blue, feet feeling tingling and swelling, blisters and open sores forming, and skin falling off.*

Treatment for trench foot is cleaning and drying the feet; using clean, dry socks daily; treating the affected areas by applying warm packs or soaking in warm water (102 to 110 degrees F) for approximately five minutes at least daily. Seek medical assistance as soon as possible.

d. Chilblains

***Chilblains**—Symptoms to look for are ulcerations of the fingers or toes, red nose, skin redness, toe and finger skin inflammation, earlobe inflammation, and itchy skin.*

Treatment for chilblains includes keeping the area warm, not scratching, and using anti-itch medications, such as calamine lotion. Get medical attention as soon as possible.

3. List some work practices for avoiding cold stress injuries.

- *Always be prepared for weather changes if there is a potential for cold exposure.*
- *Always have appropriate clothing and personal protective equipment on cold job sites.*
- *Drink plenty of liquids, but avoid caffeine and alcohol.*
- *Watch out for coworkers' symptoms of cold stress illnesses.*
- *Eat high calorie foods to maintain energy reserves.*
- *Be aware of wind chill factors and dress accordingly.*
- *Be aware that surface temperatures also affect the temperatures of your tools. At lower temperatures you will start to have limited circulation to hands, wrists, and arms and will likely have more injuries.*
- *Dress with several thermal layers.*
- *Use radiant heaters and shield work areas from drafts or winds to reduce wind chills.*

Diesel Exhaust

Figure 2.22 Smokestacks spewing diesel fuel exhaust.

Do you work around diesel exhaust? Diesel exhaust is a widespread airborne pollutant in many construction and industrial workplaces. Emissions are made up of thousands of gases, vapors, and fine particulate matter. The expanding use of diesel equipment exposes more workers everyday to adverse health effects. More than one million people work around diesel exhaust and face the health issues that are caused by the continual exposure.

Occupational Exposure

Figure 2.23 Construction machinery releases diesel fumes.

Workers such as miners, bridge and tunnel workers, material handling machine operators, and people who operate any type of vehicle or machines such as canes or forklifts that run on diesel fuel are at risk of diesel fume illnesses.

There are currently no standards that deal with diesel exhaust as a separate hazard. However, there are specific standards for dealing with the various chemical components of diesel fuel and exhaust. Under OSHA's Hazard Communication standard, diesel fuel manufacturers must include information about the fuel's cancer-causing potential on their diesel fuel material safety data sheets (MSDS).

Figuer 2.24 Diesel fumes released at a construction site.

Major components of diesel fuel are carbon dioxide, carbon monoxide, nitrogen dioxide, and particulates.

Minor components include acrolien, o-anisaldehyde, benzene, 2,3-benzofuran, coumarin, formaldehyde, menadione, naphthalene, and pyrene.

Health Effects

Some of the chemicals listed above are potential carcinogens. More than 40 substances in diesel emissions are listed by the U.S. Environmental Protection Agency (EPA) because hazardous air pollutants and particulates (particles) from diesel emissions are small enough to be inhaled into the lungs. There is also a known link between diesel emissions and lung damage.

Short-term health effects from diesel fuel include:

- Irritations of the eyes, nose, and throat
- Dizziness
- Heartburn
- Wheezing and tightness in the chest
- Headache
- Vomiting
- Tingling in the arms and legs

Figure 2.25 Irritated eye.

Longer health effects include:

- Increase in risk for lung cancer and bladder cancer.
- Possible heart problems.
- Increase in respiratory illnesses, such as asthma.

Case Report

A study has shown that the ports of Los Angeles and Long Beach are increasing the risk of cancer from diesel fumes emitted by harbor industries. The risk extends not only to the port area, but many miles inland. Lung cancer, usually fatal, was found to be the primary risk from diesel fumes. An earlier study had shown that diesel fumes accounted for 71 percent of the cancer risk associated with air pollution in the Los Angeles area.

http://articles.latimes.com/2005/oct/05/local/me-air4

Control and Work Practices


Figure 2.26 Diesel exhaust spewing into the workplace.

Not all the same control strategies can be used at all construction sites, but there are some control and work practices that you can do to reduce your exposure to diesel fumes even though you have to work around them. Read the following control strategies and work practices. How many of them are available to you on your job?

- Use low-sulfur diesel fuel that reduces irritating sulfur emissions and engine maintenance costs.
- Add exhaust filtration devices to engines to capture some exhaust before it enters the workplace. These devices include disposable diesel exhaust paper filters and particulate ceramic filters.
- Direct the exhaust away from the operator of the vehicle and nearby workers.
- Install catalytic converters to reduce carbon monoxide, aldehydes, and hydrocarbons. (Only use these with low-sulfur fuel)
- Ventilate if using diesel equipment indoors. Use roof vents, open doors and windows, or roof fans. As buildings under construction become more enclosed, fumes can increase to dangerous levels.
- Use HEPA (high efficiency particulate air) filters to reduce operators' exposure to diesel fuel.
- Service engines regularly to keep exhaust emissions down.
- Turn off engines when not using the equipment. Idling increases diesel emissions.
- Respirators are only a short-term fix. Engineering controls such as ventilation systems should be implemented.

Definitions

carcinogen—anything that causes cancer.

catalytic converter—a device that can be installed on a vehicle or machine to convert pollutants in exhaust gases into harmless compounds.

diesel fuel—a combustible fuel made from petroleum.

HEPA filters (high efficiency particulate air filters)—filters that can remove 99.97% of airborne particles 0.3 µm (micrometers) in diameter. These particles are the most difficult to filter and are the most penetrating to human tissue.

particulate—particles.

Review Questions

1. Why are diesel fumes such a health hazard to workers?

Emissions are made up of thousands of gases, vapors, and fine particulate matter, and some of them are potential carcinogens (cause cancer). More than 40 substances in diesel emissions are small enough to be inhaled into the lungs. There is also a link between diesel emissions and lung damage.

2. Name several short-term effects of exposure to diesel fumes?

Short-term effects include:

- *Irritations of the eyes, nose, and throat.*
- *Dizziness.*
- *Heartburn.*
- *Wheezing and tightness in the chest.*
- *Headache.*
- *Vomiting.*
- *Tingling in the arms and legs.*

3. Name several long-term effects of exposure to diesel fumes?

Long-term effects include:

- *Increase in risk for lung cancer and bladder cancer.*
- *Possible heart problems.*
- *Increase in respiratory illness, such as asthma.*

4. List as many work practices as you can that could limit your exposure to diesel fumes and keep you safer from diesel health hazard

- *Use low-sulfur diesel fuel that reduces irritating sulfur emissions and engine maintenance costs.*
- *Add exhaust filtration devices to engines to capture some exhaust before it enters the workplace. These devices include disposable diesel exhaust paper filters and particulate ceramic filters.*
- *Direct the exhaust away from the operator of the vehicle and nearby workers.*
- *Install catalytic converters to reduce carbon monoxide, aldehydes, and hydrocarbons. (Use these only with low-sulfur fuel.)*
- *Ventilate if using diesel equipment indoors. Use roof vents, open doors and windows, or roof fans. As buildings under construction become more enclosed, fumes can increase to dangerous levels.*
- *Use HEPA filters to reduce operators' exposure to diesel fuel.*
- *Service engines regularly to keep exhaust emissions down.*
- *Turn off engines when not using the equipment. Idling increases diesel emissions.*
- *Respirators are only a short-term fix. Primary controls such as ventilation systems should be implemented.*

Dust

Dust is tiny solid particles carried by the air that is formed from processes that grind, crush, or impact the original material. The effects of dust depend on the original material; if the original material is hazardous, the dust will be hazardous. Dusts such as silica or asbestos (topics covered separately in this chapter) are toxic and can be carcinogenic. However, any dust can become a health problem if large amounts are inhaled or if smaller amounts are inhaled over time.

Figure 2.27 Dust at construction site.

Nuisance dust is dust that contains less than 1 percent quartz. It has few adverse health effects, and symptoms are usually reversible.

The size of the dust particle is an important consideration. Some particles are so large, they settle almost immediately, while others remain in the air indefinitely. (Dust is measured in micrometers, also known as microns.)

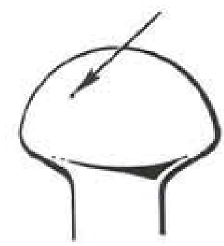


Figure 2.28 A micron-size dust particle on a pin head.

Dust can be classified according to how far it penetrates into the body:

- **Respirable dust—**dust particles small enough to penetrate the nose, the upper respiratory system, and deep into the lungs. These particles stay in the body because they are too deep to be eliminated by the body's natural mechanisms.
- **Inhalable dust—**dust that is trapped in the nose, throat, and upper respiratory tract. This dust can be eliminated by the body.
- **Total dust—**all airborne particles, regardless of size or composition to which a worker is exposed.

Health Hazards

Not all dusts produce the same kinds of health hazards. Factors such as dust composition, concentration, particle size and shape, and worker exposure time determine how severe the effects will be.

Health effects from dust exposure include:

Figure 2.29 X-ray of dust-related lung disease.

- Occupational respiratory diseases. The general name for dust-related lung diseases is pneumoconiosis. Some serious work-related types of pneumoconiosis include:
  - **Silicosis**—a lung disease caused by exposure to the dust of quartz and other silicates. This is an irreversible lung disease that progresses even if you are removed from the silica exposure. (See Silica chapter for more information.)
  - **Black lung—**a lung disease caused by exposure to coal dust particles.
  - **Asbestosis—**a lung disease caused by asbestos fibers. This is also an irreversible lung disease. (See Asbestos chapter for more information.)
- Irritation to eyes, ears, nose, throat, and skin.

Related health hazards of working with dust on the job include:

- Risk of dust explosions.
- Fire and damage to equipment.
- Impaired visibility.

Occupational Exposure and Control

Figure 2.30 Construction dust blowing at York University.

Workers in the construction industry, agriculture, and mining are exposed to dust. Dust control systems reduce adverse health effects, minimize equipment damage, and increase visibility on the job.

Three major steps to reducing dust are:

1. **Prevention.** Surely not all dust can be prevented on construction sites, but being aware of the need to reduce dust production when possible can go a long way.

2. **Control systems.** Dust on a work site can be controlled by three main methods:
   - **Dust collection systems**—consist of industrial ventilation systems to capture airborne dust from the source and transport it to a dust collector.
   - **Wet dust suppression systems**—keep the material wet to reduce the tendency to generate dust. Water is usually applied in this method, but there are also emulsion solutions available that bind to the material and prevent most of it from becoming airborne.
   - Water can also be sprayed on the dust cloud to reduce the amount of dust in the air. Dust particles stick to the atomized water and become too heavy to stay in the air. Dust that falls on the ground can be removed at the end of each shift.

Figure 2.31 Reverse air dust collector.

Figure 2.32 Water wheel on VA cemetery construction site.

3. **Dilution-Isolation.** Dilution reduces the dust concentration. Uncontaminated fresh air is pumped in to dilute the dusty air. This is not the most effective way to deal with the health hazard, but can be used when other methods do not apply. Isolation does nothing to remove the dust, but isolates the worker in an enclosed workplace and pumps in clean, filtered air.

Controlling dust protects workers from adverse health effects and also has other beneficial effects for the workplace. The possibility of dust explosions and fires is reduced, worker visibility is increased, accident risks are reduced, and cleanup and maintenance costs are more manageable.

Case Report

OSHA issued citations and fines totaling $8,777,500 against the Imperial Sugar Company and two of its affiliates. The citations and fines were issued following an explosion and fire started by large accumulations of combustible sugar dust in workrooms, on electrical motors, and on other equipment. The incident killed 13 employees and hospitalized 40 others.

The following investigation found that the company was aware of the conditions, but took no action to remedy them. "I am outraged that this company would show a complete disregard for its employees' safety by knowingly placing them in an extremely dangerous work environment," said Asst. Secretary of Labor for OSHA, Edwin G. Foulke Jr. He added, "What is even worse is that a month after the devastating catastrophe in Port Wentworth that claimed the lives of 13 people, this company had done little to ensure abatement of the combustible dust hazards at its other plant. If OSHA investigators had not inspected and posted an imminent danger notice regarding areas at the second plant, the same thing could have happened again."

OSHA issued 108 willful citations, 100 serious violations, and 4 citations for other-than-serious safety and health violations.

http://www.insurancejournal.com/news/national/2008/07/29/92297.htm

Personal Dust Sampling Equipment

Dust samplers consist of a cyclone, a filter-cassette assembly, and a sampling pump. A total dust sampler does not have a cyclone but has a filter-cassette and sampling pump.

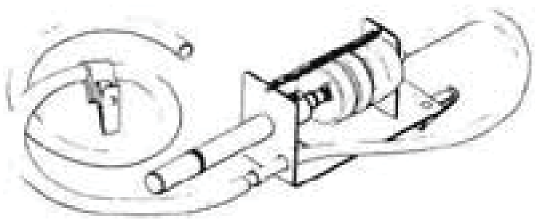


Figure 2.33 Respirable dust sampling head.

Figure 2.34 Total dust sampling head.

Wearing personal respiratory protection is your best protection against any adverse health effects from dust on the job. The type of dust being generated at your work site is the major factor in determining what kinds of health effects you may develop.

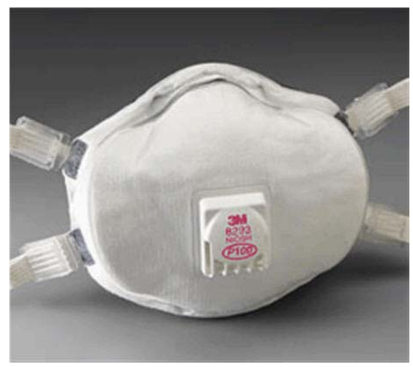


Figure 2.35 Particulate filter respirator.

Definitions

asbestosis—an irreversible lung disease caused by asbestos fibers.

black lung—a lung disease caused by exposure to coal dust particles.

carcinogenic—anything that causes cancer.

dust—tiny solid particles carried by the air that are formed from processes that grind, crush, or impact the original material.

inhalable dust—dust that is trapped in the nose, throat, and upper respiratory tract and can be eliminated by the body.

nuisance dust—dust that contains less than 1 percent quartz and has few adverse health effects.

pneumoconiosis—the general name for dust-related lung diseases.

respirable dust—dust particles small enough to penetrate the nose, the upper respiratory system, and deep into the lungs. These particles stay in the body because they are too deep to be eliminated by the body's natural mechanisms.

silicosis—an irreversible lung disease caused by exposure to the dust of quartz and other silicates.

total dust—all airborne particles, regardless of size or composition, to which a worker is exposed.

Review Questions

1. What is the difference between the terms dust and nuisance dust?

Dust is tiny solid particles carried by the air that are formed from processes that grind, crush, or impact the original material. Nuisance dust is dust that contains less than 1 percent quartz and has few adverse health effects.

2. What are the health effects from nuisance dust?

Adverse health effects of nuisance dust are much less severe than effects from other types of dust, such as silica dust or coal dust. Nuisance dust causes reversible and short-lived symptoms, such as irritation to eyes, ears, nose, throat, and skin.

3. Describe three types of serious respiratory diseases from exposure to harmful types of dust.

Pneumoconiosis is the general name for dust-related lung diseases. Three types of serious respiratory diseases from exposure to dust are:

- *Asbestosis—an irreversible lung disease caused by asbestos fibers.*
- *Black lung—a lung disease caused by exposure to coal dust particles.*
- *Silicosis—an irreversible lung disease caused by exposure to the dust of quartz and other silicates.*

4. Describe three ways to reduce dust in the workplace.

- *Prevention—work practice strategies that will reduce the amount of dust generated.*
- *Control systems—There are three types of control systems for reducing dust. Dust collection systems consist of industrial ventilation systems to capture airborne dust from the source and transport it to a dust collector. Wet dust suppression systems keep the material wet so the dust does not get into the air. Water sprays on dust clouds reduce airborne dust by making the dust particles too heavy to stay in the air.*
- *Dilution—reduces dust concentration by pumping in fresh air to dilute the dusty air. Isolation—places the worker in an enclosed area to work away from the dust.*

5. Have you ever worked on a job when dust was a major problem? What kinds of problems did the dust produce? How was the dust reduced or controlled?

Answers will vary.

Heat Stress

Many different types of operations present the risk of heat stress. Any job involving high temperatures, high humidity, or direct contact with hot objects can result in heat-related illnesses if you are not aware of the risks, the warning signs, and what to do about treating the illness before it worsens. Construction, refining, asbestos removal, and hazardous waste site work in hot weather present especially high heat stress dangers.

OHSA currently has a campaign to prevent heat illness in outdoor workers called "Water, Rest Shade."

Occupational Exposure

Heat stress occurs when the body is unable to cool itself enough to lower body temperature to a safe level. Many factors influence how efficiently a person can do that. Age, weight, physical fitness, metabolism, use of alcohol and drugs, and medical conditions such as high blood pressure affect how well a worker tolerates heat.

Figure 2.36 Victim of heat stress.

As you can see, it is more than just air temperature that determines whether or not you will develop heat stress. For example, having had a heat injury before makes it more likely that you will develop a heat illness again. Radiant heat, wind or no wind, heat conduction off work surfaces, and humidity—they all affect your response to heat.

Health Effects

There a few serious health risks associated with heat stress. Recognizing the warning signs and symptoms of heat-related conditions will help you avoid the illnesses and consequences of working in risky heat environments. Read the following heat stress illnesses and pay attention to what causes the illness, the warning signs, the treatments, and the consequences.

Heat Stroke

This is the most serious heat-related illness for workers in hot environments. Heat stroke occurs when the body cannot regulate its core temperature. Here are signs of heat stroke:

- Body temperature of 106 degrees F or higher
- Hot dry skin with a red, mottled or bluish appearance
- Mental confusion
- Loss of consciousness
- Convulsions
- Coma

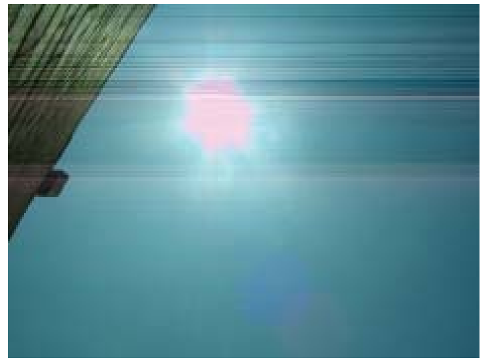


Figure 2.37 Sun-scorching conditions increase the risks for heat stroke.

Follow these steps if you are in danger of heat stroke:

- Get medical help immediately.
- Move to a cooler area in the shade.
- Soak clothing with cool water.
- Fan to increase cooling effects.

IMPORTANT: Victims of heat stroke will die unless treated promptly. While awaiting medical help, the victim must be removed to a cool area and his or her clothing soaked with cool water. He or she should be fanned vigorously to increase cooling. Prompt first aid can prevent permanent injury to the brain and other vital organs.

Case Report

A farm labor contractor was fined $77,900 for violations of heat illness prevention regulations. The fines resulted from an investigation of the death of an employee of Merced Farm Labor Contractor who worked for nine hours with little water and no shade.

Just one month before, OSHA had issued citations and fines of $262,700 against the same company and had referred the case to the local district attorney for possible criminal prosecution.

Citations were issued for failure to provide heat illness prevention training, failure to provide access to a shaded area for recovery periods of no less than five minutes, and failure to have medical response procedures in place. The company has now been ordered not to operate until they can prove compliance with OSHA heat regulations.

http://yubanet.com/california/Cal-OSHA-Cites-and-Fines-Farm-Labor-Contractor-for-Heat-Illness-Prevention-Regulation-Violations.php

Heat Exhaustion

Heat exhaustion occurs when the worker in a hot environment loses too many fluids through sweating and does not drink enough to replenish the fluids. This victim, unlike the heat stroke victim, can still sweat but cannot lower his body temperature enough to be healthy and safe.

Here are the signs of heat exhaustion:

- Extreme fatigue and weakness
- Nausea
- Headache
- Clammy skin
- Body temperature slightly higher than normal
- In severe cases vomiting or loss of consciousness

Follow these steps if you are in danger of heat stroke:

- Move to a cooler area in the shade.
- Drink large amounts of electrolyte solutions (for example, a sports drink to quickly restore potassium, calcium, and magnesium salts).

Heat Cramps

Heat cramps are painful muscle spasms that occur when workers drink large amounts of water, but do not replace their bodies' minerals. Heat cramps may not even happen until after you have finished work. Recognizing heat cramps as different from a normal muscle cramp will allow you to quickly and easily treat the condition. Simply drink liquids that contain electrolytes to relieve the condition. Under extreme conditions fluids can be given intravenously.

Fainting

Some people who are not used to the heat and who stand still for long periods of time faint in hot weather. They usually recover quickly after lying down.

Heat Rash

Heat rash occurs when sweat is not removed from the skin by evaporation. Wiping off with cool water during breaks, changing clothes after your work shift, bathing as soon as possible, and not wearing the same sweaty clothes again until laundered can prevent heat rash.

Figure 2.38 Heat rash.

Control

Adequate sampling methods can identify conditions that would require heat-related controls. Sampling methods include body temperature measurements, environment temperature measurements, and wet bulb temperature index data. Engineering controls can manage hot air temperatures that create heat stress conditions. These include:

- **General ventilation—**brings cooler air from outside.
- **Air cooling—**reduces air temperature and sometimes humidity.
- **Local air cooling—**portable blowers sometimes with built-in air chillers.
- **Convection methods—**fans that increase the rate of evaporation of sweat from the skin.
- **Conduction—**insulating a hot surface so the heat does not transfer to the air or to the worker.
- **Shields—**reduce radiant heat coming from surfaces nearby the worker.

Work Practices

There are quite a few work practices that can greatly reduce the chance that you or a coworker will develop heat stress illnesses. Some may seem like common sense, but you probably know friends who ignore some of them while they are in the middle of a job. Read the following recommendations for working in a hot environment. Do you and your co-workers always follow these recommendations?

Figure 2.39 Drink lots of fluids to avoid dehydration.

- Drink small amounts of water frequently to replace body fluids lost through sweating.
- Wear light-colored, loose-fitting clothing whenever possible.
- Take your breaks in the shade, if possible.
- Avoid caffeine and alcohol.
- Use a sunscreen with a sun protection factor (SPF) of at least 30. This won't protect you from the heat stress illnesses listed above, but they will feel worse if you also have a sunburn.
- Take advantage of training programs that will help you understand the hazards of heat stress, treatments, and the use of protective clothing.

Definitions

Conduction—the transfer of heat from a warmer object to a cooler object.

Convection—the transfer of heat by flowing materials; air flowing past the body can cool the body if the air being used is cool.

evaporation—when a liquid turns into a gas.

heat cramps—painful muscle spasms that occur in hot working conditions when you drink large amounts of water, but do not replace body minerals.

heat exhaustion—occurs when you are in a hot environment and lose too many fluids through sweating and do not drink enough to replenish the fluids.

***heat stroke*—**a severe condition resulting from prolonged exposure to excessive heat. The most serious heat-related illness for workers in hot environments, heat stroke can result in coma and death.

hyperthermia—usually high body temperature.

radiation—the transfer of heat through space; hot surfaces radiate heat to your body.

Review Questions

1. When does heat stress occur in the body?

Heat stress occurs when the body is unable to cool itself enough to lower body temperature to a safe level.

2. You are working on the same job with 10 other workers. Why can you get heat stress and not your coworkers?

Many factors determine how the body can cool itself to a safe level. Age, weight, physical fitness, metabolism, use of alcohol and drugs, and medical conditions such as high blood pressure affect how well a worker tolerates the heat.

3. You check the temperature before you set out for the job, and it is not that hot today. You still get heat sick. Why?

It is not just air temperature that determines whether or not you will develop heat stress. Having had a heat injury before makes it more likely that you will develop a heat illness again. Radiant heat, wind conditions, heat conduction off work surfaces, and humidity can also affect your ability to deal with heat.

4. What are the signs of heat stroke and what should you do if you think a coworker is suffering from heat stroke?

Signs of heat stroke are hot, dry skin with a red or bluish appearance, mental confusion, loss of consciousness, convulsions, or coma. If heat stroke is suspected, get medical help immediately, move the victim to a cooler place in the shade, soak clothing with cool water, and fan the victim to increase the cooling effects while waiting for the medical help.

5. What are the signs of heat exhaustion and what should you do if you think you may be suffering from it?

Signs of heat exhaustion are extreme fatigue and weakness, nausea, headache, clammy skin, and body temperature slightly higher than normal. To relieve heat exhaustion, move to a cooler area in the shade and drink large amounts of electrolyte solutions.

6. List as many work practices as you can that could reduce your risk of heat-related illnesses.

- *Drink small amounts of water frequently to replace body fluids lost through sweating and replace lost electrolytes.*
- *Wear light-colored, loose-fitting clothing whenever possible.*
- *Take your breaks in the shade.*
- *Avoid caffeine and alcohol.*
- *Use a sunscreen with an SPF of at least 30. This won't protect you from the heat stress illnesses listed above, but they will feel worse if you also have a sunburn.*
- *Take advantage of training programs that will help you understand the hazards of heat stress, treatments, and the use of protective clothing.*

Lead

OSHA has a specific standard, 1926.62, for construction workers who may be exposed to lead. Exposure to lead is one of the leading causes of workplace illness in the United States. Lead causes irreversible neurological damage as well as kidney disease, cardiovascular effects, and reproductive problems. Blood lead levels that were once thought to be safe are now, with new evidence, considered hazardous. There is no safe threshold for lead exposure.

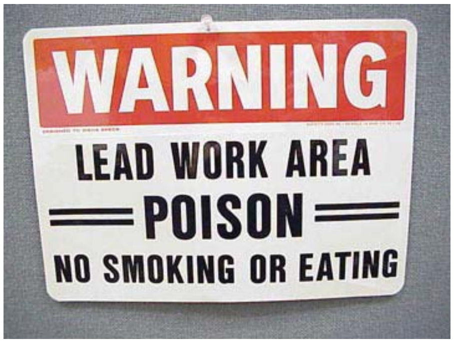


Figure 2.40 Work area warning sign

OSHA has implemented a strategic plan for reducing lead exposure and employee blood lead levels in selected industries by 15 percent in an effort to reduce negative lead health effects. As you read this information about lead exposure in construction or learn about lead exposure in a training class, think of the health consequences and remember that lead poisoning is a completely preventable disease.

Lead Characteristics

Lead is a bluish-gray, flexible metal. Lead can be shaped at standard temperatures and is highly resistant to corrosion by air, sea water, and a number of industrial chemicals. These characteristics make it widely used with other metals, such as iron and steel, for a number of industrial uses.

Occupation Exposure

In construction lead overexposures usually occur around plumbing, welding, iron work, demolition work, heating and air conditioning, carpentry, renovation, and painting work. Lead is used for roofs, cornices, tank linings, and electrical conduits. It has been banned for many uses because of its toxic health effects. Soft solder for plumbing applications has been banned, and lead is not allowed in paints used for residential applications. It is still used for bridges, railroads, ships, and lighthouses because of its corrosion-resistant property.


Figure 2.41 Lead roof repair

The employer is responsible for the development and implementation of a worker protection program in accordance with 29 CFR 1926.20 and 29 CFR 1926.62(e). The permissible exposure limit is 50 micrograms per cubic meter of air (µg/m3) averaged over an eight-hour work shift. In addition, OSHA requires blood testing to be conducted and the worker removed from the work environment if the blood lead level exceeds the set amount.

Case Report

Two contracting companies were cited and fined for nine willful violations and two serious violations for failure to protect workers from lead exposure on a demolition project. The companies failed to perform initial lead exposure tests and failed to provide respiratory protection for its workers.

http://safety.blr.com/news.aspx?id=100785

Health Effects

Lead exposure occurs through inhalation of fumes and dusts or ingestion as a result of lead-contaminated hands, foods, drinks, tobacco products, or clothing. Workers can also take lead home on their clothes or in their cars, exposing family members to negative health effects. Lead poisoning, neurological effects, and mental retardation have occurred in children of employees who work in construction occupations.

Figure 2.42 Workers removing lead paint.

Symptoms of lead poisoning include:

- Headaches and irritability.
- Tiredness and trouble sleeping.
- Stomach problems, constipation, and colic.
- Permanent kidney and brain damage.
- Impotence and infertility.
- Aching, weakness, and tremors in the arms and legs.
- High blood pressure.
- Anemia.

Chronic lead poisoning occurs when lead accumulates in the body, mostly in the bone. Some health event, such as an illness or a pregnancy, releases the lead from the bone, and your health begins to deteriorate. This can happen years after the lead exposure.

Controls

There are quite a few controls that can be implemented to reduce the risks of lead hazards in the workplace. Lead is a significant health hazard, and effective controls and good work practices are essential to protecting workers against the serious consequences of exposure to lead.

Read the following examples of controls and practices for working around lead contaminants. Are you familiar with the correct procedures for working with lead? Do you and your coworkers work as safely as possible at all times?

Figure 2.43 HEPA filters on vacuums are capable of capturing very small dust particles with 99.97% efficiency.

Figuer 2.44 Ventilations systems are effective in removing lead dust.

- **Substitution.** Use another less hazardous material when possible. Zinc-containing primers and topcoats are sometimes used instead of lead-containing coatings.
- **Exhaust ventilation.** Have adequate ventilation systems in place to direct and collect the lead dust or fumes, and use collection shrouds and high-efficiency particulate air filters on tools.
- **Encapsulation.** Cover lead-based paints with a material that bonds to the surface or enclose it with wallboard, plywood, siding, vinyl or linoleum.
- **Replacement**—replace lead-based painted components such as windows and doors, with new components or have the lead-based paint removed off-site.
- **Modify the work process.** Use brush or rollers to apply lead paints instead of spraying.
- **Isolation.** Keep employees not involved in blasting operations as far away as possible during the blasting work.
- **Establish a regulated area.** Post hazard warning signs with information in the work area.
- **Conduct ongoing education and training programs.** Communicate information on lead health hazards and review safety procedures.

Work Practices

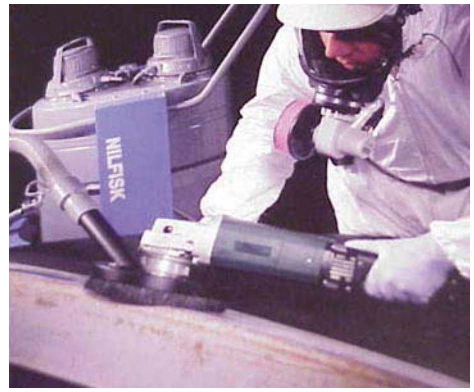


Figure 2.45 Shrouded tools can greatly reduce lead exposure.

Figure 2.46 Personal protection equipment.

Figure 2.47 Use exhaust ventilation with HEPA filters to capture dust and fumes whenever possible.

- Use appropriate personal protective equipment.
- Remove accumulations of lead dust and debris daily.
- Use HEPA filters on vacuuming equipment or wet with water before sweeping.
- Equip cleanup workers with respiratory protection and protective clothing.
- Seal lead debris into impermeable bags.
- Label waste bags as hazards.
- Employees must use washing facilities and clean change areas.
- Use separate and non-contaminated areas for eating.
- Workers should park their cars where cars will not be contaminated with lead to reduce the chances of taking lead from the work site.
- Employee street clothes must be stored separately from protective work clothing; work clothing must not be worn away from the job. Workers who do not change their clothes before leaving a job site may contaminate their cars and homes and expose family members to health hazards.
- There should be no eating, drinking, smoking, or applying cosmetics in lead-contaminated areas.
- At the end of a work shift, workers should dispose of protective clothing in a closed container.
- Workers should get clean, dry protective work clothing and equipment at no cost.
- Protective clothing includes coveralls, gloves, vented goggles or face shields, and welding or blasting helmets, if necessary.
-

Case Report

A Johnstown, PA, company was cited and fined $114,750 for failure to protect workers from lead exposure. The five willful and seven serious citations alleged that the company failed to conduct proper exposure assessments, provide personal protective clothing or change areas, monitor blood levels, or provide training to workers removing lead.

"Lead can damage the central nervous system, kidneys, cardiovascular, blood, and reproductive systems if absorbed into the body in high enough doses," said Robert Szymanski, OSHA's Pittsburgh area director. "This company was well aware of the hazards of lead but failed to protect their employees and consequently their families."

http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=NEWS_RELEASES&p_id=12061

Medical Surveillance

If a construction worker is exposed to lead at or above the action level of 30 micrograms per cubic meter of air (µg/m3) on any one day of a calendar year, the worker must have initial medical testing for blood lead and zinc protoporphyrin levels. Blood lead levels are the best indicator of personal lead exposure. Full medical surveillance must be provided to the employee exposed to lead at or above the action level for more than 30 days per year.

Figure 2.48 Leaded bridge work.

Case Report

OSHA fined a Florida-based contractor $79,000 for safety and health violations during inspection of a bridge repainting project. The company had failed to properly monitor workers with elevated blood lead levels, to give employees blood test results, and to provide employees with clean personal protective equipment when lead exposures exceeded allowed levels. Workers had been exposed to 50 times the permissible levels of lead on the job.

http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=89&p_table=NEWS_RELEASES

Definitions

action level—when an employee is exposed, without regard to the use of respirators, to an airborne concentration of lead of 30 micrograms per cubic meter of air (30 ug/m(3)) averaged over an eight-hour period.

carcinogen—anything that causes cancer.

HEPA filters (high efficiency particulate air filters)—filters that can remove 99.97% of airborne particles 0.3 µm (micrometers) in diameter. These particles are the most difficult to filter and are the most penetrating to human tissue.

lead—metallic lead, all inorganic lead compounds, and organic lead soaps; for construction purposes, this does not include organic lead compounds.

permissible exposure limits (PELs)—airborne concentrations of chemicals to which workers may be exposed day after day for a lifetime. They are measured in parts per million (ppm) or milligrams per cubic meter (mg/m3). The lower the PEL, the more dangerous the chemical.

repeat violation—a violation of a standard that occurs again after it has been previously cited or fined; repeat violations can result in fines of up to $70,000.

serious violation—a violation or condition that presents a substantial chance for death or serious physical harm.

willful violation—a violation that the employer intentionally and knowingly commits; willful violations carry penalties of $5,000 to $70,000.

Review Questions

1. Name some possible effects of working with lead.

- *Headaches and irritability*
- *Tiredness and trouble sleeping.*
- *Stomach problems, constipation, and colic.*
- *Permanent kidney and brain damage.*
- *Impotence and infertility.*
- *Aching, weakness, and tremors in the arms and legs.*
- *High blood pressure.*
- *Anemia.*

7. If lead is so toxic, why is it used so much in construction, plumbing, welding, iron work, demolition work, heating and air conditioning, carpentry, renovation, and painting work?

Lead is a flexible metal that can be shaped at standard temperatures and is highly resistant to corrosion by air, sea water, and a number of industrial chemicals. These characteristics make it widely used with other metals, such as iron and steel, for a number of industrial uses.

8. Why should you be very careful NOT to wear any lead-contaminated clothes off the work site?

Workers who do not change their clothes before leaving a job site may contaminate their cars and homes and expose family members to harmful effects of lead. There is no safe threshold for lead exposure. Lead poisoning, neurological effects and mental retardation have occurred in children of employees who work in construction.

9. List as many work practices as you can that could limit your exposure to asbestos and keep you safer from asbestos health hazards.

- *Use appropriate personal protective equipment.*
- *Remove accumulations of lead dust and debris daily.*
- *Use HEPA filters on vacuuming equipment or wet with water before sweeping.*
- *Equip cleanup workers with respiratory protection and protective clothing.*
- *Seal lead debris into impermeable bags.*
- *Label waste bags as hazards.*
- *Employees must use washing facilities and clean change areas.*
- *Use separate and non-contaminated areas for eating.*
- *Workers should park their cars where cars will not be contaminated with lead to reduce the chances of taking lead from the work site.*
- *Employee street clothes must be stored separately from protective work clothing; work clothing must not be worn away from the job.*
- *There should be no eating, drinking, smoking, or applying cosmetics in lead-contaminated areas.*
- *At the end of a work shift, workers should dispose of protective clothing in a closed container.*
- *Workers should get clean, dry protective work clothing and equipment at no cost.*
- *Protective clothing includes coveralls, gloves, vented goggles or face shields, and welding or blasting helmets, if necessary.*

10. Not every job requires the same controls for protection against lead exposure. Think of the different kinds of construction jobs and work environments you have experienced. List as many controls as you can that were used to reduce your lead exposure, and discuss your experiences with the rest of your group.

Controls include:

- ***Substitution.*** *Use another less hazardous material when possible. Zinc-containing primers and topcoats are sometimes used instead of lead-containing coatings.*
- ***Exhaust ventilation.*** *Have adequate ventilation systems in place to direct and collect the lead dust or fumes; use collection shrouds and HEPA filters on tools.*
- ***Encapsulation.*** *Cover lead-based paints with a material that bonds to the surface, or enclose it with wallboard, plywood, siding, vinyl, or linoleum.*
- ***Replacement.*** *Replace lead-based painted components such as windows and doors with new components, or have the lead-based paint removed off site.*
- ***Modify the work process.*** *Use brush or rollers to apply lead paints instead of spraying.*
- ***Isolation.*** *Keep employees not involved in blasting operations as far away as possible during the blasting work.*
- ***Establish a regulated area.*** *Post hazard warning signs with information in the work area.*
- ***Conduct ongoing education and training programs.*** *Communicate information on lead health hazards and review safety procedures.*

Mold

Public awareness about the health effects of mold has increased because of the widespread damage caused by natural disasters such as Hurricane Katrina and the numerous tornadoes that strike the Midwest. Safe mold remediation and the demolition of buildings and homes too far damaged for remediation requires that workers be aware of the health risks concerning mold and how they can reduce their risks.

Figure 2.49 Mold remediation in a flood-damaged home.

Molds are fungi and can be found anywhere—inside or outside—all year round. They are the most common type of fungi. Molds reproduce by spores. When spores land on a surface with water and oxygen present, they begin to grow and will eventually digest the material. Molds can grow especially well on wet cellulose materials, including paper and paper products, cardboard, ceiling tiles, wood, and wood products.

Figure 2.50 Moldy insulation.

It is impossible to eliminate all sources of mold in a building or home. Moisture control is the best way to reduce indoor mold.

Sources of moisture in buildings include plumbing, roof and window leaks, flooding, wet foundations due to landscaping or gutters directing water into the building, and condensation.

Mold is a serious problem. It causes structural damage, creates foul odors, and causes respiratory problems.

Occupation Exposure

Any time you have construction work in a building or home, you may be exposed to molds. You may have to fix a structure that was hit by flooding and is now overrun with mold, or you may have to demolish buildings and homes that are total disasters from mold growths and are not worth fixing.

Sampling for molds is usually not necessary; a visual inspection is typically good enough. There are currently no limits or recommendations for airborne concentrations of mold, mold spores, or mold toxins.

Health Effects

Figure 2.51 Mold growing in a closet

There are no standards or recommendations for airborne concentrations of mold, but mold can cause adverse health effects, especially if you are allergic to molds.

Allergic reactions include hay fever-type symptoms such as a runny nose and red, itchy eyes, or nasal stuffiness. Some people who are particularly allergic also have throat irritation, coughing or wheezing, skin irritation, or asthma attacks. People who have chronic lung illness may develop severe lung disease if exposed to molds.

The onset of allergic reactions to mold can be either immediate or delayed.

Control

When working mold remediation, simply killing the mold with biocide is not enough. The mold must also be removed. The allergens are still present in dead mold and can cause adverse heath effects.

You may use a variety of methods for mold remediation, and each has recommendations for avoiding risks from mold.

Figure 2.52 Cutting sheet rock with a saw equipped with a dust collection system.

- Only use a wet vacuum on surfaces that are wet. Using a wet vacuum on porous surfaces may spew mold and spores into air if insufficient liquid is present.
- Thoroughly clean all tanks, hoses, and attachments of vacuums so mold and spores that have stuck to the inside surfaces cannot grow and cause further problems.
- Carefully follow instructions on all biocides and cleaning solutions.
- Use a HEPA vacuum after materials have been cleaned and dried. Make sure the vacuum and filters are attached tightly so that all the air passes through the filter to the vacuum container.
- Dispose of debris in the HEPA vacuum in an impermeable bag.

- Dispose of debris in the HEPA vacuum in an impermeable bag.
- Building materials that are contaminated with mold should be sealed while in the indoor remediation areas. Cover large items with sheeting and seal with duct tape before disposal.
- If you use a biocide, always ventilate the area. If you use fans, make sure you do not blow mold or spores to clean areas.
- Never mix chlorine bleach solution with other cleaning solutions that contain ammonia. Highly toxic fumes may be released.
- Always use proper personal protective equipment when using a biocide or fungicide.


Figure 2.53 Applying a biocide to the ceiling. Note the full-face respirator that protects his face from spray.

Case Report

A patient's adverse health response to molds generated an investigation of the Veterans Affairs Medical Center near Martinsburg, WV. The hospital was later cited for health and safety violations.

The citations included having an employee use a Shop Vac for mold cleanup in the kitchenette without an appropriate filter, using surgical masks for personal protective equipment, and wearing masks over beards. Outpatient surgeries were apparently performed in a unit that was having mold removed. The surgical staff had been complaining of upper respiratory symptoms, and 31 employees were evaluated for mold exposure.

The medical center assigned an employee to do the mold removal at six different locations within the medical center. Samples taken two weeks later confirmed the mold was still present. The employee assigned to mold removal had a history of chronic lung disease and did not use a respirator when he worked on the mold. Independent contractors were hired to finish the work.

http://www.herald-mail.com/?cmd=displaystory&story_id=183186&format=print

Work Practices

Any mold remediation work will cause mold spores to further contaminate the air. Breaking apart moldy materials such as wallboard, tearing out paneling, peeling off wallpaper, scraping off the mold, and using fans to dry surfaces and ventilate areas will spew molds and spores throughout the air.

Using personal protective equipment prevents the inhalation and ingestion of mold and prevents mold contact with skin and eyes. Consider the following PPE for mold remediation or demolition work.


Figure 2.54 PPE protects workers from molds and spores.

- Wear gloves that extend to the middle of the forearm to protect your skin from irritating mold allergens and harsh cleaning solutions.
- Select the gloves based on the type of chemical cleaning solution you are using. For example, if you are using chlorine bleach, use gloves made from natural rubber, neoprene, polyurethane, or PVC. If you are using a mild detergent, ordinary rubber gloves are sufficient protection.
- Wear properly fitting goggles or full-face respirator. Do not wear safety goggles with open vent holes for mold work.
- Choose respiratory protection based on the level of remediation work. A half mask or full facepiece air-purifying respirator may be used. More protective respirators may be required if other harmful substances such as lead or asbestos are discovered during remediation or demolition.
- All respirators for mold work must be certified by the National Institute for Occupational Safety and Health (NIOSH).
- Employers are required to provide proper training for all employees using PPE. The employer must also develop a written respiratory protection program with complete work site procedures.
- Personal protective clothing may be reusable or disposable, but should not be used repeatedly without laundering. Wearing protective clothing prevents the transfer of molds to street clothing and protects skin from mold and chemical exposures.
- Do not eat, drink, use tobacco products, or apply cosmetics in mold remediation environments.


Figure 2.55 Worker removes the sheet rock and places it in the debris bag. Special cartridges on the respirator remove fine particulates.

Mold and spores can cause health problems even if the spores are dead or dormant (inactive). Being aware of mold health risks in the workplace and on mold remediation or demolition jobs reduces your chances of getting a mold-related illness.

Definitions

allergen—any substance that can cause an allergic reaction.

biocide—any substance that kills organisms such as mold.

fungi—a group of living things that are neither plants nor animals and that includes molds, yeasts, mushrooms, and puffballs.

fungicide—any substance that kills fungi (which includes molds).

HEPA filters (high efficiency particulate air filters)—filters that can remove 99.97% of airborne particles 0.3 µm (micrometers) in diameter. These particles are the most difficult to filter and are the most penetrating to human tissue.

mold—a type of fungi that can grow on various materials in the presence of water and oxygen and causes structural damage, respiratory problems, and foul odors.

remediate—to fix.

spore—a reproductive structure that can give rise to a new individual under proper environmental conditions.

Case Report

Dangerous mold infested the Atlanta Air Traffic Control Center, sickened employees, and caused an outside contractor to pull his employees out of the building because of serious health concerns.

Scopulariopsis, a type of mold, was in the control center spewing spores into the air. Approximately 150 employees had complained of various health problems over a period of time.

The Detroit Metro Air Traffic Control Tower has been dealing with mold problems for three years. The controllers recently filed a lawsuit in Wayne County, MI, Circuit Court alleging that FAA contractors "failed to properly remove mold, provide a work plan for effective removal of mold contamination, have a certified industrial hygienist present during remediation, conduct proper testing including clearance testing, and to advise the FAA of the deficiencies in their efforts to remediate the mold."

http://www.natca.org/mediacenter/Mold.msp

Review Questions

1. Why are molds such a problem?

When mold spores land on a surface with water and oxygen present, they begin to grow and will eventually digest the material. Molds can grow especially well on wet cellulose materials, including paper and paper products, cardboard, ceiling tiles, wood, and wood products. They cause structural damage, create foul odors, and cause respiratory problems. It is impossible to eliminate all sources of mold in a building or home.

2. What are important safety considerations to remember when working with the various methods of remediating mold?

- *Only use a wet vacuum on surfaces that are wet. Using a wet vacuum on porous surfaces may spew mold and spores into the air if insufficient liquid is present.*
- *Thoroughly clean all tanks, hoses, and attachments of vacuums so mold and spores that have stuck to the inside surfaces cannot grow and cause further problems.*
- *Carefully follow instructions on all biocides and cleaning solutions.*
- *Use a HEPA vacuum after materials have been cleaned and dried. Make sure the vacuum and filters are attached tightly so that all the air passes through the filter to the vacuum container.*
- *Dispose of debris in the HEPA vacuum in an impermeable bag.*
- *Building materials that are contaminated with mold should be sealed while in the indoor remediation areas. Cover large items with sheeting and seal with duct tape before disposal.*
- *If you use a biocide, always ventilate the area. If you use fans, make sure you do not blow mold or spores to clean areas.*
- *Never mix chlorine bleach solution with other cleaning solutions that contain ammonia. Highly toxic fumes may be released.*
- *Always use proper personal protective equipment when using a biocide or fungicide.*

3. List as many personal work practices as you can that can protect you from adverse health effects from mold exposure.

- *Wear gloves that extend to the middle of the forearm to protect your skin from irritating mold allergens and harsh cleaning solutions.*
- *Select the gloves based on the type of chemical cleaning solution you are using. For example, if you are using chlorine bleach, use gloves made from natural rubber, neoprene, polyurethane, or PVC. If you are using a mild detergent, ordinary rubber gloves are sufficient protection.*
- *Wear properly fitting goggles or full-face respirator. Do not wear safety goggles with open vent holes for mold work.*
- *Choose respiratory protection based on the level of remediation work. A half mask or full facepiece air-purifying respirator may be used. More protective respirators may be required if other harmful substances such as lead or asbestos are discovered during remediation or demolition.*
- *All respirators for mold work must be certified by NIOSH.*
- *Employers are required to provide proper training for all employees using PPE. The employer must also develop a written respiratory protection program with complete work site procedures.*
- *Personal protective clothing may be reusable or disposable but should not be used repeatedly without laundering. Wearing protective clothing prevents the transfer of molds to street clothing and protects skin from mold and chemical exposures.*
- *Do not eat, drink, use tobacco products, or apply cosmetics in mold remediation environments.*

Noise

Figure 2.56 Headset for ear protection.

Noise-induced hearing loss is one of the most common occupational illnesses. Each year almost 30 million people are exposed to hazardous noise. Ten million of these will develop permanent hearing loss. On the job, noise injuries and hearing loss develop over a long period of time and are often ignored because they have no immediate symptoms. What happens, though, is a gradual loss of hearing, communication, and socialization.

OSHA standards and guidelines specify noise limits, noise monitoring programs, employee medical surveillance, and control options for different levels of noise in the workplace. Successful controls and hearing conservation programs can effectively reduce noise-induced hearing loss, absenteeism, and accidents in the workplace.

Figure 2.57 Worker wearing ear protection.

Health Effects

The health effects of noise depend on how loud the sound is and how long the worker is exposed to it. Sound intensity is measured in decibels (dB). Hearing damage from loud noises has a cumulative effect; hearing loss gets worse as more time goes by. OSHA has guidelines for noise exposure for the maximum amount of time workers can be exposed to continuous high sound levels before hearing damage occurs.

At sounds of greater than 85 dB (decibels) workers are required to use hearing protectors to help prevent hearing loss due to noise exposure. Take a good look at the following chart. The louder the sound, the greater the risk, and the shorter amount of time the worker should work in the noisy environment, even while wearing hearing protectors.

OSHA Guidelines	
Sound Level	**Duration Per Day**
90 dB	8 hours
91.5 dB	6 hours
93 dB	4 hours
94.5 dB	3 hours
96 dB	2 hours
97.5 dB	1½ hours
99 dB	1 hour
102 dB	½ hour
105 dB	¼ hour or less
105+ dB	extreme risk

Table 2.1

Noise-related hearing loss is only one health effect of excessive noise exposure at the workplace. Here are some others:

- Hypertension
- Sleep disturbances
- Changes in the immune system
- Cardiovascular impacts
- Stress and anxiety
- Aggression and anti-social behaviors
- Muscle tension
- Headaches
- Ulcers

Figure 2.57 Sound level meter.

Aside from the physical health effects, there are also significant communication and performance effects in the workplace. Irritability, difficulty concentrating, absenteeism, and accidents result from increased noise exposure.

An effective workplace noise monitoring and control policy reduces many of the adverse health risks associated with noise exposure and also improves workplace productivity.

Occupational Exposure

Construction jobs, such as highway and building construction, concrete work, site excavation, demolition, and carpentry involve high levels of noise. The heavy equipment needed to do those jobs is also a source of noise pollution. Cranes, loaders, dozers, jackhammers, and chipping guns add significant amounts of noise to an already noisy environment.

Standards for Noise Exposure

OSHA has several standards that regulate noise exposure for construction (1926.52), for general industry (1910.95), and for the hearing protection (1926.101) of employees working around noise.

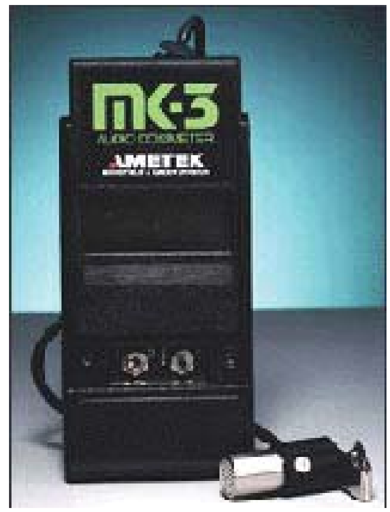


Figure 2.59 Dosimeter

It is not hard to find out if there may be a problem with noise in your workplace. It is as easy as listening to workers talk to each other. Although workers have different hearing abilities, when noise levels are above 80 decibels (dB), people have to speak very loudly. When noise levels are between 85-90 dB, people have to shout, and when levels are greater than 95 dB, people must be close to hear each other at all.

A sound level meter (SLM) is the basic instrument for assessing noise levels. A sound level meter can determine noise levels when a dosimeter (worn on a worker's clothes) is not available, and it can also evaluate hearing protectors.

A dosimeter measures the personal noise dose during the workshift or sampling period. It attaches to a worker's clothing and provides a daylong record of noise exposure.

Occupation Noise Exposure Is Most Frequent Citation for Surfacing Industry
According to OSHA's published citations information for October 2006 through September 2007, occupational noise exposure was the most frequent citation in any category in the surfacing industry. Employers are required to assess noise levels and install engineering controls if levels are exceeded. If controls do not reduce the sound to acceptable levels, hearing protectors must be provided.

http://articles.directorym.net/Whats_OSHA_Doing_In_The_Surfacing_Industry_Five_Things_To_Watch_Out_For_In_Your_Shop-a915148.html

Requirements

According to OSHA standards, if the noise exposure equals an eight-hour time weighted average of 85 decibels on the A-scale (dBA), an employer must have an effective hearing conservation program. For this reason, that 85 dBA level is also called the "action level".

Figure 2.60 Hardhat with hearing protection.

At 90 dBA, all reasonable measures must be taken to reduce the noise exposure. If reasonable engineering and work-practice controls do not sufficiently lower the noise exposure, those controls must be used with personal protective equipment.

A hearing conservation program must be implemented for employees exposed to noise levels above the 85 dBA level. The program must consist of exposure monitoring, audiometric (hearing) monitoring, hearing protection, employee training, and recordkeeping.

Figure 2.61 Noise level measurement.

Baseline audiograms are required within six months of employment and must be performed and evaluated by a professional certified in audiology. Any employee with hearing loss will be fitted with hearing protection; training programs for correct use of the protection are OSHA required.

Work Practices

Figure 2.62 A common site on job sites.

By age 25, the average carpenter has a 50-year-old hearing. That is the conclusion of NIOSH researchers. Hearing loss is one of the top three occupational illnesses in the United States. The most common reason that hearing loss continues even in the presence of hearing protection programs is that workers do not always wear their hearing PPE. If a worker cannot find hearing protection, if the person does not know how to wear it properly, or if the hearing protection choices aren't comfortable, the worker probably won't wear it.

Work with the engineering controls that are used at your workplace to reduce noise levels or your exposure to the damaging noise. Pay attention to training programs that should alert you to the dangers of noise exposure and use the correct hearing protection for your job. Make sure that your PPE fits properly for maximum benefits.

By paying attention to the safety strategies that control your noise exposures, you can prevent the hearing loss that could easily become permanent.

Case Report

Included in numerous health and safety violations given to a Houston company was a serious citation of $5,000 for subjecting employees to sound levels exceeding those listed in OSHA's guidelines. A serious violation is defined as one which could cause physical harm. "Administrative and/or engineering controls were not utilized to reduce noise levels," said John Lawson, OSHA's area director at the Houston north area office. "Employee exposure to high noise levels in the workplace is preventable."

http://www.healthandsafety.co.uk/4-25-2003-twoOSHA.html

Definitions

acoustic trauma—a single incident that produces an immediate hearing loss. Welding sprays to the eardrum, a blow to the ear, or blast noise can result in acoustic trauma.

action level—the sound level at which OSHA requires implementing an effective hearing conservation program. OSHA defines this level as 85 dBA (decibels on the A-scale).

audiologist—one who specializes in the study of hearing.

audiogram—a graphic record of hearing ability.

decibel (dB)—the unit used to express sound intensity.

dosimeter—an instrument carried by a worker for measuring noise exposure that also stores the measurements and calculates the noise exposures in terms of sound duration and time-weighted averages.

hazardous noise—any sound capable of causing permanent hearing loss.

noise—any unwanted sound.

permissible exposure limits (PELs)—the exposure level to which workers may be exposed day after day for a lifetime. For noise exposure, the PEL is 90 dBA.

sound level meter—an instrument for measuring sound levels.

time-weighted average (TWA)—an average calculated by using the constant noise level during an eight-hour period.

Review Questions

1. What is the OSHA standard for noise level exposure?

At sounds of greater than 85 dB (decibels), workers are required to use hearing protectors to help prevent hearing loss due to noise exposure. Engineering controls should already be in place.

2. List some health effects of high levels of noise exposure.

- *Temporary or permanent hearing loss*
- *Hypertension*
- *Sleep disturbances*
- *Changes in the immune system*
- *Cardiovascular impacts*
- *Stress and anxiety*
- *Aggression and antisocial behaviors*
- *Muscle tension*
- *Headaches*
- *Ulcer*

3. What is the most important work practice you can do to prevent permanent hearing loss?

Wearing personal protective equipment such as earpieces and headsets.

Silica

Silica is a serious health threat to the nearly 2 million construction workers who work in high-risk jobs such as abrasive blasting, foundry work, stonecutting, rock drilling, quarry work and tunneling.

Figure 2.63 Cutting cement blocks releases silica dust. Where is his respirator?

Crystalline silica is a human lung carcinogen. Breathing silica dust can cause respiratory illnesses, such as silicosis, which can be fatal.

Crystalline silica is a basic component of soil, sand, granite, sandstone, flint and slate, and some coal and metallic ores. Quartz is the most common form of crystalline silica. Cristobalite and tridymite are two other forms. All three forms are released when you grind, cut, chip, or drill materials that contain crystalline silica. All three forms can be breathed into your lungs.

Figure 2.64 Quartz

Figure 2.65 Ground, respirable silica

Occupational Exposure

Workers who cut, drill, grind, or abrasively blast the materials that contain silica are at high risk of silica dust disease or silicosis. The most severe exposure risks are in abrasive blasting with sand to remove paint and rust from bridges, tanks, and concrete structures. Jackhammering, rock drilling, brick and concrete block cutting and sawing, hauling concrete, demolition of masonry, trenching, excavation, and tile and grout jobs are all high-risk work for silica exposure.

Figure 2.66 Drilling dry concrete pavement generates moderate amounts of dust

Health Effects

The respirable silica dust enters the lungs, and lung tissue develops nodules and scarring around the trapped silica particles. This lung condition is called silicosis. The nodules grow larger, breathing becomes more and more difficult and death may occur. There is no cure for silicosis. During the progression of the disease, the victim is even more susceptible for other lung conditions such as tuberculosis.

Figure 2.67 Chest X-ray of a 52 year old worker with silicosis.

Symptoms for silicosis, also known as Grinder's disease or Potter's rot, are:

- Shortness of breath.
- Fever.
- Bluish skin.
- Difficulty breathing.
- Chest pain.
- Fatigue.
- Respiratory failure.

There are three types of silicosis:

- **Chronic or classic silicosis**—the most common type, occurs after 15-20 years of moderate to low exposure. Symptoms may or may not be obvious, and you need to have a chest X-ray to find out if there has been any lung damage.
- **Accelerated silicosis**—occurs after 5-10 years of high exposure. Symptoms are the same as for chronic silicosis, but less time is needed for the disease to progress.
- **Acute silicosis**—occurs after only a few months to two years of very high exposure to crystalline silica. Symptoms are disabling shortness of breath, weakness, weight loss, and death.

Figure 2.68 Informational OSHA sign.

All evidence suggests that crystalline silica is an occupational carcinogen.

The permissible exposure limit for silica is calculated by the following formula:

PEL = 10 mg/m3 □ % silica + 2 = millions of particles per cubic foot (mppcf)

Note that the PEL for silica depends on the amount of free silica present at the work site.

Case Report

A Birmingham company was cited and fined $60,000 for five safety and health violations. OSHA also plans to levy a $50,000 fine for repeat violations for employee exposure to excessive levels of silica. The plant uses silica to produce ductile iron castings.

http://www.al.com/business/index.ssf/2008/02/osha_cites_citation_corp_for_shtml

Control

Approximately 300 deaths occur each year from silicosis. Prevention and control strategies have kept this number from going up, but silicosis deaths are completely preventable. Read the following control strategies that can help you avoid a fatal lung disease caused by silica exposure. Were you aware of all the strategies?

WARNING!
Exposure to respirable crystalline silica dust during construction activities can cause serious or fatal respiratory disease.

- Know which jobs generate silica dust and plan ahead to eliminate the risks.
- Use containment methods such as wet drilling or wet sawing to control silica hazards.
- Keep dust control systems inspected and maintained in good working order.
- Conduct regular air monitoring to measure silica exposure and provide adequate protection.
- Post warning signs around work areas contaminated with respirable silica.
- Training provides valuable information on your risks and ways to eliminate or reduce them. Pay attention to all updates on PELs and medical surveillance.

Case Report

OSHA cited and fined a New York contractor and four subcontractors $176,620 for three alleged willful violations and 29 serious violations of OSHA standards. The company, working on restorations of dormitories, was repointing the brick exterior, and employees were working from improperly erected scaffolding that had been enclosed in sheeting. The enclosure increased the concentration of silica dust coming from the brick grinding.

The company did not conduct medical evaluations on employees wearing respirators, did not perform respirator fit testing, did not train employees in respirator use, did not provide the appropriate respirators, and did not inform employees of the right to access their exposure records.

http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=NEWS_RELEASES&p_id=191

Work Practices

Controls can help reduce your health risk from silica exposure. Being aware of and practicing good work habits can lower your risks even more. Do you and your coworkers practice all of the following work habits when working with materials that produce silica? Remember, silicosis deaths are completely preventable.

- Use half or full-face air-purifying respirators with appropriate filters if concentrations are at or above PELs.
- Have baseline lung function exams at your initial physical exam.
- Keep your annual lung exam records for 40 years.
- Use exhaust ventilation, blasting cabinets, and water sprays when feasible.
- Wear a NIOSH-certified respirator and make sure it fits tightly. Do not wear a beard or mustache that would prevent a good seal.
- Avoid smoking. It puts you at even more risk of developing lung disease from silica exposure.
- Do not eat, drink, smoke, or apply cosmetics in areas where crystalline silica dust is present. Wash before you do any of these activities.
- Wear disposable clothes or wash your clothes and shower if facilities are available so you do not take silica dust from the work site.

Case Report

OSHA cited the O.S. Kelly Company for “alleged serious, repeat, and failure-to-abate violations of federal workplace safety standards" for $114,600. An investigation found employee overexposure to crystalline silica even after being cited previously for having exposures well over the permissible level.

Crystalline silica is a known respiratory threat. It causes silicosis, a debilitating and sometimes fatal lung disease.

OSHA issued three serious violations for hazards in a confined space entry, personal protective equipment deficiencies, and failure to abate.

http://www.springfieldnewssun.com/hp/content/oh/story/news/local/2008/07/29/sns073008oskelly.html

Definitions

crystalline—solid material composed of regularly repeating particles that form defined patterns.

Grinder’s disease or Potter’s rot—other names for silicosis.

permissible exposure limits (PELs)—airborne concentrations of silica to which workers may be exposed day after day for a lifetime. They are measured in parts per million (ppm) or milligrams per cubic meter (mg/m3). The lower the PEL, the more dangerous the chemical.

personal protective equipment (PPE)—equipment used to prevent worker exposure to silica. This includes respirators, hoods, gloves, and goggles.

quartz—the most common type of crystalline silica.

silica—The common name for silicon dioxide.

silica flour—finely ground quartz; typically 98 person of the particles are below 55 microns in diameter.

silica sand—a common term in industry, generally used to mean a sand that has a very high percentage of silica, usually in the form of quartz.

silicosis—a serious, sometimes fatal, incurable, lung disease caused by inhaling silica particles.

Review Questions

1. What is silicosis and what are the symptoms and health effect or outcome of the disease?

Silicosis is a serious, sometimes fatal, incurable, lung disease caused by inhaling silica particles. The respirable silica dust enters the lungs, and lung tissue develops nodules and scarring around the trapped silica particles. The nodules grow larger. During the progression of the disease, the victim is even more susceptible for other lung conditions, such as tuberculosis.

Symptoms for silicosis, also known as Grinder's disease or Potter's rot, are:

- *Shortness of breath.*
- *Fever.*
- *Bluish skin.*
- *Difficulty breathing.*
- *Chest pain.*
- *Fatigue.*
- *Respiratory failure.*

Health effect or outcome:

Breathing becomes more and more difficult and death may occur. There is no cure for silicosis. During the progression of the disease, the victim is even more susceptible for other lung conditions such as tuberculosis.

2. What engineering and environment controls can reduce or eliminate the health hazard of silicosis?

- *Know which jobs generate silica dust and plan ahead to eliminate the risks.*
- *Use containment methods such as wet drilling or wet sawing to control silica hazards.*
- *Keep dust control systems inspected and maintained in good working order.*
- *Conduct regular air monitoring to measure silica exposure and provide adequate protection.*
- *Post warning signs around work areas contaminated with respirable silica.*
- *Training provides valuable information on your risks and ways to eliminate or reduce them. Pay attention to all updates on PELs and medical surveillance*

3. What is meant by the OSHA warning, "It's not just dust—it's silica"?

Some dusts on job sites are "nuisance dusts"—those dusts that contain less than 1 percent quartz and have few adverse health effects. Silica dust may look like any other kind of dust, but silica dust is extremely harmful and has serious adverse health effects. Silicosis can be fatal and there is no cure, even if lung damage is caught early.

4. List several work practices that can reduce or eliminate the risks of working with silica?

- *Use half or full-face air-purifying respirators with appropriate filters if concentrations are at or above PELs.*
- *Have baseline lung function exams at your initial physical exam.*
- *Keep your annual lung exam records for 40 years.*
- *Use exhaust ventilation, blasting cabinets, and water sprays when feasible.*
- *Wear a NIOSH-certified respirator and make sure it fits tightly. Do not wear a beard or mustache that would prevent a good seal.*
- *Avoid smoking, which puts you at even more risk of developing lung disease from silica exposure.*
- *Do not eat, drink, smoke, or apply cosmetics in areas where crystalline silica dust is present. Wash before you do any of these activities.*
- *Wear disposable clothes or wash your clothes and shower if facilities are available so you do not take silica dust from the work site.*

Other Resources

IUOE National Training Fund National HAZMAT Program Brochures
http://www.iuoeiettc.org/Print%20Publications.htm

NIOSH Pocket Guide to Chemical Hazards
http://www.cdc.gov/niosh/npg/

OSHA Fact Sheet—Compliance Assistance
http://www.osha.gov/OshDoc/data_General_Facts/compliance-assistance-factsheet.pdf

OSHA—Fatal Facts Sheet
http://www.osha.gov/OshDoc/toc_FatalFacts.html

OSHA—Imminent Danger Fact Sheet
http://www.osha.gov/OshDoc/data_General_Facts/factsheet-imminent-danger.pdf

OSHA—Job Safety and Health Fact Sheet
http://www.osha.gov/OshDoc/data_General_Facts/jobsafetyandhealth-factsheet.pdf

OSHA's Role When A Worker Dies on the Job
http://www.osha.gov/OshDoc/data_General_Facts/factsheet-death_on_the_job.pdf

AIR MONITORING

Environmental Protection Agency—Air Pollution Monitoring
http://www.epa.gov/air/oaqps/montring.html

OSHA Technical Manual—Personal Sampling for Air Contaminants
http://www.osha.gov/dts/osta/otm/otm_ii/otm_ii_1.html

ASBESTOS

Agency for Toxic Substances and Disease Registry—Asbestos
http://www.atsdr.cdc.gov/tfacts61.html#bookmark05

Agency for Toxic Substances and Disease Registry—Health Effects of Asbestos
http://www.atsdr.cdc.gov/asbestos/asbestos/health_effects/

Agency for Toxic Substances and Disease Registry—Types of Asbestos Exposure
http://www.atsdr.cdc.gov/asbestos/asbestos/types_of_exposure/

Centers for Disease Control—Asbestos Resources
http://www.cdc.gov/health/asbestos.htm

National Cancer Institute—Asbestos Exposure: Questions and Answers
http://www.cancer.gov/cancertopics/factsheet/Risk/asbestos

National Institute of Occupational Safety and Health—Asbestos
http://www.cdc.gov/niosh/topics/asbestos/

OSHA Fact Sheet—Asbestos
http://www.osha.gov/OshDoc/data_AsbestosFacts/asbestos-factsheet.pdf

OSHA—Protecting Workers from Asbestos Hazards
http://www.osha.gov/OshDoc/data_Hurricane_Facts/AsbestosHazards.pdf

OSHA Safety and Health Topics—Asbestos
http://www.osha.gov/SLTC/asbestos/index.html

OSHA Self-inspection Checklist—Asbestos
http://www.osha.gov/SLTC/asbestos/checklist.html

ASPHALT FUMES

National Roofers Constructing Association—Special Report: Asphalt Fumes
http://www.nrca.net/rp/about/insurance/specrpt/fumes02082001.aspx

National Roofers Constructing Association—Ten Steps Roofing Contractors Can Take to Manage Exposures Resulting from Emissions from Roofing Products
http://www.nrca.net/rp/about/insurance/specrpt/fumes02082001.aspx

NIOSH—Health Effects of Occupational Exposure to Asphalt
http://www.cdc.gov/niosh/01-110pd.html

NIOSH—Reducing Worker Exposure to Asphalt Fumes from Roofing Kettles
http://www.cdc.gov/niosh/docs/wp-solutions/2007-115/

NIOSH Safety and Health Topic: Asphalt Fumes
http://www.cdc.gov/niosh/topics/asphalt/

OSHA—Asphalt Fumes: Possible Solutions
http://www.osha.gov/SLTC/asphaltfumes/solutions.html

OSHA Safety and Health Topics—Asphalt Fumes
http://www.osha.gov/SLTC/asphaltfumes/index.html

Reduction of Asphalt Fumes in Roofing Kettles
http://pubs.acs.org/cgi-bin/abstract.cgi/esthag/2000/34/i12/abs/es9913075.html

The Facts About Roofing Asphalt Fumes and Health
http://www.owenscorning.com/trumbull/resources/downloads/factsaboutasphalt.pdf

COLD STRESS

Heat Stress/Cold Stress Poster
http://www.personnelconcepts.com/product/heat-stress-cold-poster/FD-HSCS-L/778/

National Weather Service Wind Chill Temperature Indicator
http://www.weather.gov/os/windchill/images/wind-chill-brochure.pdf

OSHA—Emergency Preparedness and Response: Cold Stress
http://www.osha.gov/SLTC/emergencypreparedness/guides/cold.html

OSHA Publishes Cold Stress Card
http://www.ohsonline.com/articles/57254/

U.S. Office of Consumer Affairs—Special Report on Cold Stress (Hypothermia) and Heat Stress
http://www.hoptechno.com/book41.htm

DIESEL EXHAUST

OSHA Hazards and Solutions—Diesel Exhaust
http://www.osha.gov/SLTC/dieselexhaust/recognition.html

OSHA Safety and Health Topics—Diesel Exhaust
http://www.osha.gov/SLTC/dieselexhaust/index.html

Partial List of Chemicals Associated with Diesel Exhaust
http://www.osha.gov/SLTC/dieselexhaust/chemical.html

DUST

OSHA—Dust and Its Control
http://www.osha.gov/SLTC/silicacrystalline/dust/chapter_1.html

OSHA Hazard Alert—Combustible Dust Explosions
http://www.osha.gov/OshDoc/data_General_Facts/OSHAcombustibledust.pdf

HEAT STRESS

OSHA Fact Sheet—Working Outdoors in Warm Weather
http://www.osha.gov/OshDoc/data_Hurricane_Facts/working_outdoors.pdf

OSHA Fact Sheet—Heat Stress
www.osha.gov/OshDoc/data_Hurricane_Facts/heat_stress.pdf

OSHA QuickCard—Heat Stress
www.osha.gov/Publications/osha3154.pdf

OSHA Card—Protecting Yourself in the Sun
www.osha.gov/Publications/osha3166.pdf

OSHA Safety and Health Topics—Heat Stress
http://www.osha.gov/SLTC/heatstress/index.html

U.S. Office of Consumer Affairs—Special Report on Cold Stress (Hypothermia) and Heat Stress
http://www.hoptechno.com/book41.htm

LEAD

OSHA—Lead Exposure in Construction
http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=FACT_SHEETS&p_id=161

OSHA—Lead in Construction: Engineering Controls
http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=FACT_SHEETS&p_id=162#2%20IN%20A%20SERIES%20OF%206)

OSHA—Lead Exposure in Construction: Housekeeping and Personal Hygiene Practices
http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=FACT_SHEETS&p_id=163

OSHA—Lead Exposure in Construction: Protective Clothing
http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=FACT_SHEETSid_id=164

OSHA Fact Sheet—Lead
http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=FACT_SHEETS&p_id=161

OSHA—Lead in Construction: Protecting Workers from Lead Hazards
http://www.osha.gov/OshDoc/data_Hurricane_Facts/LeadHazards.pdf

OSHA—Lead Standards
http://www.osha.gov/SLTC/lead/standards.html

OSHA Safety and Health Topics—Lead
http://www.osha.gov/SLTC/lead/index.html

MOLD

Centers for Disease Control—Facts about Mold and Dampness
http://www.cdc.gov/mold/dampness_facts.htm#health

Centers for Disease Control—Where Can I Find Additional Information About Mold?
http://www.cdc.gov/nceh/airpollution/mold/moldfacts.htm

OSHA—A Brief Guide to Mold in the Workplace: Safety and Health Information Bulletin
http://www.osha.gov/dts/shib/shib101003.html

OSHA Fact Sheet
http://www.osha.gov/OshDoc/data_Hurricane_Facts/Bulletin3.pdf

OSHA Fact Sheet—Mold
http://www.osha.gov/OshDoc/data_Hurricane_Facts/mold_fact.pdf

OSHA—Preventing Mold-related Problems in the Indoor Workplace
http://www.osha.gov/Publications/preventing_mold.pdf

OSHA Safety and Health Topics—Mold
http://www.osha.gov/SLTC/molds/index.html

NOISE

National Hearing Conservation Association
http://www.osha.gov/dcsp/alliances/nhca/nhca.html

NIOSH--Noise and Hearing Loss Prevention
http://www.cdc.gov/niosh/topics/noise/

OSHA—Noise and Hearing Conservation
http://www.osha.gov/dts/osta/otm/noise/standards.html

OSHA—Hearing and Noise Conservation: Controls
http://www.osha.gov/SLTC/noisehearingconservation/hazards_solutions.html

OSHA Safety and Health Topics—Noise and Hearing Conservation
http://www.osha.gov/SLTC/noisehearingconservation/index.html

SILICA

NIOSH—Construction Workers: It's Not Just Dust
http://www.cdc.gov/niosh/pdfs/1997-101.pdf

NIOSH Hazard Review—Health Effects of Occupational Exposure to Respirable Crystalline Silica
http://www.cdc.gov/niosh/02-129A.html

NIOSH Safety and Health Topic—Silica
http://www.cdc.gov/niosh/topics/silica/default.html

OSHA—Crystalline Silica Exposure: Health Hazard Information for Construction Employees
http://www.osha.gov/Publications/3177-2002-English.html

OSHA—Crystalline Silica Exposures in Construction
http://www.osha.gov/SLTC/silicacrystalline/roznowskiei/exposure.html

OSHA Fact Sheet—Silica
http://www.osha.gov/OshDoc/data_General_Facts/crystalline-factsheet.pdf

OSHA Safety and Health Topics—Crystalline Silica
http://www.osha.gov/SLTC/silicacrystalline/index.html

OSHA Silica Advisor eTool
http://www.osha.gov/SLTC/etools/silica/index.html

OSHA—Silica and Silicosis
www.osha.gov/.../silica/silicosis/silicosis.html

Preventing Silicosis and Deaths in Construction Workers
http://www.cdc.gov/niosh/consilic.html

Instructor Lesson Plan

Hazard Communication

Lesson Plan – CIO 269-304

Key Concepts

- Common chemicals used in construction.
- Employer responsibilities under the Hazard Communication standard.
- OSHA requirements for labeling chemical containers.
- Safety data sheets (SDS).
- Department of Transportation (DOT) placards.
- National Fire Protection Association (NFPA) labeling system.

Presentation and Materials

- Common chemicals used in construction.
- Employer responsibilities under the Hazard Communication standard.
- OSHA requirements for labeling chemical containers.
- Safety data sheets (SDS).
- Department of Transportation (DOT) placards.
- National Fire Protection Association (NFPA) labeling system.

Standards

- 29 CFR 1926.59—Construction Industry
- 29 CFR 19.10.1200—General Industry

Module 3

Hazard Communication

OSHA: 29 CFR 1910.1200 and OSHA: 29 CFR 1926.59 – CIO 269-304

Lesson Outline

Common Chemicals Used in Construction
Acids, Bases, and Alkalis
Adhesives and Sealants
Cleaners
Concrete
Fuels
Solvents
Treated Lumber

Hazard Communication Standard
Written Hazard Communication Program
Employee Information and Training
Labeled Products
SDS

SDS Content
Identification
Hazard(s) identification
Composition/information on ingredients
First aid measures
Firefighting measures
Accidental release measures
Handling and storage
Exposure control/personal protection
Physical and chemical properties
Stability and reactivity
Toxicological information
Ecological information
Disposal considerations
Transport information
Regulatory information
Other information

NFPA Labels

DOT Placarding System
HAZMAT Placards
Identification Numbers

GHS and REACH

SDS Activity

Glossary

Review and Discussion Questions

Other Resources

Overview

Since you probably use common chemical products such as adhesives, cleaners, and fuels at home, you might think nothing of using them while working at the job site. However, improper or prolonged use can be hazardous to your health. In this chapter you will learn how the OSHA hazard communication standard (HazCom), safety data sheets (SDS), National Fire Protection Association (NFPA) labels, and Department of Transportation (DOT) placards help inform you about any potential chemical hazards in your work area. Then you'll know what steps to take to prevent overexposure or other dangerous chemical situations.

Objectives

After completing this chapter, you should be able to:

Know

- Describe the employer's responsibilities under the hazard communication standard.
- Identify the OSHA requirements for labeling chemical containers.
- Name the types of information required of a SDS.
- Recognize symbols found on DOT placards.

Apply

- Give an example of a common chemical used in construction.
- Retrieve information from an SDS.
- Demonstrate use of the NFPA labeling system to determine the hazards of a product.

Common Chemicals Used in Construction

Many hazardous chemicals are used in construction. In your work as an operating engineer, you might be exposed to these chemicals. Here are some common categories of hazardous chemicals found on construction sites:

- Acids, bases, and alkalis
- Adhesives and sealants
- Cleaners
- Concrete
- Fuels
- Solvents
- Treated lumber

Acids, Bases, and Alkalis

Figure 3.1 Hazard warning on a bottle of acid.

Acids (corrosives) and bases (caustics) can be in the form of gases, liquids, or solids. Common acids include sulfuric acid, hydrochloric acid, and nitric acid. Commonly used bases are sodium hydroxide (lye) and potassium hydroxide. Both acids and bases can damage whatever they touch—particularly your skin and eyes. The extent of damage depends upon the strength of the chemical, length of contact, and actions taken.

Different acids react differently. For example, when sulfuric acid touches your skin, it reacts with the moisture in your skin, produces heat, and burns your skin. In contrast, if hydrofluoric acid spills on your skin, you might not even notice it right away. However, hours later the hydrofluoric acid will have worked its way though your skin, causing deep burns in your muscle tissues. These burns are painful and take a long time to heal. Serious burns can even cause death. If acids in a gas or vapor state are inhaled, they can react with the moisture in your nose and throat, causing irritation or tissue damage. Nitric acid vapors, for example, can quickly penetrate seriously damage your lungs.

In general, bases feel slippery like soap. Concentrated liquid bases dissolve tissue easily and can cause severe skin damage on contact. Concentrated caustic gases like ammonia can damage the skin, eyes, nose, mouth, and lungs. Dry powder forms of bases can cause damage as well if you absorb or inhale them because the powder can react with the moisture in your skin, eyes, and respiratory tract.
Wet or dry cement and mortar are alkali compounds. As dust and powder, they can damage the skin and eyes when they react with the moisture in your body. Cement and mortar can also cause allergic reactions in people who become sensitive to them.

General Rules When Working with Acids and Bases

- Know the chemicals and how concentrated they are.
- Use personal protective equipment as required.
- In case of skin or eye contact, flush with cool water for at least 15 minutes. Do not rub skin or eyes.
- When mixing acids and water, always add the acid to the water to prevent splatter.
- Keep acids and bases apart. They often react violently when mixed. Store them separately and clean up spills promptly.

Adhesives and Sealants

If you use adhesives and sealants often at work and home, then you like so many others probably take the warning labels lightly. All adhesives and sealants have some type of hazard warning on the label—and for good reason. They are toxic either because of the chemically reactive ingredients or because of the solvent base that permits them to be easily applied.

Figure 3.2 Common caulk you might use.

For example, epoxies sensitize skin and irritate the respiratory tract. Overexposure to epoxies can cause dizziness, drowsiness, nausea, and vomiting. Extreme or prolonged exposure can damage your kidneys and liver. Similarly, flooring adhesives made with acrylics irritate the skin and can cause nausea, vomiting, headache, weakness, asphyxia, and death. Other sealants made with coal tar derivatives are suspected carcinogens. In general, avoid skin contact and prolonged breathing of vapors.

Adhesives and sealants that contain solvents are also sometimes flammable. Even those that aren't, such as caulking or wood glue, can irritate eyes and skin. Avoid eye and skin contact when working with any glue. If the label says that the adhesive is flammable, be sure to use and store it away from any ignition sources.

Cleaners

Cleaners can contain a number of ingredients that can be irritating or harmful if they are swallowed, inhaled, or are in contact with your skin. Like adhesives, some cleaners are flammable. Because there are so many cleaning materials in use at construction sites, there are many possible signs and symptoms of overexposure. Therefore, it is particularly important for you to read a product's SDS to learn its specific signs and symptoms.

Do not mix cleaners together unless told to do so by an expert. When chemicals such as bleach and ammonia or bleach and a drain cleaner are mixed, they produce chlorine gas. Chlorine gas is toxic and potentially explosive!

Some chemicals can become deadly when mixed. Do not mix cleaning chemicals together unless told to do so by an expert!

Even if you use industrial cleaners at home, don't underestimate the hazards they pose. Protect yourself with the following work practices:

- Read labels and follow recommended precautions.
- Wear gloves and eye protection.
- Wash hands and face thoroughly before eating, drinking, or smoking.
- Do not inhale vapors or mists.
- Do not eat, drink, or smoke where vapors, mists, or dust are in the air.
-

Concrete

Cement and lime in concrete can cause adverse health effects. Lime irritates the skin. Moist cement can cause the skin to become hard, dry, and thick, resulting in cracks and ulcers. Cement dust irritates the eyes, nose, and mouth. Use proper personal hygiene and appropriate PPE to protect yourself from cement's irritating alkaline effects.

Cured concrete is a respiratory hazard when it is cut. Always try to use water to control the generation of dust. Also wear appropriate respiratory protection to safeguard your lungs.

Fuels

The primary hazard posed by fuels is fire. 29 CFR 1910.1200 defines a flammable liquid as a liquid having a flash point of not more than 93C (199.4F) Excessive skin contact with fuels can result in dermatitis, or inflammation of the skin. Over a long period fuel can enter your body through your skin and possibly build up in your body. Excessive inhalation of fuels can affect your nervous system and aggravate existing respiratory disease. Ingestion of fuels may cause poisoning and possible lung damage if aspirated into the lungs when ingested. Leukemia is a potential side effect of chronic exposure to fuels.

Figure 3.3 Gasoline is flammable and an eye and mucous membrane irritant. It can affect your central nervous system, and it can be fatal if swallowed. Long-term exposure can affect specific organs or cause blood disease including anemia and leukemia.

Protect yourself from fuels by reading the labels and following the recommended precautions. Wear glove and eye protection. Avoid inhaling vapors and mists. Wash your hands and face before eating, drinking, or smoking. SDS provide specific first aid procedures, but in general, if fuel gets into your eyes, flush with clean running water for at least 15 minutes. Then seek medical attention. If fuel gets on your skin, wash the area in contact.

Solvents

Solvents are substances that can dissolve another substance. Cleaners, degreasers, and thinners are the most commonly used solvents in construction. Solvents can be aqueous (water-based) or organic (carbon-containing). Excessive exposure to water-based solvents such as acids, alkalis, and detergents can result in dermatitis, throat irritation, or bronchitis. Acetone, benzene, mineral spirits, toluene, trichloroethylene, and turpentine are examples of organic solvents.

Organic solvents can cause more serious health effects depending on the solvent, the exposure level, and your body's sensitivity to the solvent. Organic solvents affect the central nervous system by acting as depressants or anesthetics. Effects range from dizziness and headaches to respiratory arrest and death. In addition to nose, throat, eye, and lung irritation, some organic solvents can damage your liver, blood, kidneys, and digestive system.

Protect yourself from solvent hazards with the following work practices:

- Know what chemicals are being used.
- Wear appropriate PPE.
- Ensure work area has plenty of fresh air.
- Avoid skin contact with solvents.
- Wash thoroughly if skin contacts the solvent.
- Flush eyes with running water for at least 15 minutes if a solvent splashes into your eyes, and get medical help.

Treated Lumber

Figuer 3.4 CCA-treated lumber stockpiles may be used until exhausted.

The pressure treatment process for lumber forces chemicals deeply into the wood. The chemicals remain in the wood for a long time to protect the lumber from decay and insect attack. From the 1940s through 2003, the majority of the wood used in outdoor residential settings was chromated copper arsenate (CCA) treated wood.
The CCA treatment process uses inorganic arsenic, copper, zinc, a pesticide, or a combination of these. The arsenic can be released from the wood when it is burned, sawed, or sanded; when it comes in contact with acid such as in deck washes or acid rain; and merely when there is direct skin contact.

As of Dec. 31, 2003, the pressure-treated wood industry discontinued the use of CCA as the primary wood preservative used for most residential and general consumer construction, allowing any existing CCA-treated stockpiles to be used until exhausted. However, there are several arsenic-free wood pressure treatment alternatives to CCA on the market, including ACQ, Borates, Copper Azole, Cyproconazole, and Propiconazole. They rely heavily on copper as the primary biocide with a range of co-biocides. Studies indicate that these alternatives do release measurable quantities of copper and co-biocides into the environment, but these are generally less toxic to people than arsenic.

Treated lumber can pose health hazards if not handled properly. When working with lumber, avoid inhalation of sawdust. Wear a dust mask when cutting, routing, or sanding. Work outdoors whenever possible to keep sawdust from accumulating indoors. Keep bystanders, children, and pets from walking in the collected sawdust. Use gloves when handling freshly treated lumber and especially the sawdust from freshly treated wood. Do not burn pressure-treated scraps because the chemicals may become part of the smoke and ashes. Do not use treated wood where the wood will come in direct contact with food or public drinking water sources.

Hazard Communication Standard

The chemical descriptions in the previous section are only a general overview of typical hazardous substances used in construction. The examples used here may not be the same as you use on the job site. That is why it is important for you to be familiar with the Occupational Safety and Health Administration (OSHA) Hazard Communication standard, your employer's written hazard communication program, product labels and markings and the SDS for each product you use—before the first time you use it.

OSHA implemented the Hazard Communication (HazCom) standard for both the general industry (29 CFR 1910.1200) and the construction industry (29 CFR 1926.59).The construction industry HazCom standard was adopted from the general industry HazCom standard, therefore, the full text of the standard will be found in general industry code of federal regulations. These two HazCom standards are exactly the same. The purpose of the HazCom Standard is to ensure that the hazards of all chemicals produced or imported are evaluated, and that information concerning their hazards is transmitted to employers and employees. require hazardous chemical manufacturers to inform employers about a product's hazards. In turn, employers must inform all workers who will use or come in contact with the chemical about its hazards. The standard applies to any chemical known to be present in the workplace that you might be exposed to under normal conditions or in an emergency.

The HazCom standard requires manufacturers and chemical importers to assess the hazards of chemicals that they produce or import and to convey chemical hazard information to employers by the means of:

- Container labels.
- Additional posters, placards, or warnings.
- Material safety data sheets.

Employers are to use this information to inform and train you and design and implement employee protection programs. Specifically, employers are required to:

- Have a written HazCom program available for your review.
- Use labeled products.
- Obtain and provide an SDS on all products.
- Provide training and information for employees.

In addition, the HazCom standard requires distributors to transmit the required information to employers.

Written Hazard Communication Program

Employers and/or contractors must develop, implement, and maintain a written hazard communication program. This written program must be made available upon request to you, your representatives, and OSHA. Often during construction there is more than one employer working on the site at the same time. In that case all employers must provide information to one another about the hazardous chemicals they are using. This sharing of information helps prevent worker exposure to chemical hazards from another employer.

Figure 3.5 Workers must have access to written hazard communication programs.

Written programs must be available at the job site and must:

- List the hazardous chemicals on the job site.
- Explain how the employer will inform you of hazards associated with non-routine tasks involving hazardous chemicals.
- Explain labels and other forms of warning used by the employer.
- Explain how the employer will provide safety data sheets to workers.
- Describe the training the employer will use to teach you about hazardous chemicals.

At multiple employer sites written hazard communication programs must:

- Explain how SDS will be provided to other employers.
- List the methods employers will use to inform other employers of measures taken to protect workers during normal operating conditions and in foreseeable emergencies.
- Explain how employers will inform other employers of the labeling systems being used.

If workers must travel between workplaces during a work shift, i.e., their work is carried out at more than one geographical location, the written hazard communication program may be kept at the primary workplace facility.

Case Study
OSHA cited and fined a plastics company in Illinois $361,000 for violations which claimed the lives of five workers and seriously injured three others. Among the 45 serious violations of safety and health regulations were citations for insufficient worker training, insufficient training for emergency response, failure to maintain fire protection equipment, and inadequate inspections and tests of equipment used in processes involving highly hazardous chemicals.

http://safety.blr.com/safety_information/company_fined_explosion_hazcom.htm

Employee Information and Training

The HazCom standard also requires the employer to train and inform you of the hazardous chemicals used on the job. The employer must provide training so you will be aware of the specific chemicals used on the job, know the safety issues and health effects of those chemicals, and be able to protect yourself.

Training must cover:

- Requirements of the OSHA HazCom regulation.
- Areas where hazardous chemicals are used.
- The location and availability of the written HazCom program.
- The list of hazardous chemicals used and SDS for all hazardous chemicals on the job site.
- Methods used to detect the presence or release of hazardous chemicals into the work area.
- How these chemicals might affect your safety and health.
- Ways to protect you from exposure to chemicals through work practices, PPE, and emergency procedures.

Anatomy of a GHS Label

All labels will be required to have pictograms, a signal word, hazard and precautionary statements, the product identifier, and supplier identification.

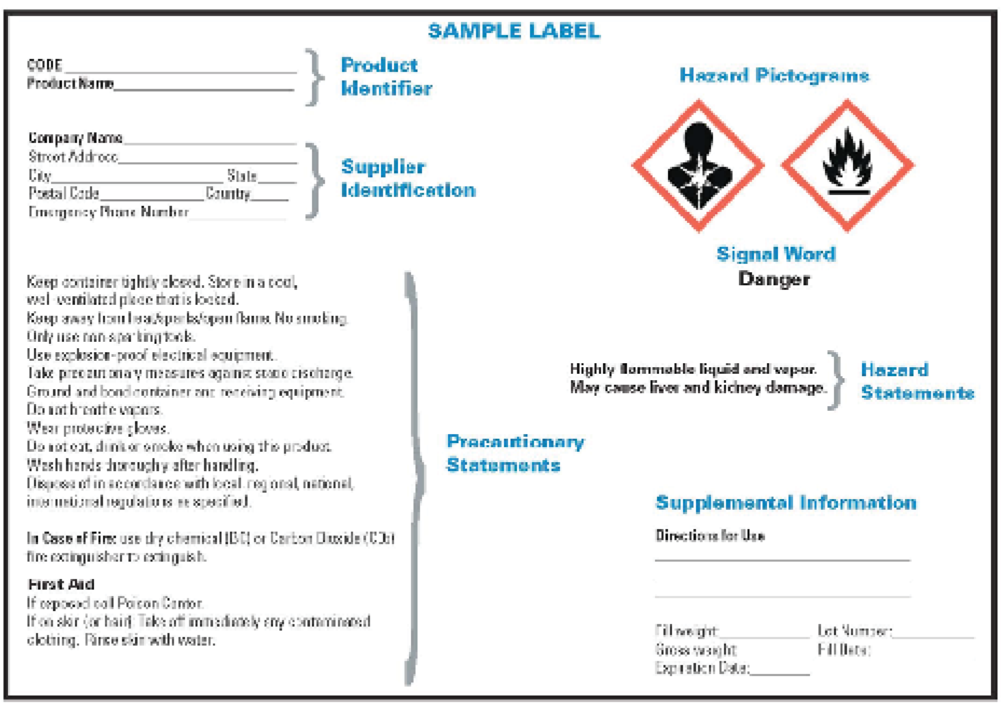


Figure 3.6

SDS

The SDS is a detailed information bulletin prepared by the manufacturer or importer of a chemical that describes the physical and chemical properties, physical and health hazards, routes of exposure, precautions for safe handling and use, emergency and first aid procedures, and control measures. Chemical manufacturers and importers must develop an SDS for each hazardous chemical they produce or import, and must provide the SDS automatically at the time of the initial shipment of a hazardous chemical to a downstream distributor or user. Distributors also must ensure that downstream employers are similarly provided an SDS.

Each SDS must be in English and include information regarding the specific chemical identity of the hazardous chemical(s) involved and the common names. In addition, information must be provided on the physical and chemical characteristics of the hazardous chemical; known acute and chronic health effects and related health information; exposure limits; whether the chemical is considered to be a carcinogen by NTP, IARC, or OSHA; precautionary measures; emergency and first aid procedures; and the identification (name, address, and telephone number) of the organization responsible for preparing the sheet.

The Hazard Communication Standard (HCS)(29 CFR 1910.1200(g)), revised in 2012, requires that the chemical manufacturer, distributor, or importer provide Safety Data Sheets(SDSs) (formerly MSDSs or Material Safety Data Sheets) for each hazardous chemical to downstream users to communicate information on these hazards. The information contained in the SDS is largely the same as the MSDS, except now the SDSs are required to be presented in a consistent user-friendly,16-section format. This brief provides guidance to help workers who handle hazardous chemicals to become familiar with the format and understand the contents of the SDSs. The SDS includes information such as the properties of each chemical; the physical, health, and environmental health hazards; protective measures; and safety precautions for handling, storing, and transporting the chemical. The information contained in the SDS must be in English (although it may be in other languages as well). In addition, OSHA requires that SDS preparers provide specific minimum information as detailed in Appendix D of29 CFR 1910.1200. The SDS preparers may also include additional information in various section(s).

Sections 1 through 8 contain general information about the chemical, identification, hazards, composition, safe handling practices, and emergency control measures (e.g., firefighting). This information should be helpful to those that need to get the information quickly. Sections 9 through 11 and 16 contain other technical and scientific information, such as physical and chemical properties, stability and reactivity information, toxicological information, exposure control information, and other information including the date of preparation or last revision. The SDS must also state that no applicable information was found when the preparer does not find relevant information for any required element. The SDS must also contain Sections 12through 15, to be consistent with the UN Globally Harmonized System of Classification and Labeling of Chemicals (GHS), but OSHA will not enforce the content of these sections because they concern matters handled by other agencies. A description of all 16 sections of the SDS, along with their contents, is presented below:

GHS Safety Data Sheets (SDSs) will provide comprehensive chemical information for workers far beyond what has been required under OSHA.

1. Identification
2. Hazard(s) identification
3. Composition/information on ingredients
4. Firstaid measures
5. Firefighting measures
6. Accidental release measures
7. Handling and storage
8. Exposure control/personal protection
9. Physical and chemical properties
10. Stability and reactivity
11. Toxicological information
12. Ecological information
13. Disposal considerations
14. Transport information
15. Regulatory information
16. Other information

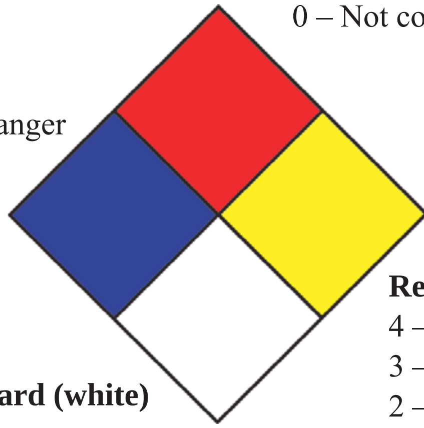
NFPA Labels

NFPA labels do not alert you to chronic health effects nor are the names of the chemical or manufacturer given.

Originally developed to quickly warn firefighters about potential chemical hazards in a fire, the National Fire Protection Association (NFPA) label system provides important information to the construction worker. However, use of the NFPA labels is not required by OSHA. The NFPA label is a diamond containing four smaller diamonds of different colors. The colors of the smaller diamonds are red (flammability), blue (health hazard), yellow (reactivity hazard), and white (specific hazards). The red, blue, and yellow squares contain a hazard rating from 0 to 4, which indicates the severity of the hazard, with 4 being the most dangerous. The white square is reserved for symbols that represent specific hazards, such as to not mix with water or radiation.

Flammability (red)
4 – Danger, very flammable (FP below 73° F)
3 – Warning, flammable (FP below 100° F)
2 – Caution, combustible (FP below 200° F)
1 – Combustible if heated (FP above 200° F)
0 – Not combustible

Health (blue)
4 – Deadly
3 – Extreme danger
2 – Hazardous
1 – Caution
0 – Normal



Reactivity (yellow)
4 – Explosive at room temperature
3 – Shock or heat may detonate
2 – Unstable or violent reaction with water
1 – May react if heated or mixed with water
0 – Stable, not reactive

Specific Hazard (white)
OXY – Oxidizer
ACID – Acid
ALK – Alkali
COR – Corrosive
W – Use no water
RAD – Radioactive

Figure 3.7

DOT Placarding System

The Department of Transportation (DOT) requires that trucks and trailers, railroad cars, and many marine vessels display placards indicating the hazards presented by material in shipment. Labels, which are smaller, are usually found on packages, carboys, and other smaller containers being transported or stored. These placards and labels are in addition to what OSHA requires.

HAZMAT Placards

Placards are diamond-shaped, 10¾-inches square, point-on-point fixtures. They should be located on all four sides of a vehicle carrying a quantity of hazardous materials that requires placarding.

Figure 3.8 Five hazmat placards on the rear of a truck.

Placards provide recognition information in a number of ways:

- Background color.
- Symbol at the top.
- Hazard class wording or identification number in the center.
- United Nations (UN) hazard class number at the bottom.

These tables summarize the color-coded backgrounds, hazard words, and symbols found on DOT labels.

Color Codes	Hazard Words
Orange	Explosive or Blasting Agent
Red	Flammable or Combustible
Green	Nonflammable
Yellow	Oxidizer, Oxygen, or Organic peroxide
White with red stripes	Flammable solids
Yellow and white	Radioactive
White and black	Corrosive
White	Poison, Chlorine
Blue	Dangerous when wet
Special	Biological Agent

Table 3.1

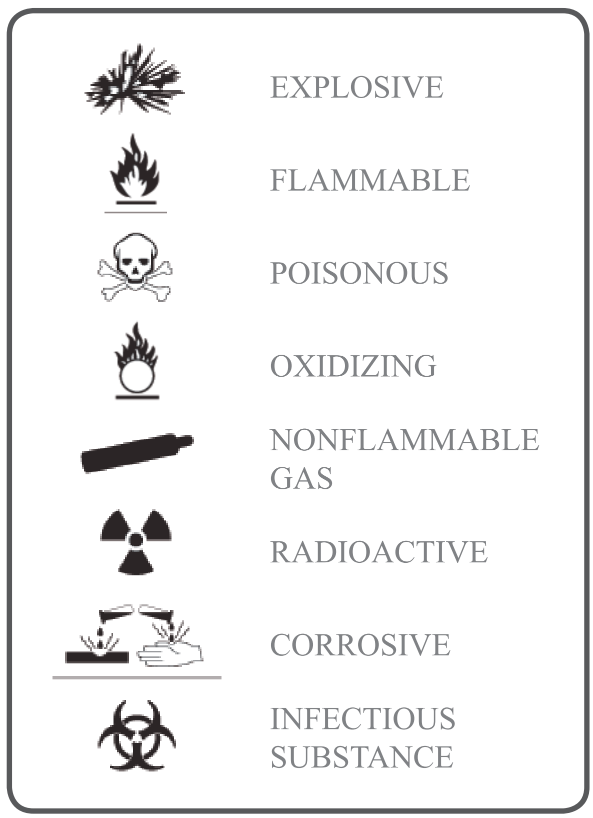


Table 3.2

Identification Numbers

Identification numbers are a four-digit number that appears in the middle of a placard to identify the chemical. The number at the very bottom of a placard refers to the HAZMAT class of the material being transported. Any numbers appearing at the top are division numbers.

The combination of color, hazard word, and hazard symbol provides a great deal of information that can be seen from a distance. However, like the NFPA labels, the DOT labels do not directly identify the product's name, manufacturer, or chemical contents.

GHS and REACH

Figure 3.9

Globally Harmonized System of Classification and Labeling of Chemicals (GHS): The GHS, first adopted by the Sub-Committee on the Globally Harmonized System of Classification and Labeling of Chemicals (SCEGHS) in December 2002, is an initiative to establish international consensus on criteria for classifying chemical hazards for international distribution, and to create consistent requirements for MSDSs. The GHS has been revised twice: once in 2005, and again in 2007. According to the GHS Sub-Committee of Experts, the GHS is now ready for worldwide implementation.

GHS is a common and coherent approach to defining and classifying hazards, and communicating information on labels and safety data sheets. Target audiences include workers, consumers, transport workers, and emergency responders. GHS provides the underlying infrastructure for establishment of national, comprehensive chemical safety programs.

Globally, Hazcom systems are different and use multiple labels and safety data sheets for the same product in international trade

No country has the ability to identify and specifically regulate every hazardous chemical product. For example, in the United States, there are an estimated 650,000 such products.
Adoption of requirements for information to accompany the product helps address protection needs. Many different countries have come to the same conclusion about using information dissemination as a regulatory means to address chemical hazards. While similar, they are different enough to require multiple labels and safety data sheets for the same product in international trade. Countries with regulation systems have different requirements for hazard definitions, as well as different information to be included on a label or material safety data sheet. For example, a product may be considered flammable or toxic in one country, but not in another to which it is being shipped. These differences impact both protection and trade. In the area of protection, users in countries that don't have specific requirements may see different label warnings or data sheet information for the same chemical. In the area of trade, the need to comply with multiple regulations regarding hazard classification and labeling is costly and time-consuming. Small-to-medium enterprises are effectively precluded from international trade in chemicals due to the regulatory burden of compliance.

Benefits of using GHS include:

- Enhanced protection for workers
- Facilitates international trade in chemicals
- Reduce testing and evaluation
- Facilitates globally sound management of chemicals

GHS was created to try to standardize Hazcom Globally.

A new hazard classification system under GHS

GHS uses classification criteria for hazards and a hazard communication system to protect workers.

Figure 3.10 Example of GHS new hazard communication system.

Hazard communication for basic worker use

Pictograms will have a black symbol on a white background with a red diamond frame. Single words ("Danger" and "Warning") are used to emphasize hazard and discriminate between levels of hazard. A GHS label should also include appropriate precautionary information.

Figure 3.11

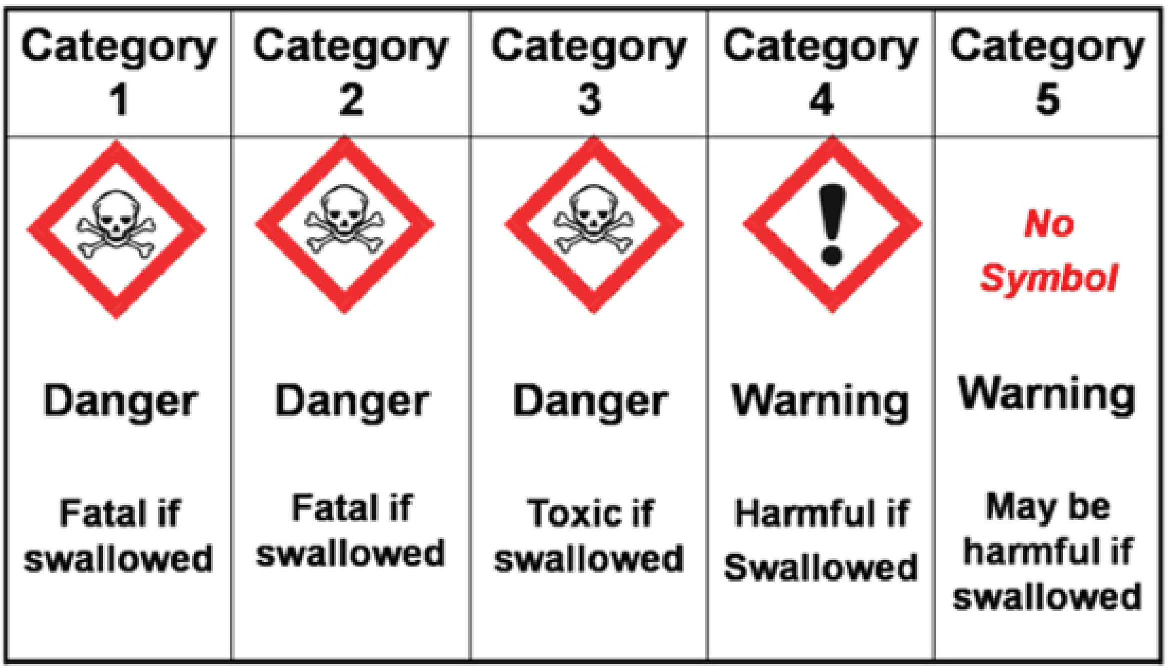
GHS will also have a single harmonized hazard statement for each level of hazard within each hazard class. As an example take flammable liquids:

Category 1: Extremely flammable liquid and vapour
Category 2: Highly flammable liquid and vapour
Category 3: Flammable liquid and vapour
Category 4: Combustible liquid

Label element allocation is based on severity

For the GHS, the assigned pictogram, signal word and hazard statement are given in that order for each category of the hazard class. This slide is one example of allocation of label elements for acute toxicity. Pictogram “Skull and cross bones” is assigned to Category 1, 2 and 3, “Exclamation mark” is assigned to Category 4, none for Category 5.

The signal Word, “Danger” is assigned to Category 1, 2 and 3, “Warning” to Category 4 and Category 5. Hazard statement, “Fatal if swallowed” is used for Category 1 and 2. Precautionary statements are not described in this table.



Category 1	Category 2	Category 3	Category 4	Category 5
				No Symbol
Danger	Danger	Danger	Warning	Warning
Fatal if swallowed	Fatal if swallowed	Toxic if swallowed	Harmful if Swallowed	May be harmful if swallowed

Figure 3.12

Registration Evaluation and Authorisation of Chemicals (REACH)

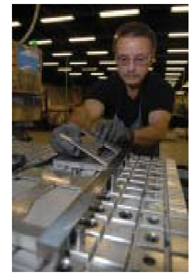


Figure 3.13

REACH is a European Union (EU) standard that was put into effect in 2007. It is basically an advanced form of chemical inventory and registration which heavily focuses on chemical safety and sharing of information. Its main goal is to achieve a high level of protection for human health and the environment. REACH shifts the burden of proving chemicals are safe to manufacturers of chemicals. Manufacturers are required to register their substances and provide environmental, health and safety data if they want them to stay/be on the market. This is great for workers since workers have been historically used as the test subjects–only after a harmful health effect is recognized, are protections implemented. This new regulation turns the use of workers as test subjects on its head. Below are the main components of REACH:

- Manufacturers and importers of chemicals > 1 ton/yr are required to register their substances to demonstrate they can be used safely
- Evaluation of some substances by Member States/European Chemicals Agency (ECHA)
- Authorization only for substances of very high concern
- Restrictions when risks are unacceptable
- Science based
- Information and cost sharing
- Information flows both up and down the supply chain
- Communication up and down supply chains
- 12-yr information availability access
- Includes labelling requirements
- Sanctions if manufactures do not comply
- Public/community safety net if harmful chemicals slip past the REACH process

The goal in the EU is to register 30,000 chemicals! REACH should help to reduce the risks workers face from chemicals due to stricter chemical regulation and a more open sharing of chemical hazard information.

SDS Activity

Materials: SDS sheets and questions, See Appendix C.

Activity: Reviewing a SDS

Time for activity: 15 minutes (10 for group work and 5 for report back)

Objective: The goal of this activity is to practice reviewing an SDS. An SDS is one of the main tools in hazard communication. This activity will allow you to review an SDS on a chemical you work with and answer (and ask) questions thatpertain to it.

Task: Take a few minutes to review and become familiar with an SDS that you work with or you may use one provided. Work together in your groups to discuss and answer the following questions regarding the provided SDS. Try to justify all answers. Select a spokesperson to report back your group's answers to the class. Try to come to a mutual answer for each of the questions.

1. What is the name of the product?

Fuels, Diesel

2. List the CAS#.

68334-30-5

3. What's the date the SDS was generated or updated?

4/2/2011

4. What are the health hazards of this product?

H304, H315, H332, H351, H373

5. Is there a fire or explosion hazard with this product?

Yes

6. Is this material incompatible with other chemicals or materials?

Yes

Glossary

container—any bag, barrel, bottle, box, can, cylinder, drum, reaction vessel, storage tank. Pipeline systems, engines, fuel tanks, and other operating systems are not considered to be containers.

distributor—a business, other than a manufacturer or importer, that supplies hazardous chemicals.

explosive—a chemical that causes a sudden release of pressure, gas, and heat when subject to sudden shock, pressure, or high temperature.

flashpoint—minimum temperature at which a liquid gives off a vapor in sufficient concentration to ignite.

hazardous chemical—any chemical that is a physical or health hazard.

hazard warning—words, pictures, or symbols that appear on a label or other appropriate form of warning to convey physical and health hazard information.

health hazard—a chemical for which there is statistically significant evidence that acute or chronic health effects may occur in exposed workers.

identity—a chemical or common name indicated on the MSDS for the chemical.

immediate use—the hazardous chemical will be under the control of and used only by the person who transfers it from a labeled container and only within the workshift in which it is transferred.

label—any written, printed, or graphic material affixed to containers of hazardous chemicals.

oxidizer—a chemical that initiates or promotes combustion in other materials.

physical hazard—a chemical that is a combustible liquid, a compressed gas, explosive, flammable, an organic peroxide, an oxidizer, pyrophoric, unstable, or water reactive.

unstable—a chemical that will vigorously polymerize, decompose, condense, or become self-reactive under conditions of shock, pressure, or temperature.

water-reactive—a chemical that reacts with water to release a gas that is either flammable or presents a health hazard.

Review and Discussion Questions

1. Give an example of a potentially hazardous chemical you have used either on the job or at home. Did you take any special precautions while using this product?

Answers will vary.

2. Explain what the Hazard Communication standard requires employers to do.

Employers are required to have a written HazCom program available for employee review; use labeled products; obtain and provide MSDS on all products; provide training and information for people who will use or come in contact with the chemical.

3. Does the hazardous chemical label at right meet OSHA regulations? Why or why not?

No. According to OSHA, labels must include product name; name, address, and phone number of the manufacturer, importer, or supplier; hazards of the product, including cautions, warnings, reactivity hazards, health hazards, target organs, measures to protect the user, and emergency first aid information.

4. Are there any circumstances where containers without labels may be used?

Yes, when portable containers such as cans or trays are used to transfer hazardous chemicals from one labeled container to another labeled container or when the chemical in the unlabeled container is intended for immediate use.

5. Name at least five types of information that must be included on an SDS.

Possible answers include, but are not limited to, product identity and manufacturer's information, hazardous ingredients, physical and chemical characteristics, fire and explosion hazard data, reactivity data, health hazard data, precautions for safe handling and use, control measures.

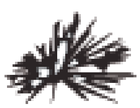
6. List three types of physical data given on an SDS.

Possible answers include, but are not limited to, boiling point, evaporative rate, melting point, solubility, specific gravity, vapor density, vapor pressure, flashpoint, LEL, UEL.

7. What does GHS stand for and explain what GHS is trying to achieve.

Globally Harmonized System of Hazard Classification, answers vary.

8. Name the hazard described by each of these DOT hazard symbols.



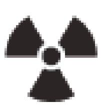
Explosive

Flammable

Poisonous

Oxidizing

Nonflammable Gas



Raioactive

Corrosive

Infectious Substance

Other Resources

OSHA Hazard Communication
http://www.osha.gov/SLTC/hazardcommunications/index.html

Draft Model Training Program for Hazard Communication
http://www.osha.gov/dsg/hazcom/MTP101703.html

OSHA/EPA Occupational Chemical Database
http://www.osha.gov/web/dep/chemicaldata/#target

NIOSH Pocket Guide to Chemical Hazards
http://www.cdc.gov/niosh/npg/

Chromated Copper Arsenate (CCA)
http://www.epa.gov/oppad001/reregistration/cca/

Safety and Precautions When Working with CCA Alternatives
http://www.epa.gov/oppad001/reregistration/cca/safetyprecautions.htm

National Fire Protection Association
http://www.nfpa.org/

ORCBS NFPA Chemical Hazard Labels
http://www.hazmat.msu.edu:591/nfpa/

U.S. DOT Pipeline and Hazardous Materials Safety Administration
http://www.phmsa.dot.gov/portal/site/PHMSA

Office of Hazardous Materials Safety Identification Number Index
http://hazmat.dot.gov/pubs/erg/unidnum.htm

A Guide to The Globally Harmonized System of Classification and Labeling of Chemicals (GHS)
http://www.osha.gov/dsg/hazcom/ghs.html

Instructor Lesson Plan

Stairways and Ladders

Lesson Plan – CIO 264-364

Key Concepts

- Safety practices for using ladders.
- Employer responsibilities.
- Types of ladders.
- Ladders and stairway standards.

Presentation and Materials

- Allow 30 minutes to present this chapter.
- Use Stairways and Ladders PowerPoint® slides.
- Try the Group Discussion Activity at the end of the chapter.
- Use Review Questions at the end of the chapter to facilitate discussion.
- Use 30-Hour Construction course manual.

Standards

Safety and Health Regulations for Construction

- 29 CFR 1926 Subpart X—Stairways and Ladders

Module 4

Stairways and Ladders

OSHA: 29 CFR 1926 Subpart X – CIO 264-364

Lesson Outline

Overview

Odds are you'll have to use and even construct ladders and stairways during your construction work. However, working on or around ladders and stairways can be hazardous work. Both are major sources of injuries that often require time off the job. In this chapter you will learn the OSHA standards and rules for stairways and ladders to help you avoid injuries and create a safer work environment.

Objectives

After completing this chapter, you should be able to:

Know

- State the general safety practices to follow when using ladders.
- Cite conditions under which employers are required to provide stairways and ladders at a job site.
- List the general requirements for ladders built on the job site.
- Describe the on-site requirements for stairways, stair rails, handrails, and midrails.

Apply

- Identify and explain safe and unsafe practices on stairways and ladders shown in the photos provided.

Analyze

- Compare and contrast the standards and safety rules for different types of ladders.

Ladders

Employer Responsibilities

The Occupational Safety and Health Administration (OSHA) standards require employers to provide stairways and ladders under certain measurable conditions. The employer must also make sure that the stairways and ladders are maintained according to the standards. The following standards describe employer responsibilities:

- Employers must provide a stairway or ladder when there is no ramp, runway, or personnel hoist available, and there is an elevation of 19 inches or more.
- If there is only one point of access between levels, employers must keep the access clear of all obstacles to allow you unrestricted passage.
- If passage of an access becomes restricted, employers must provide another point of access (if only one had been unavailable).
- Employers must install fall protection systems before you use the stairways and ladders, and they must make sure that the work site meets all standards.

Ladder Safety Rules

The requirements and rules for using ladders are, for the most part, common sense. However, you might forget them during the workday because you're trying to get a job done quicker or you think you'll just work extra carefully. The problem is that it takes just one missed step to result in an injury to yourself or coworkers. Keeping the following requirements and rules in mind when using ladders will reduce your chances of getting hurt. Do you follow each of these rules on the job all the time?

- Keep ladders free of oil, grease, or anything that is a slipping hazard.
- Do not load ladders beyond their recommended load capacity.
- Use ladders only for their intended purposes.
- Use ladders only on stable and level surfaces unless they are fully secured from slipping.
- Check surfaces for slipping hazards before setting up and using a ladder.
- Make sure the areas around the top and the bottom of the ladder are clear at all times. Use a barricade if necessary to keep activity away from the ladder.
- Do not move, shift, or extend ladders while they are being used.
- If you could come into contact with electrical equipment, use side rails that do not conduct electricity.
- Face the ladder when going up or down.

Figure 4.1 The ladder extends a proper length above the excavation.

Case Report
A person was standing under a suspended scaffold that was hoisting a worker and three sections of ladder. Sections of the ladder became unlashed and fell 50 feet, striking the worker underneath in the skull. The person was not wearing head protection and died.

OSHA Construction e-Tool:
http://www.osha.gov/SLTC/etools/construction/struckby/fatexstruck2.html

When ladders are made or built on the job site, the following safety rules apply in addition to the ones on the previous page:

- When ladders are the only way to access a work area where there are 25 or more employees OR when the ladder provides two-way traffic on the jobsite, use double-cleated ladders or two or more ladders for worker safety.
- There must be a ladder or a stairway where there is a break in elevation of 19 inches or more.

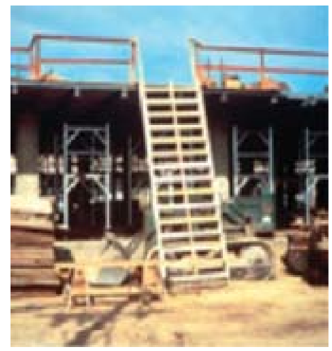


Figure 4.2 A double-cleated ladder provides access to a work area with more than 25 workers as well as allowing for two-way traffic.

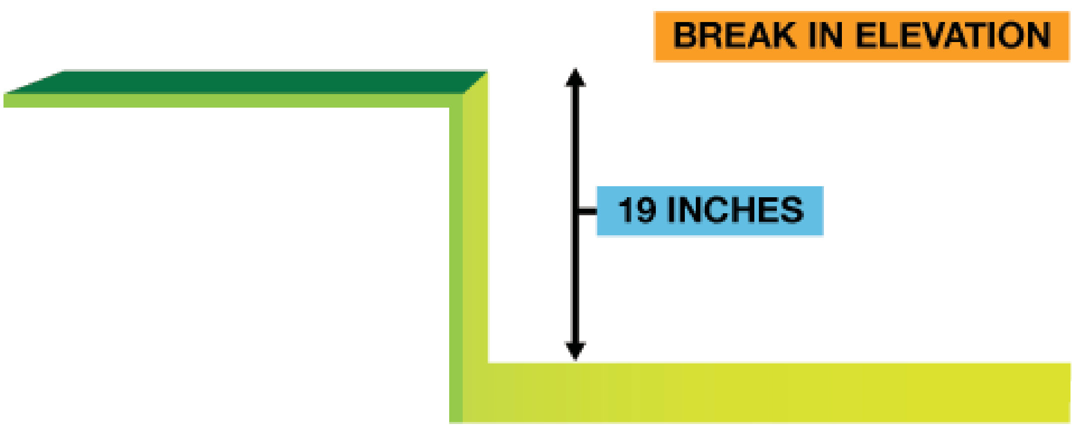


Figure 4.3

- Rungs, cleats and steps must be parallel and equally spaced.
- Do not space rungs, cleats, or steps less than 10 inches (25 cm) or more than 12 inches (36 cm) apart.
- Do not space rungs, cleats, or steps at the base section of extension trestle ladders less than 8 inches (20 cm) or more than 18 inches (46 cm) apart.
- The rung spacing on the extension section of a ladder must not be less than 6 inches (15 cm) or more than 12 inches (31 cm).
- Do not tie or fasten ladders together to make longer sections unless they are meant for that use.
- A spliced side rail must be as strong as a one-piece side rail made of the same material.
- When using two or more separate ladders to reach an elevated work area, offset the ladders with a platform or landing between the ladders, except when accessing a fixed ladder already in place.
- Make sure all ladder parts are smooth to prevent snagging of clothing and possible injury.
- Do not coat or label wood ladders except for identification and/or warning labels.

Important: A competent person must inspect ladders for defects periodically and also after any incident that may have affected its safety.

Case Report
A person was climbing a 10-foot ladder to access a landing which was nine feet above the adjacent floor. The ladder slid down, and the worker fell to the floor, sustaining fatal injuries. Although the ladder had slip-resistant feet, it was not secured, and the top of the ladder did not extend three feet above the landing.

OSHA Construction e-Tool:
http://www.osha.gov/SLTC/etools/construction/falls/fatexfalls5.html

Case Report
A laborer was working on the third level of a tubular welded-frame scaffold that was covered with ice and snow. Planking on the scaffold was inadequate, and there was no guardrail and access ladder for the various scaffold levels. The worker slipped and fell head first approximately 20 feet to the pavement below.

OSHA Construction e-Tool:
http://www.osha.gov/SLTC/etools/construction/falls/fatexfalls3.html

Types of Ladders

Figure 4.4 Never stand on the top step of a stepladder.

Some standards and safety rules apply to specific types of ladders. If you use one type of ladder more than others, you may be very familiar with the rules for safe use of that ladder but not as aware of the rules for some other types. As you read these rules, think about how you might have to use the different types of ladders on your job site and whether or not you apply these rules for your own safety and for the safety of your coworkers.

Stepladders

- Never use the top or the top step of a stepladder as a step, as pictured at left.
- The cross bracing on the back section of a stepladder is NOT for climbing unless the ladder has steps for climbing on both the front and rear sections. The picture at right is of a typical stepladder, and the arrow points to the cross bracing.
- Use metal spreaders or locking devices to hold the front and back sections in an open position when using a stepladder. The picture at right shows the metal spreaders in the locked position to prevent the ladder from collapsing.

Figure 4.5 Never climb on the back or cross bracing of a ladder.

Figure 4.6 Metal spreaders locked

Portable Ladders

- The minimum clear distance between side rails of all portable ladders must be 11.5 inches (29 cm).
- Rungs and steps must be corrugated or coated with skid-resistant material to minimize slipping.
- The side rails of a portable ladder used to access an elevated surface must extend three feet beyond the elevated surface. If this is not possible, the ladder must be secured or a grab rail must be provided. The illustration at right shows the ladder tied off to secure it, and the ladder also is extended at least three feet above the elevated surface.
- Non-self-supporting and self-supporting portable ladders must support at least 4 times the maximum intended load.
- Heavy-duty type 1A metal or plastic ladders must support 3.3 times the maximum intended load.

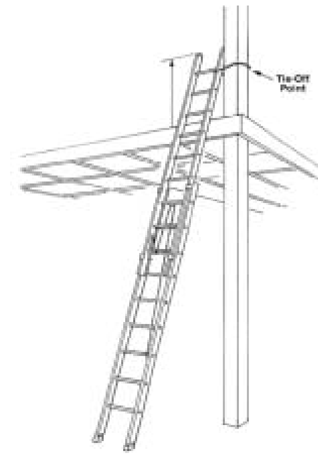


Figure 4.7 A ladder properly tied off and a proper distance above the landing area.

Fixed Ladders

Consider the following safety rules when using fixed ladders:

- When using a fixed ladder to climb 24 feet (7.3 meters) or more, choose one of the following added safety provisions: Self-retracting lifelines and rest platforms at intervals of less than 150 feet (45.7 meters) or a cage or multiple ladder sections.
- Load minimum—Fixed ladders must be able to support at least 2 loads of 250 pounds (114 kg) each. This includes any additional load caused by the rigging, weather impacts, or safety requirements.
- Side rails—Side rails of a fixed ladder used to access an elevated surface must extend 42 inches (1.1 meters) above the elevated surface. If this is not possible, a grab rail with the same lateral spacing must be provided.
- Each step must be able to support 250 pounds (114 kg) applied to the middle of the step.
- Minimum clear distance between a stepladder and a fixed ladder must be 16 inches (41 cm).
- Rungs must be shaped to prevent slipping and must be corrugated or coated with skid-resistant material to minimize slipping if manufactured after March 15, 1991.
- A clearance of at least 7 inches (18 cm) must be maintained between the rungs, cleats, or steps and any structure behind the ladder.
- A clearance of at least 30 inches (76 cm) must be maintained between rungs, cleats, and steps and any obstruction on the climbing side of the ladder.

Figure 4.8 Corrugated rungs help prevent slipping

- Step-across distance between the center of steps of fixed ladders and the nearest edge of a landing surface must be no less than 7 inches (18 cm) and no more than 12 inches (30 cm).
- If the landing area is more than 12 inches away, a landing platform must be provided.
- Cages, well, or safety devices must still be provided even if the length of climb is less than 24 feet IF the top of the ladder is greater than 24 feet above lower levels. A cage is an enclosure fastened to the side rails of the fixed ladder or to the structure to encircle the climbing space of the ladder for the safety of the person who must climb the ladder. A well is a permanent complete enclosure around a fixed ladder, which is attached to the walls of the well.
- The maximum distance between side rail extensions must not be greater than 36 inches (91 cm).

NOTE: OSHA has special requirements for cages and wells for fixed ladders, which involve rules for horizontal bands on the side rails, vertical bar requirements, maximum and minimum distances for widths and extensions, and interval spacings. Please refer to the complete descriptions in the publication OSHA 3124-12R 2003 Stairways and Ladders: A Guide to OSHA Rules.

Here are a few more rules to follow that might prevent an accident:

- Make sure the safety device, such as a harness or fall arrest system, you use can withstand a drop test of a 500 pound weight dropping 18 inches without failure.
- Make sure the safety device permits you to go up or down the ladder without having to touch the device—both hands should be free for climbing.
- All safety devices should begin working within two feet of a fall and should limit the speed of the falling worker to seven feet/second or less.

Figure 4.9 If a ladder needs to be repaired, don't use it. Ladders with broken or missing rungs, cleats, or steps; broken rails; or corrosion on fastenings should be labeled as defective and tagged with "Do Not Use" signs. All defective ladders should be repaired to meet all OSHA standards.

Stairways

The OSHA requirements that apply to stairways are generally broken down into rules for stairways and rules for stair rails, handrails, and midrails. They discuss the angle of construction, stair height and tread depth, and the placing of stairways at safe locations in the construction site.

Consider the following requirements to stairways at construction sites:

- Stairways must be at least 30 degrees and no greater than 50 degrees from the horizontal.
- Stairway landings must be at least 30 inches (76 cm) deep and 22 inches (56 cm) wide and must be provided every 12 feet (3.7 meters) or less.
- There must not be a variation of riser height or tread depth of more than ¼ inch.
- Metal landings and metal treads must be secured and filled in with concrete or other fill material (unless temporarily filled in with wood).
- Treads that have been worn down below the top edge of the pan of filler must be replaced.
- Correct all slip hazards on stairways immediately.
- Do not use spiral stairways that will become a permanent part of the constructed site as work stairways.

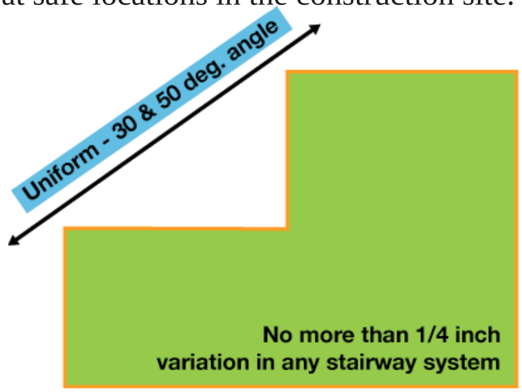


Figure 4.10

Figure 4.11

Stair Rails

Stair rail systems are an important part of a safe workplace. You probably go up and down stairways all the time with loads that do not always allow you to see exactly every step you take. While that may not be the safest working habit, having a stair rail will at least ensure that you do not fall off an edge of the stairway. The following rules about stair rails, handrails, and midrails help you to remain safe on stairs:

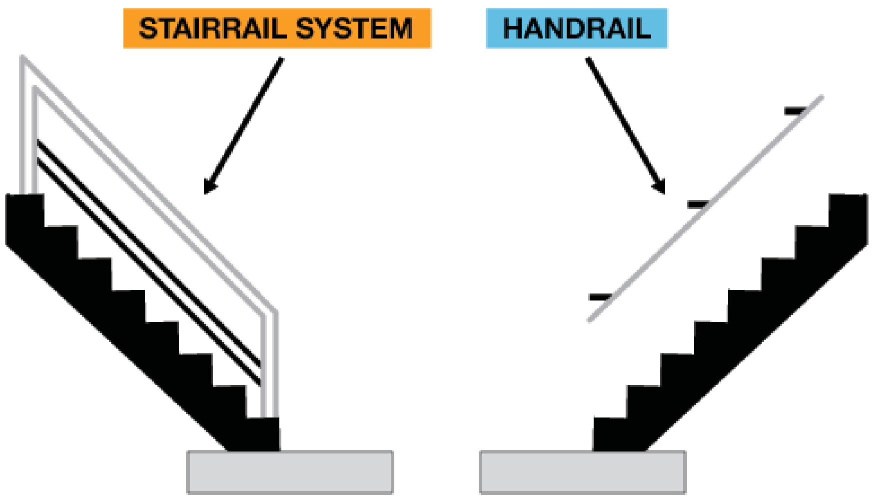


Figure 4.12

- Stairways must have a stair rail on every unprotected side.
- If the top edge of the stair rail is also used as a handrail, the height must be no greater than 37 inches (94 cm) or less than 36 inches (91.5 cm).
- Stair rails installed after March 15, 1991, must not be less than 36 inches (91.5 cm) in height.
- The stair rails and handrails must be surfaced to prevent injuries. Projections can cause puncture wounds and cuts. You can trip or fall from snagged clothing catching on parts of the stair rails that have not been properly maintained.
- The ends of stair rail systems and handrails must not have projections (such as rails that protrude out beyond the ends of posts) that would cause dangerous conditions.

Case Report
An employee preparing masonry fascia for removal from a building fell from the third level of a tubular welded-frame scaffold. No guarding system was provided for the scaffold. Further, the platform was coated with ice, creating a slippery condition.

OSHA Construction e-Tool: http://www.osha.gov/SLTC/etools/construction/falls/fatexfalls3.html

Handrails

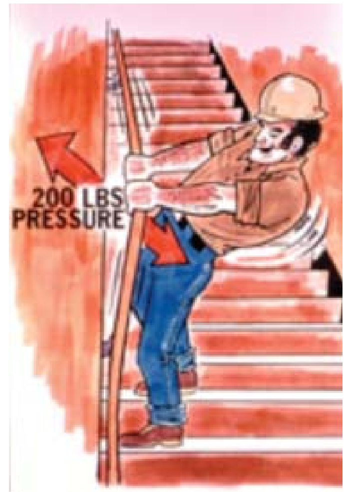


Figure 4.13 Handrails must be able to support 200 pounds of force.

- Stairways with unprotected sides must have the standard 42-inch (1.1-meter) guardrail systems.
- Balusters or other individual materials used as guardrails must not be more than 19 inches (48 cm) apart.
- Handrails must be able to support at least 200 pounds of weight applied within two inches (5 cm) of the top edge in any downward or outward direction.
- Handrails must not be greater than 37 inches (94 cm) high or less than 30 inches (76 cm) from the top of the handrail to the tread.
- Adequate handholds on the handrails must be provided.
- There must be a minimum clearance of three inches (8 cm) between the handrail and walls and stair rail systems on temporary handrails.
- Any stairway with four or more risers or that are more than 30 inches (76 cm) in height must have at least one handrail.
- Spiral stairways must have a handrail to prevent use of areas where the tread is less than 6 inches (15 cm).

Midrails

Midrails, screens, mesh, intermediate vertical members or equivalent intermediate structural members must be provided between the top rail and stairway steps to a stair rail system.

Case Report
A person taking measurements was killed when he fell backward from an unguarded balcony to the concrete 9½ feet below.

OSHA Construction e-Tool:
http://www.osha.gov/SLTC/etools/construction/falls/fatexfalls11.html

Training Requirements

Figure 4.14 Training in proper ladder use is an important safety precaution.

Employers are responsible for training all employees to recognize safety hazards on or around stairways and ladders. Training by a competent person should include fall hazards, the correct procedures for constructing and disassembling fall protection systems, the safe construction and handling of ladders and stairways, and maximum intended loads.

The key component of stairway and ladder safety is understanding what safety provisions should be present and how to maintain and use them. Treads and rails on ladders must be constructed according to safety requirements, and they must also be used in a way that at least reduces the risk of accidents. Landings and platforms and free access to stairways are important features to preventing injuries. Even a short fall can cause serious injury.

Common Citations

Here are some common citations that OSHA inspectors issue regarding ladders and stairways:

- Ladder not extending 36 inches about the landing. This enables you to safely step off the ladder without having to bend down to reach the top handrail.
- No guardrails on stairs. Most of these citations are for stairs under 10 feet. Violations occur most often at stairs to trailers, to another floor in residential construction, and to pits and vaults.
- A ladder constructed at the job site with no filler blocks. Filler blocks provide support for the cleats or rungs. Without filler blocks the cleats may break at the nailed areas, and the rungs may break off.

Group Discussion Activity

As a group, look at the following images and answer the question for each. Most photos or illustrations ask the question, “What is wrong with this picture?” (There could be more than one unsafe practice shown in the picture.) Use the images for discussion of violations, unsafe practices, recommendations, and examples of safe practices too.

1. What is wrong with this job site practice?

Figure 4.15

2. How many pounds of pressure should a handrail be able to withstand?

Figure 4.16

3. What is wrong with this picture?

Figure 4.17

4. What is wrong with this picture?

Figure 4.18

5. What safety practice is being seen here as the worker applies a substance to the steps?

Figure 4.19

6. What is wrong with this picture?

Figure 4.20

7. What is wrong with this picture?

Figure 4.21

8. When should you use the ladder pictured here?

Figure 4.22

9. How far away should the ladder be positioned from the building?

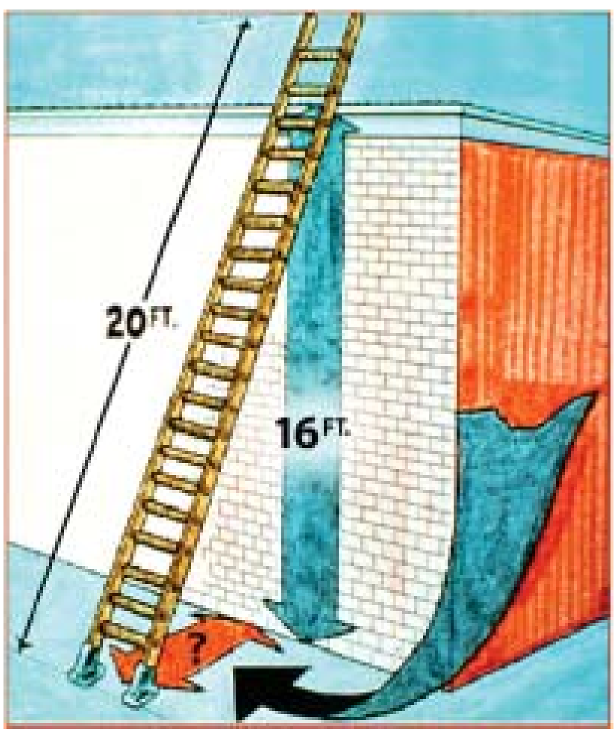


Figure 4.23

10. What is wrong with this picture?

Figure 4.24 Photo courtesy of IBEW Local 725.

11. What is wrong with this picture?

Figure 4.25 Photo courtesy of IBEW Local 725.

12. What is wrong with this picture?

Figure 4.26 Photo courtesy of IBEW Local 725.

13. What is wrong with this picture?

Figure 4.27

14. What is wrong with this picture?

Figure 4.28

15. What two things are wrong in this picture?

Figure 4.29

16. What is wrong with this picture?

Figure 4.30

17. What is wrong with this picture?

Figure 4.31

18. What is wrong with this picture of a worker at work several stories high?

Figure 4.32

19. What is wrong with this picture?

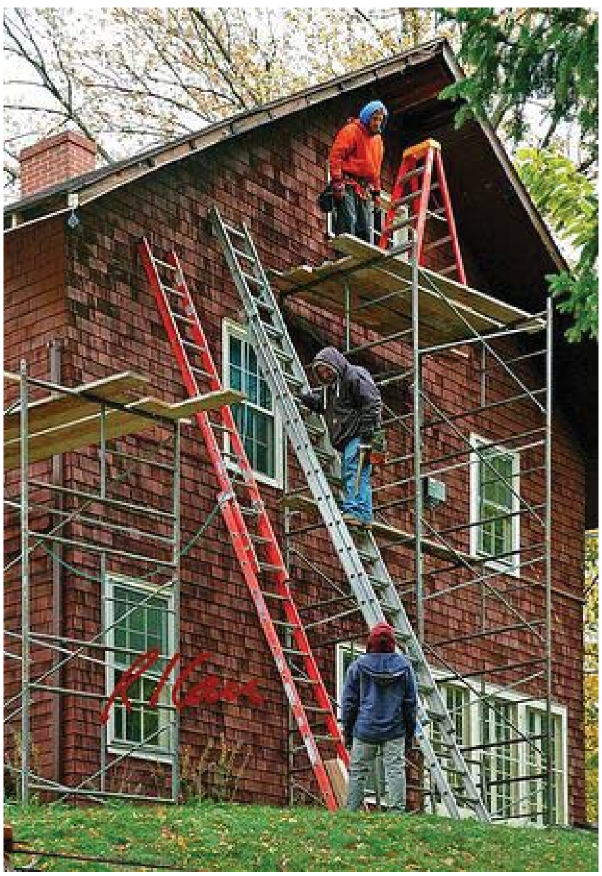


Figure 4.33

20. What is wrong with this picture?

Figure 4.34 Photo courtesy of www.workplacegroup.net.

21. What is wrong with this picture?

Figure 4.35 Photo courtesy of www.myconstructionphotos.com.

22. What is wrong with this picture?

Figure 4.36

23. What is wrong with this picture?

Figure 4.37 Photo courtesy of www.myconstructionphotos.com.

Glossary

cleat—a ladder crosspiece of rectangular cross section placed on edge upon which a person may step while ascending or descending a ladder.

double-cleat ladder—a ladder with a center rail to allow simultaneous two-way traffic for people going up or down.

failure—load refusal, breakage, or separation of components.

fixed ladder—a ladder that cannot be readily moved or carried because it is an integral part of a building or structure.

handrail—a rail used to provide workers with a handhold for support.

job-made ladder—a ladder that is fabricated by workers, typically at the construction site; not commercially manufactured.

load refusal—the point where the structural members lose their ability to carry the load.

point of access—all areas used by workers for work-related passage from one area or level to another.

portable ladder—a ladder that can be readily moved or carried.

riser height—the vertical distance from the top of a tread or platform to the top of the next higher tread or platform/landing.

side-step fixed ladder—a fixed ladder that requires a person to get off at the top to step to the side of the ladder side rails to reach the landing.

single-cleat ladder—a ladder consisting of a pair of side rails connected by cleats, rungs, or steps.

stair rail system—a vertical barrier erected along the unprotected sides and edges of a stairway to prevent people from falling to lower levels.

temporary service stairway—a stairway where permanent treads and/or landings are to be filled in at a later date.

through fixed ladder—a fixed ladder that requires a person getting off at the top to step between the side rails of the ladder to reach the landing.

tread depth—the horizontal distance from front to back of a tread, excluding nosing, if any.

Review Questions

1. List several requirements of employers concerning stairways and ladders on the job site.

- *Employers must provide a stairway or ladder when there is no ramp, runway, or personnel hoist available, and there is an elevation of 19 inches or more.*
- *If there is only one point of access between levels, employers must keep the access clear of all obstacles to allow unrestricted passage by workers.*
- *If passage of an access becomes restricted, employers must provide another point of access (if only one had been unavailable).*
- *Employers must install stairways and ladders fall protection systems before employees use the stairways and ladders and they must make sure that the worksite meets all standards.*

2. Describe safety practices you should follow to avoid injuries when using ladders.

- *Keep ladders free of oil, grease, or anything that is a slipping hazard.*
- *Do not load ladders beyond their recommended load capacity.*
- *Only use ladders for their intended purposes.*
- *Only use ladders on stable and level surfaces unless they are fully secured from slipping.*
- *Check surfaces for slipping hazards before setting up and using a ladder. If needed, use a barricade to keep activity away from the ladder.*
- *Make sure the areas around the top and the bottom of the ladder are clear at all times.*
- *Do not move, shift, or extend ladders while they are being used.*
- *If you could come into contact with electrical equipment, use side rails that do not conduct electricity.*
- *Face the ladder when going up or down.*

3. Describe safety provisions that should be in place to reduce the possibility of accidents using stairways in the workplace.

- *Stairways must be at least 30 degrees and no greater than 50 degrees from the horizontal.*
- *Stairway landings must be at least 30 inches (76 cm) deep and 22 inches (56 cm) wide and must be provided every 12 feet (3.7 meters) or less.*
- *There must not be a variation of riser height or tread depth of more than ¼ inch.*
- *Metal landings and metal treads must be secured and filled in with concrete or other fill material (unless temporarily filled in with wood).*
- *Treads that have been worn down below the top edge of the pan of filler must be replaced.*
- *Correct all slip hazards on stairways immediately.*
- *Do not use spiral stairways that will become a permanent part of the constructed site as work stairways.*
- *Stairways must have a stair rail on every unprotected side.*
- *If the top edge of the stair rail is also used as a handrail, the height must be no greater than 37 inches (94 cm) or less than 36 inches (91.5 cm).*
- *Stair rails installed after March 15, 1991, must be not less than 36 inches (91.5 cm) in height.*
- *The stair rails and handrails must be surfaced to prevent injuries. Projections can cause puncture wounds and cuts. Workers can trip or fall from snagged clothing catching on parts of the stair rails that have not been properly maintained.*
- *The ends of stair rail systems and handrails must not have projections (such as rails that protrude out beyond the ends of posts) that would cause dangerous conditions. Stairways with unprotected sides must have the standard 42 inch (1.1 meter) guardrail systems.*
- *Handrails must be able to support at least 200 pounds of weight applied within two inches (5 cm) of the top edge in any downward or outward direction.*
- *Handrails must not be greater than 37 inches (94 cm) high or less than 30 inches (76 cm) from the top of the handrail to the tread.*
- *Adequate handholds on the handrails must be provided.*
- *There must be a minimum clearance of three inches (8 cm) between the handrail and walls and stair rail systems on temporary handrails.*
- *Any stairway with four or more risers or that are more than 30 inches (76 cm) in height must have at least one handrail.*
- *Spiral stairways must have a handrail to prevent use of areas where the tread is less than six inches (15 cm).*

4. What do you consider to be the most important safety practice for your job?

Answers will vary.

5. What are the training requirements for your job?

Answers will vary.

6. What training concerning safety hazards on or around stairways and ladders are employers responsible for providing employees?

To recognize the safety hazards, such as fall hazards, the correct procedures for constructing and disassembling fall protection systems, the safe construction and handling of ladders and stairways, and maximum intended loads.

7. Describe a work experience that was difficult because of stairways and ladders being used on the job. (This could be because you had to construct the ladders and stairways for a number of different job site conditions; because you had a difficult time getting the materials to construct a safe, approved stairway or ladder; or for other jobsite factors.) Include a description of what you did to work through the task.

Answers will vary.

8. State at least three recommendations to follow for each type of ladder listed below.

Stepladders

- *Never use the top or the top step of a stepladder as a step.*
- *The cross bracing on the back section of a stepladder is NOT for climbing unless the ladder has steps for climbing on both the front and rear sections.*
- *Use metal spreaders or locking devices to hold the front and back sections in an open position when using a stepladder.*

Portable Ladders

- *The minimum clear distance between side rails of all portable ladders must be 11½ inches (29 cm).*
- *Rungs and steps must be corrugated or coated with skid-resistant material to minimize slipping.*
- *The side rails of a portable ladder used to access an elevated surface must extend three feet beyond the elevated surface. If this is not possible, the ladder must be secured, or a grab rail must be provided.*
- *Loads for portable ladders:*
- *Must support at least four times the maximum intended load.*
- *Heavy-duty type 1A metal or plastic ladders must support 3.3 times the maximum intended load.*

Fixed Ladders

- *Load minimum—Fixed ladders must be able to support at least two loads of 250 pounds (114 Kg) each. This includes any additional load caused by the rigging, weather impacts, or safety requirements.*
- *Side rails—Side rails of a fixed ladder used to access an elevated surface must extend 42 inches (1.1 meters) above the elevated surface. If this is not possible, a grab rail with the same lateral spacing must be provided.*
- *Each step must be able to support 250 pounds (114 Kg) applied to the middle of the step.*
- *Minimum clear distance between a stepladder and a fixed ladder must be 16 inches (41 cm).*
- *Rungs must be shaped to prevent slipping and must be corrugated or coated with skid-resistant material to minimize slipping if manufactured after March 15, 1991.*
- *A clearance of at least seven inches (18 cm) must be maintained between the rungs, cleats, or steps and any structure behind the ladder.*
- *A clearance of at least 30 inches (76 cm) must be maintained between rungs, cleats, and steps and any obstruction on the climbing side of the ladder.*
- *Step-across distance between the center of steps of fixed ladders and the nearest edge of a landing surface must be no less than seven inches (18 cm) and no more than 12 inches (30 cm).*
- *If the landing area is more than 12 inches away, a landing platform must be provided.*
- *Cages, well, or safety devices must still be provided even if the length of climb is less than 24 feet if the top of the ladder is greater than 24 feet above lower levels.*
- *The maximum distance between side rail extensions must not be greater than 36 inches (91 cm).*

9. Have you met the training requirements for your job?

Answers will vary.

Other Resources

American National Standards Institute (ANSI)
http://www.ansi.org/

ANSI/OSHA Ladder Requirements—EZ Facts: Safety Info Online.
http://www.labsafety.com/refinfo/ezfacts/ezf132.htm

Compliance Assistance Quick Start: Construction Industry
http://www.osha.gov/dcsp/compliance_assistance/quickstarts/construction/index_construction.html

IUOE National Training Fund National HAZMAT Program. (2007). Construction Industry Outreach. Publication no.: M-18-2007.

OHSA: Stairways and Ladders: A Guide to OSHA Rules
http://www.osha.gov/Publications/osha3124.pdf

Laborers-AGC Education and Training Fund. (2003). *OSHA Construction Safety and Health*

OSHA 3071. Job Hazard Analysis (2002 revised)
http://www.osha.gov/Publications/osha3071.pdf

OSHA Construction e-Tool—Ladder Safety
http://www.osha.gov/SLTC/etools/construction/falls/4ladders.html

OSHA Construction e-Tool—Unprotected Sides, Wall Openings, and Floor Holes
http://www.osha.gov/SLTC/etools/construction/falls/unprotected.html

OSHA Construction Safety and Health Outreach Program—Stairways and Ladders
http://www.osha.gov/doc/outreachtraining/htmlfiles/stairlad.html

OSHA Laws, Regulations, and Interpretations
http://www.osha.gov/comp-links.html

OSHA QUICKCARD: Portable Ladder Safety Tips
http://www.docstoc.com/docs/9676/OSHA-QUICK-CARD-PORTABLE-LADDER-SAFETY-TIPS

OSHA QUICKCARD Supported Scaffold Safety Tips
http://www.docstoc.com/docs/9690/OSHA-QUICK-CARD-SUPPORTED-SCAFFOLD-SAFETY-TIPS

OSHA Worker Safety Series: Construction
http://www.osha.gov/Publications/OSHA3252/3252.html

Stairways and Ladders: OSHA Publication 3124 (Revised 2003)
http://www.osha.gov/Publications/osha3124.pdf

Selected Construction Regulations (SCOR) for the Home Building Industry (29 CRF 1926) OSHA Publication (Revised 1997).
http://www.osha.gov/Publications/scor1926.pdf

Bureau of Labor Statistics: Injuries, Illnesses, and Fatalities, 2003 Forward
http://data.bls.gov/cgi-bin/surveymost?fi

Instructor Lesson Plan

Confined Space

Lesson Plan – CIO 268-317

Key Concepts

- Permit-required and non permit-required confined spaces
- Hazardous atmospheres in confined spaces
- Other hazards in confined spaces

Presentation and Materials

- Allow 60 minutes to present this chapter.
- Use Confined Spaces PowerPoint® slides.
- Use the questions at the end of the chapter to review.
- Use 30-Hour Construction Outreach course manual.

Module 5
Confined Space
CIO 268-317

Lesson Outline

Confined Space
Permit Required vs. Non Permit Required
Confined Space Entry Permit
Confined Space Decision Flow Chart

Training

Hazardous Atmospheres
Oxygen Deficient
Oxygen Enriched
Flammable
Toxic

Testing for Hazardous Atmospheres
Pre-entry Testing
Periodic Testing and Continuous Monitoring

Controlling Hazardous Atmospheres
Ventilation
Isolation
Entering a Tank or Vault
Work in Sewers
Special Precautions for Welders
Continuous Monitoring

Other Hazards
Engulfment
Falling Objects
Temperature Extremes
Noise
Moving or Driven Equipment
Electrical Hazards
Process Liquids and Steam
Animals and Insects

Review Questions

Other Resources

Overview

Search the Internet for "confined space deaths," and you'll soon find a series of stories—some innocent sounding (overcome by gas from a propane heater), others bordering on the bizarre (asphyxiation while working in a manure pit). All are characterized by the failure of workers—and quite often their would-be rescuers—to exercise proper precautions and follow procedures when working in a confined space. One of the most dangerous tasks you face as an operating engineer is working in a confined space. That's why OSHA imposes regulations on employers to protect workers from such tragedies. This chapter will teach you about the types of confined spaces and how to work safely in these environments.

Objectives

After completing this chapter, you should be able to:

Know

- List the characteristics of a permit-required confined space.
- State the types of atmospheric testing done for confined spaces.
- Name the pre-entry atmosphere tests required for confined spaces.

Apply

- Determine if air is oxygen deficient or enriched.
- Describe the areas to be tested in and around confined spaces.

Analyze

- Interpret the OSHA definition of a confined space.
- Distinguish ventilation systems.

Confined Space

Figure 5.1 Workers in PPE ready to enter a confined space.

Of the 5,849 workplace fatalities reported by the U.S. Bureau of Labor Statistics for 2006, 12 percent (749) were categorized as exposure to harmful substances and atmospheres or fires and explosions[1]. In addition, another 107 workers, or 2 percent, were killed when caught in or crushed in collapsing materials[2]. When you work in a confined space, these are the most common dangers you face. However, if you understand the precautions you should take and the procedures you should follow, you can ensure your safety.

Three traits define a confined space, according to the Occupational Safety and Health Administration (OSHA):

- Adequate size and shape to allow a person to enter.
- Limited openings for workers to enter and exit.
- Not designed for continuous human occupancy.

In addition, a confined space has unfavorable natural ventilation, which could contain or produce dangerous air contaminants. Typical examples of confined spaces are storage tanks, septic tanks, underground vaults, storage bins, hoppers, manholes, pits, trenches, silos, process vessels, pipelines, and digesters.

According to the National Institute for Occupational Safety and Health (NIOSH), two major factors lead to fatal injuries in confined spaces:

- Failure to recognize and control the hazards associated with confined spaces, such as asphyxiation, electrical shock, engulfment, falls, or heat stress.
- Inadequate or incorrect emergency response. Without an emergency plan people react spontaneously in an emergency, and in the case of confined spaces, too often this results in injuries or deaths to rescuers as well as victims. Different NIOSH reports have put the percentage of would-be rescuers killed in confined spaces anywhere from 36 percent to 60 percent. One report makes clear that most rescuers were not trained rescue personnel[3].

1 U.S. Bureau of Labor Statistics (BLS), http://www.bls.gov/iif/oshwc/cfoi/cfch0005.pdf
2 BLS, http://www.bls.gov/news.release/cfoi.t01.htm
3 NIOSH, http://www.cdc.gov/niosh/pdfs/94-103-b.pdf

Permit Required vs. Non Permit Required

OSHA defines confined space as either permit required or non permit required. The permit-required standard (29 CFR 1910.146) requires you to complete a written safety checklist before work can begin. Work in these spaces is considered more dangerous and might pose an immediate danger to life and health (IDLH). The OSHA standard requires your employer to evaluate the workplace and determine which spaces require the permit and which do not. A permit-required space will be designated as such.

A permit-required confined space has one or more of the following characteristics:

Don't enter a confined space until it has been classified as either permit required or non permit required. Don't assume it's safe because it's not marked.

- Contains or has the potential to contain a **hazardous atmosphere.** Perhaps chemicals have been stored there, or activities such as welding, cutting, or cleaning with solvents have taken place there, making the atmosphere dangerous.
- Contains a material that can **engulf** you when you enter. Granular materials such as grains or sands or sludge-like materials can act like quicksand.
- Features a **shape** such as an inwardly converging wall or a floor that slopes downward and tapers to a small cross-section (like a funnel), such as a grain bin. These spaces can trap you or asphyxiate you.
- Contains any other recognized **serious hazard**, such as exposed live wires, moving equipment, extreme temperatures, noise, falling objects, or wet or slick surfaces.

Non permit-required confined spaces do not or could not contain hazards that could cause serious harm. You can enter these spaces and begin work without having to complete a written safety checklist.

Confined Space Entry Permit

Figure 5.2 Warning sign for a confined space.

OSHA requires employers to have a written permit-required confined space entry program to set procedures for proper and safe entry into hazardous confined spaces. A part of that plan is the confined space entry permit. It's an authorization form that must be completed by the entry supervisor, dated and signed by the necessary personnel, and read by you before you're permitted to enter a permit-required confined space. The form outlines the hazards you'll face and how to control them. The permit must be posted at the entrance to the confined space for the length of the job.

The confined space entry permit must contain the following information:

- Location of space to be entered.
- Purpose of entry.
- Date and authorized duration of the permit.
- Authorized entrants.
- Authorized attendants.
- Name of entry supervisor.
- Hazards in the confined space.
- Measures used to isolate the space or control hazards.
- Acceptable entry conditions.
- Results of initial and periodic monitoring tests.
- Rescue and emergency services.
- Communication procedures.
- Equipment needed, such as personal protective equipment, alarm systems, and testing, communications, and rescue equipment.
- Any other necessary information.
- Any additional permits issued.

A permit usually features a checklist of safety measures that includes all the equipment needed and the steps to be taken before entering the confined space. As the operating engineer entering the space, you must review the checklist with the supervisor and the attendant before you enter to make sure all precautions have been taken.

Confined Space Decision Flow Chart

The employer is responsible for following OSHA regulations in determining whether a confined space meets the criteria for a permit. This flow chart offers a guide for making that determination.

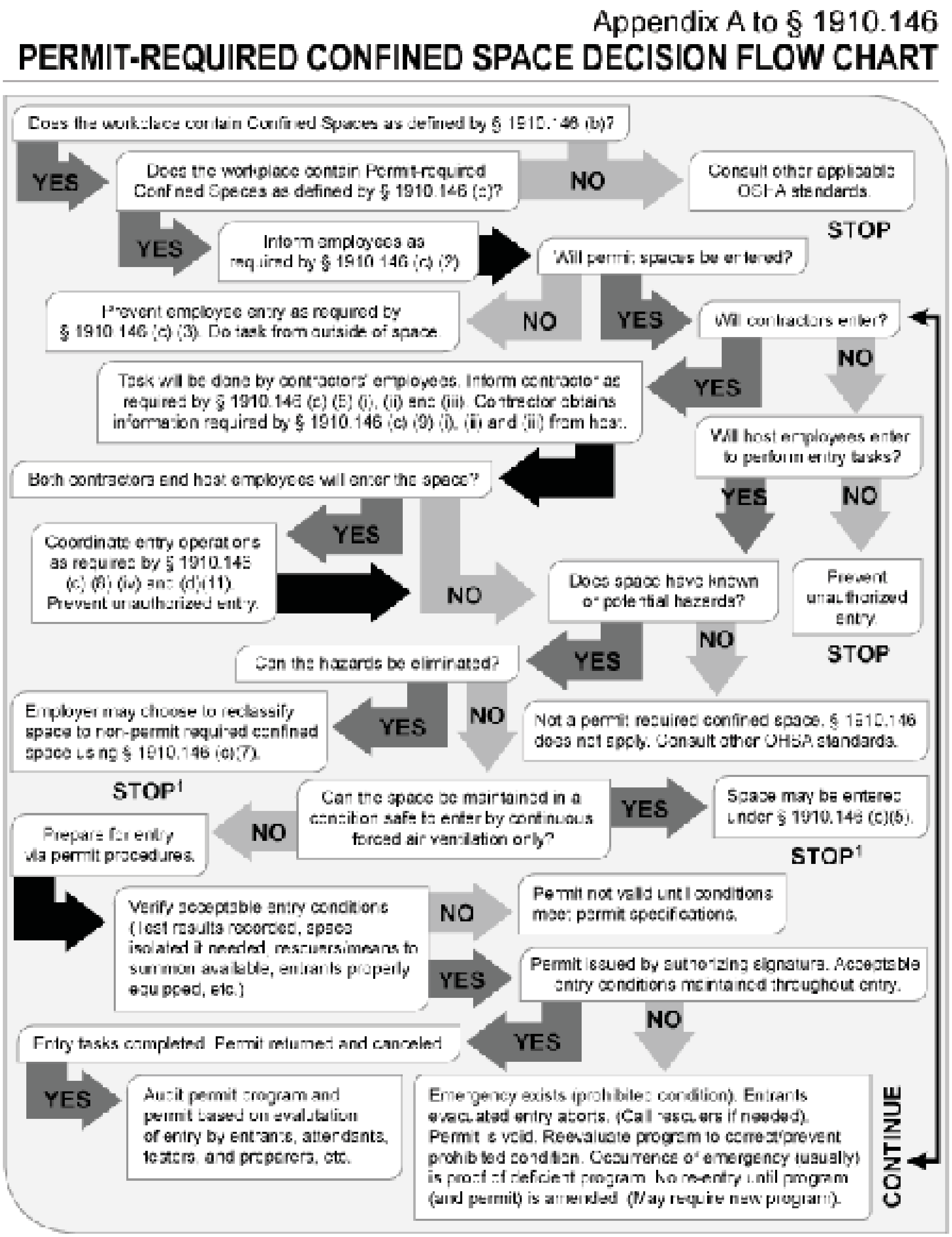


Figure 5.3

Training

If you are going to be working in a confined space, you must receive appropriate training as outlined by the OSHA confined space standard. Keep in mind that the material you are learning in this chapter is merely an overview. It does not substitute for a confined space entry program, which would entail specific confined space training.

You should be required to complete confined space training:

- Before you are first assigned confined space work.
- Before there is a change in your assigned duties within confined space.
- When a change in operations presents a new hazard for which you haven't been trained.
- Whenever the employer suspects that the procedures for the permit-required confined space are being deviated from or are inadequate.
- When the employer must establish that you are proficient working in confined space.

The employer is required to certify that you have completed the required training.

Hazardous Atmospheres

Most deaths and injuries in confined spaces are blamed on hazardous atmospheres. Confined spaces by their very definition are places ripe for collecting air that can be extremely hazardous. Often a lack of ventilation traps air that either cause breathing problems or that's flammable. This situation is especially true when you're working in a space that was used to store or process chemicals or organic substances that decay.

OSHA organizes the hazardous atmospheres into four main categories:

- Oxygen deficient
- Oxygen enriched
- Flammable
- Toxic

Atmosphere that is less than 19.5 percent oxygen by volume is oxygen deficient. Atmosphere greater than 23.5 percent oxygen by volume is oxygen enriched.

Oxygen Deficient

OSHA defines an oxygen-deficient atmosphere as one containing less than 19.5 percent oxygen by volume. Normal oxygen content in the air you breathe is approximately 21 percent. Asphyxiation is your primary danger in an oxygen-deficient atmosphere. The less oxygen you inhale, the more you suffer physically. Your judgment becomes faulty, and you lose your coordination. You should not enter this type of atmosphere without a self-contained breathing apparatus (SCBA).

Various factors can decrease the oxygen level in a confined space. Certain chemical reactions, such as rusting, decrease oxygen. Some bacterial actions, such as fermentation or decomposition, do as well. Even the work you're doing might lessen the oxygen levels. Welding, cutting, and brazing reduce oxygen levels in a confined space.

Oxygen Enriched

When the atmosphere contains more than 23.5 percent oxygen, it is considered oxygen enriched. This situation poses its own risks, mainly as a serious combustion hazard. The high levels of oxygen cause flammable and combustible materials to burn more violently when ignited and make ignition of a fire or explosion easier.

Beware of leaking oxygen equipment or the use of oxidizing chemicals, which release oxygen molecules as a part of a chemical reaction.

Flammable

Flammable or explosive atmospheres occur when ignitable or explosive vapors, gases, aerosols, mist, or dust exist at a concentration greater than 10 percent of their lower explosive limit. For a flammable or explosive atmosphere to exist, the following elements must be present in the correct proportions:

- Fuel
- Oxygen
- Heat

Different gases have different flammable ranges. If a source of ignition, such as a spark from a tool, enters the flammable atmosphere, an explosion may result.

Also keep in mind that when flammable gases or vapors have displaced the oxygen level so much that they exceed their upper explosive limit, ventilating the confined space might dilute them and bring them back to an explosive concentration again.

Toxic

Toxic, or poisonous, atmospheres feature chemical or biological agents that can adversely affect the human body. Chemical agents can be solids, liquids, or gases and affect certain organs or areas of the body. They're usually of greater concern as a gas because they can be inhaled.

Toxic gases come from biological or chemical processes inside the confined space. For instance, decomposing organic material can create hydrogen sulfide, a deadly gas.

Your work might also create toxic gases. Welding, for example, releases nitrogen oxides, ozone, and carbon monoxide. Cleaning solvents and paints you use are another source.

Speaking of carbon monoxide, it's a great example of the poor warning properties many toxic gases have. Carbon monoxide is colorless and odorless, yet it's deadly in the right dose.

Toxic atmospheres develop in confined spaces in other ways as well:

- Liquids, residues, or sludge from material previously stored in the space can be toxic.
- Toxic material absorbed into the walls can give off toxic gases or vapors when they are removed or cleaned.

Testing for Hazardous Atmospheres

Before you enter a confined space, you want to know what hazards you face. Testing the air is the most important step of that process. Special equipment is used to test and analyze the air. To ensure your safety, two types of atmospheric testing take place: pre-entry testing, and periodic testing and continuous monitoring.

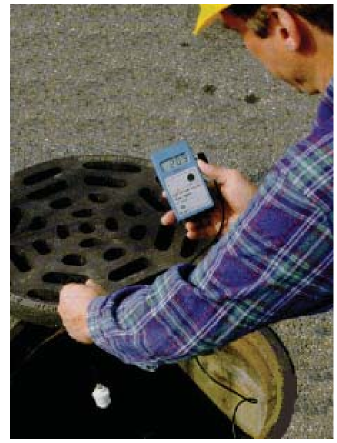


Figure 5.4 A worker conducts a pre-entry test of a confined space.

Pre-entry Testing

Before anyone enters the confined space and before an entry permit to work in any confined space is completed, testing must determine concentrations and composition inside the confined space. It's the only way to ensure safe entry. The atmosphere is always tested first from outside the confined space. The pre-entry testing also should be performed in the following order and include these specific tests:

1. Oxygen level test
2. Flammability test
3. Toxic air contaminants test

Confined spaces or low-lying areas are particularly vulnerable to oxygen deficiency and should always be monitored before entry. Qualified field personnel should always monitor oxygen levels and use atmosphere supplying respiratory equipment.

It's also important to test all areas of a confined space because some vapors and gases have different vapor densities than normal air. That means some will settle below normal air, while others will rise higher. As a result, the air must be tested at the top of the space, the middle, and the bottom. Additionally, it should be tested outside the space, just inside, one foot down, and then every four feet. Those are a lot of precautions, but they're important for ensuring your safety.

Never rely on your senses in a confined space!

Acutely hazardous concentrations of chemicals may persist in confined and low-lying spaces for long periods of time. Look for any natural or artificial barriers, such as hills, tall buildings, or tanks, where the still air might allow concentrations to build up. Examine any confined spaces such as cargo holds, mine shafts, silos, storage tanks, box cars, buildings, bulk tanks, and sumps where chemical exposures capable of causing acute health effects are likely to accumulate. Low-lying areas, such as hollows and trenches, are also suspect. Monitor these spaces for immediately dangerous to life and health (IDLH) and other dangerous conditions. Also consider whether the suspected contaminants are lighter or heavier than air. Then, based on the type of contaminants present, consider sampling on hilltops, under any cover or canopy where workers might work or congregate, and in trenches and low-lying areas.

Periodic Testing and Continuous Monitoring

Just because the air was tested safe when you started work in the confined space does not guarantee that it continues to be safe. As soon as you enter a confined space, retest the air's oxygen level, flammability, and toxicity following the same protocol as the pre-entry testing (top, middle, bottom; one foot down, every four feet).

Remember that the work you're doing inside the space could be creating a hazardous situation. If you're doing hotwork, such as welding, or you're painting, scraping or scaling, or using solvents, you might be changing the content of the atmosphere.

Air monitoring sensors should be placed in the space to continuously monitor the atmosphere, especially in areas where contaminants can leak into the confined space or in workers' breathing zones. Some monitors are designed to be worn by workers providing constant testing and alarm features. When an air monitoring alarm sounds, leave the confined space immediately. The air must be tested and brought under control before you reenter.

Common Mistakes in Confined Space Monitoring
From Occupational Hazards, an online website (www.occupationalhazards.com) dedicated to occupational safety, health, and loss prevention.

1. Not knowing OSHA standards and recommendations.
2. Using your own senses.
3. Disregarding the importance of training.
4. Not implementing a gas monitor maintenance program.
5. Not knowing which toxic gases may be present.
6. Not performing a pre-entry test.
7. Considering the confined space safe after pre-entry testing.
8. Not assigning an attendant.
9. Not having an emergency plan.

Controlling Hazardous Atmospheres

Ventilation

Figure 5.5 Ventilation can move fresh air into or contaminated air out of a confined space.

The solution to controlling most hazardous atmospheres is relatively simple—ventilation. A blower or fan can move fresh, uncontaminated air into confined spaces and push out contaminated air, either eliminating or reducing the hazard. Of course, it's rarely as simple as turning on a fan. Confined spaces come in all shapes and sizes and are used for many purposes. For instance, some tankers have internal baffles that hinder air movement. Other spaces have angles and corners that make ventilation tricky. Still, ventilation is one of the best ways to control or minimize a hazardous atmosphere.

There are two basic types of ventilation. **General ventilation** involves ventilating the entire space. Fresh, uncontaminated air is used to weaken the concentration of contaminants within the confined space. General ventilation also cools workers inside a confined space.

Local exhaust removes contaminants at the source from which they are generated. This process is common during welding operations. Fume hoods are placed above the area where the welding is taking place, and the hoods gather the fumes before they spread throughout the confined space. It's not unlike the hood and fan over your stove.

Supply and Exhaust Systems

To ventilate an area, whether it's general ventilation or local exhaust, requires one of two systems. A **supply system** pushes fresh air into a space using blowers or natural air movement. An **exhaust system** pulls air from the space using fans or fume hoods. A supply system is the far more efficient of the two because it's much easier to push air far than it is to pull it far.

Mechanical or Forced Air Ventilation

Mechanical ventilation uses blowers or fans and ducts to ventilate a confined space. It's the most common type of ventilation and also the most reliable as long as the equipment is properly maintained. In addition, you can adjust the blowers or fans as needed to remove contaminants. The equipment you use depends on the size of the openings, the gases present, and the means available to vent air.

Locate ventilation equipment so that it won't be an ignition source in an explosive or flammable atmosphere and guard all moving parts.

Mechanical ventilation does have drawbacks—setup and maintenance costs, possible ignition sources, electrical and mechanical hazards, and higher noise levels—but it remains the preferred way to ventilate.

For mechanical ventilation to be effective, make certain the exhausted air is not recirculated into the area. The intake and exhaust points should be well separated and monitored. In addition, you should test the atmospheric air periodically. If it tests hazardous, leave immediately until the situation is under control.

A non permit-required confined space can have its atmosphere remedied by continuous forced air ventilation alone.

Isolation

Sometimes a confined space must be isolated before it can be ventilated. The space is removed from service and completely protected against the release of energy or materials into it. Certain procedures are used to create isolation.

Lockout/Tagout refers to specific practices and procedures to safeguard you from the unexpected energization or startup of machinery and equipment, or the release of hazardous energy during service or maintenance activities. This requires that a designated individual turns off and disconnects the machinery or equipment from its energy source(s) before performing service or maintenance and that the authorized employee(s) either locks or tags the energy-isolating device(s) to prevent the release of hazardous energy and takes steps to verify that the energy has been isolated effectively.

Figure 5.6 Tagout procedures are safeguards against the unexpected startup of equipment.

The lockout refers to a lock that is often placed on a switch or valve. Only the designated person has the key. Tags are essentially warning devices placed on an energy isolating device. They don't provide the physical restraint that locks do. Tags must not be removed except by the person who applied them.

Blanking, tagging, and bleeding is the process of removing air, gas, or liquids from a line or pipe to prevent it from leaking. This can involve disconnecting lines, which should be done only after a thorough review of material safety data sheets for the hazardous substances in the line and surrounding area. It's also vital to know whether the material is under pressure or at a high temperature.

Blanking, or blinding, is the absolute closure of a pipe, line, or duct. A solid plate is fastened over the opening to completely cover it. The plate must be able to withstand the maximum pressure of the pipe, line, or duct with no leakage.

Double block and bleed is a three-valve system for closing off a pipe using a T configuration. Two valves close off each end of the pipe. A third valve at the bottom of the pipe drains off the material left between the two end valves.

Tagging is the warning device placed on the pipe, line, or duct describing the procedure for isolating it.

All **mechanical linkages**, such as belt or chain drives, must be disconnected during isolation procedures. **Mechanical moving parts** must be secured as well with latches, chains, chocks, blocks, or other devices.

Entering a Tank or Vault

If it is necessary to enter a tank or vault (i.e., confined spaces) for any reason (for example, to clean off solid materials or sludges on the bottom or sides of the tank or vault), take the following precautions:

- Monitor according to 20 CFR 1910.146 and then ventilate thoroughly before entry.
- Disconnect connecting pipelines.
- Before entry, take air samples to prove the absence of flammable or other hazardous vapors and to demonstrate that adequate levels of oxygen exist.
- Equip the entry team with appropriate respiratory protection, protective clothing, safety harnesses, and ropes.
- Equip a safety observer with appropriate respiratory protection, protective clothing, a safety harness, and ropes.
- Establish lifeline signals before entry so that the worker and safety observer can communicate by tugs on the rope.
- Have an additional person available in the immediate vicinity to assist the safety observer if needed.
- Instruct the safety observer not to enter the space until additional personnel are on scene.

Work in Sewers

Sewer entry has three distinct conditions compared to other permit entries. First, sewers are continuous systems, so it is nearly impossible to isolate the space to be entered. Secondly, because sewer sections cannot be isolated, sudden and unpredictable changes in the atmosphere can cause lethally hazardous conditions. Finally, sewer workers frequently work in permit space environments, so they need to be especially knowledgeable about their work.

Employers should follow a strict adherence to procedures. Only employees who are thoroughly trained should be designated as entrants. These entrants need to be skilled and equipped with atmospheric monitoring equipment that sounds an audible alarm and has visual readouts. Atmospheric monitoring should include oxygen concentrations, flammable gas or vapor percentages, and hydrogen sulfide and carbon monoxide levels.

Sewer crews should develop and maintain liaisons with local weather bureaus and fire and emergency services. Sewer work may need to be delayed or interrupted and entrants withdrawn if sewer lines might be suddenly flooded by rain or firefighting situations. Also, flammable or other hazardous materials are released into sewers during emergencies by industrial or transportation accidents.

Entry into large bore sewers may require the use of special equipment. Such equipment might include: atmosphere monitoring devices with automatic audible alarms, escape self-contained breathing apparatus (ESCBA) with at least 10-minute air supply (or other NIOSH approved self-rescuer), and waterproof flashlights, and may also include boats and rafts, radios and rope stand-offs for pulling around bends and corners as needed.

Special Precautions for Welders

Welders present a special set of hazards when working in a hazardous atmosphere. They should follow these precautions in a confined space:

- Always ventilate.
- Wear air purifying respirators (APRs) to prevent breathing toxic welding fumes.
- Keep oxygen/fuel tanks outside the confined space because they might leak gas or pure oxygen.
- Always remove the torch from the confined space as soon as the work is finished, during breaks, etc. Always turn off the torch at the tank. A small leak in the hose could quickly fill the confined space with flammable gases or pure oxygen.

Continuous Monitoring

Continue to monitor the air inside the confined space. When readings show it to be hazardous, leave immediately and ventilate the area. Let the proper authorities know about the situation so they can decide when it's safe to reenter.

Other Hazards

This chapter has focused primarily on atmospheric hazards in confined spaces because they make up the majority of deaths and illness that occur in confined spaces. However, numerous other physical hazards can be just as dangerous depending on the environment of the confined space you're working in.

Engulfment

After atmospheric-related causes, engulfment is one of the leading causes of deaths in confined spaces. When enclosed areas are filled with loose materials or liquid, you must be alert to the dangers they pose. You can't predict how the material will move if you stand on it. Engulfment and suffocation are hazards associated with storage tanks, bins, silos, hoppers, and sewage treatment plants. When materials like grains, sand, or gravel shift, you can be buried in a matter of seconds, and the material sinks so quickly that escape is virtually hopeless.

Bridging is a hazard that can lead to tragic consequences. Bridging happens when grain or similar loose material clings to the sides of a container that's being emptied from below. A hollow space is carved out below the thin layer remaining on top. Stand on the bridge or below it and you're asking for trouble. Bridging occurs more often when the diameter of the storage vessel is small, and the moisture content of the stored material is high, or there's high humidity.

Falling Objects

Imagine a confined space with an opening on top. Tools and other objects may fall in and strike you. This hazard is especially worth considering when work is being performed above the confined space. To prevent this, secure tools or materials on top of the confined space. And never drop materials into a confined space. Lower them instead.

Temperature Extremes

A confined space is often a very hot place. You need to be aware of the signs and dangers of heat stress, especially if you are wearing heavy duty personal protective equipment. Cold temperatures can also put stress on your body.

Noise

Working in a confined space, such as a tank or storage bin with metal walls, can amplify noise to levels that damage your hearing. Noise is also hazardous if it causes you a physical or mental disturbance or interferes with your hearing voice communication, warnings, or alarms. Noise might even disrupt your job, rest, relaxation, or sleep.

Moving or Driven Equipment

Before you start work in a confined space, all movable parts should be removed from service. Not only do you risk injury from contact with the moving parts, starting the equipment might cause sparks that lead to combustion. Or the equipment might end up releasing material that engulfs you.

Electrical Hazards

All electrical circuits must be locked out or tagged out to prevent electrocution or sparking a hazardous atmosphere. All temporary lights should be protected against damage, and the cords should be heavy duty and kept clear of working spaces. Only low voltage, battery-operated, or ground-fault protected equipment should be used near liquids.

Process Liquids and Steam

Water and other liquids create the potential for drowning, toxic exposure, and slips and falls. Wet surfaces also might provide a grounding surface and increase the possibility of electrocution.

Animals and Insects

In confined spaces that stored organic materials, it's possible that rodents or insects might be present. They certainly can present a threat to your health and safety that you should guard against. If you find they're a problem, let your supervisor know.

Traffic and Weather

Trenches and culverts can also be confined spaces. In those environments a supervisor needs to look out for weather conditions and possibly traffic considerations.

Review Questions

1. You have been sent to work in a space that is large enough and shaped for a human to enter. There is one small opening and no natural ventilation. Does this space meet the OSHA definition of a confined space?

OSHA's definition of a confined space has three traits: having a size and shape adequate enough for a person to enter, having limited entrances and exits for workers, and not being designed for continuous human occupancy. Additionally, a confined space has unfavorable natural ventilation.

2. List the four characteristics of a permit-required confined space.

- *Contains or potentially can contain a toxic atmosphere.*
- *Contains materials that can act like quicksand and engulf you.*
- *Contains spaces that can trap or asphyxiate you.*
- *Contains any serious recognized hazard.*

3. Is the following statement true or false?
The information presented in this chapter certifies you to be assigned confined space work.

False. You are required to take an additional confined space entry program before you are assigned to confined space work.

4. The pre-entry air test of a confined space has a reading of 25 percent oxygen by volume. Is this an oxygen deficient or oxygen enriched atmosphere? What is the primary danger associated with this atmosphere?

Any reading above 23.5 percent oxygen by volume is an oxygen-enriched atmosphere. This atmosphere can create serious fire hazards. The high levels of oxygen cause flammable and combustible materials to burn more violently when ignited and make ignition of a fire or explosion easier.

5. What is the definition of an oxygen-deficient atmosphere?

An oxygen-deficient atmosphere is one containing less than 19.5 percent oxygen by volume. Normal oxygen content in the air you breathe is approximately 21 percent.

6. What elements are necessary for a flammable or explosive atmosphere to exist?

Flammable or explosive atmospheres need fuel, oxygen, and heat in correct proportions.

7. What two types of atmospheric testing must be done to ensure your safety?

The two types of atmospheric testing are pre-entry testing, and then periodic testing and continuous monitoring.

8. What are the three specific pre-entry atmosphere tests required for a confined space? In what order must these tests be performed?

The pre-entry testing also should be performed in the following order and include these specific tests:

- *Oxygen level test*
- *Flammability test*
- *Toxic air contaminants test*

9. Why must air in a confined space be tested at the top, middle, and bottom of that space?

Some vapors and gases have different vapor densities than normal air. That means some will settle below normal air, while others will rise higher. So the air must be tested at the top of the space, the middle, and the bottom. Air should also be tested outside the space, just inside, one foot down, and then every four feet.

10. Why must trenches or hollows be monitored for hazardous atmospheres?

Acutely hazardous concentrations of chemicals may persist in confined and low-lying spaces, like trenches or hollows, for long periods of time. Look for any natural or artificial barriers, which might allow concentrations to build up.

11. What's the difference between general ventilation and local exhaust ventilation?

General ventilation uses fresh, uncontaminated air to ventilate and weaken the concentration of contaminants within the confined space. This also cools workers inside a confined space. Local exhaust uses hoods to gather and remove contaminants at the source before they spread throughout the confined space.

12. Is it more efficient to use a supply system or exhaust system to ventilate an area?

A supply system is far more efficient than the exhaust system because it's much easier to push air far(supply) than it is to pull it far (exhaust).

13. Describe how a lockout or tagout keeps you safer in hazardous atmospheres in a confined space.

A lockout or tagout is in place to safeguard you from the unexpected energization or startup of machinery and equipment, or the release of hazardous energy during service or maintenance activities.

14. Is the following statement true or false?
The majority of the deaths and illnesses associated with confined spaces result

True. Atmospheric hazards in confined spaces make up the majority of deaths and illness that occur. However other hazards, like engulfment, falling objects, extreme temperatures or noise, moving equipment, electrical hazards, water or other liquids, and rodents or insects, can all be a cause of death or illness.

Other Resources

OSHA Permit-required Confined Space Standard
http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=9797

OSHA Control of Hazardous Energy (Lockout/Tagout)
http://www.osha.gov/SLTC/controlhazardousenergy/index.html

OSHA QUICKCARD – Permit-required Confined Spaces
http://www.osha.gov/Publications/3214-10N-05-english-06-27-2007.html

OSHA Confined Spaces Hazards and Solutions
http://www.osha.gov/SLTC/confinedspaces/recognition.html

OSHA Ventilation
http://www.osha.gov/SLTC/ventilation/index.html

Facility Safety Management Online Magazine – Confined Space Awareness: Know the Criteria and Prevent Injuries
http://www.fsmmag.com/Articles/2007/11/Confined%20Space%20Awareness.htm

American Welding Society – Confined Spaces
http://files.aws.org/technical/facts/FACT-11.PDF

Common Mistakes in Confined Space Monitoring
http://www.occupationalhazards.com/Issue/Article/37605/Common_Mistakes_in_Confined_Space_Monitoring.aspx

Electronic Library of Construction Occupational Safety and Health – Confined Space Entry
http://www.cdc.gov/eLCOSH/docs/d0400/d000485/d000485.html

Instructor Lesson Plan

Cranes, Derricks, Hoists, Elevators, and Conveyors

OSHA: 29 CFR 1926 Subpart N – CIO 232 -332-366-367

Key Concepts

- Primary hazards of crane operations.
- Emergency procedures.

Presentation and Materials

- Allow 45 minutes to present this chapter.
- Use Cranes, Derricks, Hoists, Elevators, and Conveyors PowerPoint® slides.
- Use Review Questions at the end of the chapter to facilitate discussion.
- Use 30-Hour Construction Outreach course manual.

Updates

Please review the student manual as there have been many updates to the text. The following sections have been added and or updated to reflect changes and additions in Subpart CC - Cranes & Derricks in Construction and Subpart H – Materials Handling, Storage, Use, and Disposal (rigging equipment). Below is a list of updates and additions:

- 2010 Crane Standard Update Overview.
- Importance of ground conditions (Subpart CC Section 1402).
- Assembly and Disassembly (A/D) requirements under Subpart CC.
- Outriggers and stabilizers.
- Operator Qualification and Certification.
- Signal Person Qualifications under Subpart CC.
- When a qualified rigger is required and qualification methods.
- Certified operator and the requirements of a qualified rigger.
- Attaching the Load.
- Power Lines.
- Glossary.
- Review Questions.

Standards

Safety and Health Regulations for Construction

- 29 CFR 1926 Subpart CC - Cranes & Derricks in Construction
- 29 CFR 1926 Subpart N - Helicopters, Hoists, Elevators, and Conveyors
- 29 CFR 1926 Subpart H – Materials Handling, Storage, Use, and Disposal (rigging equipment)

Module 6

Cranes, Derricks, Hoists, Elevators, And Conveyors

OSHA: 29 CFR 1926 Subpart N and CC- CIO 232 -332-366-367

Lesson Outline

Overview

The high profile fatalities caused by crane failures that have made the news in recent years point out the many dangers of working with cranes. However, cranes, along with hoists and other lifts, are necessary and vital pieces of equipment on many construction sites, especially when building multistory facilities. This chapter will teach you about the regulations in place to ensure safe usage of cranes and other aerial equipment.

Objectives

After completing this chapter, you should be able to:

Know

- List primary hazards of crane operations.
- Define pinch points.
- Cite the biggest danger of working with cranes.

Apply

- Describe procedures for dealing with a crane that has contacted an energized power line.
- Demonstrate the hand signal to give a crane operator for an emergency stop.

Analyze

- Compare safety issues associated with various cranes.

Cranes

Figure 6.1 The March 2008 New York City crane collapse. Photo courtesy of the New York Times.

In March 2008 seven people, including two construction workers, were killed and 24 injured when a crane topples and plows into several residential buildings in New York City. Less than two months later two construction workers are killed when another crane collapses in the city. The accidents make international news and, more importantly, illustrate the dangers inherent in working with cranes.

The Occupational Safety and Health Administration says that 20 to 25 percent of all construction fatalities each year are crane related. Nearly half of those deaths (44 percent) are caused by electrocution, when the boom strikes an overhead power line. Load handling and rigging account for another 30 percent. A third of crane-related accidents are caused by operator error, making it the leading cause, followed by support failure, outrigger use, and mechanical failure.

In 2008 an in-depth report by CPWR—the Center for Construction Research and Training—on U.S. crane fatalities found the number of crane-related deaths among construction workers is significant, with an average of 22 workers killed annually.

Despite the media attention given crane collapses like those in New York City, the CPWR report found the leading cause of death among workers was electrocution when the crane touched an overhead power line. Of the 323 worker deaths recorded by BLS, 102 workers (32 percent) were electrocuted, and 68 (21 percent) died because of a crane collapse. Of the 59 deaths (18 percent) of workers struck by a crane boom/jib, 52 deaths were caused by falling booms or jibs (the jib is the short piece that extends on the other side of the boom). A falling boom or jib can happen when the crane is being assembled or dismantled.

2010 Crane Standard Update Overview

Most requirements of the prior OSHA standard for cranes and derricks used in construction work (29 CFR 1926.550) incorporated requirements of certain pre-1970 national consensus standards. This standard sets forth most of its requirements in the text of the standard and incorporates national consensus standards by reference in only a few locations. In addition, this new standard includes a number of new provisions designed to improve safety. Several significant changes are:

- Effective November 10, 2014, most operators must be formally qualified or certified.
- New requirements during assembly and disassembly will protect workers from being struck or crushed by unanticipated movement of crane components and will ensure that equipment is properly assembled.
- New requirements are included for maintaining sufficient clearance distances from power lines and protecting against electrocution hazards.
- New requirements for pre-erection inspection of tower cranes, use of synthetic slings during climbing of tower cranes and other assembly activities, and use of qualified riggers for those activities, will ensure the structural stability of such equipment.
- The new standard covers more types of equipment (such as floating cranes) that were subject to very few requirements in the prior standard because the prior standard did not incorporate national consensus standards applicable to such equipment. It also covers equipment (such as dedicated pile drivers) that was not subject to the prior standard at all.

Hazards

Obviously there are many hazards associated with cranes. Simple physics will tell you that cranes pose problems. Cranes act as a lever and pulley system. They're the solution to moving materials to and among higher places when building a tall structure. The higher the structure, the longer the boom needs to be and the more safeguarding is necessary to maintain its center of gravity. When working in congested areas, such as between the jungle of buildings in a city, cranes face even more difficulties. Here are the primary hazards in crane operation:

- **Power line contact.** A crane operator must be aware of the hazards overhead and take all caution to avoid them. Striking a power line turns the machine and everything touching it into a conductor.
- **Swing radius crushing.** People working below the swing radius of a crane—the area the crane rotates above—are in danger of being struck by the crane or having materials being hoisted by the crane fall on them.
- **Structural failure.** The crane's main frame, crawler track and/or outrigger supports, boom sections, and attachments are all considered part of the structural integrity of lifting. In addition, all wire ropes, including stationary supports or attachment points, help determine lifting capacity and are part of the overall structural integrity of a crane's lifting capacity. Overload the crane and any of those parts can fail and collapse.
- **Rigging failure.** Rigging is the hooking and unhooking of the load. The rigging must be secure, or else the load can shift or fall, endangering anyone near.
- **Tipover.** The crane's main frame acts as a fulcrum. The farther the boom sections extend out, the greater the risk the crane can tip over if it's not supported properly or it exceeds the load limits set by the crane's manufacturer.

Figure 6.2 The hoist cable contacts a power line.

Figure 6.3 A telescoping boom rough terrain crane sits on its outriggers. Photo courtesy of www.myconstructionphotos.com.

Figuer 6.4 Tipover is always a possibility.

Causes of Crane Failures

When cranes fail, the problems can usually be classified into two causes: improper setup or overload.

Improper setup puts the crane at a disadvantage before it even begins work. Here are some typical setup problems:

- **Inadequate outrigger cribbing.** Outriggers are extendable or fixed members attached to the mounting base of the crane. They extend out and rest on pads to help stabilize the crane. Cribbing is additional support placed under the pads. If the outriggers don't have enough support, they'll sink or collapse through the ground, perhaps tipping the crane or causing other damage.
- **Underground utilities.** If you don't know that an underground utility line is beneath the crane or its outriggers, you could face trouble. When the outrigger is set and its rigging is not widened to dissipate the load, the outrigger could puncture straight through the utility line running underneath.
- **Unlevel crane.** Since the crane acts as a fulcrum in a lever setup, it needs to be level to be effective. If it's not level, it risks tipover. Being even a little bit unlevel also reduces the weight of the material it can bear. While the operator might believe he or she is within the load limit, an unlevel crane still might buckle under that load if its supporting structure is not level and distributed as equally as possible.
- **Inspection failure.** If the crane's inspection records are inadequate or unavailable, or the person inspecting the crane is not familiar with all the regulations surrounding safe crane use, there can be problems. Either way, what is meant as a safeguard fails to meet its purpose.

Overload is the other main cause of crane failure. Crane manufacturers test their equipment and set load limits. Of course, these tests involve new equipment on flat ground under optimum conditions. What you face on a work site is often less than optimal. That's why it's important to assess the conditions at the worksite. Too much load can cause mechanical failure in the crane or cause the hydraulics to fail. A boom is not designed to drag a load sideways (side loading), which can also cause failure. Wind is another factor in crane failures. OSHA cited three subcontractors for failing to take into account the effects of the wind in the collapse of a crane in 1999 in the building of Miller Park baseball stadium in Milwaukee. Three ironworkers were killed in the collapse.

Site Superintendent Crane Responsibilities

The site superintendent on a construction job plays a major role in the safety of crane operations. Here are six questions the superintendent should answer before crane work begins:

- Do you have the right crane for the job?
- Are there electrical or other hazards?
- Is the crane set up on a solid foundation?
- Are outriggers properly extended?
- Are there sufficient clearances for access and lifting?
- Are pinch (nip) points—anywhere that a body part can get caught between two moving parts or a moving part and a stationary object—guarded? Is there too much congestion around the crane?

Following these guidelines can help ensure safe operations.

Figure 6.5 Cab of Manitowoc 4000W 150 ton track mounted lattice boom crane with flying jib. Crane and its cab, including rear counterweights, can rotate 360 degrees. Note the metal rods extending from brackets on the end track drive rollers, to which yellow caution tape has been attached to mark the rotating counterweight hazard area and guard against pinch points. Photo courtesy of www.myconstructionphotos.com.

OSHA General Requirements

OSHA regulations cover a number of factors for safe crane operations. Here are some of them:

- The employer must follow the crane's specifications and limitations as set by the manufacturer. If those specs aren't available, a qualified engineer competent in crane operations will determine the limitations and put them in writing. Attachments used with cranes shall not exceed the capacity, rating, or scope recommended by the manufacturer.
- The crane's rated load capacities, recommended operating speeds, special hazard warnings, or instruction must be posted on all equipment, and operators must be able to see them while they are at their control stations.
- The hand signals you give to crane and derrick operators must be the applicable ANSI (American National Standards Institute) standard for the type of crane in use. An illustration of the signals shall be posted at the job site. See the diagram on the following page for common, industry standard signals. OSHA signal person qualifications are discussed later in the module.
- An inspector appointed by the employer must inspect all machinery and equipment before and during each use to make sure it is in safe operating condition. Any problems must be fixed before the crane can be used.
- The employer must keep a record and results of annual inspections for each crane or hoist.
- Wire rope shall be taken out of service when any of the following conditions exist:
  - In running ropes there are six randomly distributed broken wires in one lay or three broken wires in one strand in one lay.
  - In standing ropes there are more than two broken wires in one lay in sections beyond end connections or more than one broken wire at an end connection.
  - One-third of the original diameter of outside individual wires has worn away.
  - Kinking, crushing, bird caging, or any other damage results in distortion of the rope structure.
  - Evidence of any heat damage from any cause exists.
  - There are reductions from nominal diameter of more than:
    - 1/64 inch for diameters up to and including 5/16 inch.
    - 1/32 inch for diameters of 3/8 inch to and including ½ inch.
    - 3/64 inch for diameters of 9/16 inch to and including ¾ inch.
    - 1/16 inch for diameters of 7/8 inch to 1⅛ inches inclusive.
    - 3/32 inch for diameters 1¼ to 1½ inches inclusive.
-

Figure 6.6 Common, industry standard signals

- Belts, gears, shafts, pulleys, sprockets, spindles, drums, fly wheels, chains, or other reciprocating, rotating, or other moving parts or equipment shall be guarded if they are exposed to you or otherwise create a hazard.
- Accessible areas within the swing radius of the rear of the rotating superstructure of the crane, either permanently or temporarily mounted, must be barricaded to prevent someone from being struck or crushed by the crane.
- All exhaust pipes shall be guarded or insulated in areas where it's possible for someone to contact them in their normal duties.
- The air must be tested when the crane's engine exhausts in enclosed spaces to make sure people aren't exposed to unsafe concentrations of toxic gases or oxygen deficient atmospheres.
- All windows in cabs shall be of safety glass that doesn't distort the operator's view.
- A ladder or steps must be provided for access to a cab roof. Guardrails, handholds, and steps are required for easy access to the car and cab.
- Platforms and walkways must have anti-skid surfaces.
- The fuel tank filler pipe must be located or protected in a way to prevent spill or overflow from running onto the machine's engine, exhaust, or electrical equipment.
- The cab or operator stations must have an accessible fire extinguisher of 5BC rating or higher.
- The employer cannot modify the crane to change its capacity or safe operation without the manufacturer's written approval. If such modifications or changes are made, the capacity, operation, and maintenance instruction plates, tags, or decals, shall be changed accordingly. In no case shall the original safety factor of the equipment be reduced.
- The employer shall comply with Power Crane and Shovel Association Mobile Hydraulic Crane Standard No. 2.
- Sideboom cranes mounted on wheels or crawler tractors shall meet the requirements of SAE J743a-1964.
- All employees shall be kept clear of loads about to be lifted and of suspended loads.

Importance of ground conditions (Section 1402)

Adequate ground conditions are essential for safe crane operations because the crane's capacity and stability depend on the ground on which the crane is working. If, for example, the ground is muddy or otherwise unstable, a crane could overturn even if operated within the load limits specified by the manufacturer.

The **Controlling Entity** must provide adequate ground conditions. You must not assemble or use a crane unless ground conditions are firm, drained, and graded to a sufficient extent so that, in conjunction (if necessary) with the use of supporting materials (such as blocking, mats, cribbing, or marsh buggies (in marshes/ wetlands), the equipment manufacturer's specifications for adequate support and degree of level of the equipment are met. The requirement for the ground to be drained does not apply to marshes/wetlands.

A contractor operating a crane on a construction site may not have the ability or authority to provide for adequate ground conditions at the site. The standard therefore places the responsibility for ensuring that the ground conditions are adequate on the "controlling entity" at the site, that is the prime contractor, general contractor, construction manager, or other legal entity with overall responsibility for the project's planning, quality, and completion.
The controlling entity must also inform the user and operator of the equipment of hazards beneath the equipment set-up area (such as voids, tanks, utilities, etc.) if those hazards are identified in documents (such as site drawings, as-built drawings, and soil analyses) in the possession of the controlling entity (whether at the site or off-site) and of any other hazards known to the controlling entity.

If there is no controlling entity for the project, the responsibility for providing adequate ground conditions rests on the employer that has authority at the site to make or arrange for ground preparations.

Although the controlling entity is responsible for providing adequate ground conditions, the company operating the crane will often be better able than the controlling entity to determine whether those conditions are adequate. **If you are operating a crane and decide that ground conditions are inadequate, you must discuss the problem with the controlling entity and see that the problem is corrected before beginning or continuing operations.**

Assembly and Disassembly (A/D) requirements under Subpart CC (Sections 1403-1406)

Accidents during assembly and disassembly of lattice boom and tower cranes are one of the major causes of crane-related fatalities. Sections 1403-to-1406 are designed to prevent such accidents by requiring safe assembly/disassembly procedures for lattice boom and tower cranes. Hydraulic-boom cranes are not generally assembled on-site, but these sections contain some provisions, such as the requirement (section 1404(q)) for proper setting of outriggers and stabilizers, that apply to cranes with hydraulic booms.

Under this standard, employers must comply with all manufacturer prohibitions regarding assembly and disassembly. However, the standard generally allows employers to choose between the manufacturer's procedures or their own (see exception below for synthetic slings procedures). Employer procedures must be developed by a "qualified person" and must satisfy a number of specified requirements, such as providing adequate support and stability for all parts of the equipment, and positioning employees involved to minimize exposure to any unintended movement or collapse.

Assembly/Disassembly responsibilities

The Assembly/Disassembly Director

All assembly/disassembly operations must be directed by an individual who meets the criteria for both a competent person and a qualified person, or by a competent person who is assisted by one or more qualified persons. The A/D director must understand the applicable assembly/disassembly procedures. The A/D director must take the following precautions to protect against potential hazards associated with the operation.

- The rule requires the work to be directed by an A/D director. The A/D director must meet the criteria for both a "competent person" and a "qualified person," which are defined terms in this rule, or must be a "competent person" assisted by a "qualified person."
- The A/D director must understand the applicable procedures.
- The A/D director must review the procedures immediately prior to beginning work unless he or she understands the procedures and has used them before for that equipment type and configuration.
- The A/D director must ensure that each member of the crew understands his or her tasks, the hazards of the tasks, and any hazardous positions or locations to avoid.
- The A/D director must verify all capacities of any equipment used, including rigging, lifting lugs, etc.
- The A/D director must also address hazards associated with the operation, including 12 specified areas of concern: site and ground conditions, blocking material, proper location of blocking, verifying assist crane loads, boom & jib pick points, center of gravity, stability upon pin removal, snagging, struck by counterweights, boom hoist brake failure, loss of backward stability, and wind speed and weather.

Inspection

Upon completion of assembly, but before use, the equipment must be inspected by a “qualified person” to ensure that it is configured in accordance with the manufacturer’s equipment criteria. If these criteria are unavailable, the employer’s “qualified person,” with the assistance of a registered professional engineer if necessary, must develop the appropriate configuration criteria and ensure that these criteria are met. See Table A-Crane Inspection Summary for who is allowed to perform crane inspections.

Table A-Crane Inspection Summary	
Type of inspection	**Who inspects**
Modified or repaired/adjusted	Qualified person
Post-assembly	Qualified person
Shift	Competent person
Monthly	Competent person
Annual	Qualified person

Table 6.1

All documentation required by the inspection provisions must be available to all inspectors performing required inspections; including wire rope inspections (§1926.1412 & §1926.1413).

The crane standard also calls for a pre-erection inspection for Tower Cranes with a requirement to inspect crane components after transportation to the work site and prior to erection of the crane (§ 1926.1435).

General requirements during assembly/disassembly

- A crew member who moves out of the operator's view to a location where the crew member could be injured by movement of the equipment (or load) MUST inform the operator before going to that location. The operator must not move the equipment until that crew member informs the operator that he or she has relocated to a safe position.
- Employees must never be under the boom or jib when pins (or similar devices) are being removed, unless it is required by site constraints and the A/D director has implemented procedures that minimize the risk of unintended movement and the duration and extent of exposure under the boom.
- Component weights must be readily available for all components to be assembled.
- All rigging must be done by a "qualified rigger."
- Pins may not be removed during disassembly when the pendants are in tension.
- Booms supported only by cantilevering must not exceed manufacturer limitations or RPE limitations, as applicable.
- Component selection and equipment configuration that affects the capacity or safe operation of the equipment must be in accordance with manufacturer requirements and limits or RPE requirements and limits, as applicable.

Synthetic slings

- The employer must follow the manufacturer's procedures when using synthetic slings during rigging assembly or disassembly (even when the employer has developed its own A/D procedure as an alternative to the manufacturer's other procedures.)
- Synthetic slings must be protected from abrasive, sharp or acute edges, and configurations that might reduce the sling's rated capacity.

Outriggers and stabilizers

When outriggers or stabilizers are used or are necessary in light of the load to be handled and the operating radius:

- Outriggers and stabilizers must be fully extended or, if permitted by manufacturer procedures, deployed as specified in the load chart.
- Outriggers must be set to remove equipment weight from the wheels, except for locomotive cranes.
- Outrigger floats, if used, must be attached to the outriggers; stabilizer floats, if used, must be attached to the stabilizers.
- Each outrigger or stabilizer must be visible to the operator or to a signal person during extension and setting.
- Outrigger and stabilizer blocking must be placed under the float/pad of the jack or, if there is no jack, under the outer bearing surface of the outrigger or stabilizer beam. Blocking must also be sufficient to sustain the loads and maintain stability and must be properly placed.

Tower cranes

Tower cranes are subject to additional requirements for erecting, climbing and dismantling, including a pre-erection inspection (Section 1435).

Operator Qualification and Certification (Section 1427)

In accordance with Subpart CC – Cranes and Derricks in Construction: cranes must be operated by qualified and certified personnel—the designated operator, trainees under the direct supervision of the operator, maintenance and test personnel when necessary, and crane inspectors.

Employers must pay for certification or qualification of their currently uncertified or unqualified operators.

Who needs to be certified or qualified?

Any person engaged in a construction activity who is operating a crane covered by the new cranes and derricks rule, except:

- Sideboom cranes*
- Derricks*
- Equipment with a rated hoisting/lifting capacity of 2,000 pounds or less*

***Operators of the listed equipment must meet the criteria for minimum expertise described in the applicable section in subpart CC.**

Are operators of digger derricks required to be qualified or certified?

Yes, unless the digger derrick is being used to auger holes for poles carrying electric or telecommunication lines, place or remove the poles, or handle associated materials to be installed on or removed from the poles.

What is required in the testing for certification?

Certification has two parts:

1. A written examination that includes the safe operating procedures for the particular type of equipment the applicant will be operating and technical understanding of the subject matter criteria required in 1926.1427(j).
2. A practical exam showing the applicant has the skills needed to safely operate the equipment, including, among other skills, the ability to properly use load chart information and to recognize items required in the shift inspection.

Does an operator need more than one certification?

With respect to certification from an accredited testing organization, an operator must be certified for the type and capacity of crane he or she is going to operate. Each accredited testing organization develops its own categories for crane type and capacity.

How is an operator certified or qualified?

There are 4 ways that an equipment operator can be qualified or certified and meet OSHA requirements.

3. A certificate from an accredited crane operator testing organization.
4. Qualification from the employer through an audited employer program.
5. Qualification by the US Military (only applies to employees of Department of Defense or Armed Forces and does not include private contractors)
6. Licensing by a state or local government (if that licensing meets the minimum requirements set forth by OSHA) *

***When a state or local government requires a crane operator license, the crane operator must be licensed accordingly to meet OSHA requirements.**

Accredited crane operator testing organization

The testing organization must be accredited by a nationally recognized accrediting agency and must test according to the criteria listed at §§ 1926.1427(j)(1) and (j)(2). This certification is portable from employer to employer. The testing organization must have its accreditation reviewed every 3 years. The certificate must note the type and capacity of equipment for which the operator is tested and certified. The certificate is valid for 5 years.

Audited employer program

An employer may provide a crane operator testing program under the oversight of an independent auditor. An accredited crane operator testing organization must certify the auditor to evaluate the administration of written and practical tests. The auditor must conduct audits of the employer's program according to nationally recognized auditing standards. Crane operator qualification under an employer program is only valid while the operator is an employee of the employer and is operating a crane for the employer. The qualification is valid up to 5 years.

U.S. Military. This qualification applies only to civilian employees of the Department of Defense or Armed Services and is not portable. This qualification does not include employees of private contractors.

Licensing by a government entity

This license is obtained from a government entity, such as a city or state that has a required certification program. When this license meets the minimum requirements of 1926.1427(e)(2) and (j), OSHA requires a crane operator to have this license when operating in the applicable city, county, or state. This license is not portable outside the boundaries of the government entity that issues the license, and is valid for a maximum of 5 years.

Timeline for Operator licensing and certification

- November 8, 2010: State or local license required if (1) working within a state or locality that has licensing requirements and (2) the licensing program meets the licensing and certification criteria listed in subpart CC.
- November 8, 2010-November 10, 2014: Employer must ensure that all operators are competent to operate the equipment safely and are trained and evaluated on that training before operating the equipment.
- November 10, 2014: All operators must be certified or qualified.

Qualifications for Operators

Operators must pass a written or oral examination and a practical operating examination unless they can furnish satisfactory evidence of qualifications and experience. They can operate only the equipment for which they've passed an exam.

Operators also must meet physical qualifications:

Figure 6.7 A worker uses the aid of a crane to move material.

- Vision of 20/30 in one eye and 20/50 in the other, minimum, with or without corrective lenses.
- Ability to distinguish colors regardless of position.
- Adequate hearing, with or without hearing aid.
- Sufficient strength, endurance, agility, coordination, and speed of reaction to operate the equipment.
- Normal depth perception, field of vision, reaction time, manual dexterity, coordination, and no tendencies to dizziness or similar undesirable characteristics.

Specialized clinical or medical judgments and tests may be required if there is evidence of physical defects, emotional instability, seizures, or loss of physical control.

Conduct of Operators

Running a crane safely is the first responsibility of the crane operator. Here are some guidelines for crane operators to ensure everyone's safety:

- Operators cannot be engaged in activities that distract her or his attention while operating the equipment (for example, no cellular phone use unless used for signaling).
- Don't operate the equipment if you're physically or mentally unfit.
- Respond to signals from the person directing the lift or an appointed signal person. Obey a stop signal at all times no matter who gives it.
- Take responsibility for those operations under your direct control. If you have any doubt about safety, consult with the supervisor before handling loads.
- Before leaving the crane unattended:
    - Land any load, bucket, lifting magnet, or other device.
    - Disengage the master clutch.
    - Set travel, swing, boom brakes, and other locking devices.
    - Put controls in the off or neutral position.
    - Secure the crane against accidental travel.
    - Stop the engine. An exception may exist when crane operation is frequently interrupted during a shift, and you must leave the crane.
- When a local weather storm warning exists, follow the manufacturer's recommendations for securing the crane.
- If there is a warning sign on the switch or engine starting controls, don't close the switch or start the engine until the warning sign has been removed.
- Be familiar with the equipment and its proper care.
- Test all controls at the start of a new shift.
- Follow the manufacturer's boom assembly and disassembly procedures.
- Keep workers out from under the boom when they are removing pins or bolts from a boom.
- Keep each outrigger visible to you or a signal person during extension or setting.
- Do not move loads over people.
- Rigging must be performed by qualified riggers

General requirements for crane operations

Operating procedures must be developed by a qualified person when the manufacturer's procedures are unavailable. Procedures related to the capacity of the equipment must be developed by a registered professional engineer (familiar with the equipment) when the manufacturer's procedures are unavailable. This information must be readily available in the cab of the crane.

When any necessary repairs or adjustments are needed for the equipment and alternative methods are being implemented, the employer must communicate this information to all affected employees at the beginning of each shift. (§1417(j))

Signal Person Qualifications under Subpart CC

A signal person is required when:

- The point of operation is not in full view of the operator (1926.1419(a)).
- The operator's view is obstructed in the direction the equipment is traveling.
- Either the operator or the person handling the load determines that a signal person is needed because of site-specific safety concerns.

The signal person is considered qualified if he or she:

- Knows and understands the type of signals used at the worksite.
- Is competent in using these signals.
- Understands the operations and limitations of the equipment, including the crane dynamics involved in swinging, raising, lowering and stopping loads and in boom deflection from hoisting loads.
- Knows and understands the relevant signal person qualification requirements specified in subpart CC (1926.1419-1926.1422; 1926.1428).
- Passes an oral or written test and a practical test.

How does a signal person become qualified?

Employers must use one of the following options to ensure that a signal person is qualified (see 1926.1428).

1. Third-party qualified evaluator. The signal person has documentation from a third-party, qualified evaluator showing that he or she meets the qualification requirements.
2. Employer's qualified evaluator (not a third party). The employer's qualified evaluator assesses the individual, determines the individual meets the qualification requirements, and provides documentation of that determination.

This assessment may not be relied on by other employers. Refer to 1926.1401 for definitions of qualified evaluators.

How will an employer show that a signal person is appropriately qualified?

Employers must make the documentation of the signal person's qualifications available at the worksite, either in paper form or electronically. The documentation must specify each type of signaling (e.g., hand signals, radio signals, etc.) for which the signal person is qualified under the requirements of the standard.

When are signal persons required to be qualified?
The qualification requirements for signal persons went into effect on November 8, 2010.

When a qualified rigger is required (Subpart CC)
Employers must use qualified riggers during hoisting activities for assembly and disassembly work (Section 1404(r)(1)). Additionally, qualified riggers are required whenever workers are within the fall zone and hooking, unhooking, or guiding a load, or doing the initial connection of a load to a component or structure (Section 1425(c)).

Who can be a qualified rigger?
A qualified rigger is a rigger who meets the criteria for a qualified person. Employers must determine whether a person is qualified to perform specific rigging tasks. Each qualified rigger may have different credentials or experience. A qualified rigger is a person that:

- Possesses a recognized degree, certificate, or professional standing, or
- has extensive knowledge, training, and experience, and
- Can successfully demonstrate the ability to solve problems related to rigging loads.

The person designated as the qualified rigger must have the ability to properly rig the load for a particular job. It does not mean that a rigger must be qualified to do every type of rigging job. Each load that requires rigging has unique properties that can range from the simple to the complex. For example, a rigger may have extensive experience in rigging structural components and other equipment to support specific construction activities. Such experience may have been gained over many years. However, this experience does not automatically qualify the rigger to rig unstable, unusually heavy, or eccentric loads that may require a tandem lift, multiple-lifts, or use of custom rigging equipment. In essence, employers must make sure the person can do the rigging work needed for the exact types of loads and lifts for a particular job with the equipment and rigging that will be used for that job.

Riggers do not have to be certified by an accredited organization or assessed by a third party. Employers may choose to use a third party entity to assess the qualifications of the rigger candidate, but they are not required to do so.

Certified operator and the requirements of a qualified rigger
A certified operator does not necessarily meet the requirements of a qualified rigger. Determining whether a person is a qualified rigger is based on the nature of the load, lift, and equipment used to hoist that load plus that person's knowledge and experience. A certified/qualified operator may meet the requirements of a qualified rigger, depending on the operator's knowledge and experience with rigging.

Attaching the Load
All rigging equipment must have a permanently affixed, legible identification marking with manufacturer recommended safe working load and rigging conditions. DO NOT USE rigging equipment without affixed, legible markings as described here (reference 29CFR1926.251).
Do not wrap the hoist rope around the load. Attach the load to the hook with slings or other approved devices.

Holding the Load
When the crane is holding the load, follow these safety guidelines:

- The operator shall not leave the controls while the load is suspended.
- No one should stand or pass under a suspended load.
- If the load hoist mechanism is not equipped with an automatic brake and the load must remain suspended for any considerable length of time, the operator must hold the drum from rotating in the lowering direction by activating a brake.

Moving the Load
The person supervising the lift must determine that:

- The crane is level and blocked properly where necessary.
- The load is well secured and properly balanced before being lifted more than a few inches.
- The lift and swing path are clear of obstructions.
- All persons are clear of the swing radius of the crane counterweight.

Before starting to hoist, determine that:

- There are no kinks or other problems with the rope.
- Multiple-part lines are not twisted around each other.
- The effect of ambient wind on the load and on crane stability is accounted for.

Bring the hook over the load in a way to minimize swinging. If there’s slack in the rope, make sure the rope is seated on the drum and in the sheaves as the slack is removed. During hoisting avoid sudden acceleration or braking of a moving load. Make sure the load, boom, or other parts don’t contact an obstruction. Side loading of booms must be limited to freely suspended loads. Cranes must not be used for dragging loads sideways.

In moving loads the operator:

- Should avoid carrying loads over people.
- Should not move the crane while anyone is on the load or hook.
- Must test the brakes each time a load approaching the rated load is handled by lifting it a few inches and applying the brakes.
- Use outriggers when the load to be handled at a particular radius exceeds the manufacturer's rated load without the outriggers.
- Should not lower either the load or boom to the point where less than two full wraps of rope remain on their respective drums.

When moving a crane with a load, a spotter is required to ensure everyone's safety on the ground.

Power Lines

The biggest danger people face when working with cranes is electrocution. What's the culprit? Overhead power lines. As noted earlier in the 2008 CPWR report, nearly a third of the study's 323 crane-related deaths—102 workers (32 percent)—were electrocuted. Here are a couple of examples from OSHA's fatal accident files on how electrocutions typically occur:

> One employee was unloading a 40-foot wood telephone pole from a pipe rack mounted on a truck crane. The truck operator raised the 17-foot boom to provide sufficient distance for the employee to place a cable sling around the pole and then attach the sling to the crane hook. However, in raising the boom, the operator made contact with overhead power lines. The victim reached for the metal bicycle-chain style come-along that secured the pole to the truck rack and received a fatal electrical shock.

> Employees were moving a steel canopy structure using a "boom crane" truck. The boom cable made contact with a 7,200 volt electrical power distribution line, electrocuting the operator of the crane; he was the foreman at the site.

Figure 6.8 Grove wheel-mounted self-propelled hydraulic telescoping boom mobile crane lifts two wide flange structural steel sections to be placed by two ironworkers. Note the closeness to the power lines. Photo courtesy of www.myconstructionphotos.com.

Search the Internet and you're likely to find even more examples:

> A 29-year-old worker died in Sterling, CO after cables from the crane hook he was holding touched high-voltage power lines. The worker was part of a crew that was pumping water out of the South Platte River to hydrotest a pipeline they had just put in. The site superintendent said the workers had just used the truck crane to pick up a water pump from beside the river and were in the process of lifting a pipe and drafting basket out of the river when the incident happened. The superintendent said the worker had the sling with the pipe in one hand and the crane hook in the other when the crane cable touched the high voltage lines above.
>
> A construction worker was electrocuted while on the ground trying to get a cable around a crane. His company said the crane operator didn't hit any overhead wires, but humid weather caused electricity to jump from the wire to the crane.
>
> A crane contacted an energized 7,200 volt overhead power line as two employees were attempting to attach the crane's rigging equipment to a section of a modular home that was being constructed. One of the employees was killed and the other seriously injured by the electric current. OSHA's inspection found that the crane was being operated within 10 feet of the power line, which had not been de-energized beforehand, as required.

As you can see, all it takes is a boom touching a power line, and the entire apparatus becomes energized. And in the one case, the crane didn't even touch the lines but got close enough to become energized nonetheless.

OSHA Power Line Safety Regulations (Sections 1407-1411)

The best option for working safely around power lines is to de-energize them and visibly ground them. That's what OSHA recommends. The next best option is to place insulating barriers over the lines to prevent contact with the cranes. Barring those options, here are the OSHA regulations if the line remains energized:

Consider any overhead power line energized unless the owner of the line or the electric utility company indicates it has been de-energized, and it is visibly grounded.

- Survey the work site and establish a crane work zone; is there a possibility a crane will come within 20 feet of a 350,000 volt power line? The crane work zone is either Marking Boundaries or 360 degrees around the crane up to the maximum working radius.

OSHA has laid out an evaluation flow chart (see below) for determining methods of handling crane work near power lines.

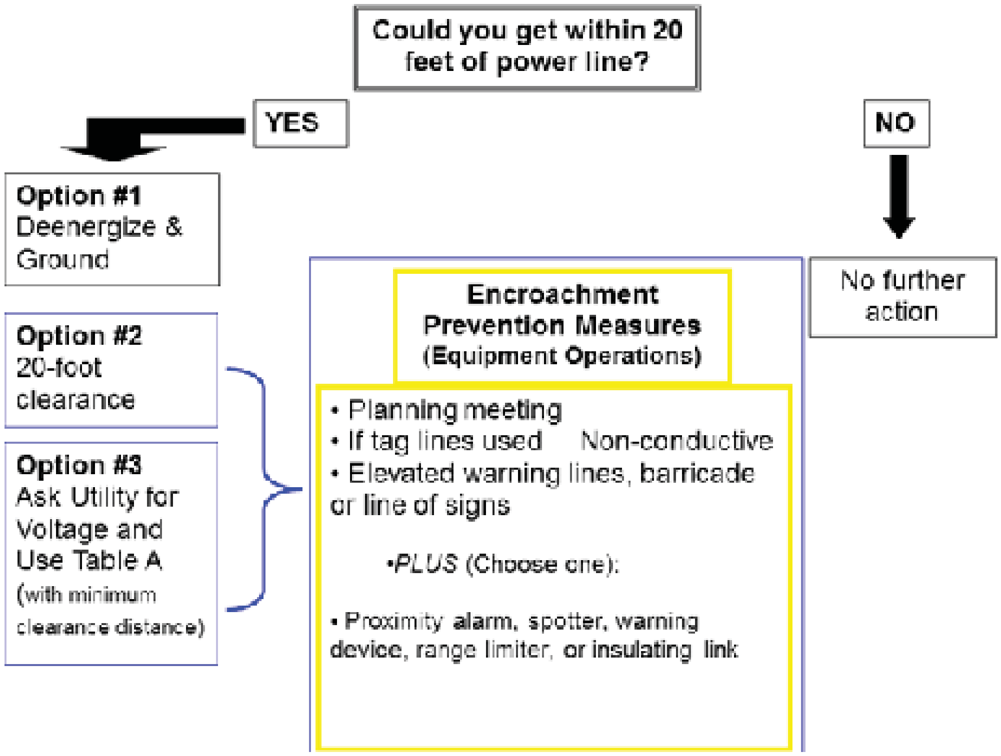


Figure 6.9

- Maintain minimum clearance between energized power lines and the crane and its load.
- Where it is difficult for the crane operator to see if he or she has clearance, a trained spotter is required on the ground to check for clearance between the energized power lines and the crane and its load. Don't give the spotter any other duties so that his or her attention is on the clearance.
- The use of cage-type boom guards, insulating links, or proximity warning devices are not a substitute for de-energizing and grounding lines or maintaining safe line clearances.
- For lines rated 50 kV or below, minimum clearance between the lines and any part of the crane or load shall be 10 feet.
- For lines rated over 50 kV, minimum clearance between the lines and any part of the crane or load shall be 10 feet plus 0.4 inch for each 1 kV over 50 kV, or twice the length of the line insulator, but never less than 10 feet (see Table B-Minimum Clearance Distance below).

Table B-Minimum Clearance Distance	
Voltage (nominal, kV, alternating current)	**Minimum clearance distance (feet)**
up to 50	10
over 50 to 200	15
over 200 to 350	20
over 350 to 500	25
over 500 to 750	35
over 750 to 1000	45
over 1000	(as established by the power line owner/ operator or registered professional engineer who is a qualified person with respect to electrical power transmission and distribution)

Table 6.2

Intentionally Working Closer Than Table B Zones

In this case, you must show that staying outside work zone is infeasible or that it is infeasible to de-energize and ground the power lines. If one of these criteria is met, then **ALL** of the following are required:

1. Power line owner – sets minimum approach distance
2. Planning meeting – minimum procedures
    - Dedicated spotter
    - Elevated warning line or barricade
    - Insulating link/device
    - Nonconductive rigging
    - Range limiter (if equipped)
    - Nonconductive tag line (if used)
    - Barricades - 10 feet from equipment
    - Limit access to essential workers
    - Prohibit non-operator workers from touching above insulating link
    - Properly ground crane
    - Deactivate automatic re-energizer
    - Insulating line cover-up installed
    -

- In transit with no load and boom lowered, the equipment clearance shall be a minimum of 4 feet for voltages less than 50 kV, and 10 feet for voltages over 50 kV, up to and including 345 kV, and 16 feet for voltages up to and including 750 kV.
- Electric Utilities – employers whose employees are qualified to perform power distribution and transmission work are considered to be in compliance with §§ 1926.1407-1926.1411 of subpart CC (power lines sections) when performing subpart V work in accordance with § 1910.269 (§ 1926.1400(g))
- Before beginning work near transmitter towers where an electrical charge can be induced in the equipment or materials being handled, the transmitter shall be de-energized or tests shall be made to determine if electrical charge is induced on the crane. The following precautions shall be taken when necessary to dissipate induced voltages:
    - The equipment shall be provided with an electrical ground directly to the upper rotating structure supporting the boom.
    - Ground jumper cables shall be attached to materials being handled by boom equipment when electrical charge is induced while working near energized transmitters. Crews shall be provided with nonconductive poles having large alligator clips or other similar protection to attach the ground cable to the load.
    - Combustible and flammable materials shall be removed from the immediate area before operations begin.

CSA Power Line Safety Tips

The Construction Safety Association (CSA) of Ontario, Canada, adds the following safe work practices in addition to the OSHA regulations:

- Operate the crane at a slower-than-normal rate in the vicinity of power lines.
- Exercise caution near long spans of overhead power lines since wind can cause the power lines to sway laterally and reduce the clearance between the crane and the power line.
- Mark safe routes where cranes must travel repeatedly beneath power lines.
- Exercise caution when travelling over uneven ground that could cause the crane to weave or bob into power lines.
- Keep all personnel well away from the crane whenever it is close to power lines.
- Prohibit persons from touching the crane or its load until a signal person indicates that it is safe to do so.

To protect against electrical shock injury if a crane does contact an energized line:

- The crane operator should remain inside the cab.
- All other personnel should keep away from the crane, ropes, and load, since the ground around rhe machine might be energized.
- The crane operator should try to remove the crane from contact by moving it in the reverse direction from that which caused the contact.
- If the crane cannot be moved away from contact, the operator should remain inside the cab until the lines have been de-energized.

Other Power Line Safety Tips

Here are some other tips that will keep you safe when cranes are operating near power lines:

- **Notify power line owners.** Before beginning operations near electrical lines, notify the owners of the lines or their authorized representatives and provide them with all pertinent information, such as type of equipment (including length of boom) and date, time, and type of work involved. Ask the owner's cooperation in de-energizing and grounding the lines or providing insulated barriers.
- **Develop safety programs.** Develop and implement written safety programs to help workers recognize and control the hazards of crane contact with overhead power lines.
- **Evaluate job sites.** Before starting, determine the safest areas for material storage, the best placement for machinery during operations, and the size and type of machinery to be used. Know the location and voltage of all overhead power lines at the site before operating or working with any crane.
- **Evaluate alternative work methods.** Look for ways to get the work done without using a crane. For example, it may be possible to use concrete pumping trucks instead of crane-suspended buckets for placing concrete near overhead power lines. Review the new methods carefully to make sure they don't bring new hazards.
- **Train workers.** Ensure that workers assigned to operate cranes and other boomed vehicles are specifically trained in safe operating procedures. Workers should also be trained to recognize the hazards and use proper techniques when rescuing coworkers or recovering equipment in contact with electrical energy. Everyone at the site should be trained in cardiopulmonary resuscitation (CPR).
- **Call for help.** Calling for assistance when an emergency occurs should be easy.

Crawler, Locomotive, and Truck Cranes

Crawler cranes move via crawler tracks. Locomotive cranes operate on a rail car. Truck cranes are mounted on a truck chassis and can travel via roads. OSHA has the following requirements for crawler, locomotive, and truck cranes:

- All jibs shall have positive stops to prevent their movement of more than 5 degrees above the straight line of the jib and boom on conventional type crane booms. The use of cable type belly slings does not constitute compliance with this rule.
- All crawler, truck, or locomotive cranes in use shall meet the applicable requirements for design, inspection, construction, testing, maintenance, and operation as prescribed in the ANSI B30.5-1968 Safety Code for Crawler, Locomotive, and Truck Cranes. The employer must keep on file a certification record that includes the inspection date, inspector's signature, and a serial number or other identifier for the crane.

Hammerhead Tower Cranes

The hammerhead, or giant cantilever, crane is a fixed-jib crane consisting of a steel-braced tower on which revolves a large, horizontal, double cantilever; the forward part of this cantilever or jib carries the lifting trolley, the jib is extended backward in order to form a support for the machinery and counterbalancing weight. In addition, the lifting trolley, with the load suspended, can be moved in and out along the jib without altering the level of the load. Hammerhead cranes are generally large and can handle heavy loads.

Figure 6.10 A hammerhead tower crane on the River Tyne in Scotland. Photo courtesy of www.FreeFoto.com.

OSHA has the following requirements for hammerhead tower cranes:

- Adequate clearance shall be maintained between moving and rotating structures of the crane and fixed objects to allow the passage of workers without harm.
- The horizontal boom of hammerhead tower cranes shall have handrails for people working on them or people should have a personal fall arrest system.
- Buffers shall be provided at both ends of travel of the trolley.
- Cranes mounted on rail tracks shall be equipped with limit switches restricting the travel of the crane on the track and stops or buffers at each end of the tracks.
- All hammerhead tower cranes in use shall meet the applicable requirements for design, construction, installation, testing, maintenance, inspection, and operation as prescribed by the manufacturer.
- Monthly inspections must include tower mast bolts, upper-most tie-in, braces, floor supports, and floor wedges.

Overhead and Gantry Cranes

A gantry crane has a hoist in a trolley that runs horizontally along gantry rails, usually fitted underneath a beam spanning between uprights which themselves have wheels so that the whole crane can move at right angles to the direction of the gantry rails. These cranes come in all sizes, and some can move very heavy loads. You're likely to see these kinds in shipyards, loading and unloading ship-borne containers.


Figure 6.11 Large rotating lattice boom two-level gantry crane. Photo courtesy of www.myconstructionphotos.com.

An overhead, or suspended, crane works in the same way as a gantry crane but without uprights. The hoist is on a trolley that moves in one direction along one or two beams, which move at right angles to that direction along elevated tracks, often mounted along the side walls of an assembly area in a factory. Some of them can lift very heavy loads.

OSHA has the following requirements for overhead and gantry cranes:

- The rated load of the crane shall be plainly marked on each side of the crane. If the crane has more than one hoisting unit, each hoist shall have its rated load marked on it or its load block. You must be able to read this marking from the ground or floor.
- Bridge trucks shall be equipped with sweeps that extend below the top of the rail and project in front of the truck wheels.
- Except for floor-operated cranes, overhead or gantry cranes must have an audible warning signal to indicate when they're moving.
- All overhead and gantry cranes in use shall meet the applicable requirements for design, construction, installation, testing, maintenance, inspection, and operation as prescribed in the ANSI B30.2.0-1967 Safety Code for Overhead and Gantry Cranes.

Derricks

A derrick crane features a movable boom equipped with cables and pulleys, but it is connected to the base of an upright stationary beam or beams. The Empire State Building was constructed using derrick cranes. OSHA requires that all derricks in use meet the applicable requirements for design, construction, installation, inspection, testing, maintenance, and operation as prescribed in American National Standards Institute B30.6-1969 Safety Code for Derricks.


Figure 6.12 A derrick crane at work on the Hoover Dam Bypass bridge over the Colorado River. Photo courtesy of www.hooverdambypass.org.

Floating Cranes and Derricks

Here are OSHA requirements for **mobile cranes mounted on barges:**

- The rated load of the crane shall not exceed the original capacity specified by the manufacturer.
- A load rating chart with clearly legible letters and figures shall be provided with each crane and securely fixed where the operator can see it easily.
- When load ratings are reduced to stay within the limits for list of the barge with a crane mounted on it, a new load rating chart must be provided.
- Mobile cranes on barges must be positively secured.


Figure 6.13 A mobile crane mounted on a construction barge on the Saone River in France. Photo courtesy of www.myconstructionphotos.com.

Here are the OSHA requirements for **permanently mounted floating cranes and derricks:**

- A load rating chart with clearly legible letters and figures shall be provided and securely fixed at a location where the operator can see it easily.
- Floating cranes and floating derricks in use shall meet the applicable requirements for design, construction, installation, testing, maintenance, and operation as prescribed by the manufacturer.

Helicopters

Figure 6.14 A helicopter lifts a bridge section into place. Photo courtesy of Dave Christy and www.wapa.gov.

Helicopter cranes shall be expected to comply with any applicable regulations of the Federal Aviation Administration. Here are the OSHA requirements:

- **Briefing.** Before each day's operation a briefing shall be conducted outlining the plan of operation for the pilot and ground personnel.
- **Slings and tag lines.** The load shall be properly slung. Tag lines shall be of a length that will not permit their being drawn up into rotors. Pressed sleeve, swedged eyes, or equivalent means shall be used for all freely suspended loads to prevent hand splices from spinning open or cable clamps from loosening.
- **Cargo hooks.** All electrically operated cargo hooks shall have the electrical activating device designed and installed to prevent inadvertent operation. In addition, these cargo hooks shall be equipped with an emergency mechanical control for releasing the load. The hooks shall be tested before each day's operation.
- **Personal protective equipment.** Those receiving the load must wear complete eye protection and hard hats secured by chin straps. Loose-fitting clothing likely to flap in the downwash, and thus be snagged on the hoist line, shall not be worn.
- **Loose gear and objects.** Every practical precaution shall be taken to protect you from flying objects in the rotor downwash. All loose gear within 100 feet of the place of lifting the load, depositing the load, and all other areas susceptible to rotor downwash shall be secured or removed.
- **Housekeeping.** All helicopter loading and unloading areas must be kept clean.
- **Operator responsibility.** The helicopter operator shall be responsible for size, weight, and manner in which loads are connected to the helicopter. If for any reason the helicopter operator believes the lift cannot be made safely, the lift shall not be made.
- **Hooking and unhooking loads.** When you are required to perform work under hovering craft, a safe means of access must be provided for you to reach the hoist line hook and engage or disengage cargo slings. You shall not perform work under hovering craft except when necessary to hook or unhook loads.
- **Static charge.** Static charge on the suspended load shall be dissipated with a grounding device before ground personnel touch the suspended load, or protective rubber gloves shall be worn by all ground personnel touching the suspended load.
- **Weight limitation.** The weight of an external load shall not exceed the manufacturer's rating for the helicopter.

- **Ground lines.** Hoist wires or other gear, except for pulling lines or conductors that are allowed to "pay out" from a container or roll off a reel, shall not be attached to any fixed ground structure or allowed to foul on any fixed structure.
- **Visibility.** When visibility is reduced by dust or other conditions, ground personnel shall exercise special caution to keep clear of main and stabilizing rotors. The employer also must take precautions to eliminate reduced visibility as much as possible.
- **Signal systems.** Signal systems between aircrew and ground personnel shall be understood and checked in advance of hoisting the load. This applies to either radio or hand signal systems. Use the hand signals shown in the drawing on the next page.
- **Approach distance.** No unauthorized person shall be allowed to approach within 50 feet of the helicopter when the rotor blades are turning.
- **Approaching helicopter.** Whenever approaching or leaving a helicopter with blades rotating, remain in full view of the pilot and keep in a crouched position. Avoid the area from the cockpit or cabin rearward unless authorized by the helicopter operator to work there.
- **Personnel.** Sufficient ground personnel shall be provided when required for safe helicopter loading and unloading operations.
- **Communications.** There shall be constant reliable communication between the pilot and a designated employee of the ground crew who acts as a signalman during loading and unloading. This signalman shall be distinctly recognizable from other ground personnel.
- **Fires.** Open fires shall not be permitted in an area that could result in such fires being spread by the rotor downwash.

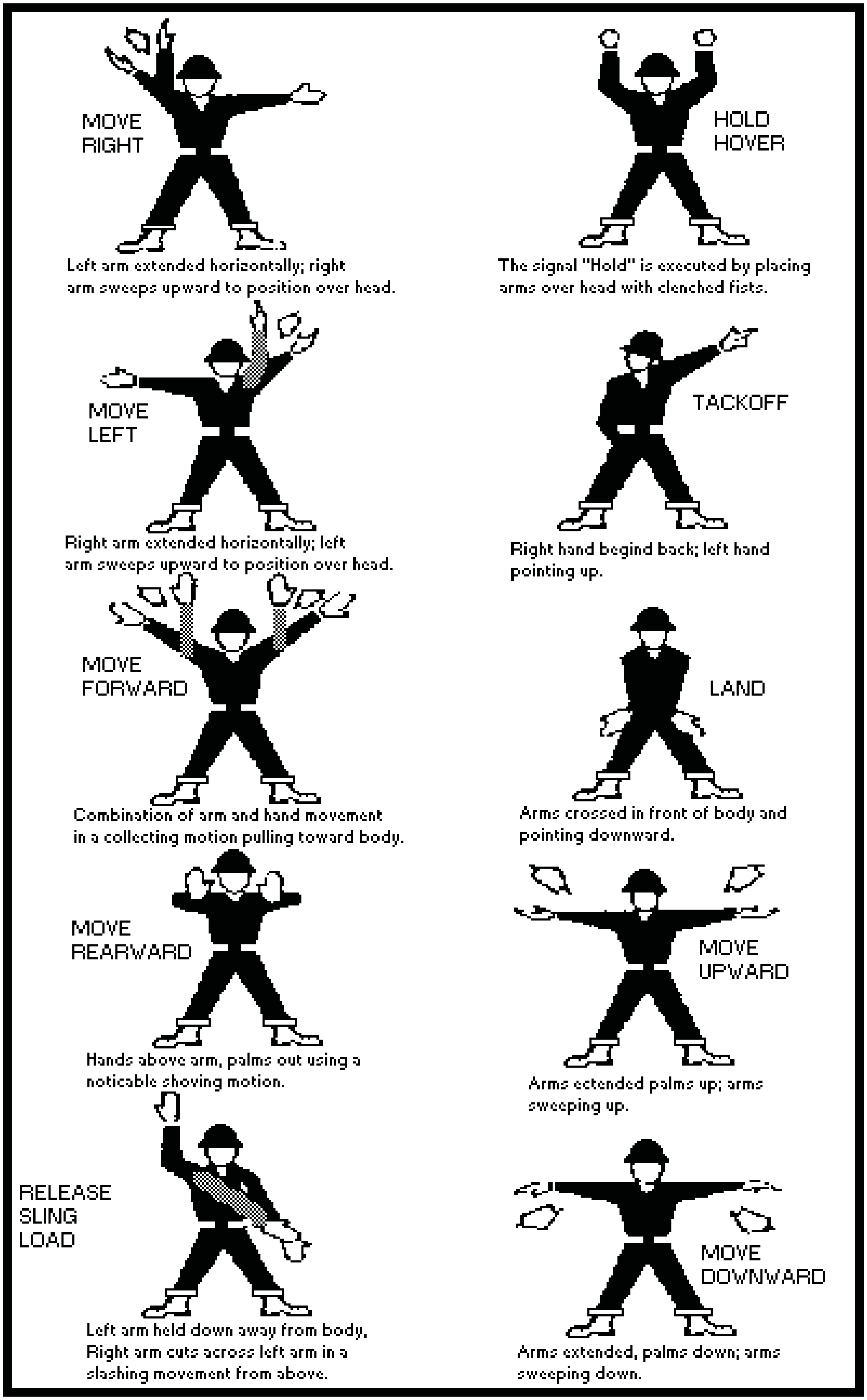


Figure 6.15 Helicopter hand signals

Hoists, Elevators, Conveyors, and Aerial Lifts

Cranes aren't the only way to move materials up on a construction site. Hoists and elevators also work to lift both materials and people to higher levels. Hoists and elevators come with their own set of safety requirements, whether they are moving materials or people.

OSHA General Requirements for Hoists and Elevators

OSHA has the following requirements for the safe use of hoists and elevators:

- The employer must follow the manufacturer's specifications and limitations for hoists and elevators.
- Rated load capacities, recommended operating speeds, and special hazard warnings or instructions shall be posted on cars and platforms.
- Wire rope shall be removed from service when any of the following conditions exists:
  - In hoisting ropes there are six randomly distributed broken wires in one rope lay or three broken wires in one strand in one rope lay.
  - Abrasion, scrubbing, flattening, or peening exists, causing loss of more than one-third of the original diameter of the outside wires.
  - There is evidence of any heat damage from a torch or any damage caused by contact with electrical wires.
  - The nominal diameter has been reduced more than 3/64 inch for diameters up to and including 3/4 inch; 1/16 inch for diameters 7/8 to 1 inches; and 3/32 inch for diameters 1¼ to 1½ inches.
- Hoisting ropes must be installed according to the wire rope manufacturer's recommendations.
- The installation of live booms on hoists is prohibited.
- The use of endless belt-type manlifts on construction sites is prohibited.

Material Hoists

Material hoists are for just that—hoisting material. People aren't allowed on them except for inspections and maintenance. A "No Riders Allowed" sign must be posted on the car frame or a crosshead so that people can quickly see it. The operator's station should also have posted rules on the allowable line speed for various loads and the signal system.

Substantial gates or bars, painted with diagonal contrasting colors, such as yellow and black, should guard all entrances of the hoistways. The gates or bars must be able to latch as well.

The top of the hoist cage or platform must be covered with 2-inch planking, ¾-inch plywood, or other solid material of equivalent strength. The operator's station also must be covered.

Hoist towers can be fully enclosed or not. If the tower is not enclosed, then the hoist platform or car must be fully enclosed.

Material hoists also require a braking device in case a rope fails.

Personnel Hoists

Personnel hoists are used to deliver you from one floor to another at a job site. OSHA has in place a number of requirements designed to protect your safety when you ride a personnel hoist. Here are some of them:

- Hoist towers outside the structure being built must be enclosed for the full height on the side or sides used for entrance and exit to the structure. At the lowest landing the enclosure on the sides not used for exit or entrance to the structure must be enclosed with at least 10-foot walls. Other sides of the tower adjacent to floors or scaffold platforms must be enclosed 10 feet above the level of such floors or scaffolds. Towers inside of structures must be enclosed on all four sides for the full height of the tower.
- Towers must be anchored to the structure at a maximum of every 25 feet. In addition to tie-ins, a series of guys shall be installed. Where tie-ins aren't practical, the tower must be anchored with guys made of wire rope at least ½ inch in diameter, securely fastened to anchorage to ensure stability.
- Hoistway doors or gates must be a minimum of 6 feet 6 inches high and have mechanical locks accessible only to those riding on the car, not those on the landing side.
- Cars must be permanently enclosed on all sides and the top, except sides used for entrance and exit, which have car gates or doors. The doors or gates must have electric contacts that prevent the hoist from moving when the door or gate is open.
- The top of the personnel hoist must be covered with 2-inch planking, ¾-inch plywood, or other solid material of equivalent strength.
- Safeties shall be capable of stopping and holding the car and rated load when traveling at governor tripping speed.
- Cars must have a capacity and data plate where you can read it in the car or on a crosshead. Only the number of persons needed for the work being performed are allowed on the personnel hoist, and that number may not exceed four people at any one time.
- Internal combustion engines are prohibited for direct drive.
- The car must have normal and final terminal stopping devices as well as an emergency stop switch in the car.
- The minimum number of hoisting ropes used shall be three for traction hoists and two for drum-type hoists. The minimum diameter of hoisting and counterweight wire ropes shall be ½ inch.
- Hoists should be inspected before they're put into service and then at least every three months.

- All personnel hoists used by employees shall be constructed of materials and components that meet the specifications for materials, construction, safety devices, assembly, and structural integrity as stated in the American National Standard A10.4-1963 Safety Requirements for Workmen's Hoists.
- Personnel hoists used in bridge tower construction must be approved by a registered professional engineer and erected under the supervision of a qualified engineer competent in this field.
- Hoists that aren't in an enclosed hoist tower must be inspected and maintained on a weekly basis. Whenever the hoisting equipment is exposed to winds exceeding 35 miles per hour, it shall be inspected and put in operable condition before reuse.

Crane or Derrick Suspended Personnel Platforms

Figure 6.16 A tower crane safely moves two structural ironworkers in a personnel basket from the top of a structural steel frame to the ground during steel erection. Photo courtesy of www.myconstructionphotos.com.

OSHA prohibits the use of a crane or derrick to hoist workers on a personnel platform. However, the prohibition does not apply at all times. When conventional means of reaching the work site—personnel hoist, ladder, stairway, aerial lift, elevating work platform or scaffold—would be more hazardous or impossible to build, use, and dismantle because of structural design or conditions at the site, then the crane or derrick can be used to hoist a personnel platform. A number or regulations exist, though, to ensure that this is a safe operation:

- Hoisting of the personnel platform must be performed in a slow, controlled, and cautious manner with no sudden movements of the crane or derrick or the platform.
- Load lines must be capable of supporting at least seven times the maximum intended load.
- Load and boom hoist drum brakes, swing brakes, and locking devices such as pawls or dogs must be engaged when the occupied personnel platform is in a stationary position.
- A land-based crane must be level and located on firm footing.
- All pneumatic tired cranes used to lift or lower personnel platforms shall be equipped with outriggers or stabilizers, and carrier wheels within the boundary of the outrigger shall be relieved of their weight.
- Crawler tracks shall be fully extended.
- The total weight of the loaded personnel platform and related rigging must not exceed 50 percent of the rated capacity for the radius and configuration of the crane or derrick.
- The use of machines having live booms (booms in which lowering is controlled by a brake without aid from other devices that slow the lowering speeds) is prohibited.
- On mobile cranes when using a personnel hoist platform refer to manufacturer recommendations.
- The crane must have a load moment indicator system that monitors load limits, boom angle, boom length, and anti two-blocking which, if a parameter is exceeded, automatically deactivates that parameter.
- Cranes and derricks with variable angle booms shall be equipped with a boom angle indicator, readily visible to the operator.
- Cranes with telescoping booms shall be marked or equipped with a device to indicate clearly to the operator at all times the boom's extended length. Additionally, an accurate

determination of the load radius to be used during the lift shall be made before hoisting personnel.

- A positive acting device shall be used to prevent contact between the load block or overhaul ball and the boom tip (anti two-blocking device), or a system shall be used that deactivates the hoisting action before damage occurs in the event of a two-blocking situation (two-block damage prevention feature).
- The load line hoist drum shall have a system or device on the power train, other than the load hoist brake, that regulates the lowering rate and prohibits free fall.
- The personnel platform and suspension system shall be designed by a qualified engineer or a qualified person competent in structural design. The suspension system shall be designed to minimize tipping.
- The personnel platform itself, except the guardrail system and personal fall arrest system anchorages, shall be capable of supporting without failure, its own weight and at least five times the maximum intended load.
- Each personnel platform shall be equipped with a guardrail system and overhead protection and allow headroom for people to stand.
- Access gates must not swing outward during hoisting and must be equipped with a restraining device to prevent accidental opening.
- The personnel platform must have a plate or other permanent marking that indicates the weight of the platform and its rated load capacity or maximum intended load.
- Only the number of people required for the work being performed, and no more than four, can occupy the personnel platform.
- Personnel platforms shall not be used to hoist only materials or tools when not hoisting personnel.
- Materials and tools for use during a personnel lift shall be secured and evenly distributed.
- A trial lift with the unoccupied personnel platform loaded at least to the anticipated lift weight shall be made from ground level, or any other location where people will enter the platform, to each location at which the personnel platform is to be hoisted and positioned. This trial lift shall be performed immediately before placing personnel on the platform. The operator must ensure that the hoist will remain under 50 percent of its rated capacity. Whenever the crane or derrick is moved or the lift route changes significantly, the trial lift must be repeated. A qualified person on the ground also must inspect the crane or derrick, rigging, personnel platform, and the crane derrick base support or ground after the trial lift.
- When workers are to exit or enter a hoisted personnel platform that is not landed, the platform must first be secured to the structure where work is to be performed, unless securing to the structure creates an unsafe situation. When people are to work from the platform, the platform may not be secured to another structure. Workers are not permitted to stand on or work from any portion of the platform except the floor.

- Tag lines must be used unless their use creates an unsafe condition.
- The crane or derrick operator shall remain at the controls at all times when the crane engine is running and the platform is occupied.
- If dangerous weather approaches, hoisting must stop immediately.
- Employees being hoisted must remain in continuous sight of and in direct communication with the operator or signal person or must maintain radio contact.
- Except over water, workers occupying the personnel platform must use a body belt/harness system with lanyard appropriately attached to the lower load block or overhaul ball, or to a structural member within the personnel platform that is capable of supporting a fall impact for people using the anchorage.
- No lifts must be made on another of the crane's or derrick's loadlines while personnel are suspended on a platform.
- Except for portal, tower, locomotive, gantry, and overhead cranes, hoisting of people while the crane is traveling is prohibited.
- When a crane would travel while hoisting personnel, crane travel shall be restricted to a fixed track, the boom must be parallel to the direction of travel, and a complete trial run must be performed before personnel are allowed to occupy the platform.
- A meeting attended by the crane or derrick operator, signal person(s) (if necessary for the lift), people to be lifted, and the person responsible for the task to be performed must be held before the trial lift at each new work location and must be repeated for any people newly assigned to the operation.

Base-mounted Drum Hoists

Base-mounted drum hoists must have guards over all of their exposed moving parts, such as gears, projecting screws, setscrews, chains, cables, chain sprockets, and reciprocating or rotating parts. All controls must be within easy reach of the operator's station.

Electric motor operated hoists shall be provided with:

- A device to disconnect all motors from the line upon power failure and not permit any motor to be restarted until the controller handle is brought to the "off" position.
- Where applicable, an overspeed preventive device must be used.
- A way to stop remotely operated hoists when any control is ineffective must be employed.

Overhead Hoists

When using an overhead hoist, do not exceed the safe working load as determined by the manufacturer. This limit must be indicated on the hoist. In addition:

- The supporting structure to which the hoist is attached must have a safe working load equal to that of the hoist.
- The support shall be arranged so as to provide for free movement of the hoist and shall not restrict the hoist from lining itself up with the load.
- The hoist shall be installed only in locations that will permit the operator to stand clear of the load at all times.
- Air hoists shall be connected to an air supply of sufficient capacity and pressure to safely operate the hoist. All air hoses supplying air shall be positively connected to prevent their becoming disconnected during use.

Conveyors

You might also find a conveyor system in place on the job site. OSHA has these requirements for safe conveyors:

- There must be a way to stop the conveyor at the operator's station. Conveyor systems must have an audible warning signal that sounds immediately before the conveyor starts. If the operator's station is at a remote point, there also must be a way to stop the conveyor at the motor or engine location.
- Emergency stop switches shall be arranged so that the conveyor cannot be started again until the actuating stop switch has been reset to the running or "on" position.
- Screw conveyors must be guarded to prevent employee contact with turning flights.
- Where a conveyor passes over work areas, aisles, or thoroughfares, guards must be in place to protect people required to work below.
- All crossovers, aisles, and passageways shall be conspicuously marked by suitable signs.
- Conveyors must be locked out or rendered inoperable and tagged out with a "Do Not Operate" tag during repairs and when operation is hazardous to people performing maintenance work.
- All conveyors in use shall meet the applicable requirements for design, construction, inspection, testing, maintenance, and operation, as prescribed in the ANSI B20.1-1957 Safety Code for Conveyors, Cableways, and Related Equipment.

Aerial Lifts

The use of aerial lifts has become quite common in construction and maintenance work in recent years. They include extensible boom platforms, aerial ladders, articulating boom platforms, vertical towers, or some combination of the above. Because they're mounted on vehicles and can move freely where needed, they are a tremendous convenience at a job site and a big leap from the old days when scaffolding often had to be built to do high work.

Aerial lifts do pose one major danger, though. They have been involved in a number of the electrocution cases in recent years. Too often they have come into contact with energized overhead power lines. For your well-being, follow the tips for working safely around power lines that were covered earlier in this chapter.

Here are the specific OSHA requirements for the different kinds of aerial lifts:

Ladder Trucks and Tower Trucks

- Aerial ladders must be secured in the lower traveling position by the locking device on top of the truck cab, and the manually operated device at the base of the ladder before the truck is moved for highway travel.

Extensible and Articulating Boom Platforms

- Lift controls must be tested each day before use.
- Only authorized persons shall operate an aerial lift.
- Belting off to an adjacent pole, structure, or equipment while working from an aerial lift is not permitted.
- Always stand firmly on the floor of the basket. Don't sit or climb on the edge of the basket or use planks, ladders, or other devices for a work position.
- Wear a body belt and a lanyard attached to the boom or basket when working from an aerial lift.
- Do not exceed the manufacturer's boom and basket load limits.
- Set the brakes when outriggers are used, and position the outriggers on pads or a solid surface. Install wheel chocks before using an aerial lift on an incline, provided they can be safely installed.
- Do not move an aerial lift truck when the boom is elevated in a working position with men in the basket, unless the equipment is specifically designed for this type of operation.
- Articulating boom and extensible boom platforms primarily designed as personnel carriers must have controls in both the platform (upper) within easy reach of the operator and at the base (lower) (to allow for overriding the upper controls). Do not operate the lower level controls unless the person in the lift has given permission or there's an emergency.
- Do not wear climbers while working from an aerial lift.
- The insulated portion of an aerial lift shall not be altered in any manner that might reduce its insulating value.
- Before moving an aerial lift for travel, inspect the boom to make certain it is properly cradled and check that outriggers are stowed.

Common Citations

Here are some common citations that OSHA inspectors issue regarding the operation of cranes:

- **No annual inspection records.** Records are necessary to track repairs and maintenance on cranes. They must be available to OSHA but do not have to be located in the crane.
- **No competent person inspecting the crane.** Some of the material needed to inspect a crane will be OSHA regulations, ANSI standards, and the manufacturer's instructions. Most citations are issued for inspectors not inspecting parts of the crane per requirements.
- **Operator cannot read load rating chart(s).** A problem with many new cranes is they have many load rating charts. Without prior training in reading them, most operators find it difficult to know exact crane capacity at a certain lifting angle.
- **Person supervising the lift does not know crane capacity, rigging capacity, or weight of the load.** Without knowing all three items, you should never perform a lift. The capacity of the crane is its weakest component, whether it be the jib, hook, lifting bar, or other components. If the load is unknown, a load moment indicator or a scale should be used to obtain the actual reading.
- **Crane works next to power lines.** As the CPWR study revealed, this is the leading cause of all fatalities involving cranes. The 10-foot safe distance is for voltages under 50,000 volts. For more than 50,000 volts, increased distance is necessary. De-energizing the line is the first choice if possible. If it cannot be de-energized, insulating the line and ensuring safe distance are necessary.

Glossary

Assembly/Disassembly— means the assembly and/or disassembly of equipment covered under this standard. With regard to tower cranes, "erecting and climbing" replaces the term "assembly" and "dismantling" replaces the term "disassembly." Regardless of whether the crane is initially erected to its full height or is climbed in stages, the process of increasing the height of the crane is an erection process.

A/D director (Assembly/Disassembly director) — means an individual who meets this subpart's requirements for an A/D director, irrespective of the person's formal job title or whether the person is non-management or management personnel.

aerial lifts—extensible boom platforms, aerial ladders, articulating boom platforms, vertical towers, or some combination each mounted on a vehicle.

ambient—in the immediately surrounding area (e.g., ambient wind).

ANSI—American National Standards Institute.

bird caging—a distortion of a wire where strands open to resemble a bird cage.

conveyors—a device that transports or transmits something, especially a conveyor belt.

CPWR—Center for Construction Research and Training; formerly known as The Center to Protect Workers' Rights (CPWR), a nonprofit organization created by the Building and Construction Trades Department of the AFL-CIO.

crawler—a tractor or other vehicle moving on an endless caterpillar track.

cribbing—additional support placed under the pads.

CSA—Construction Safety Association.

derrick—a crane featuring a movable boom equipped with cables and pulleys that is connected to the base of an upright, stationary beam or beams.

fulcrum—the point or support on which a lever pivots.

gantry crane—crane with a hoist in a trolley that runs horizontally along gantry rails, usually fitted underneath a beam spanning between uprights which themselves have wheels so that the whole crane can move at right angles to the direction of the gantry rails.

hammerhead tower crane—a fixed-jib crane consisting of a steel-braced tower on which revolves a large, horizontal, double cantilever; the forward part of this cantilever or jib carries the lifting trolley; the jib is extended backward in order to form a support for the machinery and counterbalancing weight.

jib—the arm of a mechanical crane or the boom of a derrick.

outriggers—extendable or fixed members attached to the mounting base of the crane.

overhead crane—an overhead or suspended crane that works in the same way as a gantry crane but without uprights.

rigging—the hooking and unhooking of the load.

swing radius—the area the crane rotates above.

Review Questions

1. List the five primary hazards associated with crane operations.

a. Power line contact
b. Swing radius crushing
c. Structural failure
d. Rigging failure
e. Tipover

2. Cranes generally fail because of overloading or improper setup. Give an example of a typical setup problem.

Possible answers are inadequate outrigger cribbing; puncturing underground utilities; cranes tip over or buckle because they are unleveled; or failure to properly inspect the crane and/or keep adequate records of inspections.

3. Define pinch points.

Pinch points are anywhere a body part can get caught between two moving parts of a crane or between a moving part and a stationary object.

4. Demonstrate the ANSI hand signal that you would give to a crane or derrick operator to tell the operator to stop the equipment for an emergency.

To motion for an emergency stop, you extend an arm with your palm down and move your hand rapidly to the right and left. (See the diagram for an emergency stop on page 3-9.)

5. Name a condition of a wire rope that would require you to take it out of service.

- *In running ropes there are six randomly distributed broken wires in one lay or three broken wires in one strand in one lay.*
- *In standing ropes there are more than two broken wires in one lay in sections beyond end connections or more than one broken wire at an end connection.*
- *One-third of the original diameter of outside individual wires has worn away.*
- *Kinking, crushing, bird caging, or any other damage results in distortion of the rope structure.*
- *Evidence of any heat damage from any cause exists.*
- *There are reductions from nominal diameter of more than:*
    - *1/64 inch for diameters up to and including 5/16 inch.*
    - *1/32 inch for diameters of 3/8 inch to and including ½ inch.*
    - *3/64 inch for diameters of 9/16 inch to and including ¾ inch.*
    - *1/16 inch for diameters of 7/8 inch to 1⅛ inches inclusive.*
    - *3/32 inch for diameters 1¼ to 1½ inches inclusive.*

6. Outline how crane operators may become certified or licensed under the crane standard.

In accordance with Subpart CC – Cranes and Derricks in Construction: cranes must be operated by qualified and certified personnel.

Certification has two parts:

1. A written examination that includes the safe operating procedures for the particular type of equipment the applicant will be operating and technical understanding of the subject matter criteria required in 1926.1427(j).

2. A practical exam showing the applicant has the skills needed to safely operate the equipment, including, among other skills, the ability to properly use load chart information and to recognize items required in the shift inspection.
There are 4 ways that an equipment operator can be qualified or certified and meet OSHA requirements.

> *1. A certificate from an accredited crane operator testing organization.*
> *2. Qualification from the employer through an audited employer program.*
> *3. Qualification by the US Military (only applies to employees of Department of Defense or Armed Forces and does not include private contractors)*
> *4. Licensing by a state or local government (if that licensing meets the minimum requirements set forth by OSHA) **

**When a state or local government requires a crane operator license, the crane operator must be licensed accordingly to meet OSHA requirements.*

7. Who oversees assembly and disassembly of cranes and what criteria must they meet according to the crane standard?

The assembly/disassembly (A/D) director oversees assembly and disassembly of cranes. All assembly/disassembly operations must be directed by an individual who meets the criteria for both a competent person and a qualified person, or by a competent person who is assisted by one or more qualified persons.

8. Is the following statement true or false?
A certified operator meets the requirements of a qualified rigger. Justify your answer.

A certified operator does not necessarily meet the requirements of a qualified rigger. Determining whether a person is a qualified rigger is based on the nature of the load, lift, and equipment used to hoist that load plus that person's knowledge and experience. A certified/qualified operator may meet the requirements of a qualified rigger, depending on the operator's knowledge and experience with rigging.

9. Is the following statement true or false?
You are qualified as a crane operator as long as you pass a practical operating exam.

False. Qualified crane operators must pass a written exam and must meet a number of physical qualifications in addition to the practical operating exam.

10. Is the following statement true or false?
Crane operators are to obey a stop signal at all times no matter who gives it.

True. There will an appointed signal person for the job. However, stop signals are obeyed at all times.

11. What problems can winds cause for crane operators?

Winds can be strong enough to catch the load and cause the crane to become unstable. Winds can also cause power lines to sway laterally enough to reduce the required clearance between the crane and the power line.

12. What is the biggest danger when working with cranes?

Electrocution is the biggest danger.

13. What is the minimum clearance between a power line rated 50 kV or below and any part of a crane or its load?

The minimum clearance distance is 10 feet.

14. If a crane does contact an energized line, what do you do to protect yourself from electrical shock injury?

- *The crane operator should remain inside the cab.*
- *All other personnel should keep away from the crane, ropes, and load because the ground around the machine might be energized.*
- *The crane operator should try to remove the crane from contact by moving it in the reverse direction from that which caused the contact.*
- *If the crane cannot be moved away from contact, the operator should remain inside the cab until the lines have been de-energized.*

15. Compare and contrast safety issues for helicopter cranes and ground cranes.

Answers will vary. An example of an issue unique to helicopter cranes is the rotor downwash area, which requires loose gear be secured or removed, and not permitting open fires that could be spread by the downwash.

Other Resources

OSHA Cranes and Derricks in Construction Final Rule (updated for July 28, 2010) factsheet
http://www.osha.gov/as/opa/cranesderricks-factsheet.html

OSHA Standard – Cranes, Derricks, Hoists, Elevators, and Conveyors
http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10760

OSHA – Crane, Derrick, and Hoist Safety
http://www.osha.gov/SLTC/cranehoistsafety/index.html

OSHA – Construction and Safety Outreach Program – Cranes, Derricks, Hoists, Elevators, and Conveyors
http://www.osha.gov/doc/outreachtraining/htmlfiles/subpartn.html

OSHA-Subpart CC: Cranes and Derricks in Construction: Signal Person Qualification factsheet
http://www.osha.gov/Publications/cranes-signal-person-factsheet.pdf

OSHA-Subpart CC: Cranes and Derricks in Construction: Qualified Rigger factsheet
http://www.osha.gov/Publications/cranes-qualified-rigger-factsheet.pdf

OSHA – Crane Safety for Site Superintendent Video
http://www.osha.gov/video/cranesafety/index.html

NIOSH – Preventing Electrocutions of Crane Operators and Crew Members Working Near Overhead Power Lines
http://www.cdc.gov/niosh/docs/95-108/

Wikipedia – Crane
http://en.wikipedia.org/wiki/Crane_(machine)

Instructor Lesson Plan
Ergonomics

Key Concepts

- Dynamic vs. static work
- Risk factors for musculoskeletal disorders
- Keeping manual lifting in the power zone
- Using the NIOSH lifting equation to evaluate a lifting scenario

Presentation and Materials

- Allow 45 minutes to present this chapter.
- Use Ergonomics PowerPoint® slides.
- Use 30-Hour Construction Outreach course manual.

Module 7
Ergonomics

Lesson Outline

Ergonomics

Material Handling Guidance

Change the behaviors, environment and people to prevent MSDs

NIOSH's Lifting Equation

Resources

Overview

NIOSH reported that construction is one of the most hazardous industries in the United States. The number of back injuries in U.S. construction was 50% higher than the average for all other U.S. industries in 1999 (CPWR, 2002). Backaches and pain in the shoulders, neck, arms, and hands were the most common symptoms reported by construction workers in one study (Cook et al, 1996). Material handling incidents account for 32% of workers' compensation claims in construction, and 25% of the cost of all claims. The average cost per claim is $9,240 (CNA, 2000). Musculoskeletal injuries can cause temporary or even permanent disability, which can affect the worker's earnings and the contractor's profits.

Objectives

After completing this chapter, you should be able to:

Know

- Explain the difference between dynamic and static work
- Describe at least four of the six risk factors for musculoskeletal disorders
- Give examples of the types of injuries that can result from exposure to musculoskeletal disorder risk factors
- Describe several common sense ways to keep manual lifting in the power zone

Apply

- Use the NIOSH lifting equation to evaluate a lifting scenario
- Describe how to properly set up a computer work station

Analyze

- Explain OSHA's current approach to ergonomics. Does an ergonomics standard play a role in this approach?

Ergonomics

Let's look at the stats for construction work (NIOSH)

- Back injuries in U.S. construction was 50% higher than the average for all other industries in 1999 (CPWR, 2002)
- Backaches and pain in the shoulders, neck, arms, and hands were the most common symptoms reported by construction workers (Cook et al, 1996)
- Material handling incidents account for 32% of workers' compensation claims in construction, and 25% of the cost of all claims. The average cost per claim is $9,240 (CNA, 2000)

What percent of construction workers report back pain?

In one survey, seven out of ten construction workers from 13 trades reported back pain, and nearly a third went to the doctor for it (Cook et al, 1996).

What is a working definition of ergonomics? Why should operating engineers care about ergonomics?

Ergonomics is the science of fitting the workplace, furniture, tasks, tools and equipment to the worker. Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance. (International Ergonomics Association)

Ergonomics has deep roots in the productivity improvement movement that characterized much of the technology advancements of the 1900s. The movement didn't arise to ensure primarily as a concern for worker safety and health.

Ladders vs. stairs

When designing a facility, engineers will often say that stairs are not required. The people who use the facility will often walk out of their way or go the wrong way to use stairs and avoid a ladder.

Figure 7.1 Courtesy Dr. Richard Marklin of Marquette University and the Electric Power Research Institute (EPRI)

Ergonomics can increase comfort, productivity, quality, efficiency and morale or decrease fatigue, pain, injuries, costs and errors.

- Reduce occurrence of musculoskeletal disorders (MSDs), cumulative trauma disorders (CTDs) and repetitive stress injuries (RSIs)
- Increase comfort and productivity
- Decrease fatigue, pain and injuries
- Decrease costs such as health insurance, workers compensation and lost time

Rate of overexertion injuries with days away from work, by selected construction occupation, 2005

The following research was performed by CPWR the Center for Construction Research and Training and based on U.S. Bureau of Labor Statistics, 2005 Survey of Occupational Injuries and Illnesses, 2005 Current Population Survey. Operating engineers suffer approximately 19 overexertion injuries among 10,000 full-time workers. Note, too, that laborers have 3 times the rate that operating engineers experience.

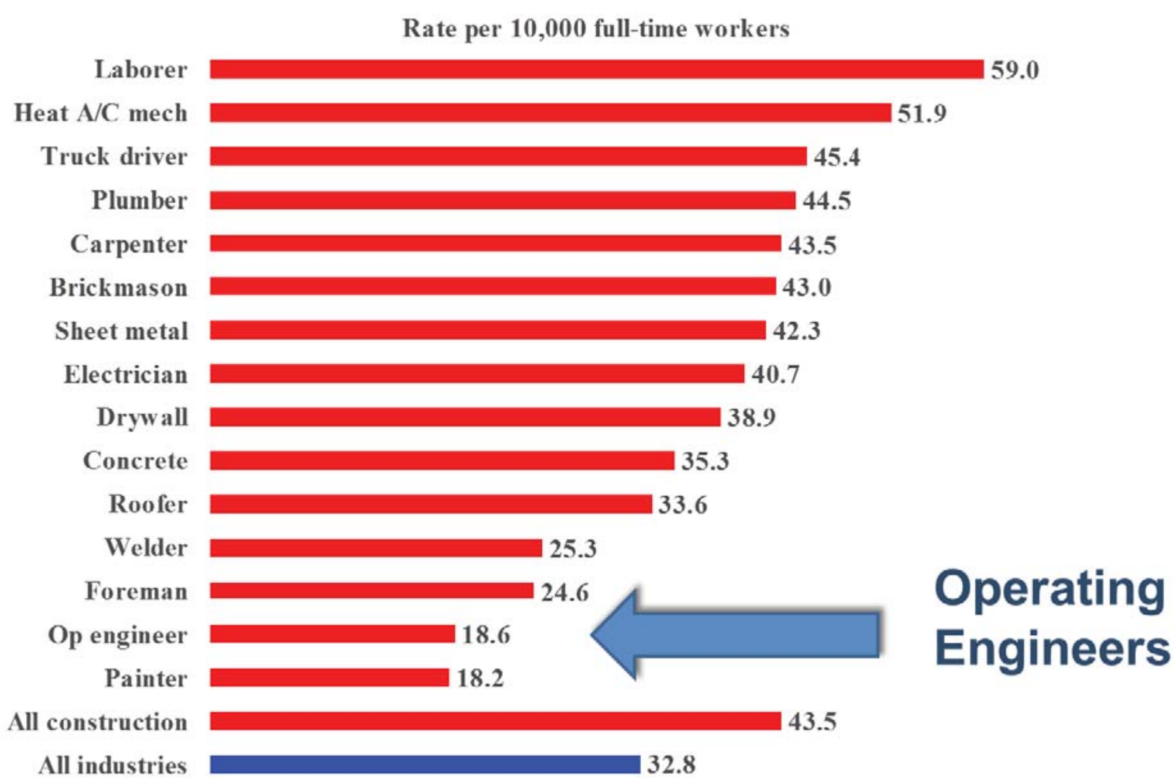


Figure 7.2

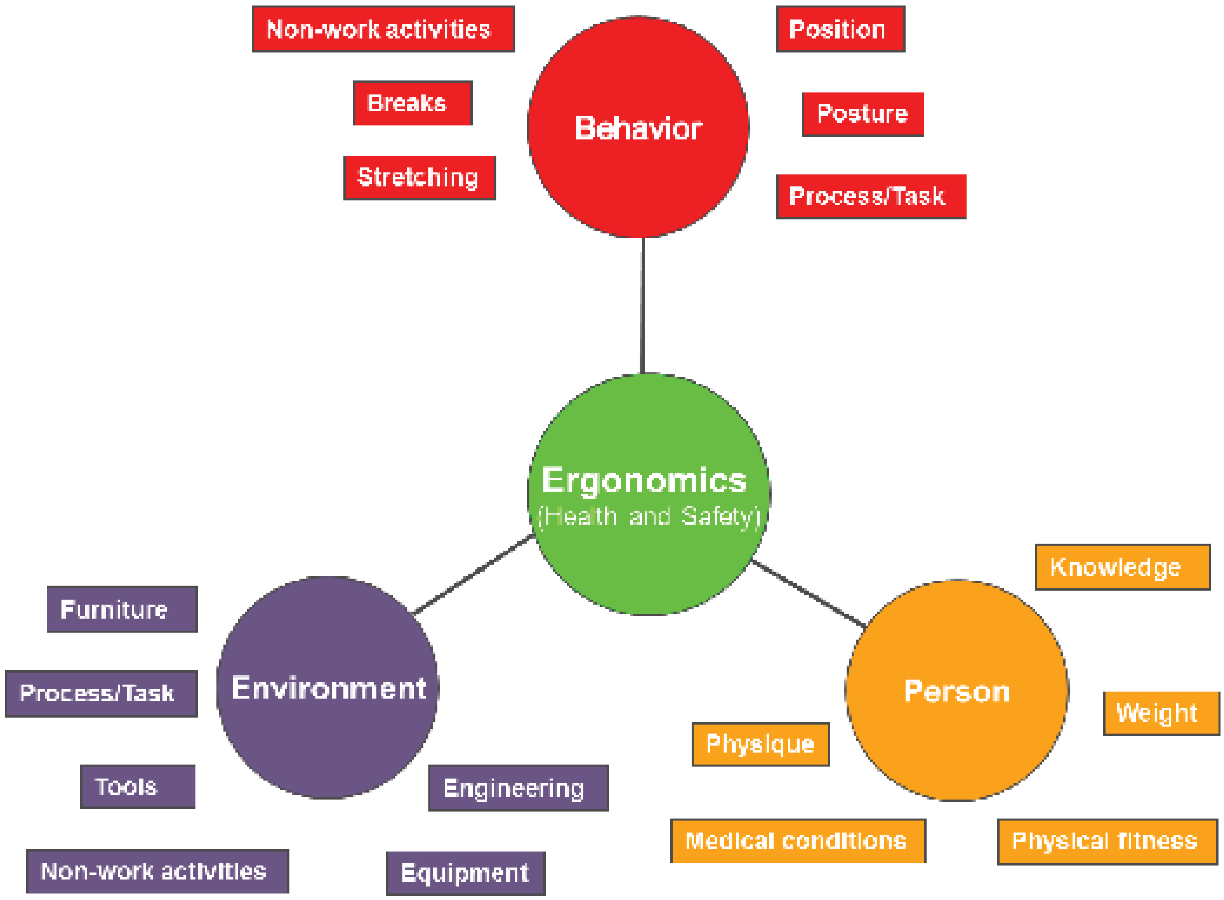


Figure 7.3

What is the most important characteristic of a muscle?

The key function of a muscle is its ability to shrink to half its normal length during contraction. This is how all work gets done, through contraction. The longer the muscle the more work that can be done. This is why athletes work at making their muscles longer through stretching.

Figure 7.4 courtesy of NASA.

What is the difference between static and dynamic muscular efforts? Why is this important?

- Dynamic effort is characterized by regularly altering from contraction to extension, tension to relaxation.
- Static effort is a prolonged contraction of the muscles, usually from taking a posture or holding an object.

During static effort the blood vessels are compressed by the internal pressure of the muscle tissue, so that blood doesn't flow throw the muscle and tends to be restricted in proportion to the force exerted. If the effort is 60% of the maximum, the flow is almost completely interrupted. Compression squeezes blood out of the muscle; relaxing the muscle brings fresh blood, as much as 10-20 times as much blood as during rest.

This is the important point: Static work does not get enough sugar or oxygen to the muscle so waste builds up and fatigue and pain set in quickly. Avoid static tasks.

Static efforts can be serious under several circumstances

- High level of effort for 10 sec. or more
- Moderate effort for 1 min. or more
- Slight effort (1/3 of maximum force) for 5 minutes or more

Many common jobs involve high static requirements

- Bending the back either forwards or sideways
- Holding things in the arms
- Holding arms out horizontally
- Putting weight on one leg while the other works a pedal
- Standing in one place for long periods
- Pushing and pulling objects

Dynamic or static?

Figure 7.5 Photo courtesy of www.constructionphotographs.com

Figure 7.6 Photo courtesy of www.constructionphotographs.com

Figure 7.7 Photo courtesy of www.
constructionphotographs.com

Figure 7.8 Photo courtesy of www.
constructionphotographs.com

Under similar conditions, static efforts lead to greater stress

- Higher energy consumption
- Raised heart rate
- Longer rest periods

Static loads increase oxygen consumption

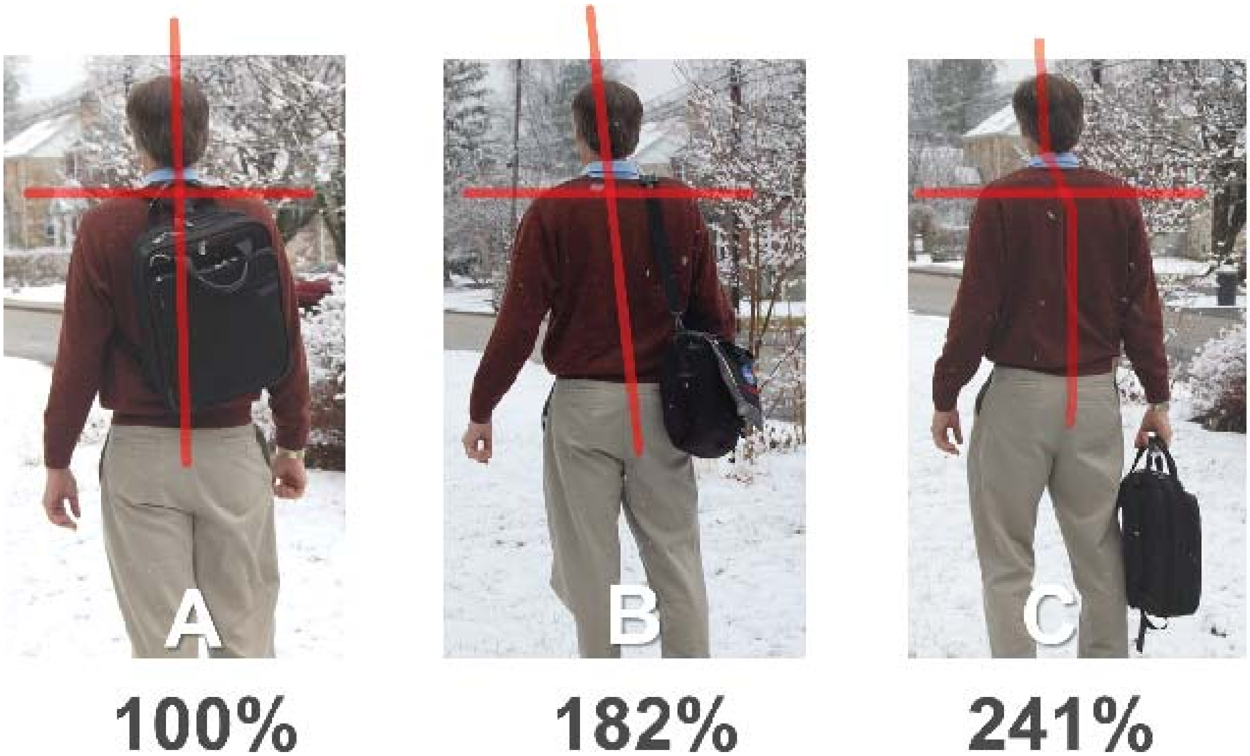


Figure 7.9 Based on Malhotra and Sengupta, 1965

This is from research conducted on schoolchildren where the researchers demonstrated that carrying a book bag on your back required considerably less oxygen than slinging it over your side or, worse, carrying it in one hand, which takes nearly 2.5 times as much work due solely to static requirement of holding the body at an angle.

Age and gender affects the power of our muscles

The following is an important graphic of the power of our muscles over our lives. The peak for both men and women is reached between the ages of 25 and 35. Workers between 50 and 60 can only produce about ¾ of the muscle strength as they could when at their peak. This is important because workers may recall being able to handle materials when they were younger that put them at risk later in life.

In the graphic below, the star represents the mean age (42.9 years) of IUOE members surveyed by the University of Michigan.

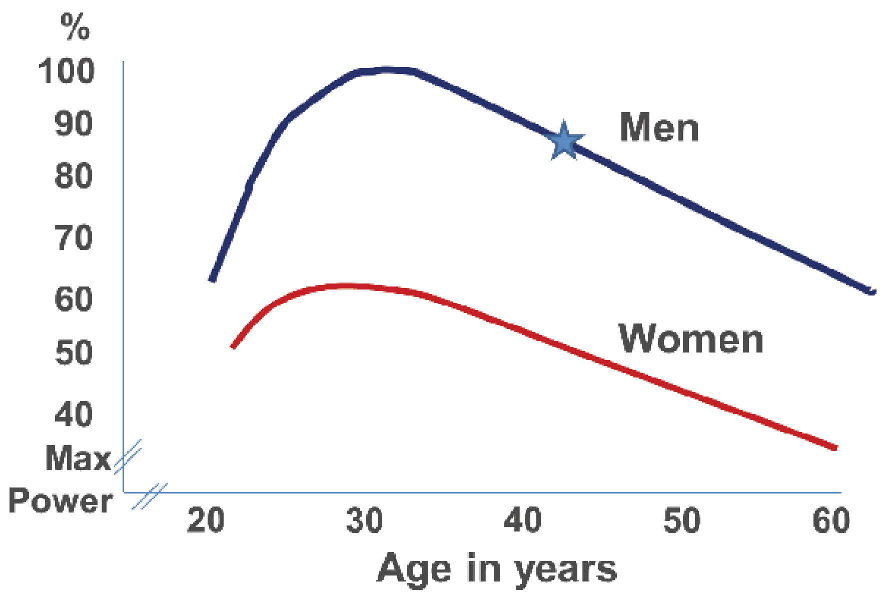


Figure 7.10 Grandjean, 1988.

Injury or Illness?

- 29 CFR 1904 Recording and Reporting Occupational Injuries and Illnesses
- Injury - result from instantaneous event (acute)
- Illness - result from non-instantaneous event (chronic)

Cumulative Trauma Disorder

Key factors:

- repetition
- high force
- awkward joint posture
- direct pressure
- vibration
- prolonged constrained posture
- cold

A pistol grip screwdriver reduces deviated wrist posture

Compared to a conventional screwdriver, a pistol grip screwdriver reduces deviated wrist posture (ulnar deviation) and allows for the generation of an average of twice the torque. Pistol grip screw drivers are also two to three times more efficient for high torque tasks; meaning they allow the user to generate the needed torque with less effort.

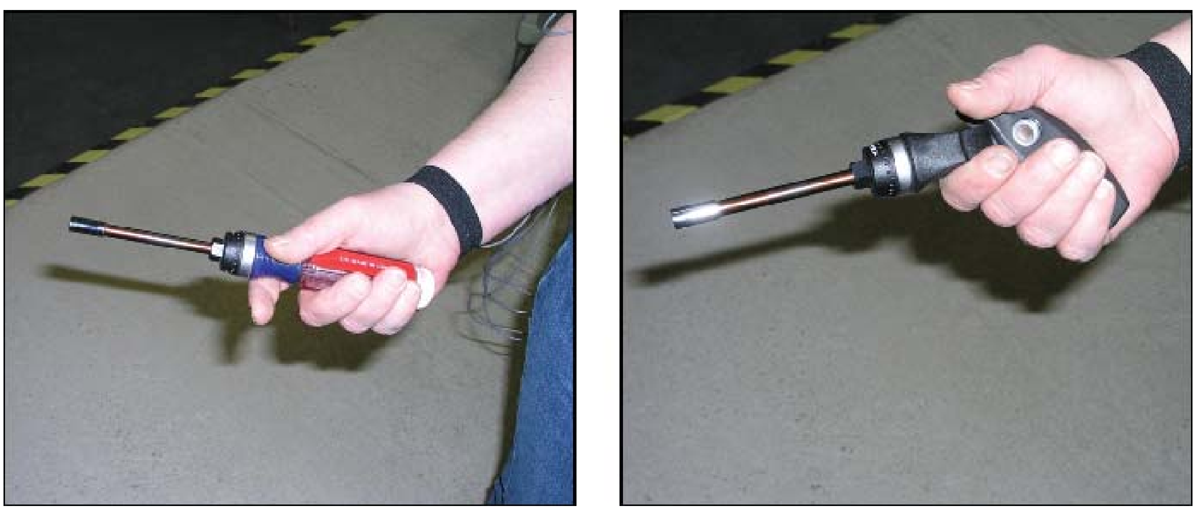


Figure 7.11 Courtesy Dr. Richard Marklin of Marquette University and the Electric Power Research Institute (EPRI)

Cumulative trauma disorders include a broad range of problems

- Carpal Tunnel Syndrome
- Cubital Tunnel Syndrome
- Rotator Cuff
- Radial Tunnel Syndrome
- Trigger Finger
- Epicondylitis
- Gamekeepers Thumb
- Bowlers Thumb

Figure 7.12 Carpal tunnel drawing courtesy of NIH

Material Handling Guidance

Taken from California OSHA:
http://www.dir.ca.gov/DOSH/etools/08-004/index.htm

Position materials so you can work from your power zone

Position materials so all manual material handling is done from this power zone. Trying to move materials outside this zone encourages ergonomic injury.

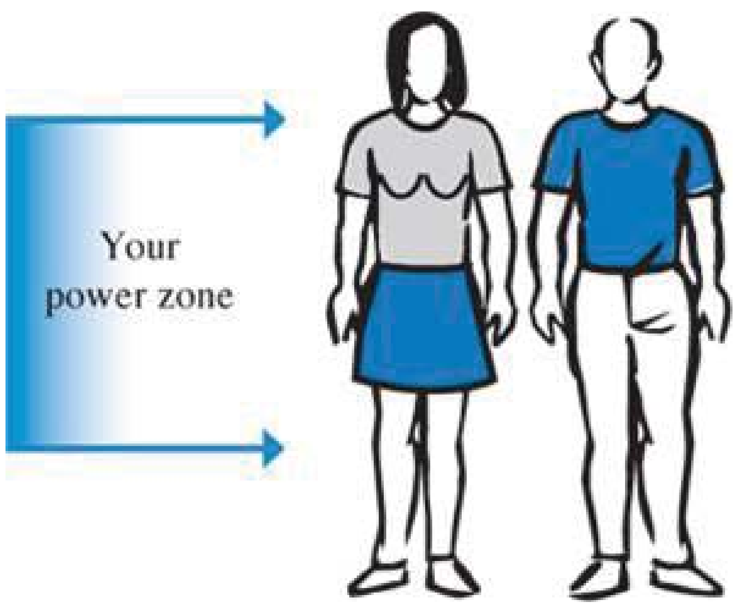


Figure 7.13 Image courtesy California OSHA

Using a lifting device greatly reduces risk

California OSHA recommends using a scissors lift, load lifter, or pneumatic lifter to raise or lower the load so that it is level with the work surface. Then slide the load instead of lifting.

Figure 7.14 Images courtesy California OSHA

Raising the worker also reduces risk

Portable work platforms can be adjusted to each workers' height.

Figure 7.15 Images courtesy California OSHA

Can the force required to move a cart with a heavy load be reduced?

Figure 7.16 Courtesy Dr. Richard Marklin of Marquette University and the Electric Power Research Institute (EPRI)

Yes. This study found that turning six wheel carts required significantly less force than four wheel carts. Also, when standard wheels were replaced with low rolling resistance wheels the force required to push the cart was reduced by 20 to 45 percent. These changes made the carts so easy to move that they had to install brakes on them. Another good indicator of a desirable design was the fact that the workers hid the test carts from the researchers so that they could continue to use them.

It is critical to match people with their tasks

- Design tasks and equipment to ensure ease and efficiency of manual material handling
- Train people in safe and efficient procedures
- Select people who are capable of performing the labor

Training has not been the answer for safe lifting

Many operating engineers have had training on safe lifting. Unfortunately, studies do not indicate great success with training. The National Training Council says that two training approaches have worked:

1. Teaching the physics involved in manual materials handling and on how the body reacts; and
2. Teaching how to improve individual physical fitness through exercise and warm-ups.

"Designing a safe job is better than training people to behave safely in an unsafe job."

- National Safety Council, Fundamentals of Industrial Hygiene, 1996

The standard "safe lifting" training has failed because workers often revert to previous habits if the training isn't constantly reinforced or they face emergency situations, make quick movements or have weight or fatigue issues. Workers should always look to the hierarchy of controls and insist that lifts be engineered out if at all possible.

There are no sure-fire rules for safe lifts, but some dos and don’ts apply

Do	Don’t
Perform work between knuckle and shoulder	Twist the back or bend sideways
Be in good physical shape	Lift or lower awkwardly
Think before acting	Hesitate to get mechanical help
Get a good grip on the load	Lift or lower with arms extended
Get the load close to the body	Continue heaving when the load is too heavy

Table 7.1

Evidence does not support the use of back belts

Evidence does not support the use of back belts for reducing back pain or injury. Back belts may create a false sense of security.

Figure 7.17 Photo courtesy TM Information Services

Overexertion leads to greater than 75% of MSDs in construction

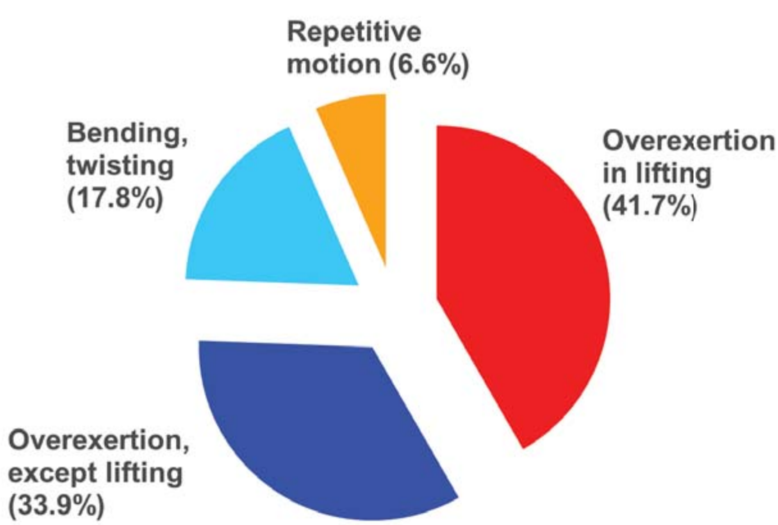


Figure 7.18 Risk factors for musculoskeletal disorders with days away from work in construction, 2005 (Source: CPWR Chartbook)

Sprains and strains are the leading injuries on the job

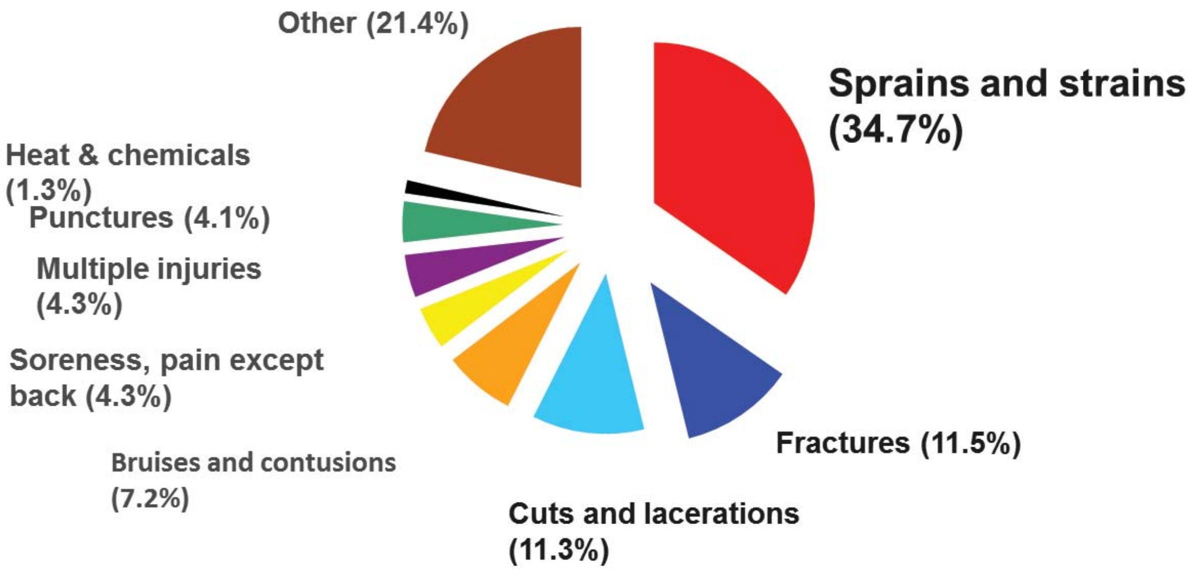


Figure 7.19

The spinal column protects the spinal cord while providing support and flexibility

Figure 7.20 Framatome oxy-acetylene torch demonstration.

Vertebrae -- Vertebrae, (33 in number) are cylindrical bones which enclose the spinal cord, stacked vertically together, separated by discs to form the vertebral column or spine.

The spine's basic functions include:

- Providing support
- Protecting the spinal cord
- Providing flexibility to allow bending and rotating
- When normally aligned, the spine forms 3 natural curves (cervical, thoracic, lumbar
- Maintaining these natural curves keeps the spine in balance.

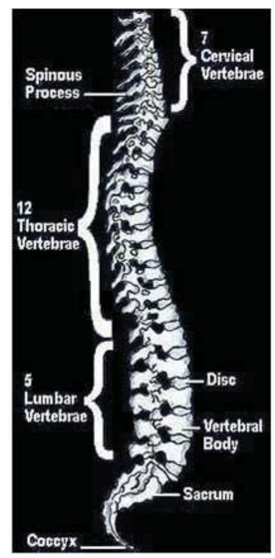


Figure 7.21

Discs -- The discs (articular pads composed of dense fibrocartilage) lie between each vertebrae. Each disc contains a jelly-like center surrounded by rings of tough fibrous tissue. Pressure placed on these discs, through manual handling or other activities, can cause them to bulge and deform. This can lead to disc-related back injuries as the bulging disc presses against nerves in the low back These discs act as "spinal shock absorbers" during activities such as sitting, standing, walking, lifting, etc. The L5/S1 disc is the lowest disc in the spinal column. It is located between the 5th lumbar vertebrae (bone) and the 1st sacral vertebrae. Because it is the lowest disc in the back, it always has the highest compressive forces placed against it, and it is consequently the disc that is most frequently injured in the back.

Nerves -- Nerves are a collection of fibers which carry electrical impulses throughout the body. The spinal cord stretches the length of the spine through the vertebral column. Smaller nerves branch out between each vertebrae to carry messages around the body.

Muscles, Ligaments, Tendons -- Muscles are tissues in the body which provide support and contract to produce movement. Ligaments are bands of fibrous tissue that connect bones or cartilage together - serving to support and strengthen joints. Tendons are fibrous cords of connective tissue which attach muscle to bone.

Erector spinae muscles -- As the name suggests, the function of these very small muscles is to keep the torso erect. If we bend at the back (stoop instead of squat) we ask these muscles to work harder than they may be capable of, thereby increasing back injury risk.

Bending and shock absorbing

The discs (articular pads composed of dense fibrocartilage) lie between each vertebrae. Each disc contains a jelly-like center surrounded by rings of tough fibrous tissue. These discs act as “spinal shock absorbers” during activities such as sitting, standing, walking, lifting, etc.

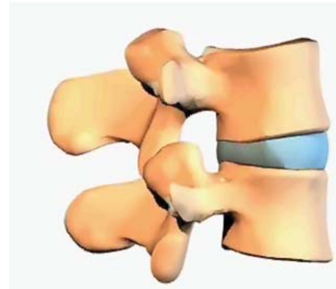


Figure 7.22

The erect body can tolerate amazing compression

Figure 7.23

The lower back is pivot point during lifting

Think of your back as a lever. With the fulcrum in the center of the lever, it only takes ten pounds of pressure to lift a ten pound object. Most back injuries, whether they are muscle strains or disc-related injuries, occur in the low back area.

1. The muscles in the low back are very small, and are subject to strains when overexerted.
2. The discs in the low back bear the heaviest load (compressive force) with or without lifting, due to their location.
3. The low back is the pivot point when we bend to lift, or twist during a lift.

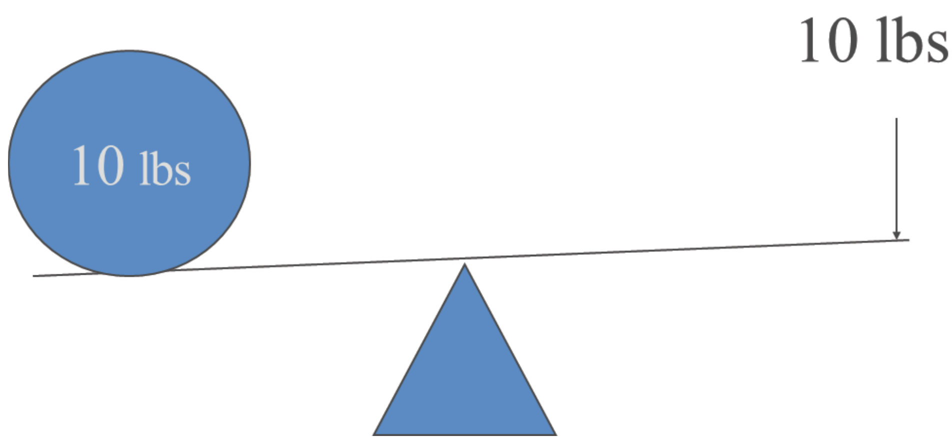


Figure 7.24

As the distance between the object and the lower back is increased, the force on the lower back increases

However, if you shift the fulcrum to one side, it takes much more force to lift the same object. Your waist actually acts like the fulcrum in a lever system, and it is not centered. In fact, it operates on a 10:1 ratio. Lifting a ten pound object actually puts 100 pounds of pressure on your lower back.

It is important to keep an object close to the body when lifting the object. As the weight of an object moves away from the body, it increases compressive forces on the discs in the low back, and the amount of weight we can safely handle decreases significantly.

Add in the average human upper torso: 105 pounds
Lifting a ten pound object puts 1,150 pounds of pressure on the lower back.

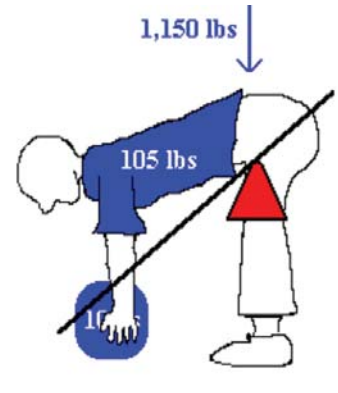


Figure 7.25

The amount of force required depends on the grip

The amount of force required to grip something depends on a number of factors; one of the most important of these is how you grip it. Gripping something with the whole hand, called a power grip, is 5 times stronger than gripping something with the fingertips, known as a pinch grip. So, picking up something that weighs 2 pounds with a pinch grip is just as stressful as picking up 10 pounds with a power grip.

Minimal muscle force is required to hold objects in a power grip posture. The pinch grip requires excessive fingertip pressure, and can lead to a cumulative trauma disorder.

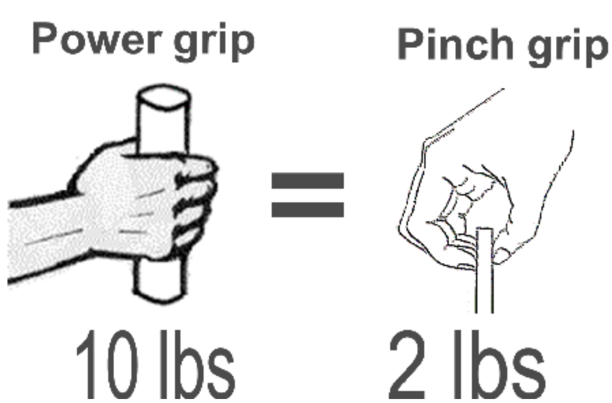


Figure 7.26

Vibration in vehicles or from tools can contribute to MSDs

Heavy equipment operators have heightened exposures for MSDs because of the vibration of their equipment, but anyone who handles vibrating tools is at risk, too.

Figure 7-27 Photo courtesy of Chicago Pneumatic

How can we reduce exposure to vibration?

When feasible, vibration should be reduced at the source by driving on smoother surfaces, reducing driving speed on rough surfaces and keeping equipment maintained and properly tuned. When the source of vibration can not be reduced, the operator's exposure must be reduced through isolation or damping.

Figure 7.28 Photo courtesy John Deere

Several principles can guide designing workstations

- Avoid bent, unnatural postures
- Avoid keeping an arm outstretched
- Work sitting down as much as possible
- Carry out most frequent movements with elbows bent and near the body

Ergonomics and visibility were considered in this design

The cab of the new John Deere motor grader was designed with visibility, ergonomics and comfort in mind. The low-effort fingertip controls are arranged in the standard pattern and should reduce strains and fatigue. The redesigned seat has an adjustable lumbar support and a wider, higher backrest. Visibility was improved by increasing the size of the windows and reducing the width of the stationary console.

Figure 7.29 John Deere's 872GP motor grader. Courtesy John Deere.

Figure 7.30 Child being cut out of chair he got caught in after pushing his head through the back.

Design should consider "foreseeable misuse"

"Nothing is fool-proof in the hands of a fool."

The workplace should ideally be suited to the body size of the operators

Everyone should agree that workplaces, particularly cabs of heavy equipment, should ideally be suited to the body size of the operators. The problem with designing to average height is that no one is average in all body dimensions. Designers generally work to cover 90 to 95% of individuals.

Ergonomic design includes considering the needs of workers who perform maintenance

Data reported by the National Institute for Occupational Safety and Health indicated that for 1997, 48 percent of workers fatally caught in machinery were performing maintenance while only 45 percent were actually operating the equipment when killed, even though a far greater proportion of time is spent operating the equipment.[1] Taylor found specific accident rates for similar equipment varied by a factor of over 100, due to differences in maintenance practices and routine inspections.[2]

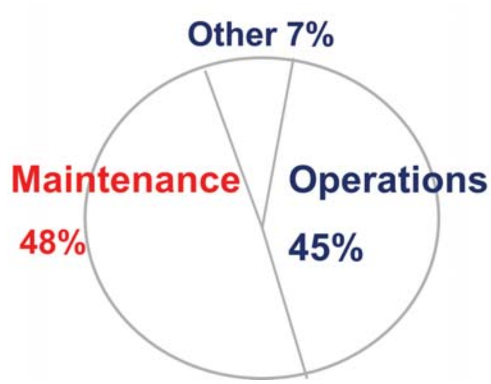


Figure 7.31 Machinery Fatalities in 1997Etherton, NIOSH quoting Windau 1999

Exercise:

What are 6 key risk factors for MSDs?

1. Repetition / Duration
2. Force
3. Posture / Position
4. Compression / Contact stress
5. Vibration
6. Cold

1 Etherton, J. (2001, July 19). Machine tool safety research 2001, the injury data. Paper presented at the meeting of the American National Standards Institute's B11 committee, San Diego, CA.

2 Taylor, J.R. (1994). Risk analysis for process plant, pipelines, and transport. London: Chapman & Hall. 411.

Change the behaviors, environment and people to prevent MSDs

How do we Prevent Injuries?

- Change behaviors:
  - Breaks and stretching
  - Improve posture
  - Proper use of furniture and equipment
- Change the environment
  - Fit the equipment to the person
    - Adjust furniture and/or equipment
    - Acquire adjustable ergonomic furniture and equipment
- Change the person???
  - Physical fitness (strengthen and stretch)
  - Weight loss (reduce forces)
  - Non-work Activities (computer use, sports, hobbies)

What behavioral changes can reduce MSDs?

To reduce MSDs, people can:

- Improve their physical fitness through strength and stretching exercises
- Lose weight if they are overweight
- Examine non-work activities such as computer use, sports, and hobbies for possible problems
- Take breaks
- Improve posture
- Adjust and use furniture and equipment properly

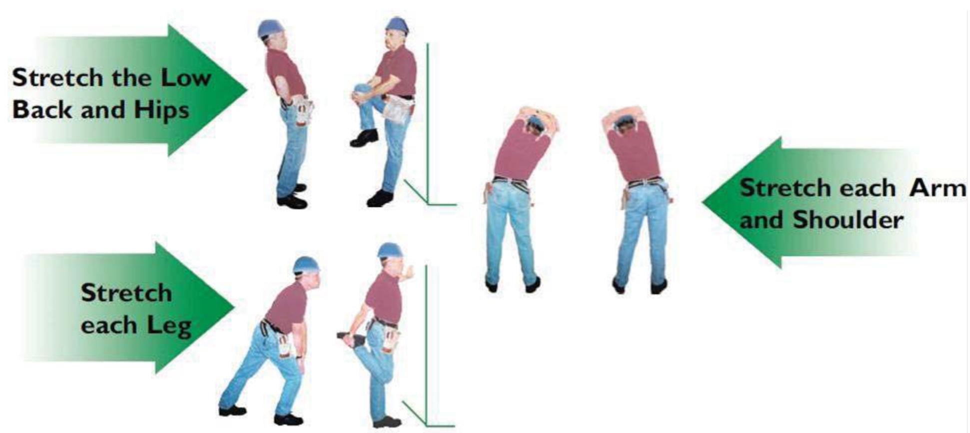


Figure 7.32 Image courtesy California OSHA

Let's take a moment to stretch

- Warm-up for 5 minutes prior to stretching
- Exercises should be tailored to commonly performed job duties
- Stretch regularly: 2–3 days/week, minimum
- Perform stretches correctly:
- Use static or PNF stretches (not ballistic stretching where the muscle is bounced)
- Hold stretch 15–30 seconds
- 3–4 repetitions per muscle group
- Stretch bilaterally, emphasize tight muscles
- Intensity should be to a position of mild discomfort
- Trained instructors should lead and monitor classes
- Compliance should be monitored
- Stretch at appropriate work times throughout the day
- Company commitment to work time and program overhead costs

Hamstring Stretch (left)

- Place your leg on a table or chair at a comfortable height.
- Slightly bend the leg on the ground at the knee.
- Bend forward at your waist until you feel a stretch in the back of the raised leg.
- Hold for 10 seconds.
- Switch legs and repeat.

Figure 7.33

Quadriceps Stretch (Right)

- Grasp the top of your ankle and pull heel towards buttocks until a stretch is felt in front of the thigh.
- Try not to bend forward.
- Hold for 10 seconds.
- Switch legs and repeat.

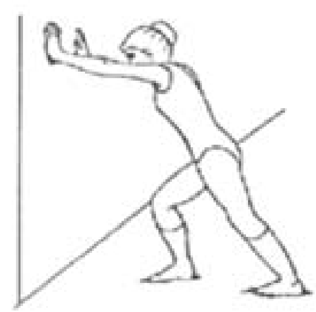


Figure 7.34

Triceps Stretch (Left)

- With arms overhead, hold the elbow of one arm with the hand of the other arm.
- Gently pull the elbow behind your head, creating a stretch. Move slowly.
- Hold for 5-10 seconds.
- Repeat with other arm.

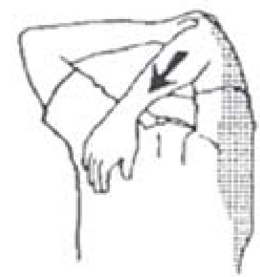


Figure 7.35

Overhead Stretch (Right)

- Interlace your fingers above your head.
- Turn your palms upward as you push your arms back and up.
- Hold for 5-10 seconds, then relax and repeat.

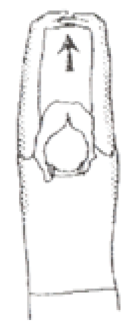


Figure 7.36

NIOSH's Lifting Equation

NIOSH's Lifting Equation has been widely used

- Recommended Weight Limit
- Tool for assessing the physical stress of two-handed manual lifting task
- Designed to meet specific lifting-related criteria covering biomechanical, work physiology and psychophysical assumptions and data

NIOSH Lifting Equation provides a Recommended Weight Limit (RWL)

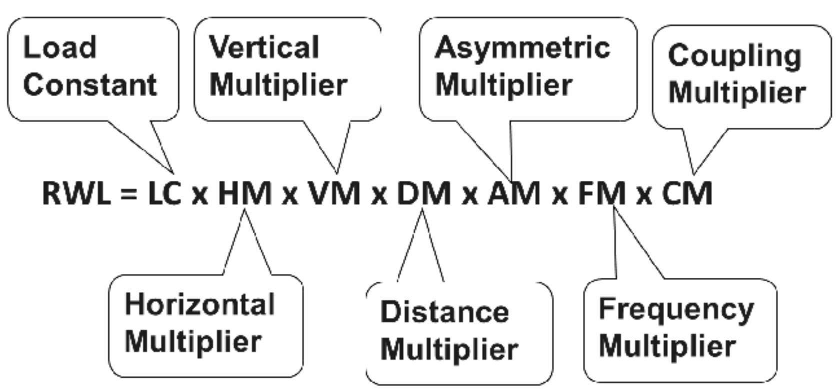


Figure 7.37 NIOSH Lifting Equation

NIOSH Lifting Equation - LI

Figure 7.38

- Lifting Index
- Provides a relative estimate of the level of physical stress associated with a particular manual lifting task

The goal is to design all lifting jobs to be below an LI of 1.0

$$LI = \frac{\text{Load Weight (L)}}{\text{Recommended Weight Limit (RWL)}}$$

Figure 7.39

RWL can be used to design safer lifts

- RWL used as guide to redesign existing or design new manual lifting jobs
- LI used to estimate magnitude of physical stress for a task or job
- LI used to prioritize ergonomic redesign (jobs with higher indices would benefit most from redesign)

The NIOSH lift equation does not apply if any of the following occur:

- Lifting/lowering for >8 hours
- One-handed lifts
- Lifting while seated or kneeling
- Lifting in an unfavorable environment (temperature, humidity, etc.)
- High speed lifting (>30 inches/second)
- Lifting with shovels

Consult a medical doctor if you experience symptoms of an MSD

Resources

California Division of Occupational Safety and Health: Improving Manual Material Handling etool
http://www.dir.ca.gov/dosh/etools/08-004

Cornell University Ergonomics Web
http://ergo.human.cornell.edu

CPWR – The Center for Construction Research and Training: Construction Chart Book
http://www.cpwr.com/rp-chartbook.html

CPWR – The Center for Construction Research and Training: Construction Solutions
http://www.cpwrconstructionsolutions.org

Electric Power Research Institute: Ergonomics Handbooks for Electric Utilities
http://my.epri.com/portal/server.pt?open=512&objID=400&&PageID=226973&mode=2

NIOSH Safety and Health Topic: Ergonomics and Musculoskeletal Disorders
http://www.cdc.gov/niosh/topics/ergonomics

U.S. Army Center for Health Promotion and Prevention Medicine Ergonomics Program
http://chppm-www.apgea.army.mil/ergopgm

Instructor Lesson Plan
Excavations
LESSON PLAN – CIO 239-339

Key Concepts

- Excavation dangers.
- Protection methods.
- Confined spaces.
- Soil types affecting excavation.
- Slope measurements.

Presentation and Materials

- Allow 30 minutes to present this chapter.
- Use Excavations PowerPoint slides.
- Try the Group Discussion Activity at the end of the chapter.
- Use Review Questions at the end of the chapter to facilitate discussion.
- Use 30-Hour Construction Outreach course manual.

Standards

Safety and Health Regulations for Construction

- 29 CFR 1926 Subpart P—Excavations

Module 8

Excavations

OSHA: 29 CFR 1926 Subpart P – CIO 239-339

Lesson Outline

Overview

Digging a hole is a lot more dangerous than it sounds. Construction workers die in excavation or trenching incidents at a rate 2½ times greater than any other construction-related event. Conservative estimates put the number of deaths from cave-ins at nearly 100 per year. Another 100 workers are permanently disabled and cannot return to work, while nearly 200 more are injured to the extent that they cannot perform the same duties and must be retrained.

Most deaths occur without warning in trenches that are 5 to 15 feet deep. It is estimated that more than 10,000 entrapments occur each year, with about 10 percent of those resulting in lost-time injuries.

This chapter will teach you about safe practices to follow when working with excavations.

Objectives

Know

- Describe causes of trench collapses.
- Discuss other potential excavation dangers.
- Define protection methods (sloping, benching, shoring, trench shields).
- State the conditions when a trench can be a confined space and the protection methods for employees entering confined spaces.
- Describe characteristics of different soil types that can affect an excavation.

Apply

- Calculate slope measurements for various soil types and trench depths.
- Identify dangerous activities in various excavation images.

Analyze

- Compare and contrast what needs to be known and done before beginning various excavations.

Excavation Safety

An excavation is any manmade cut, cavity, trench, or depression in an earth surface, formed by earth removal—regardless of depth, width, ultimate use, or excavation method. Each year excavations pose one of the most common hazards at a job site. Unfortunately, unsafe excavations and trenches claim a number of lives.

The Occupational Safety and Health Administration has a number of requirements employers must follow to ensure your safety when working in and around excavation sites. But as with all safety issues, the more you know yourself about working safely at a job site, the more protected you'll be.

Basic Safety Requirements

Before excavation begins, the employer must evaluate the site to determine potential hazards and take action to reduce or eliminate them. The employer must also establish emergency procedures and a schedule for periodic inspections of the excavation operation as well as make sure all underground utilities are marked according to local requirements.

Figuer 8.1 This excavation job features a number of safety precautions, including a trench shield extending above the trench to protect workers in the trench and a ladder to allow them to exit. Photo courtesy of www.myconstructionphotos.com.

Here are some other basic safety requirements:

- Prevent workers from traveling under elevated loads or working over unprotected people.
- Ensure that all employees wear the proper personal protective equipment.
- Provide walkways for access and egress.
- Maintain spoil piles at least two feet from the edge of the excavation.
- Erect secured ladders at least every 25 feet when the excavation is deeper than four feet. The ladders must extend above the surface by three feet.

OSHA regulations also require the presence at an excavation site of a **competent person** who can identify existing and predictable hazards or unsanitary, hazardous or dangerous working conditions. This person also must have authorization to promptly correct any problems. Here are some of the factors this person will check for but that you should be aware of as well:

- Has the engineering survey been read and soil type determined?
- Have utilities been notified and locations of utility lines/pipes marked?
- Are there any potential hazards (fuel tanks, gases, etc.)?
- What is the final size of excavation, including sloping?
- Is there enough room to safely operate excavating vehicles?
- How will street traffic be controlled?
- How will pedestrian traffic be controlled?
- How will adjacent properties be protected?
- Are the necessary barricades erected?
- Are helmets and goggles distributed and being worn?
- Will shoring or shielding be required?
- Where are shoring or shielding equipment and ladders?
- Has weather been checked?
- Are water pumps available? Where are they?
- Where is the nearest hospital or doctor?
- Where is the first aid kit?
- Where are the toilets?
- Where is the potable water?
- Is all equipment located the necessary distance away from any excavations?

Causes of Excavation Dangers

The greatest danger you face in an excavation or trenching operation is a cave-in. Each time the trapped worker exhales, the weight of the load makes it more difficult to inhale the next breath. Slow suffocation usually follows unless rescue is immediate. Because it is very difficult to quickly remove someone trapped in a cave-in, death tragically is the ultimate result, even though most cave-ins occur in trenches only 5 to 15 feet deep.

Excavation dangers are typically caused by four factors: vibrations, adjacent structures, freezing and thawing of soil, addition or removal of water, and heavy equipment. Be on the lookout for these signs that can cause excavations to collapse.

Vibrations

Vibrations can destabilize soil, causing it to crack or fissure. Here are some typical operations that cause vibrations:

- Traffic
- Railroads
- Heavy equipment
- Jackhammers
- Tamping machines
- Blasting

Adjacent Structures

Structures such as buildings, sheds, or utility poles may be close enough to the excavation that they have the potential to be hit by excavators or become unstable and collapse. The same vibrations that can affect an excavation site can destabilize structures as well. Protect structures from collapse by providing structural shoring, for example, and make sure equipment operators are aware of their surroundings above, below, and around them. Use a spotter if necessary to add equipment operators.

Freezing and Thawing

Freezing and thawing of soil can further destabilize an excavation. Check for cracks or fissures in the excavation that might be caused by extreme temperature swings.

Addition or Removal of Water

Soil conditions change when the soil is exposed to water. Continuously monitor wet soil. Remove water immediately and do not work in flooded trenches. You might have to remove water continually during an excavation project. Precautions for type C soil (such as gravel, sand, loamy sand, or submerged soil or unstable rock) must be followed once soil becomes wet. Remember too that the presence of water increases the potential for electrocution.

Heavy Equipment

Heavy equipment puts extra pressure on the soil on one or more sides of the trench, even if the equipment is kept beyond the recommended two feet from the beginning of the trench slope. Pay close attention to the soil when heavy equipment continues to work close to the excavation.

Figure 8.2 A piece of heavy equipment straddles a trench.
Would you work down there?

Anatomy of a Cave-in

Picture a tall house of cards. Pull a card from the bottom of the pile, and the whole house will likely fall, right? Cave-ins often work in the same way. The greatest pressure in a trench is on the deepest soil, which has the most soil weight above it. Trench collapses typically occur in multiple stages, beginning with a cave-in of soil at the bottom into the trench. Next, the soil immediately above this layer collapses. Finally, the top layer, which now has little support left beneath it, can crack or fissure and collapse.

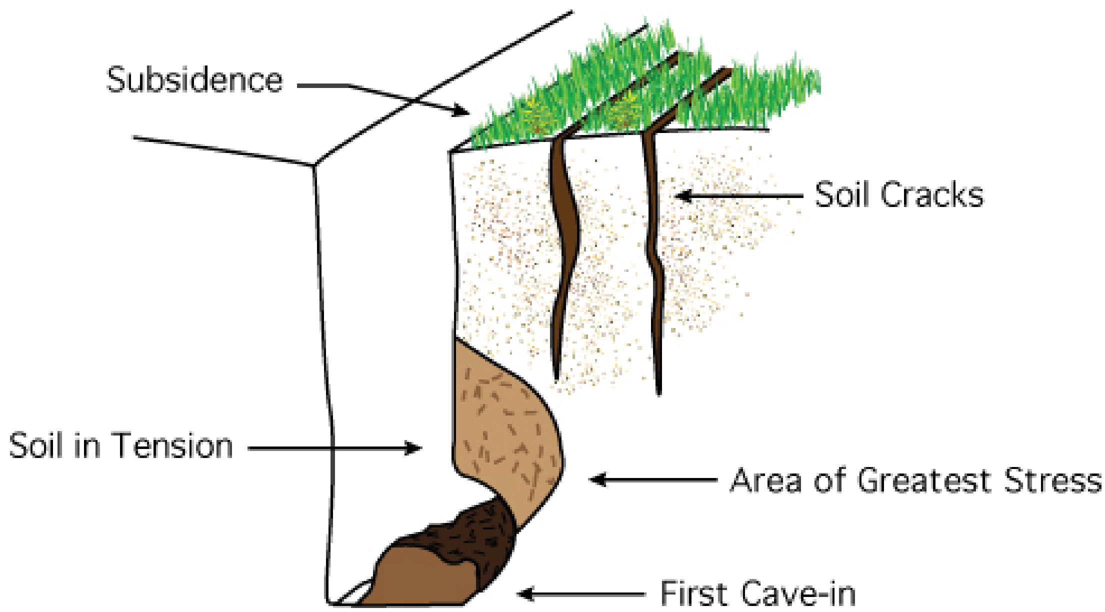


Figure 8.3 This image shows a cave-in in progress. The bottom of the excavation has already collapsed. The layer above it is no longer supported, and two soil cracks indicate surface layers ready to give way.

Shielding or shoring procedures must be in place to prevent cave-ins and protect workers. You play an important role too in protecting your safety. Monitor the soil conditions for signs of change or danger. If dangerous conditions exist, get out of the excavation area and make sure the person in charge orders other workers out as well.

Other Excavation Dangers

Cave-ins aren't the only hazard involved in excavation work. Here are a number of other potentially dangerous situations:

- **Surface encumbrances.** OSHA requires that anything that creates a hazard to people working around the excavation must be removed or supported. The regulations term these as surface encumbrances, and they can include fencing, pipes, cables, and electric boxes.
- **Adjacent structures.** Some excavations will take place near structures such as buildings or utility poles that are already in place and can't be moved. Excavator operators have to be aware of their surroundings and take care not to strike these structures.
- **Utility lines.** Excavator operators must be especially keen to how close they are to utility lines—either in or above ground. Striking a charged power line can electrocute the operator and those near the equipment. Rupturing a gas line can lead to an explosion. Utility line indicators must be observed, and excavation activities must be kept at appropriate distances to avoid accidental strikes.
- **Visibility.** If visibility between the vehicle and the trench is hindered in any way, a warning system must be in place. The warning might be an upward grade at the approach of a trench or stop logs to prevent vehicles from getting too close to the trench edge.
- **Moving equipment.** When you work around excavations, you also need to be alerted to equipment movement. Appropriate barricades must be in place to ensure that you or civilians are never under moving equipment or too close to the edge of the excavation.
- **Toxic or explosive gases or oxygen deficiency.** When excavations are at least four feet deep, they become partially confined spaces with limited air exchange. That brings a new set of rules. All safety precautions for confined spaces must be followed. Before you enter a confined space, the air inside it must be tested to ensure it is safe to enter or determine whether the excavation needs to be ventilated or you need a respirator. You might face an oxygen-deficient atmosphere or high levels of combustible gas or other hazardous substances. For instance, carbon monoxide exhaust from power machinery can build up and become toxic in a trench. Fumes from leaking gas lines or given off by landfill material also might be present and be toxic or explosive. Sparks from power equipment can cause explosions in the presence of flammable gases.
-

Protection from Falls, Falling Loads, and Mobile Equipment

Because excavations are located below ground, equipment operators, other workers, and pedestrians are at risk of accidentally falling in. Here are some guidelines to prevent that from happening:

- Install barricades, including stop blocks that will stop vehicles and people.
- Use hand or mechanical signals to communicate with equipment operators.
- Grade soil away from the excavation. Uphill movement and stop logs communicate that the operator is approaching the edge.
- Fence or barricade trenches left open overnight.
- Use a flagger when signs, signals, and barricades are not enough protection.
- Use appropriate sheeting material (wood for human activity or steel for heavy equipment) to distribute pedestrian and vehicular weight evenly along the edges of trenches.
- Wear hard hats and other safety equipment as determined by the conditions and your assignment at each excavation site.

Figure 8.4 What could have prevented this?

Trench Protection Methods

Once the locations of all utility lines have been identified and marked, the excavation site must have protective systems established. The protective systems must be able to withstand all loads that could potentially be applied to the system. The person designated by OSHA rules as the competent person will make these decisions.

The protective systems aren't required if the excavations are made entirely in stable rock, or if the excavations are less than five feet deep and the competent person has examined the ground and found no indication of potential cave-in.

For trenches at least four feet deep, ladders must be placed to allow workers to leave the trench within 25 feet of their work. The ladders must extend at least three feet above the excavation.

Sloping, shoring, shielding, and benching are all methods to prevent the possibility of cave-ins during excavations. These tried and true practices have reduced excavation accidents and fatalities.

Sloping
Sloping involves cutting the walls of the trench at an angle that keeps the walls of the trench stable to avoid a cave-in. Sloping requires a ratio of slope width to trench depth with shallower slopes for less stable soil types, according to a strict set of engineering tables. You can practice determining trench slope sizes later in this chapter.

Shoring

Shoring is the process of using combinations of boards or beams and bracing (horizontal walers with perpendicular cross braces, metal sheeting, or hydraulic systems with locking pins in case of hydraulic system failure) to stabilize the sides of the excavation.

Figure 8.5 Note the combination of vertical shoring beams held apart by a hydraulic waler system.

Figure 8.6 Note the substantial upright wood sheeting supported by horizontal wales and held apart by equally substantial cross braces.

Figure 8.7 What's wrong with this picture?

Figure 8.8 And this one?

Shielding

Shielding or trench shield systems include prefabricated boxlike structures that support the walls on both sides of a trench. Trench shields should extend at least 18 inches above the bottom of side slopes.

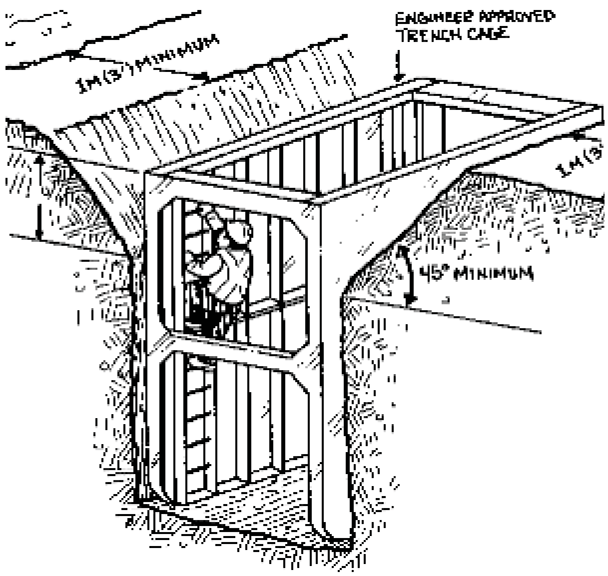


Figure 8.9 A prefabricated trench shield.

Figure 8.10 A trench shield built on the worksite

Benching

Benching is a method of protecting workers by excavating to form one or a series of horizontal steps, or “benches,” which are separated by appropriately sloped areas.

Figure 8.11 Note the benching at the front portion of this image.

Soil Classifications

Stable Rock
Stable rock is a natural solid mineral matter that can be excavated with vertical sides and remain intact while exposed. Stable rock is usually identified by a rock name, such as granite or sandstone.

Type A Soil
Type A soil is cohesive (it sticks together) with an unconfined compressive strength of at least 1.5 tons per square foot. Examples of type A soils are clay and soils with high clay content (silty clay, sandy clay, clay loam, and in some cases, silty clay loam or sandy clay loam).

Soil is **not** type A if:

- It is fissured.
- It is subject to vibrations from heavy traffic, pile driving, etc.
- It has been previously disturbed (past excavations for utilities, etc.).
- It is part of a sloped, layered system.
- It is subject to other factors that would make it less than stable, including water.

Type B Soil
Type B soil is cohesive with an unconfined compressive strength between 0.5 tons and 1.5 tons per square foot. Examples of soils less cohesive than type A soils are angular gravel, silt, silty loam, sandy loam, and silty clay loam.

Type B soils are previously disturbed soils **except**:

- Soils that can be classified as type C.
- Dry rock that is not stable.
- Soil that would be classified as type A except it is fissured or subject to vibration.

Type C Soil
Type C soil is cohesive with unconfined compressive strength of less than 0.5 tons per square foot. Examples include granular soils such as gravel, sand, and loamy sand. Type C soil may also be submerged soil or soil from which water is freely seeping, or submerged rock that is not stable. Wet soil is automatically classified as type C soil.

Mixed Soil Layers
From time to time excavators will encounter layering of different soil types. All soil should be treated as if it were the type of the least cohesive layer when the less stable layer is under the others. For example, when type A soil is found above type C soil, the entire excavation should be handled as if it is occurring in type C soil.

If the more cohesive layer is on the bottom of a relatively deep excavation in which sloping is being used, the excavation slope may change from 1½:1 to ¾:1 when the more cohesive/stable layer is encountered. (See CFR 1926 Subpart P, Appendix A (c), Requirements (4), Layered Systems: In a layered system the system shall be classified in accordance with its weakest layer. However, each layer may be classified individually where a more stable layer lies under a less stable layer.)

Soil Testing
There are several methods to test for soil type. Visual and contact inspections are required. Excavated samples as well as samples in the sides of the excavation should be tested. After classifying a deposit, if the properties, factors, or conditions affecting its classification change in any way, the designated competent person must evaluate the changes and reclassify the deposit if needed.

Figure 8.12 Soil testing is important in excavation work.

Dry strength tests involve observing how easily clumps of soil break apart. The more cohesive soils (with high clay content) tend to stay together in large clumps (type A soil **unless there are signs of fissuring**), while sandy and gravely soils break apart into the smallest pieces (type C soil).

Plasticity or wet thread tests involve molding a moist soil sample into a ball, then rolling it into a thin thread ⅛ inch in diameter by 2 inches long. The sample is held at one end. If the soil “thread” doesn’t break, the soil is considered cohesive.

Thumb tests measure soil cohesiveness (how well it sticks together). If the thumb barely compresses the soil, it is probably type A soil, which is very cohesive. If the thumb is able to puncture as far as the bottom of the thumbnail before it cannot penetrate any deeper, soil is classified as type B. If the thumb is able to extend completely into the soil, it is classified as type C, the least cohesive.

Pocket penetrometers allow direct reading using a spring-operated mechanism to determine the unconfined compressive strength of saturated cohesive soils. Penetrometers have large error rates between +/- 20 percent to 40 percent.

Shearvanes, or torvanes, are tools that are pressed into the ground with a twisting action. The deeper they penetrate the soil, the less cohesive, or stable, the soil.

Visual testing includes an evaluation of the whole excavation site, done daily and after any change in conditions (vibrations from traffic, rain, freezing, underground obstruction, etc.).

The competent person will:

- Inspect the soil being removed from the excavation.
- Verify that the original soil type determination was correct.
- Check for crack-line openings (fissures).
- Look for existing utilities that indicate the soil had been previously disturbed.
- Look at the open side of the excavation for layered soil types.
- Look for signs of bulging, boiling, or sluffing.
- Check the spoil distance from the edge of the excavation.
- Inspect heavy equipment distance.
- Look for signs or effects of vibration.
- Observe traffic control.
- Check barricade (fall protection) positioning.
- Inspect access and egress from the excavation.

Calculating Trench Slope Size

Sloping as a method to prevent excavation cave-ins requires a ratio of slope width to trench depth using shallower slopes for less stable soil types, according to a strict set of engineering tables.

Slope Horizontal to Vertical Distance Ratios for Excavations ≤20 Feet Deep		
Soil Type	**Slope Width : Trench Depth**	**Angle of Slope**
Stable rock	No slope required	90°
A	0.75 : 1	53°
B	1 : 1	45°
C	1.5 : 1	35°

Table 8.1

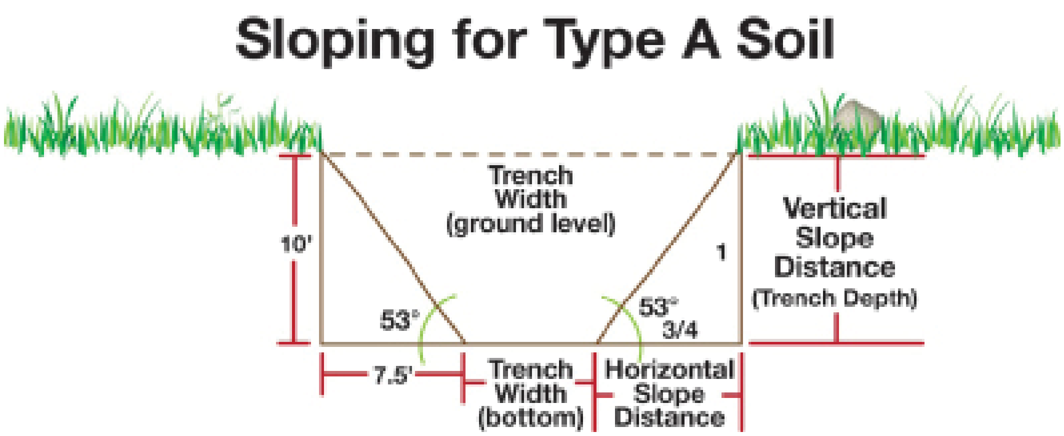


Figure 8.13

Type A soil: For the most stable type A soil, the allowable ratio of slope horizontal distance to vertical distance (trench depth) for an excavation no greater than 20 feet is ¾:1 (or 0.75:1) with a maximum slope angle of 53 degrees.

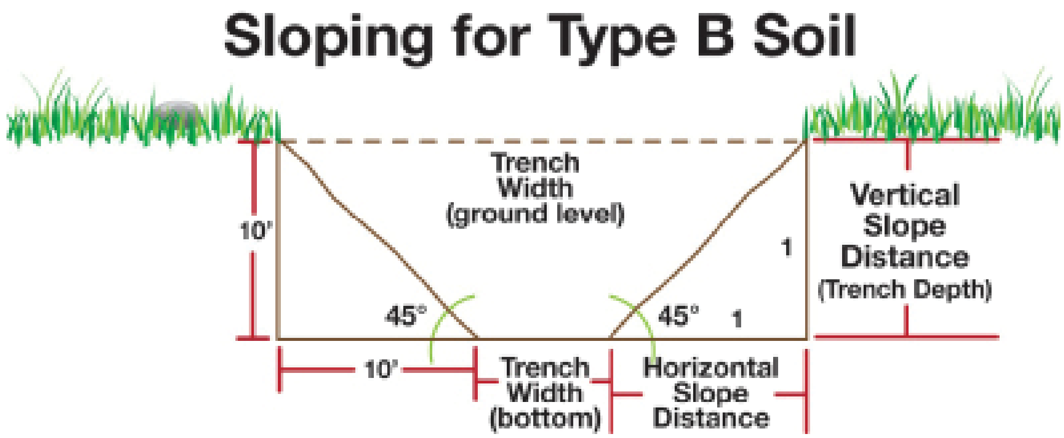


Figure 8.14

Type B Soil: For type B soil the allowable ratio of slope horizontal distance to vertical distance (trench depth) for an excavation no greater than 20 feet is 1:1 with a maximum slope angle of 45 degrees.

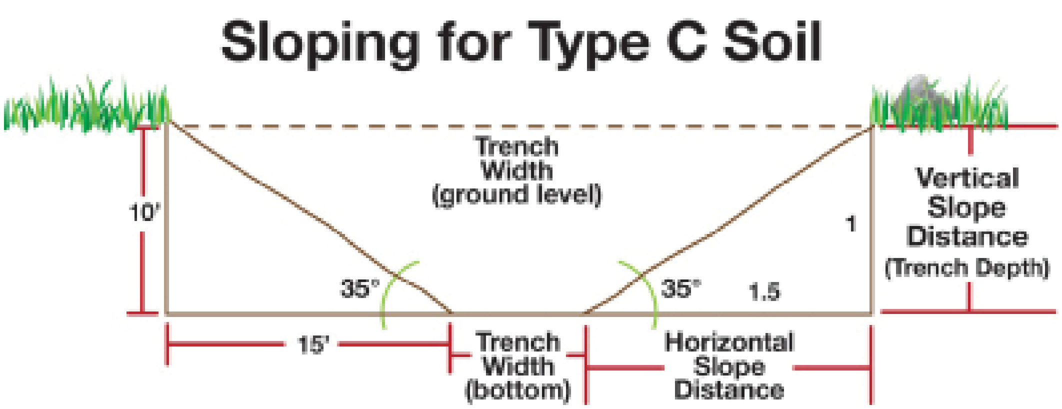


Figure 8.15

Type C Soil: For the least stable type C soil the allowable ratio of slope width to trench depth for an excavation no greater than 20 feet deep is 1½ : 1 (or 1.5 : 1) with a maximum slope angle of 35 degrees.

Sample Calculations

A. Calculate the horizontal distance of a slope of an 8-foot wide trench (at the bottom) that is 16 feet deep in type A soil.

From the table above, the Type A soil slope ratio of horizontal distance to vertical distance is 0.75:1. Start by setting up this ratio as a fraction, with the horizontal slope distance over the vertical slope distance (0.75 over 1). Set this equal to your actual but unknown D horizontal slope distance over the given trench depth:

$$\frac{0.75}{1} = \frac{D}{16 \text{ ft}}$$

Cross-multiply each numerator (the upper number in a fraction) by the opposite denominator (the number under the division line) to solve for X, the width of the trench slope:

$$\frac{0.75}{1} = \frac{D}{16\text{ft}} \qquad (1 \times D) = (0.75 \times 16 \text{ ft})$$

The answer is D = 12 ft

B. Calculate the total trench width (at ground level) for the above example.

The trench width at ground level consists of the trench width at the bottom plus the left and right horizontal slope distances.

Total trench width (at ground level) = 8 ft. trench width at the bottom + 12 ft. left horizontal slope distance and 12 ft. right horizontal slope distance = 30 ft.

Sloping Calculations—Your Turn

1. In a trench with type A soil, which is 5 ft. wide at the bottom and 4 ft. deep, calculate the horizontal slope distance and the total trench width (at ground level).

2. In a trench with type A soil, which is 5 ft. wide at the bottom and 12 ft. deep, calculate the horizontal slope distance and the total trench width (at ground level).

3. In a trench with type B soil, which is 6 ft. wide at the bottom and 15 ft. deep, calculate the horizontal slope distance and the total trench width (at ground level).

4. In a trench with type C soil, which is 15 ft. wide at the bottom and 20 ft. deep calculate the horizontal slope distance and the total trench width (at ground level).

Common Citations

Here are some common citations that OSHA inspectors issue regarding excavation:

- Not sloping to the proper angle. If sloping is chosen as the method of cave-in protection, the employer must follow the charts in the OSHA standards or have tabulated data by an engineer.
- No competent person on site. OSHA requires a competent person to be on site to observe changing conditions and take corrective action as necessary. The competent person must know how to perform manual and visual tests as well as classify soil. Failure to meet these basic requirements has resulted in many citations being issued.
- Allowing water in trenches. Water is a hazard to soil because it weakens the soil layer and causes undercutting of the trench walls. Water must be pumped out as it occurs, and the protection must be for type C soil.
- Unacceptable means of egress from the trench. Most citations occur when workers must crawl out the end of the trench. Ladders should be used if you are exposed to a hazard when exiting from a trench box.
- Storage of material at the edge of the excavation. Surface encumbrances must be protected from rolling at the edge. Materials commonly cited are pipe, wood, and cylinders.

Group Discussion Activity

Materials: Assignment card, chart paper, markers

Group 1
You are required to dig a trench 5 feet deep and 50 feet long in type C soil. Describe what you need to know and do before you begin.

Group 2
You are required to dig a trench 10 feet deep and 25 feet long in type B soil. Describe what you need to know and do before you begin.

Group 3
You are required to dig a trench 20 feet deep and 30 feet long in stable rock. Describe what you need to know and do before you begin.

Group 4
You are required to dig a trench 10 feet deep and 75 feet long in type C soil. It is raining. Describe what you need to know and do before you begin.

Group 5
You are required to dig a trench 12 feet deep and 100 feet long in type C soil over type A soil. Describe what you need to know and do before you begin.

Glossary

benching—a method of protecting workers from cave-ins by digging the sides of an excavation to form one or a series of horizontal levels or steps, usually with vertical or near-vertical surfaces between levels. Benching is used only in type A or B soil.

cave-in—the separation of a mass of soil or rock material from the side of an excavation, or the loss of soil from under a trench shield or support system, and its sudden movement into the excavation, either by falling or sliding, in sufficient quantity so that it can entrap, bury, or otherwise injure and immobilize a person.

competent person—one who is capable of identifying existing and predictable hazards in the surroundings, or working conditions that are unsanitary, hazardous, or dangerous to workers, and who has authorization to take prompt corrective measures to eliminate them. A competent person can identity soil types and determine required slopes for excavations.

cross braces—the horizontal members of a shoring system installed perpendicular to the sides of the excavation, the ends of which bear against either uprights or wales.

excavation—any manmade cut, cavity, trench, or depression in an earth surface, formed by earth removal.

faces/sides—the vertical or inclined earth surfaces formed as a result of excavation work.

failure—The breakage, displacement, or permanent deformation of a structural member or connection to reduce its structural integrity and its supportive capabilities.

fissured soil—a soil material that has a tendency to break along definite planes of fracture with little resistance, or a material that exhibits open cracks, such as tension cracks, in an exposed surface.

hazardous atmosphere—an atmosphere, which by being explosive, flammable, poisonous, corrosive, oxidizing, irritating, oxygen-deficient, toxic, or otherwise harmful, may cause death, illness, or injury.

kick-out—the accidental release or failure of a cross brace.

protective system—a method of protecting workers from cave-ins, from materials that could fall or roll from an excavation face or into an excavation, or from the collapse of adjacent structures. Protective systems include support systems, sloping and benching systems, shield systems, and other systems that provide the necessary protection.

ramp—an inclined walking or working surface that is used to gain access to one point from another and is constructed from earth or from structural materials such as steel or wood.

registered professional engineer—a person who is registered as a professional engineer in the state where the work is to be performed. However, a professional engineer, registered in any state is deemed to be a registered professional engineer within the meaning of this standard when approving designs for "manufactured protective systems" or "tabulated data" to be used in interstate commerce.

sheeting—the members of a shoring system that retain the earth in position and in turn are supported by other members of the shoring system.

shield—a structure that is able to withstand the forces imposed on it by a cave-in and thereby protect workers within the structure. Shields can be permanent structures or can be designed to be portable and moved along as work progresses. Additionally, shields can be either pre-manufactured or job-built. Shields used in trenches are usually referred to as "trench boxes" or "trench shields."

shoring—a structure such as a metal hydraulic, mechanical, or timber shoring system that supports the sides of an excavation and that is designed to prevent cave-ins. A shoring system may include sheeting, wales, uprights, and cross braces.

sloping—a method of protecting workers from cave-ins by digging to form sides of an excavation that are inclined away from the excavation. The angle of incline required to prevent a cave-in varies with differences in such factors as the soil type, environmental conditions of exposure, and application of surcharge loads.

stable rock—natural solid mineral material that can be excavated with vertical sides and will remain intact while exposed. Unstable rock is considered to be stable when the rock material on the side or sides of the excavation is secured against caving in or movement by rock bolts or by another protective system that has been designed by a registered professional engineer.

structural ramp—a ramp built of steel or wood, usually used for vehicle access. Ramps made of soil or rock are not considered structural ramps.

support system—a structure such as underpinning, bracing, or shoring that provides support to an adjacent structure, underground installation, or the sides of an excavation.

surface encumbrance—anything located to create a hazard to workers, including cables, pipe, wood, cylinders, and electric boxes.

Tabulated data—tables and charts approved by a registered professional engineer and used to design and construct a protective system.

trench—A narrow excavation (in relation to its length) made below the surface of the ground. In general, the depth is greater than the width, but the width of a trench (measured at the bottom) is not greater than 15 feet. If forms or other structures are installed or constructed in an excavation to reduce the dimension measured from the forms or structure to the side of the excavation to 15 feet or less (measured at the bottom of the excavation), the excavation is also considered to be a trench.

Unconfined compressive strength—the load per unit area at which a soil will fail in compression. It can be determined by laboratory testing or estimated in the field using a pocket penetrometer or other methods (plasticity, dry strength, thumb penetration, hand-operated shearvane)

uprights—vertical members of a shoring system.

wales—horizontal members of a shoring system, also known as rangers or stringers. These are installed parallel to side of the excavation face.

Review Questions

1. When a trench has been rained into, the soil is automatically rated as soil type:

a. A
b. B
c. C
d. D

c. C—Wet soil is automatically rated type C. Wetting soil reduces its stability.

2. Which of the following may contribute to an excavation cave-in?

a. Supercharged loads
b. Vibrations
c. Water
d. All of the above

d. All of the above

3. For excavations less than or equal to 20 feet in depth, the correct ratio of slope width to trench depth for type A soil is:

a. 1 ½ : 1
b. 1 : 1
c. ¾ : 1
d. ½ : 1

c: ¾ : 1

4. The correct ratio of slope length to trench depth for type C soil is:

a. 1 ½ : 1
b. 1 : 1
c. ¾ : 1
d. ½ : 1

a: 1 ½ : 1

5. The most common cause of death to workers during an excavation is:

a. Shield systems collapsing
b. Suffocation caused by cave-ins
c. Trenches flooding due to rain
d. Occupied vehicles overturning

b. Suffocation caused by cave-ins

6. A structure such as a metal hydraulic, mechanical ,or timber system that supports the sides of an excavation and which is designed to prevent cave-ins.

a. Benching
b. Sheeting
c. Shielding
d. Shoring

d. Shoring

7. The minimum distance between ladders in a trench that is 6 feet deep and 50 yards long:

a. 25 yards
b. 10 yards
c. 25 feet
d. 10 feet

c. 25 feet

8. Vehicles and soil piles must be at least what distance from a trench edge?

a. 1 foot
b. 2 feet
c. 3 feet
d. 5 feet

b. 2 feet

9. How often do trenches need to be inspected by a competent person?

a. Every two hours
b. Every eight hours
c. Once a shift
d. Daily and every time conditions change (e.g., rain, freezing, vibrations)

d. Daily and every time conditions change

10. Shield systems must project at least what height above the beginning of a trench slope?

a. 36 inches
b. 24 inches
c. 18 inches
d. 10 inches

c. 18 inches

Other Resources

IUOE National Training Fund National HAZMAT Program. *(2007). Construction Industry Outreach.* Publication no. M-18-2007.

IUOE National Training Fund National HAZMAT Program. *(2007). Excavation and Trenching Safety Training Manual.* Publication no. M-57-2007

Laborers-AGC Education and Training Fund. (2003). *OSHA Construction Safety and Health.*

OSHA Standard – Subpart P, Excavations
http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10930

OSHA eTool – Trenching and Excavation
http://www.osha.gov/SLTC/etools/construction/trenching/mainpage.html

OSHA Fact Sheet – Trenching and Excavation Safety
http://www.osha.gov/Publications/trench_excavation_fs.html

Trench Safety Tutorial
http://www.trenchsafety.org/

Instructor Lesson Plan

Fire Protection and Prevention

OSHA: 29 CFR 1926 Subpart F

Key Concepts

- EO1 Explain the hazards associated with fire protection and prevention.
- EO2 Describe the requirements for fire protection and prevention.

Presentation and Materials

- Allow 60 minutes to present this chapter.
- Use Fire Protection and Prevention PowerPoint slides.
- Use 30-Hour Construction Outreach course manual.

Module 9

Fire Protection and Prevention

29 CFR 1926 Subpart F

Lesson Outline

Fire Protection and Prevention
Fire Protection - Subpart F
Fire Classifications

Fire Protection- 1926.150
General Requirements:
Water Supply
Portable Firefighting Equipment:
Fixed Firefighting Equipment
Fire Alarm Devices
Fire Cutoffs
Ignition Hazards
Temporary Buildings
Open Yard Storage
Indoor Storage

Flammable and Combustible Liquids 1926.152
General Requirements
Inside Storage Rooms
Storage Outside Buildings
Fire Control
Dispensing Liquids
Service and Refueling Areas
Tank Design and Storage

Liquefied Petroleum Gas (LP Gas)1926.153
General Requirements
Containers

Liquefied Petroleum Gas (LP Gas)1926.154 Storage of Containers

Temporary Heating Devices - 1926.154

Additional Sections

Overview

Upon the successful completion of this module, participants will be able to recognize fire hazards and explain related requirements using the key parts of 29 CFR 1926 Subpart F and present or critique a presentation on fire protection and prevention suitable for an OSHA 30-hour course

Objectives

After completing this chapter, you should be able to:

Know

- EO1 Explain the hazards associated with fire protection and prevention.
- EO2 Describe the requirements for fire protection and prevention.

Fire Protection and Prevention

Fire Protection - Subpart F

Fire Protection	1926.150
Fire Prevention	1926.151
Flammable/Combustible Liquids	1926.152
Liquefied Petroleum Gas (LP-Gas)	1926.153
Temporary Heating Devices	1926.154
Definitions	1926.155
Fixed Extinguishing Systems	1926.156,157
Fire Detection Systems	1926.158
Employee Alarm Systems	1926.159

Fire Classifications

- Class A = Combustibles - wood, paper, trash
- Class B = Flammable liquids - gas, oil, paints
- Class C = Electrical
- Class D = Metals

Fire Protection- 1926.150

General Requirements:

- Employer shall develop fire protection program to be carried out in all phases of construction
- Employer shall provide necessary equipment.
- Access to equipment maintained at all times.
- Equipment conspicuously located.
- Periodically inspected and maintained.
- If project warrants - may need a trained fire brigade to assure protection to life.

Water Supply

- Adequate supply to operate firefighting equipment available as soon as combustibles accumulate.
- Underground mains available for use ASAP.

Portable Firefighting Equipment:

- At least 2A extinguisher every 3000 sq ft of building area
- No more than 100 feet of travel to nearest extinguisher
- 55 gal drum and 2 pails or 1/2 inch garden hose instead
- At least one 2A F.E. on each floor, one adjacent to stairs
- 10B F.E. within 50 ft of 5 gallons or more of flammable or combustible liquids
- Employee training initially and at least annually
- F.E. fully charged, maintained, and inspected annually
- During demolition, charged hose lines, water tanker or equivalent shall be available

Fixed Firefighting Equipment

- Automatic sprinklers installed ASAP on each floor
- During demolition, sprinklers retained in service
- Standpipes brought up ASAP and available for service

Fire Alarm Devices

- An alarm, telephone, or siren system installed to alert employees and local fire department of emergencies
- Alarm codes and reporting instructions posted at phones and employee entrances

Fire Cutoffs

- Fire walls and exit stairways given construction priority
- Fire doors hung as soon as possible

Ignition Hazards

- Electrical installed in compliance with Subpart K.
- Exhausts on engine-powered equipment well away from combustible materials.
- If piped outside building under construction, 6 inches maintained between piping and combustible material.
- Smoking prohibited and posted where fire hazards exist.
- Portable battery powered equipment used near flammable gases or vapors approved for hazardous location.
- Nozzles used in cleaning or venting of tanks and vessels containing flammable air concentrations must be bonded to the tank or vessel.

Temporary Buildings

- Not erected where it will adversely affect means of exit.
- If located within another bldg, shall be of noncombustible construction or have a fire resistance of not less than 1 hr.
- Temporary bldgs not used to store flammables, explosives, blasting agents, etc shall be at least 10 feet from other buildings or structures.

Open Yard Storage

- Combustible materials piled no higher than 20 feet.
- Driveways between piles at least 15 feet wide.
- Kept free of accumulation of combustibles.
- Solid piles whenever possible. 10 ft from buildings.
- 2A extinguishers in place. No more than 100 ft of travel.

Indoor Storage

- Storage shall not obstruct means of exit.
- Noncompatible materials segregated by 1 hour barrier.
- Aisle space maintained to accommodate widest vehicle which may be used in building for firefighting.
- Clearance of 36 inches maintained between top level of material and sprinkler deflectors.
- Clearance maintained around lights and heating units.
- Clearance of 24 inches around path of travel of fire doors, unless a barricade is provided.
- Material shall not be stored within 36 inches of a fire door opening.

Flammable and Combustible Liquids 1926.152

General Requirements

- Only approved containers for storage and handling.
- Not stored in areas used for exits or stairways.
- No more than 25 G outside approved storage cabinet.
- No more than 60 G of flammable liquids in one cabinet.
- No more than 120 G of combustible liquids in one cabinet

Inside Storage Rooms

- Proper fire resistive rating.
- Electrical designed for Class I Division I Hazardous location
- Exhaust system changes air 6 times per hour.
- Containers over 30 G not stacked.
- Quantity for spraying operations not exceed 1-day supply.

Storage Outside Buildings

- Storage shall not exceed 1100 G in one pile or area.
- Piles separated by 5’ and kept 20’ from buildings.
- 12 ft wide access way within 200’ for fire control apparatus.
- Area graded away from building or supplied with 12” dike
- Portable tanks no closer than 20’ to buildings
- Kept free of debris and weeds

Fire Control

- 20-B F.E. located outside door and within 10 feet of rooms holding 60 gallons or more.
- 20-B F.E. between 25-75 feet from outside storage area.
- 20-B:C F.E. on all tank trucks or other transport vehicles.

Dispensing Liquids

- Transfer area separated from other operations by 25 ft or 1 hour rated fire division.
- Transfer containers electrically bonded.
- Transfer through closed piping, from safety cans by device drawing through the top, or by gravity or pumps. Transfer by air pressure on tank not allowed.
- Units protected from collision damage.
- Liquids in closed containers when not in use.
- Used only where no ignition sources are within 50 feet.

Service and Refueling Areas

- Approved containers, hoses and fittings.
- Automatic-closing dispensing nozzle without latch-open device.
- Clearly identified and accessible remote shut-off switches.
- No smoking or open flames in the area.
- Area posted with no smoking signs.
- Motors of all equipment shut off before fueling.
- One 20-B:C F.E. within 75 feet of each pump, dispenser, fill pipe, and lubricating and service area.

Tank Design and Storage

- Multiple requirements for equipment, safety devices, construction, and location of above and below ground tanks.

Liquefied Petroleum Gas (LP Gas)1926.153

General Requirements

- Welding is prohibited on containers.
- Valves, fittings, accessories connected to container must have rated working pressure of at least 250 psig.
- Connections should have shut-off valves as close as possible to the container.
- At least 1 or more safety relief valve.
- Shutoff valves not installed between safety valve and container.
- Dispensing into fuel containers on trucks or vehicles from bulk storage not performed less than 25' from buildings.
- Dispensing into portable containers not less than 50' from buildings.

Containers

- Containers stored outside should be upright on firm foundations and secured.
- Containers used indoors only when infeasible to use outside.
- Systems with water capacity greater than 2.5 lbs require excess flow valves.
- Regulators directly connected to container valves or manifolds.
- Valves protected from damage while in use or storage.
- Aluminum piping and tubing not used.
- Portable heaters equipped with automatic flow shutoff in the event of flame failure.
- Temporary heaters at least 6 ft from LP-Gas containers.

Liquefied Petroleum Gas (LP Gas)1926.154

Storage of Containers

- Storage of LPG within buildings is prohibited.
- Requires one 20-B:C fire extinguisher
- Outside Storage away from buildings.

Quantity	Distance
500 lbs or less	0
501 to 6,000 lbs	10
6,002 to 10,000 lbs	20
Over 10,000 lbs	25

Table 9.1

Temporary Heating Devices - 1926.154

- Ventilation provided to ensure health of workers.
- Use in confined spaces requires ventilation to ensure combustion and limit temperature rise.
- Clearance to combustible materials.
- Heaters not suitable for resting on wood supplied with insulating materials if required.
- Located at least 10 ft from combustible tarps or coverings.
- Set horizontally when in use unless allowed by manufacturer.
- Solid fuel salamanders prohibited in buildings and on scaffold.
- Flammable liquid fired heaters equipped with safety fuel shutoff in the event of flame failure.
- Heaters designed for gravity oil feed used only with integral tanks.

Additional Sections

- Definitions: 1926.155
- Fixed Extinguishing Systems – General: 1926.156
- Fixed Extinguishing Systems – Gaseous: 1926.157
- Fire Detection Systems: 1926.158
- Employee Alarm Systems: 1926.159

Instructor Lesson Plan

Materials Handling, Storage, Use, and Disposal

LESSON PLAN – CIO 245-345

Key Concepts

- Safety precautions for working with cranes, forklifts, and slings.
- Safety precautions for stored or stacked materials.
- Lifting heavy items.
- Training requirements for operators of powered industrial trucks.

Presentation and Materials

- Allow 30 minutes to present this chapter.
- Use Materials Handling, Storage, Use, and Disposal PowerPoint® slides.
- Try the Group Discussion Activity at the end of the chapter.
- Use Review Questions at the end of the chapter to facilitate discussion.
- Use 30-Hour Construction Outreach course manual.

Standards

Safety and Health Regulations for Construction

- 29 CFR 1926 Subpart H—Materials Handling, Storage, Use, and Disposal

Module 10

Materials Handling, Storage, Use, and Disposal

OSHA: 29 CFR 1926 Subpart H – CIO 245-345

Lesson Outline

Materials Handling Hazards
Precautions for Moving Materials Manually
Precautions for Moving Materials Mechanically
Avoiding Storage Hazards
Precautions for Stacking Materials

Safety Measures for Operating Mechanical Equipment Working with Materials
Conveyors
Cranes
Slings
Chains
Forklifts
Powered Industrial Trucks
Training Requirements for Operating Vehicles

Ergonomics

Disposal of Waste Material

Common Citations

Group Discussion Activity

Glossary

Review Questions

Other Resources

Overview

The handling, storing, use, and disposal of the many types of materials used at construction, business, and manufacturing sites is essential to industry. The constant flow of materials also presents a significant safety issue. Numerous injuries result every year from the improper handling of materials. Knowing the proper way to move materials, whether you are moving them manually or mechanically, can drastically reduce your risk of being injured. In this chapter you will learn the safest ways to move materials.

Objectives

After completing this chapter, you should be able to:

Know

- State safety precautions for working with cranes, forklifts, and slings.
- Describe how to manually lift heavy items safely.
- List the training requirements for operators of powered industrial trucks.

Apply

- Identify important safety practices that help you avoid injuries from stored or stacked materials on the job site.

Analyze

- Identify examples of safe or unsafe work site practices shown in the photos provided.

Materials Handling Hazards

Handling construction materials presents many hazards in the workplace. The size, weight, and shape of the materials are major factors to consider when you want to move or store materials safely. Preventing back injuries caused by improper lifting, carrying, holding, and lowering while manually moving materials is a major workplace safety challenge. Mechanical handling of materials presents other safety issues that are just as serious.

Hazards from handling materials include:

- Falling objects.
- Improperly stacked materials,
- Strains and sprains from improperly lifting loads.
- Carrying loads that are too large or too heavy.
- Fractures and bruises from being struck by materials.

Precautions for Moving Materials Manually

When moving materials manually, use the following precautions to avoid workplace injuries:

- Attach handles or holders to loads.
- Always use proper lifting techniques.
- Get help if a load is so bulky that you cannot lift it properly, when you cannot see around it or over it, or when you think you cannot safely handle it.
- Always wear appropriate personal protective equipment: Hand and forearm protection, (such as gloves), eye protection, steel-toed safety shoes or boots, metal, fiber or plastic metatarsal guards to protect the instep area.
- Use blocking materials to manage loads safely.
- Do not use blocking materials that have cracks, splinters, or dry rot.

Figure 10.1 Carry a load by handles or straps.

Figure 10.2 Foot and hand protection are necessities.

Precautions for Moving Materials Mechanically

If you have to use mechanical equipment such as conveyors, cranes, and lifts to handle materials, you can actually increase the potential hazards and chance for injuries. You need to be aware of both manual precautions and the safety procedures for the particular mechanical equipment being used.

Being aware of the following recommendations for safe handling of materials by mechanical means will increase safety in your workplace for you and your coworkers:

- Do not overload the equipment.
- Be aware of the capacities of your equipment; employers must ensure that the capacity is displayed on each piece of equipment and is not exceeded except for load testing.
- Follow the manufacturer's operational recommendations.
- Pile and cross-tier all stacked load correctly.

Avoiding Storage Hazards

Figure 10.3 This storage area is clean and well organized.

Workers should be aware of materials that are stored at a worksite. Employers should make sure that workers know the materials' heights and weights, how accessible they should be to the user, and the condition of any storage containers.

Consider the following recommendations when materials are stored at your worksite:

Figure 10.4 Worker equipped with personal fall arrest system

- Keep storage areas free from materials that cause tripping, fires, or explosions, or that attract rats and other pests.
- Store materials inside buildings under construction at least 6 feet from hoist ways or inside floor openings and 10 feet away from exterior walls.
- Store incompatible materials separately.
- Equip workers with lifelines and safety belts when necessary, as pictured at left.
- Secure bound materials stored on racks by stacking, blocking, or interlocking to prevent sliding, falling, or collapsing.
- Separate flammable liquids from other material by a fire wall.
- Store combustibles where smoking, open flames, or spark-producing devices are prohibited.
- Allow for adequate clearance for aisles and passageways when moving materials at loading docks, through doorways, or wherever turns must be made. This will reduce the possibility of a worker getting pinned between fixtures or loads and will also reduce the chances of the load striking a surface and falling on a worker.

Precautions for Stacking Materials

Stacked materials can be dangerous if not stacked properly and can crush or pin workers, causing injuries or death. To protect yourself and your coworkers from injuries from improper stacking of materials, follow these recommendations:

- Stack lumber no more than 16 feet high if stacked manually, and no more than 20 feet high if using a forklift.
- Remove all nails from used lumber before stacking.
- Stack and level lumber on supported bracing.
- Make sure stacks are stable and self-supporting.
- Do not store pipes and bars in racks that face main aisles to avoid hazards to passersby when you remove materials from the racks.
- Stack bags and bundles in interlocking rows.
- To remove bags from a stack, always start at the top row first.
- Store baled paper and rags inside a building no closer than 18 inches to the walls or sprinkler heads.
- Boxed materials should be banded with cross-ties or shrink plastic fiber.
- Stack drums, barrels, or kegs symmetrically.
- Block the bottom tiers of drums, barrels, or kegs to keep them from rolling, if they are stored on their sides.
- Place planks, sheets of plywood, or pallets between each tier of drums, barrels, or kegs to form a flat stacking surface, as shown at right.
- Chock the bottom tier of drums, barrels, or kegs on each side to prevent shifting when stacking two or more tiers high.
- Stack and block poles, structural steel, bar stock, and other cylindrical materials to prevent spreading if they are not stored in racks.
- Paint walls or posts with stripes to show maximum stacking heights.
- Stack loose bricks no more than seven feet high. When the brick stack is four feet high, taper back two inches for every foot of height above the four-foot level.
- When masonry blocks are stacked higher than six feet, taper the stacks back one-half block for each tier above the six-foot level.

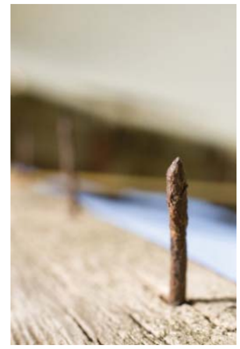


Figure 10.5 Nails are very dangerous.


Figure 10.6 Pallets keep these barrels steady.


Figure 10.7 Improperly stacked bricks.

Case Report
A 34-year old worker was positioning vertical and horizontal rebar for a cap tie beam to be poured the next day. Gusting winds caused a free standing masonry block wall to collapse, fatally injuring him. Bracing and shoring could have prevented the collapse or lessened the impact.

OSHA Construction e-Tool:
http://www.osha.gov/SLTC/etools/construction/struckby/fatexstruck3.html

Safety Measures for Operating Mechanical Equipment Working with Materials

You often use equipment in the handling, storage, use, and disposal of materials. There are safety concerns that are specific to each type of equipment being used. Knowing how to safely operate each piece of equipment is vital to having a safe, injury-free workplace.

Consider the following safety issues for the different types of equipment listed below.

Conveyors

Hazards for workers operating conveyors moving materials include getting their hands caught in the conveyor, getting pulled into the conveyor, and being struck by material falling off the conveyor. These can result in serious injuries. To avoid these injuries, make sure your employer takes the following precautions:

- Install an emergency button or pull cord that stops the conveyor at your work station.
- Emergency stop cables extend the entire length of the conveyor so that the cables can be accessed from any location along the conveyor.
- The emergency stop switch must be reset before the conveyor can be restarted.
- Appropriate personnel inspect the conveyor and clear stoppages before restarting a conveyor that has stopped from an overload.
- People are prohibited from riding on the conveyor.
- Install protective guards where conveyors pass over work areas to prevent workers from being struck by falling material.
- Cover screw conveyors completely (except at loading and unloading points) to protect workers from contacting the moving screw.

Case Report
A contractor was operating a backhoe when an employee attempted to walk between the swinging superstructure of the backhoe and a concrete wall. As the employee approached from the operator's blind side, the superstructure hit the victim, crushing him against the wall. Employees had not been trained in safe work practices, and no barricades had been erected to prevent employee access to a hazardous area.

OSHA Construction e-Tool:
http://www.osha.gov/SLTC/etools/construction/struckby/fatexstruck1.html

Cranes

Only trained and competent workers should operate cranes. Operators should know what material they are lifting, what it weighs, the lift capacity of their crane, and the specifications of the crane. For example, a crane with a telescoping boom may safely lift a load at a short boom length or short boom radius, but may overload if the boom is extended.

Figure 10.8 Cranes require trained operators who are expert in moving loads and operating the crane with worker safety in mind.

Be aware of the following safety concerns for operating cranes:

- All cranes that have adjustable booms should have boom angle indicators.
- Cranes with telescoping booms should have some way of measuring boom length unless the load rating is independent of boom length.
- Load rating charts should be posted in the cab of cab-operated cranes.
- Check the crane's load chart to avoid overloading.
- Plan lifts before starting them.
- Take additional precautions around power lines. Electrocution is the biggest cause of fatalities in crane-related accidents, more so than the more publicized boom failures and crane tipovers. Not only should the crane operator be especially aware of overhead power lines, you should take precautions as well, making certain not to touch a crane that is touching a power line and informing a crane operator when the boom is close to power lines.
- Outriggers on mobile cranes must rest on firm ground, on timbers, or be cribbed to spread the weight of the crane and load over a large enough area.
- Hoisting chains and ropes should be kept free of kinks and never wrapped around a load.
- Attach loads to the load hook by slings or fixtures that can support the load on the hook.
- Pad or cover sharp edges of loads to prevent cutting the slings.
- Maintain proper sling angles so that slings are not overloaded.
- Make sure that cranes are inspected frequently by persons who are thoroughly knowledgeable about all aspects of the crane operation.
- Inspect the critical parts of the crane daily. These include the operating mechanisms, hooks, and air or hydraulic systems.

Case Report

Figure 10.9 Crane contacts power line.

Figure 10.10 46,000 volts travel through the crane.

Figure 10.11 Crane and cab explode in flames.

Figure 10.12 Hydraulic fluid adds to fuel.

Figure 10.13 Concrete slabs are lifted into the air.

Figure 10.14 Roadbed and equipment are engulfed.

OSHA Construction e-Tool:
http://www.osha.gov/SLTC/etools/construction/electrical_incidents/cranefire.html

Case Report
A crew was erecting tilt-up wall panels around the perimeter of the slab floor of a one-story warehouse. The last three wall slabs were being hoisted into place with two 12-foot nylon web slings in a basket hitch. While the second panel was suspended in preparation for being set, it tilted in the sling and slid slightly, cutting through one sling and partially through the other. The erection crew scattered as it dropped, but a worker stopped momentarily to look back as he fled the building. Just then, the upper edge of a previously set panel, which had been dislodged by the falling panel, fell on him. He was crushed and killed.

OSHA Construction e-Tool:
http://www.osha.gov/SLTC/etools/construction/struckby/fatexstruck3.html

Slings

A competent person must inspect slings before and during use for maximum safety. Make sure you follow these recommendations below to prevent injuries to yourself or your coworkers:

- Get rid of damaged slings immediately.
- Do not shorten slings with knots or bolts or any makeshift device.
- Keep suspended loads clear of obstructions.
- Stay clear of loads about to be lifted or suspended.
- Do not shock load.
- Do not kink sling legs.
- Do not overload slings.
- Synthetic slings should show the trademark of the manufacturer and the rated capacities for the hitch type.
- Fittings for synthetic slings should be as strong as the sling and free of sharp edges.
- Use only stitching to attach the end fittings to webbing.
- Remove damaged web slings from service.

Figure 10.15 This damaged sling should not be used.

Figure 10.16 Look for kinks in sling legs.

Figure 10.17 This synthetic sling properly shows the manufacturer's trademark.

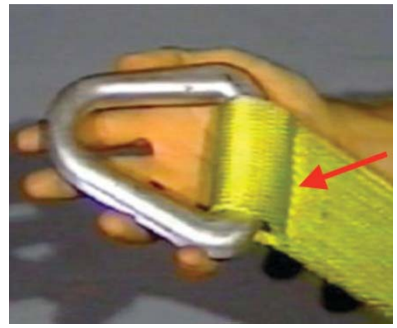


Figure 10.18 Stitching attaches end fittings to the webbing.

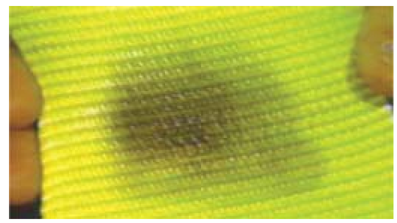


Figure 10.19 This damaged synthetic web sling should be removed from service.

Case Report

Two connectors were erecting lightweight steel I-beams on the third floor of a 12-story building, 54 feet above the ground. One worker removed a choker sling from a beam and then attempted to place the sling onto a lower hook on a series of stringers. While the crawler tower crane was booming away from the steel, the wind moved the stringer into the beam the worker was standing on. The beam moved while the person was trying to disengage the hook, causing him to lose his balance and fall to his death.

OSHA Construction e-Tool:
http://www.osha.gov/SLTC/etools/construction/falls/fatexfalls11.html

Chains

Steel chains are used to lift and move heavy loads and are the best choice for hoisting hot materials. They are also a good choice for most loads because they adapt to the shape of the load. Follow these guidelines when using steel chains and hooks:

- Chains must have a fixed tag stating the size, grade, rated capacity and sling manufacturer.
- Do not use makeshift attachments on chains or hooks.
- Hooks, rings, or links must have a rating at least equal to the chain's rating.
- Remove damaged chains from service.
- Keep ropes and chains lubricated.

Figure 10.20 Look for a tag stating the size, grade, and capacity of a chain.

Figure 10.21 Makeshift attachments such as on these hooks are not safe.

Figure 10.22 Some hooks and rings you might use.

Forklifts

Forklifts are often used at construction sites to quickly lift and move heavy loads. Practicing good safety techniques can make the work go faster and reduce the risk of accidents. Consider the following safety precautions when operating forklifts:

- Center the load on the forklift as close to the mast as possible. This minimizes the risk of the truck's tipping or the load's falling.
- Do not overload the lift truck to avoid tipping the truck or reducing control of the truck.
- Move slowly to avoid accidents if you have to stop quickly.
- Do not take on riders unless there is an approved seat.
- Wear safety belts.
- Do not place extra weight on the rear of a forklift to allow for an overload.
- Adjust the load to a lower position when moving.

Figure 10.23 Forklifts are a common site in material handling.

Figure 10.24 Center the load on the forklift as closely as possible to the mast. For an awkward load such as this rock, move slowly.

Case Report
A 17-year-old male warehouse laborer was fatally injured when the forklift he was operating tipped over and crushed him. He had apparently lost control of the forklift which had a load on its forks and the mast fully extended as he was making a right turn, causing the forklift to tip over 90 degrees onto its left side. The unrestrained victim was crushed under the extended boom/mast of the forklift. Fire department personnel and police officers responding to the 911 call and company workers used two forklifts to lift the forklift off the victim.

Source: NIOSH

Powered Industrial Trucks

Follow the operational and safety requirements on all powered trucks, platform lift trucks, motorized hand trucks, and other specialized industrial trucks powered by electricity or internal combustion engines. These requirements should be listed with each type of truck. Here are some requirements and safety precautions:

- Industrial trucks (except those for earth moving or over-the-road hauling) must meet the design and construction requirements described in the American National Standard for Powered Industrial Trucks, Part II, ANSI B56.1-1969.
- Workers or employers are not allowed to make modifications affecting capacity and safe operations of the trucks without written approval from the manufacturer. If changed, decals must display the changes made.
- Do not use powered industrial trucks in atmospheres containing hazardous concentrations of:
    - Acetylene
    - Butadiene
    - Acetaldehyde
    - Cyclopropane
    - Ethylene
    - Isoprene
    - Hydrogen
    - Ethylene oxide
    - Propylene oxide
    - Diethyl ether
    - Unsymmetrical dimethyl hydrazine
    - Hazardous metal dust
- EX industrial powered trucks must be used in work areas with atmospheres containing carbon black, coal, or coke dust.
- Powered industrial trucks used in atmospheres having flammable vapors or dusts must be equipped with safeguards for their exhaust and fuel systems, must not have electrical systems, must have temperature limitation features, and must have the electric motors completely enclosed. These trucks are designated as DS, DY, ES, EE, EX, GS, or LPS.
- Confine any flammable liquids or gases within closed containers or closed systems.
- Put vertical load backrest extensions on fork trucks if the load presents a hazard.
- Locate battery-charging installations in designated areas.
- Make sure you can flush and neutralize spilled materials when changing or recharging batteries to prevent fires and to protect the charging apparatus from being damaged.
- Use provided equipment for handling batteries.
- Use auxiliary lighting on the truck where general lighting is less than two lumens per square foot.
- Do not place your arms or legs between the uprights of the mast or outside the running lines of the truck.

- Set brakes and use other protection provided to prevent movement of trucks, trailers, or railroad cars when using powered industrial trucks to load or unload materials.
- Make sure there is sufficient headroom under overhead installations, lights, pipes, and sprinkler systems.
- Make sure you can shut off power to a truck when working on a loading platform.
- Make sure that dockboards are secured so that they will not move when equipment or materials move over them.
- Disconnect batteries before repairing electrical systems on trucks.
- Make sure replacement parts used on trucks are equivalent to the original parts.

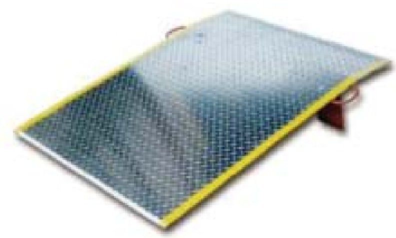


Figure 10.25 Anchor dockboards so they don't move.

Case Report
A worker was driving a front-end loader up a dirt ramp onto a lowboy trailer. The tractor was not centered, and the tread slipped off the trailer. When the tractor began to tip, the operator jumped from the cab. As he hit the ground, the tractor's rollover protective structure fell on top of him, crushing him. The tractor was not equipped with seatbelts.

OSHA Construction e-Tool:
http://www.osha.gov/SLTC/etools/construction/struckby/fatexstruck1.html

Training Requirements for Operating Vehicles

Employers must have training programs specifically designed for the type of truck or work vehicle to be driven on their job sites. Employers must also evaluate the operator's performance and certify that each operator has received training. Operator performance must be evaluated every three years. Evaluations must also occur after observed unsafe practices, accidents, or assignment to a different vehicle type.

Case Report
A worker was operating a bulldozer at the top edge of a sloped drainage ditch. The bulldozer slid down the side of the snow- and ice-covered excavation, tipped over on its side, and pinned the worker under the roll bars. The driver was not wearing a seatbelt.

OSHA Construction e-Tool:
http://www.osha.gov/SLTC/etools/construction/struckby/fatexstruck1.html

Ergonomics

Ergonomics is the study of designing workplaces to meet the needs of the workers. Basically, ergonomics says that the job should be adapted to fit the worker rather than forcing the worker to fit the job. Ergonomics focuses on features of the work environment (design and function), items (work station, controls, displays, safety devices, tools), and movements by workers while doing their jobs.

For materials handling and storing a good ergonomics plan might include reducing the size or weight of a load, installing a mechanical lift, or changing the height of a load.

Another important issue for reducing injuries on the job is training for correct ways to lift and move loads. Proper lifting techniques can greatly reduce back injuries. Follow these tips:

- Plan ahead before lifting. Make sure you know how heavy the load is so you can plan for help, slings, or mechanical lifting devices as needed.
- Lift close to your body.
- Keep feet shoulder width apart.
- Bend your knees and keep your back straight.
- Tighten your stomach muscles.
- Lift with your legs.
- Wear a belt or back support.
- Don’t twist or bend.

Disposal of Waste Material

Safe disposal of materials requires that particular rules be followed. Accidents could easily occur if materials for disposal were not kept in separate disposal facilities. Follow these recommendations on a construction site:

- Use an enclosed chute when dropping material more than 20 feet outside a building.
- Drop material through holes in the floor without chutes and enclose the drop area with barricades.
- Remove scrap and waste material as quickly as possible as work progresses.
- Keep solvent waste, oily rags, and flammable liquids in fire-resistant covered containers until they can be removed from the work site.
- When disposing of demolition materials through floor openings, the openings must be less than 25 percent of the entire floor area.
- Shore up floors weakened by demolition work.

Figure 10.26 An enclosed chute removes waste materials.

Figure 10.27 Remove waste materials as soon as possible when doing demolition work.

Common Citations

Here are some common citations that OSHA inspectors issue regarding material handling and cranes:

- Storage material within 10 feet of the exterior. There have been cases where material, such as plywood sheeting, was picked up by the wind, hitting a worker or pedestrian below. Guardrails may not be an adequate replacement for full meshing to the top of some stored material.
- No chute for disposal of material above 20 feet. Many workers have slipped off of roofs while throwing material off the edge. Fall protection should be provided above six feet.

- No competent person inspecting rope slings. One of the main problems for this citation involves the use of wire rope to lift heavy objects such as I-beams. The beam's sharp corners crush the inner wires of the sling and permanently stretch and deform the outer wires causing a kink. It is not unusual to find a steel erector with 100 percent of the slings kinked and unusable for lifting.
- No proof testing for custom-made lifting devices. Citations result if a company makes its own lifting devices such as spreader bars. Standards require a proof testing of 125 percent of the rated load.
- Defective alloy steel chains slings. Some of the deficiencies found include no tags, diameter worn too much, and non-alloy steel chain used for lifting.
- No annual crane inspection records. Records are necessary to track repairs and maintenance on cranes. They must be available to OSHA, although it is not required they be located in the crane.
- No competent person inspecting the cranes. A competent person must know the requirements of the OSHA regulations, ANSI standards, and the manufacturer's instructions. Most citations under this category are issued for not inspecting parts of the crane according to requirements.
- An operator cannot read load charts. A problem with many new cranes is they have many load rating charts. Without prior training in reading them, most operators find it difficult to know the exact crane capacity at a certain lifting angle.
- The competent person supervising the lift does not know crane capacity, rigging capacity, or weight of the load. If all three aspects of a load are not known, a lift should never be performed. If the load is unknown, a load indicator or scale should be used to obtain an actual reading.
- A crane is working next to power lines. Contacting power lines is the leading cause of all fatalities involving cranes. The 10-foot safe distance is for voltages under 50,000 volts. For lines carrying over 50,000 volts, increase the distance as necessary. De-energizing the line is the first choice if possible. If it cannot be de-energized, insulate the line and ensure a safe distance.

Group Discussion Activity

As a group, look at the following images and answer the question for each. Most photos or illustrations ask the question, “What is wrong with this picture?” (There could be more than one unsafe practice shown in the picture.) Use the images for discussion of violations, unsafe practices, recommendations, and examples of safe practices too.

1. What is wrong with this picture?

2. What safety practice do you see in this picture?

3. What proper technique for using a forklift to move a load do you see in this picture?

4. What proper technique for using a forklift to move a load do you see being used in this picture?

5. What proper technique for using a forklift to move a load do you see being used in this picture?

6. What is wrong with this picture?

7. What is wrong with this picture?

8. What safety rules were ignored in this job?

9. What is wrong with this picture?

10. What is improper about this lifting technique?

11. What is wrong with this picture?

12. What is wrong with this picture?

13. What is wrong with this picture?
http://www.craneaccidents.com/dummy/stupid.htm

Photo courtesy of www.craneaccidents.com.

Glossary

ANSI—the American National Standards Institute, a private, nonprofit membership organization representing more than 1,000 public and private organizations, businesses, and government agencies. It develops technical, political, and policy consensus among various groups.

boom—a long, straight beam hinged at one end and used for lifting heavy objects by means of cables and/or hydraulics.

boom radius—the horizontal distance from the axis of rotation of a crane or derrick boom to the boom tip; the area in which the boom can rotate.

bracing—a diagonal piece of structural material that serves to strengthen something.

chassis—the frame upon which a vehicle's body is mounted.

competent person—one who can identify health and safety hazards in the workplace and has the authority to correct them.

crib—to line or support with a framework of timber.

cumulative trauma disorders—injuries that result from continuous or repetitive motions over prolonged periods of time.

EX industrial powered truck—an electrically powered industrial truck designed with electrical fittings and equipment that allow it to be used safely in certain atmospheres containing flammable vapors or dusts.

outrigger—a projecting member that extends from the main structure to provide additional stability or support.

powered industrial trucks—forklift trucks, tractors, platform lift trucks, motorized hand trucks, and other specialized industrialized trucks powered by electrical or internal combustion engines.

rigger—a worker who prepares heavy equipment or loads of material for lifting.

Review Questions

1. State four recommendations that should be followed when using each type of equipment listed below:

Cranes

- *All cranes that have adjustable booms should have boom angle indicators.*
- *Cranes with telescoping booms should have a way of measuring boom length unless the load rating is independent of boom length.*
- *Load rating charts should be posted in the cab of cab-operated cranes.*
- *Check the crane's load chart to avoid overloading.*
- *Take additional precautions around power lines.*
- *Outriggers on mobile cranes must rest on firm ground, on timbers, or be cribbed to spread the weight of the crane and load over a large enough area.*
- *Hoisting chains and ropes should be kept free of kinks and never wrapped around a load.*
- *Attach loads to the load hook by slings or fixtures that can support the load on the hook.*
- *Pad or cover sharp edges of loads to prevent cutting the slings.*
- *Maintain proper sling angles so that slings are not overloaded.*

Forklifts

- *Center the load on the forklifts as close to the mast as possible. This minimizes the risk of the truck's tipping or the load's falling.*
- *Do not overload the lift truck to avoid tipping the truck or reducing control of the truck.*
- *Move slowly to avoid accidents if you have to stop quickly.*
- *Do not take on riders unless there is an approved seat.*
- *Wear safety belts.*
- *Do not place extra weight on the rear of a forklift to balance an overload being carried in the front.*
- *Adjust the load to the lower position when moving.*

Slings

- *Get rid of damaged slings immediately.*
- *Do not shorten slings with knots or bolts or any makeshift device.*
- *Do not kink sling legs.*
- *Do not overload slings.*
- *Stay clear of loads about to be lifted.*
- *Synthetic slings should show the trademark of manufacturer and the rated capacities for the hitch type.*
- *Fittings for synthetic slings should be as strong as the sling and free of sharp edges.*
- *Use only stitching to attach the end fittings to webbing.*

2. Describe ways to prevent back injuries when lifting a load manually.

- *Plan ahead before lifting. Make sure you know how heavy the load is so you can plan for help, slings, or mechanical lifting devices as needed.*
- *Lift close to your body.*
- *Keep feet shoulder-width apart.*
- *Bend your knees and keep your back straight.*
- *Tighten your stomach muscles.*
- *Lift with your legs.*
- *Wear a belt or back support.*
- *Don't twist when lifting.*

3. What are several rules you should follow to avoid injuries from stored materials?

- *Keep storage areas free of materials that cause tripping, fires, or explosions or that attract rats and other pests.*
- *Store materials inside buildings under construction at least six feet from hoist ways or inside floor openings and 10 feet away from exterior walls.*
- *Store incompatible materials separately.*
- *Equip workers with lifelines and safety belts when necessary.*
- *Secure bound materials stored on racks by stacking, blocking, or interlocking to prevent sliding, falling, or collapsing.*
- *Separate flammable liquids from other material by a fire wall.*
- *Store combustibles where smoking, open flames, or spark-producing devices are prohibited.*
- *Allow for adequate clearance for aisles and passageways when moving materials at loading docks, through doorways, or wherever turns must be made. This will reduce the possibility of a worker getting pinned between fixtures or loads and will also reduce the chances of the load striking a surface and falling on a worker.*

4. What are several rules you should follow to avoid injuries from stacking materials on the job site?

- *Stack lumber no more than 16 feet high if stacked manually and no more than 20 feet high if using a forklift.*
- *Remove all nails from used lumber before stacking.*
- *Stack and level lumber on supported bracing.*
- *Make sure stacks are stable and self-supporting.*
- *Do not store pipes and bars in racks that face main aisles to avoid hazards to passersby when you remove materials from the racks.*
- *Stack bags and bundles in interlocking rows.*
- *Store baled paper and rags inside a building no closer than 18 inches to the walls or sprinkler heads.*
- *Boxed materials should be banded with cross-ties or shrink plastic fiber.*
- *Stack drums, barrels, or kegs symmetrically.*
- *Block the bottom tiers of drums, barrels, or kegs to keep them from rolling, if they are stored on their sides.*
- *Place planks, sheets of plywood, or pallets between each tier of drums, barrels, or kegs to form a flat stacking surface.*
- *Chock the bottom tier of drums, barrels, or kegs on each side to prevent shifting when stacking two or more tiers high.*
- *Stack and block poles, structural steel, bar stock, and other cylindrical materials to prevent spreading if they are not stored in racks.*
- *Paint walls or posts with stripes to show maximum stacking heights.*
- *Stack loose bricks no more than seven feet high. When the brick stack is four feet high, taper back two inches for every foot of height above the four-foot level.*
- *When masonry blocks are stacked higher than six feet high, taper the stacks back one-half block for each tier about the six-foot level.*

5. What are the training requirements of operators of powered industrial trucks?

- *Employers must have training programs designed for the type of truck to be driven by the operator.*
- *Employers must evaluate the operator's performance and certify that each operator has received training.*
- *Operator performance must be evaluated every three years.*
- *Evaluations must also occur after observed unsafe practices, accidents, or assignment to a different truck type.*

6. What do you consider to be the most important safety practice for your job?

Answers will vary.

7. Have you met the training requirements for your job?

Answers will vary.

8. Describe a work experience that was a difficult material handling, storage, or disposal job. (This could have been a difficult job because of the materials being handled, the location of the site, or for other jobsite factors.) Include a description of what you did to work through the task.

Answers will vary.

Other Resources

American National Standards Institute (ANSI)
http://www.ansi.org/

OSHA Compliance Assistance Quick Start – Construction Industry
http://www.osha.gov/dcsp/compliance_assistance/quickstarts/construction/index_construction.html

OSHA – Crane Safety for the Site Superintendent Video
www.thecrcenter.com/archives/category/equipment/

Crane Accidents – ABC video.
www.thecrcenter.com/archives/category/equipment/

Ergonomics Guidelines for Manual Materials Handling
http://www.dir.ca.gov/DOSH/dosh_publications/mmh.pdf

IUOE National Training Fund National HAZMAT Program. (2007). Construction Industry Outreach. Publication no.: M-18-2007.

IUOE Office of Training and Education. Material Handling, Storage, Use and Disposal, MSDS Subpart H PowerPoint presentation.

Laborers-AGC Education and Training Fund. (2003). OSHA Construction Safety and Health

OSHA 2236. (2002 revised). Materials Handling and Storage.

OSHA 3071 – Job Hazard Analysis (2002 revised.)
http://www.osha.gov/Publications/osha3071.pdf

OSHA QUICK CARD – Protect Yourself Crane Safety
http://www.docstoc.com/docs/9679/OSHA-QUICK-CARD-PROTECT-YOURSELF-CRANE-SAFETY

OSHA Worker Safety Series – Construction.
http://www.osha.gov/Publications/OSHA3252/3252.html

OSHA – Crane, Derrick and Hoist Safety
http://www.osha.gov/SLTC/cranehoistsafety/recognition.html

OSHA Video – Back Safety
http://www.osha-safety-training.net/BAC/back.html

OSHA – Selected Construction Regulations for the Home Building Industry
http://www.osha.gov/Publications/scor1926.pdf

Instructor Lesson Plan

Motor Vehicles, ROPS and Signs Signals and Barricades

29 CFR 1926.600-605 Subpart O

Key Concepts

- Subpart O 1926 600-605
- 1926.600 Equipment
- 1926.601 Motor Vehicles
- 1926.602 Material Handling Equipment
- 1926.603 Pile Driving Equipment
- 1926.604 Site Clearing
- (R O P S) 1926.1000 - 1003

Presentation and Materials

- Allow 60 minutes to present this chapter.
- Use Motor Vehicles, ROPS and Signs Signals and Barricades PowerPoint® slides.
- Use 30-Hour Construction Outreach course manual.

Module 11

Motor Vehicles, ROPS and Signs Signals and Barricades

29 CFR 1926.600-605 Subpart O

Lesson Outline

Subpart O 1926 600-605
Most Frequently Cited Violations for Subpart O

1926.600 Equipment
1926.600 Equipment Maintenance

1926.601 Motor Vehicles
1926.601 Motor Vehicle Requirements
Maintenance

1926.602 Material Handling Equipment

1926.603 Pile Driving Equipment
Pile Driving Equipment

1926.604 Site Clearing
Environmental Assessment

(R O P S) 1926.1000 - 1003
Rollover protective structures
Subpart W - ROPS; Overhead Protection

1926.1000 (R O P S)
Compactors and rubber-tired skid-steer
equipment:

(R O P S) 1926.1001
Signs, Signals, and Barricades - Subpart G
Signs
Signals
Barricades

Objectives

After completing this chapter, you should be able to:

Know

- Define Subpart O 1926 600-605

Subpart O 1926 600-605

- 600- Equipment
- 601- Motor Vehicles
- 602- Material Handling Equipment
- Roll Over Protection Systems (Subpart W)
- 603-Pile Driving Equipment
- 604-Site Clearing
- Signs and Barricades (Subpart G)
- 605-Maritime Operations

Most Frequently Cited Violations for Subpart O

- 61 - 602(a)(9)(ii) Earthmoving/compacting equipment- Reverse signal alarm
- 42 - 602(a)(9)(I) Bi-directional Machines- Horn
- 41 – 602(c)(1)(vi) Industrial Trucks - ANSI B56.1- 1969
- 38 - 601(b)(4) Vehicles with obstructed rear view Alarm/observer
- 31 - 602(c)(1)(viii)(A) Lifting/hauling equipment- Use of Safety Platform

1926.600 Equipment

Equipment in use or unattended for identifying location adjacent to a highway.

- Barricades
- Lights
- Reflectors

1926.600 Equipment Maintenance

- Maintenance of Job site Equipment
  - Wheels
    - Split rims or locking rings requirements
      - Inflating, Mounting and Dismounting tires shall have a:
        - Safety Tire Rack
        - Cage

- Heavy Equipment parts suspended by slings, hoists, or jacks, or when being repaired
  - Blocked
  - Cribbed
  - Engine stopped
  - Controls in neutral
  - Brakes set
  - Wheels Chocked

- Cab Glass
  - Safety Glass
    - No Cracked Glass
    - No Broken Glass

- Batteries
  - Charging
    - Caps in place
    - vent caps are functioning
  - PPE
    - Face Shield
    - Aprons
    - Rubber Gloves
    - Emergency Eyewash Within 25 Feet

1926.601 Motor Vehicles

Those pieces of equipment that can operate at both a jobsite and or the highway. Examples include dumps, Flat beds, pick ups. Transporting workers, equipment, and materials are some of their functions

1926.601 Motor Vehicle Requirements

- 2 Headlights, operable condition
- 2 Taillights, operable condition
- Brake Lights
- Additional lights if visibility conditions warrant
- Audible warning device, operable
- Obstructed view to rear
  - Reverse signal alarm
  - An observers signals it safe to do so
- Windshields
  - Wipers
  - Defogging Devices
  - Defrosting Devices

- Haulage Vehicles (loaded by cranes, power shovels,loaders)
  - Cab Shield and/or canopy
  - Tools secured to prevent movement

- Vehicles used to transport employees
  - Shall have a seat for each employee
    - Secured
    - Seatbelts

- Trucks with dump or haulage bodies
  - Equipped with positive means of support
    - Permanently attached
    - Capable of being in a locked position
      - During maintenance
      - inspection work

- Levers controlling hoisting or dumping body devices
  - Equipped with a latch or other dedvice
    - Prevents accidental starting or tipping of mechanism
  - Tailgate trip hazards
    - Arrange so that the operator will be in the clear

- Rubber tire equipment
  - Must have fenders
  - Mud flaps - Vehicles not designed for fenders

Maintenance

- Checked Beginning of each shift for safe operating conditions
  - Service Brakes
  - Trailer Brakes
  - Parking System (hand brake)
  - Emergency Stopping System (brakes)
  - Tires
  - Horns
  - Steering Mechanism
  - Coupling Devices
  - Seat Belts
  - Operating Controls
  - Safety Devices
  - Lights
  - Reflectors
  - Windshields
  - Wipers
  - Defrosters
  - Fire Extinguishers

1926.602 Material Handling Equipment

Types of Earthmoving equipment covered:

- Scrapers
- Bulldozers
- Off-Highway trucks
- Graders
- Agriculture
- Similar Equipment

- Seat belts provided on all equipment
  - Exceptions
    - Equipment not equipped with rollover protective structure
    - Equipment only designed for stand-up operation

- Access roadways and grades
  - Constructed and maintained to accommodate safe movement
  - To restrain and control runaway vehicles

- Brakes
  - Capable of stopping and holding equipment fully loaded

- Audible Alarms
  - On all bi-directional machines
  - Distinguishable from surrounding noise level
  - Operable when needed
    - When machine is moving in either direction
  - Maintained in operative condition
  - Obstructed View to the rear (prohibited movement unless)
    - Reverse signal alarm is used
      - Distinguishable from surrounding noise level
      - Or an employee signals that it is safe to do so

- Scissors points
  - Front end loaders
    - which constitute a hazard to the operator (under normal operation) shall be guarded

- Lift Trucks, Stackers, etc.
  - Meet requirements of 1926.600 and the following
  - Equipment with overhead guards meeting ANSI B56.1 1969
  - Rated capacity clearly posted
  - Modifications or additions affecting capacity or safe operation must have manufacturer's written approval
    - Instruction plates, tags, or decals must be changed accordingly
    - prohibit reducing original safety factor of the equipment

1926.603 Pile Driving Equipment

1926.603 Pile Driving Equipment General Requirements

- Boilers and piping systems must meet the requirements of the ASME, Power Boilers
- Pressure vessels must meet the requirements of the ASME, Pressure Vessels
- Overhead protection
  - Equivalent of 2-inch planking, or
  - Other solid material of equivalent strength
- Stops blocks to prevent the hammer from being raised against the head block
- A blocking device while employees are working under the hammer
- Guards across the top of the head block to prevent the cable from jumping out of the sheaves
- When the leads must be inclined for driving batter piles, provisions shall be made to stabilize the leads
- Fixed leads shall be provided with ladder and adequate rings so the loft worker can attach a lanyard to the leads
- If the leads have loft platforms, standard guardrails must be in place
- Steam hose leading to a steam hammer or jet pipe shall be securely attached
- Air hammer hoses shall be provided with same protection
- Safety chains (1/4") for each hose connection
- Steam lines must consist of two shutoff valves
- Guys, outriggers, thrustouts, or counterbalances to maintain stability of pile driver rigs

Pile Driving Equipment

- Engineers and winchmen, accept signals only from designated signal-men
- Employees shall be kept clear when piling is being hoisted into the leads
- When piles are being driven in an excavated pit, walls shall be sloped or sheet-piled and braced
- When steel tube piles are being "blown out", employees shall be kept beyond the range of falling material
- When cutting off the tops of driven piles, pile driving operations shall be suspended, except where the cutting operations are located at least twice the length of the longest pile from the driver

1926.604 Site Clearing

(a) General Requirements (1) Employees engaged in site clearing shall be protected from hazards of irritant and toxic plants and suitably instructed in the first aid treatment available.

Environmental Assessment

- Make a determination of inherent hazards and potential exposures
  - Snakes, wasps, poisonous vegetation
  - Accessibility to the clearing site
  - Time to medical facility(1926.50)
  - Fire potential,Water availability(1926.51)
  - Hazard Communication, MSDS (1926.59)
  - PPE storage, use.

(R O P S) 1926.1000 - 1003

Objective

To minimize the likelihood of a complete overturn and thereby minimize the possibility of the operator being crushed as a result of a rollover or upset.

Rollover protective structures

- All equipment manufactured from Sept. 1, 1972 to present must have ROPS
- Labeled Information
  - Manufacturer or fabricator's name
  - ROPS model number, if any
  - Machine make, model or series number that structure is designed for

Subpart W - ROPS; Overhead Protection

- 1926.1000 - Rollover protective structures for material handling equipment
- 1926.1001 - Minimum performance criteria for rollover protective structures for designated scrapers, loaders, dozers, graders, and crawler tractors
- 1926.1002 - Protective frames (rollover protective structures) for wheel type agricultural and industrial tractors used in construction
- 1926.1003 - Overhead protection for operators of agricultural and industrial tractors

1926.1000 (R O P S)

- All rubber-tired self-propelled scrapers
- Rubber-tired front-end loaders
- Rubber-tired dozers
- Wheel-type agricultural and industrial tractors
- Crawler tractors, crawler-type loaders, and motor graders

Compactors and rubber-tired skid-steer equipment:

(R O P S) for equipment listed above is reserved pending consideration of standards currently being developed.

- Must meet minimum performance criteria detailed in 1926.1001 and 1926.1002
- Or shall be designed, fabricated, and installed in a manner which will support, based on the ultimate strength of the metal, at least two times the weight of the prime mover applied at the point of impact.

Machines with ROPS that meet one of the following existing governmental requirements shall be deemed in compliance with this standard:

State of California
U.S. Army Corp. of Engineers
Bureau of Reclamation , U.S. Dept of the Interior

Figure 11-1

- At least 52” vertical clearance from deck
- Remounting of ROPS must be equal or stronger than original mounting
- Manufacturer or fabricator’s name and address (permanently affixed to structure)

Figure 11-2

- R O P S model number, if any
- Machine make, model, or series number that the structure is designed to fit
- (Permanently affixed to structure)

(R O P S) 1926.1001

Covers the **minimum performance criteria** for rollover protective structures for designated scrapers, loaders, dozers, graders, and crawler tractors. Test procedures shall:

- Verify energy absorbing capabilities of ROPS
- Verifying the support capabilities to cover the possibility of the vehicle coming to rest on its top
- Verify low temperature impact strength of material used in the ROPS

Signs, Signals, and BarricadesSubpart G

- Signs- warning of hazard, temporarily or permanently affixed or placed, at locations where hazards exits.
- Signals- moving signs, provided by workers, such as flagmen, or by devices, such as flashing lights, to warn of possible or existing hazards.
- Barricades-an obstruction to deter the passage of persons or vehicles.

Signs

Danger Signs: Used only where an immediate hazard exists. The blank space on the sign is used for additional wording.

Figure 11-3 Danger Sign

Caution Signs: Used only to warn against potential hazards. The blank space on the sign is used for additional wording.

Figure 11-4 Caution Sign

Exit Signs: Background must be white. Letters must be red, minimum 6 inches high & 3/4 inch wide

Figure 11-5 Exit Sign

Traffic Signs

- Shall conform with ANSI D6.1-1971 Manual on Uniform Traffic Control Devices for streets and highways.
- Certain State guidelines may pertain to work activity(PA Publication 203)

Accident Prevention Tags- temporary means to warn of existing or immediate hazards, usually attached to a piece of equipment.

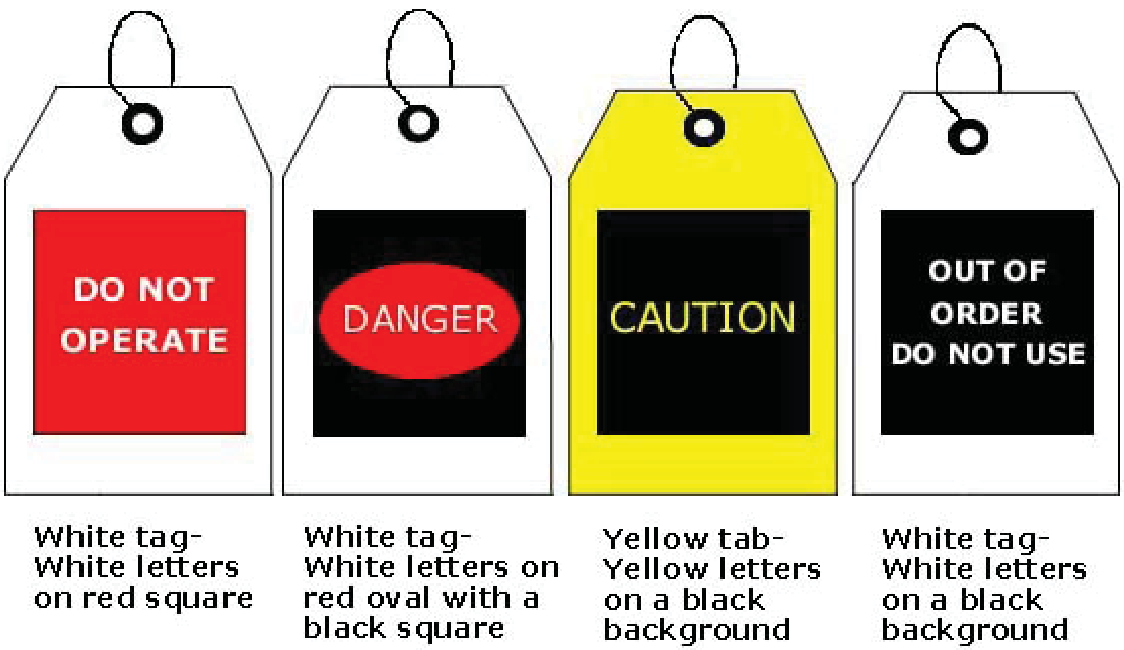


Figure 11.6 Accident Prevention Tags. Courtesy of OSHA.

Signaling

Flagman- used when signs, signals, and barricades do not provide the necessary protection on or adjacent to a highway or street.

- Signaling directions shall conform to ANSI D6.1-1971
- Must wear red or orange garment during flagging
- Must wear reflective material during night operation
- Flags or paddles must be 18 inches square
- Red lights must be used during darkness
- May also conform to Publication 203

A Flagger should have PRIDE

- Professional: And have a neat, clean appearance; be alert and properly positioned.
- Responsive: And able to adjust to changing conditions.
- Informed: And properly briefed by the supervisor, and know limits of work area.
- Decisive: And give signals that are clear.
- Effective: And able to efficiently control the flow of traffic.

Barricades

Shall conform to ANSI D6.1 - 1971, Manual on Uniform Traffic Control Devices for Streets and Highways, relating to barricades.

Instructor Lesson Plan

Safety and Health Programs and Subpart C – General Safety and Health Provisions

29 CFR 1926 Subpart C

Key Concepts

- EO1 Discuss the costs of accidents and the benefits of safety and health programs.
- EO2 Describe the OSHA requirements and guidelines for safety and health programs in construction.
- EO3 Discuss the relevance and application of ANSI/AIHA Z10-2005, American National Standard for Occupational Health and Safety Management Systems.
- EO4 Discuss OSHA cooperative programs.
- EO5 Describe the key concepts in 29 CFR 1926 Subpart C.
- EO6 Critique the presentation.

Presentation and Materials

- Allow 60 minutes to present this chapter.
- Use Safety and Health Programs and Subpart C – General Safety and Health Provisions PowerPoint® slides.
- Use 30-Hour Construction Outreach course manual.

Module 12

Safety and Health Programs and Subpart C – General Safety and Health Provisions

29 CFR 1926 Subpart C

Lesson Outline

Subpart C: General Safety & Health Provisions
Subpart C Sections

Definitions

1926.20 Contractor Requirements

1926.20 Accident Prevention

1926.21 Safety Training & Education
Construction Safety Programs

Safety and Health Programs
Exemplary Workplaces
S & H Program Guidelines
Major Elements
Management Commitment
Management Commitment & Employee Involvement
Employee Involvement
Worksite Analysis
Hazard Prevention and Control
Safety and Health Training

OSHA Alliances, Strategic Partnerships, and VPPs
Alliances
OSHA Strategic Partnerships
OSHA Consultation Service

Overview

Upon the successful completion of this module, participants will be able to describe the OSHA and ANSI guidelines for safety and health programs and present or critique a presentation on safety and health programs and general safety and health provisions in construction suitable for an OSHA 30-hour course.

Objectives

After completing this chapter, you should be able to:

Know

- Discuss the costs of accidents and the benefits of safety and health programs.
- Describe the OSHA requirements and guidelines for safety and health programs in construction.
- Discuss the relevance and application of ANSI/AIHA Z10-2005, American National Standard for Occupational Health and Safety Management Systems.
- Discuss OSHA cooperative programs.
- Describe the key concepts in 29 CFR 1926 Subpart C.

Subpart C: General Safety & Health Provisions

Subpart F-Fire Protection and Prevention provides additional specific requirements for construction fire safety.

Subpart C Sections

- 1926.20 General safety and health provisions
- 1926.21 Safety Training and Education
- 1926.23 First aid and medical attention
- 1926.24 Fire protection and prevention
- 1926. 25 Housekeeping
- 1926.26 Illumination
- 1926.27 Sanitation
- 1926.28 Personal protective equipment
- 1926.29 Acceptable certifications
- 1926.30 Shipbuilding and ship repairing
- 1926.31 Incorporation by reference
- 1926.32 Definitions
- 1926.33 Access to employee medical records
- 1926.34 Means of egress
- 1926.35 Employee emergency action plans

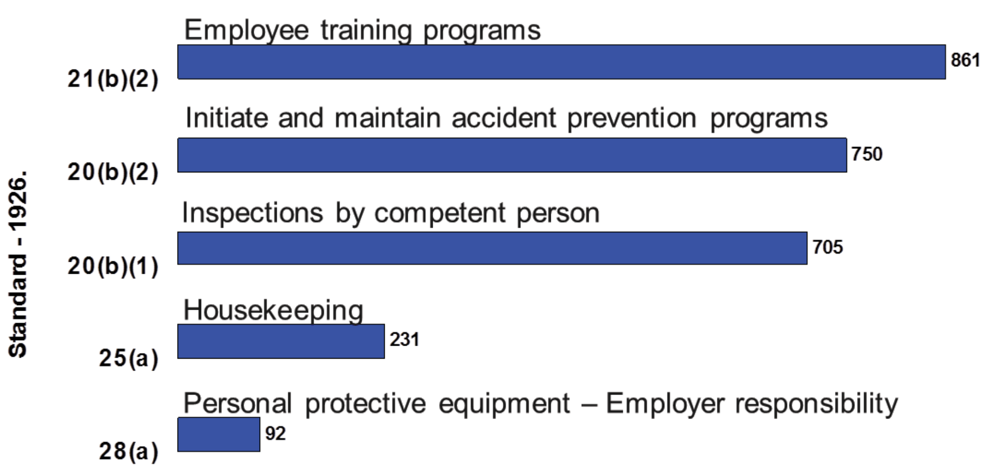


Figure 12.1

Definitions

Competent Person: Has authorization to take corrective action & is able to recognize existing and predictable hazards.

Authorized Person: A person assigned by the employer to perform a duty or to be at a particular jobsite.

Qualified: means one who, by possession of a:

- recognized degree,
- certificate, or
- professional standing, or
- who by extensive knowledge, training, and experience, has successfully demonstrated his ability to solve or resolve problems relating to the subject matter, the work, or the project.

1926.20 Contractor Requirements

Employer: means contractor or subcontractor.

No laborer or mechanic performing contract allowed to work under working conditions which are:

- Unsanitary,
- Hazardous, or
- Dangerous to their health or safety

The above is 1926 (a) (1) Contractor requirements. These requirements are every contractor's responsibility.

1926.20 Accident Prevention

Responsibility of employer to initiate and maintain programs necessary to comply CFR Part 1926 Construction Industry. This is 1926.20 (b) (1). The programs established must provide for frequent and regular inspections of the jobsite by a competent person designated by the employer.

1926.21 Safety Training & Education

- Instruct each employee in the recognition and avoidance of unsafe conditions.
- All 1926 regulations that apply to the work.
- Control or eliminate any hazards or other exposure to illness or injury.

The employer should take advantage of the training and education that OSHA provides. The goal is for all employees going home safe at the end of each shift. Illnesses include exposures to dusts, chemicals, fumes and vapors.

Construction Safety Programs

- Although compliance with the law, including specific OSHA standards, is an important objective, an effective program looks beyond specific requirements of law to address all hazards.
- It will seek to prevent injuries and illnesses, whether or not compliance is at issue.

The extent to which the program is described in writing is less important than how effective it is in practice. As the size of a worksite or the complexity of a hazardous operation increases, however, the need for written guidance increases to ensure clear communication of policies and priorities as well as a consistent and fair application of rules.

Safety and Health Programs

Research indicates benefits to companies who establish effective construction worker safety and health programs:

- Reduction in the extent and severity of work-related injuries and illnesses
- Improved employee morale
- Higher productivity
- Lower workers' compensation costs

Exemplary Workplaces

Common characteristics of effective construction safety and health programs:

- Assignment of responsibility to managers, supervisors, and workers
- Regular inspections to control hazards
- Employee training and orientation for the recognition and avoidance of hazards

S & H Program Guidelines

Figure 12.2 S & H Program Guidelines trains workers to identify, evaluate, and control hazards.

- Systematic approach to construction related hazard:
    - Identification
    - Evaluation
    - Control
- Goes beyond specific construction requirements of the law to focus on all hazards
- As the size of the workplace increases so does the need for a formalized written program
- Program effectiveness more important than "In Writing"
- Element taken from the 'Safety and Health Program Guidelines - 1989'

Major Elements

Keys to an effective program:

- Management commitment and employee involvement
- Worksite analysis
- Hazard prevention and control
- Safety and health training

Management Commitment

Management provides:

- Direction and motivation
- Resources
- Activity control
- Safety and health policy statement
- Clear program goals and objectives
- Visible involvement in program from top management
- Leadership
- Assignment of safety and health responsibilities
- Clear communication of program goals
- Adequate authority to responsible personnel
- Holds managers, supervisors and employees accountable for meeting their responsibilities

Management Commitment & Employee Involvement

- Complement one another
- Management provides the motivating force and resources for safety and health programs
- Employee involvement provides workers opportunities to develop and express their own commitment to the safety and health program

Employee Involvement

Active role for employees:

- Workplace inspections
- Hazard analysis
- Development of safe work rules
- Training of coworkers & new hires

Worksite Analysis

Figure 12-3 worksite hazard identification and analysis.

Figure 12-4 Perform job hazard analysis.

- Hazard Identification:
    - Facilities
    - Processes
    - Materials
    - Equipment
- Use professionals that understand the processes involved
- Perform job hazard analysis
    - Break tasks down into elements
    - Identify the hazards in each element
    - Identify control measures and safe work rules for each element
- Identify existing hazards
- Anticipate hazards where procedures or operations change
- Provide for regular site safety and health inspections
- Method for reporting and correcting hazards:
    - Communication of hazards
    - Method for correcting reported hazards
    - Prioritizing work
    - Timeliness
    - Without fear of reprisal

- Effective system for:
  - Accident Investigations
  - Near Misses
- Identify root causes
- Contributing factors
- Methods for prevention of reoccurrence
- Analyze injury and illness trends over time:
  - Identify injury type patterns
  - Identify injury task patterns
  - Analyze by department
- Identify common causes and prevent reoccurrence

Hazard Prevention and Control

- Make a determination that a hazard exists
- Where feasible, eliminate by job or task design/redesign
- If elimination is not feasible, then control the hazard:
  - Engineering controls
  - Administrative controls
  - Personal protective equipment (PPE)
- System for timely correction or control of hazards
- Safe work procedures:
  - Developed from worksite analysis
  - Training
  - Correction of unsafe performance
  - Positive reinforcement
  - Enforcement
- Provide for facility and equipment maintenance
- Plan and prepare for emergencies:
  - Training and drills
- Medical Program
  - First aid
  - Physician and emergency care

Safety and Health Training

- Effective new employee orientation:
  - Employee safety and health responsibilities
  - Protective measures
  - Proper procedures for machine operation
  - Understand all safeguards
  - Exits and emergency procedures
- Cover all required employee training
- Documentation where required
- Reinforcing employee training:
  - Continual feedback
  - Refresher training as needed

OSHA Alliances, Strategic Partnerships, and VPPs

Alliances

Enables organizations committed to workplace safety and health to collaborate with OSHA to prevent injuries and illnesses in the workplace. OSHA and its allies work together to reach out to, educate, and lead the nation's employers and their employees in improving and advancing workplace safety and health.

Alliance Benefits

- Build trusting, cooperative relationships with the Agency.
- Network with others committed to workplace safety and health.
- Leverage resources to maximize worker safety and health protection.

How Alliances Work

OSHA and the participating organization must define, implement and meet a set of short and long-term goals that fall into three categories:

1. Training and education
2. Outreach and communication
3. Promote the National Dialogue on Workplace Safety and Health

Getting Started with Alliances

- For national Alliances, contact OSHA's Office of Outreach Services and Alliances at 202-693-2340.
- For regional or local Alliances, contact the OSHA regional office for your area.

OSHA Strategic Partnerships

- The OSHA Strategic Partnership Program for Worker Safety and Health (OSPP), adopted on November 13, 1998
- An expansion of OSHA's experience with voluntary programs.
- Extended, voluntary, cooperative relationship with **groups of employers, employees, and employee representatives**
- Opportunity to identify a common goal, develop plans for achieving that goal, and cooperate in implementation.
- Most are small businesses, with an average employment of 22 workers.
- Many of these partnerships focus on areas of concern addressed in OSHA's Strategic Plan.
- These partnerships are seeking solutions to silica and lead exposures
- Serious hazards in the:
    - Nursing home,
    - Food processing,
    - Logging, and
    - Construction industries.

Voluntary Protection Program

- Designed to recognize and promote effective safety and health management.
- In the VPP, management, labor, and OSHA establish a cooperative relationship at a workplace that has implemented a strong program:
    - Management program that meets OSHA criteria
    - Employees participate & work with management
    - OSHA provides public recognition
    - Removal from routine inspections

OSHA Consultation Service

- Free Service:
    - Find out about potential hazards in the workplace
    - Improve safety & health management systems
    - Qualify for one-year exemption from routine inspection
- Delivered by state governments:
    - Well trained staff
    - On-site consultation
    - Confidential
- Commitment to correcting serious job hazards

Instructor Lesson Plan

Scaffolds

Lesson Plan – CIO 249-349

Key Concepts

- Scaffold capacity.
- Scaffold safety.
- Scaffold training.

Presentation and Materials

- Allow 30 minutes to present this chapter.
- Use Scaffolds PowerPoint slides.
- Try the Group Discussion Activity at the end of the chapter.
- Use Review Questions at the end of the chapter to facilitate discussion.
- Use 30-Hour Construction Outreach ourse manual.

Module 13

Scaffolds

OSHA: 29 CFR 1926 Subpart L – CIO 249 -349

Lesson Outline

Scaffold Capacity

Scaffold Platform Construction

Supported Scaffolds

Suspension Scaffolds
Outrigger Beams
Counterweight Systems
Tiebacks
Support Devices
Winding Drums and Ropes
Clips and U-Bolts
Hoists

Access to Scaffolds
Ladders
Stairways
Ramps and Walkways
Prefabricated Scaffold Access Frames

Scaffold Use
Welding on a Scaffold

Fall Protection While Using Scaffolds
Guardrails

Falling Object Protection

Other Requirements
Competent Person vs. Qualified Person
Training Requirements

Common Citations

Group Discussion Activity

Glossary

Review Questions

Other Resources

Overview

You most likely have used or even constructed different types of scaffolds during your construction work. It is estimated that 2.3 million construction workers, or 65 percent of the construction industry, work on scaffolds frequently. Working on or around scaffolds is hazardous and is a major source of injuries that often require time off the job. Scaffolding accidents are one of the leading causes of injuries and deaths at construction work sites. Knowing the OSHA standards and rules for health and safety using scaffolding will help you avoid injuries and create a safer work environment. This chapter will teach you about the OSHA general requirements for scaffolds, the provisions for specific types of scaffolds, and the fall protection systems you can use.

Objectives

After completing this chapter, you should be able to:

Know

- State the OSHA standard for scaffold capacity.
- Define a stall load and give the capacity requirement.
- List safety items that protect you from falling objects.
- Cite the training required for persons who work on scaffolds and for persons who erect scaffolds.

Apply

- Describe the proper use of a suspension scaffold system.
- Use the clearance chart to determine safe distances required between a scaffold and energized power lines.

Analyze

- Detect safe and unsafe practices when using scaffolds shown in the photos provided.

Scaffold Capacity

Scaffold capacity refers to the ability of scaffolds and their component parts to hold a load without failure. Specifications include precautions concerning the timber, planks, counterweights, connections, hardware, ropes, and screen for toeboards and midrails.

According to Occupational Safety and Health Administration (OSHA) standards, all scaffolds and scaffold components should be able to support four times the maximum intended load without failure. Load-carrying timbers, except for scaffold planks, should support a minimum 1,500 pound-feet per square inches (lb-ft/in2). Planks should be identified by the proper grade stamp with wood being graded by the American Softwood Lumber Standards of the United States.

Do not use planks that have splits, checks, notches, or accumulated layers of material that can weaken the plank.

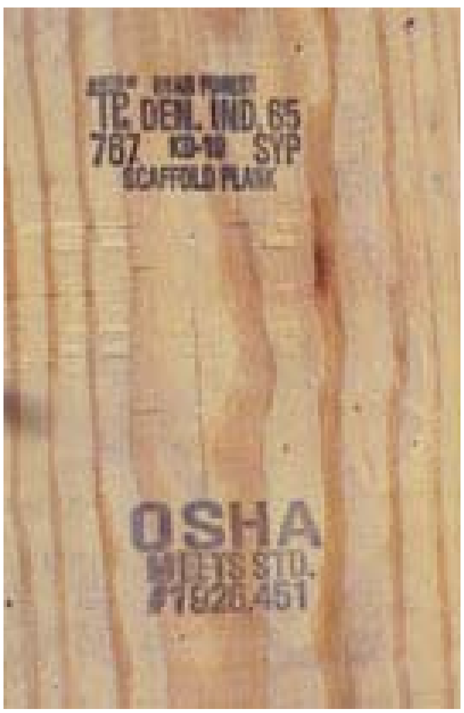


Figure 13.1 OSHA does not inspect lumber. The lumber can be stamped that it meets OSHA standards, but since the plank may be used long after it was inspected, you should still pay attention to the quality of the plank.

Figure 13.2 Splits

Figure 13.3 Checks

Figure 13.4 Notches

Figure 13.5 Accumulated Material

Counterweights and connections used in adjustable suspension scaffolds should be able to remain upright and intact while withstanding four times the tipping moment.

Stall load is the load at which the prime mover of a power-operated hoist stalls, or the power to the prime mover is automatically disconnected. The stall load of any scaffolding should not exceed three times the rated load.

Case Report
A worker fell from the third level of a tubular welded-frame scaffold as he prepared masonry fascia for removal from a building. No guarding system was in place, and the platform was coated with ice.

OSHA Construction e-Tool:
http://www.osha.gov/SLTC/etools/construction/falls/fatexfalls3.html

Scaffold Platform Construction

Almost every platform on a scaffold should be planked. The employer determines how wide the platform should be to maintain safe working conditions. Scaffolds that already have walkways used for access do not have to be planked, but they must have walkways that are at least 18 inches wide. (Remember, walkways must have guardrails or full fall arrest systems.)

There are some exceptions to this rule. Four types of scaffolds do NOT have to have an 18 inch platform: ladder jack scaffolds, top plate bracket scaffolds, roof bracket scaffolds, and pump jack scaffolds. Sometimes the work area is just too small to allow an 18 inch platform to be constructed. In these cases the platform or walkway is simply built as wide as possible, and the scaffold must be protected from fall hazards and have fall arrest systems.

Here are some other platform provisions:

- Edges of platforms should not be more than 14 inches from the work face unless a guardrail system or fall arrest system is installed.
- Platforms must also extend six inches over a support to prevent the platform from slipping off. An exception to this provision is when a platform has hooks and planks with cleats to stabilize it. In this case the platform is not likely to shift.
- Scaffold platforms 10 feet long or less should not hang past the support more than 12 inches.
- Scaffold platforms longer than 10 feet should not hang past the support more than 18 inches. Exceptions would include platforms that have guardrails or when the overhang is built to support workers and equipment without tipping.
- Scaffold planks in a long run should overlap at least 12 inches unless nailed together.
- When constructing a scaffold that has a change in direction, first lay the planks on the bearers NOT at right angles to the platform. Next lay the planks that will sit at right angles on top of the first set of planks.
- Do not apply opaque finishes to wood except for identification purposes. The wood may, however, be coated with preservatives, fire retardant finishes, or slip-resistant finishes.

Case Report
A construction worker was killed when he fell 14½ feet from an unguarded scaffold inside a reactor vessel.

OSHA Construction e-Tool:
http://www.osha.gov/SLTC/etools/construction/falls/fatexfalls3.html

Supported Scaffolds

A supported scaffold is one with platforms supported by some type of rigid support, such as frames, beams, brackets, poles, legs, or upright posts.

You probably have had to work on supported scaffolds on many of your construction jobs. Perhaps you had to make the scaffold you and your coworkers used. Are you fully aware of the rules and regulations concerning scaffold construction and use? Read the following provisions for scaffolds. Do you and your coworkers follow these rules?

- Legs, posts, frames, or poles should rest on base plates or other firm foundation and should be plumb and braced to prevent slipping.
- Footings (or mudsills) should be level, sturdy, and able to support the load.
- Unstable objects such as bricks or blocks should not be used as support for scaffolds.
- If a scaffold has a height to base ratio of more than 4:1, use guys, ties or braces to prevent tipping.
- Install braces at locations where horizontal parts support the inner and outer surfaces of the scaffold.
- Install the braces according to the manufacturer's recommendations or at the closest horizontal part to the 4:1 height.
- If scaffold platforms are 3 feet wide or less, tie off vertically every 20 feet or less.
- If scaffold platforms are more than 3 feet wide, tie off vertically every 26 feet.
- Do not use any equipment to support scaffold platforms unless designed for that use by the manufacturer.

Case Report
A worker was fatally injured when he fell 7½ feet off a scaffold platform while he was installing overhead boards. The platform was simply two 2 x 10" boards with no guardrails.

OSHA Construction e-Tool:
http://www.osha.gov/SLTC/etools/construction/falls/fatexfalls3.html

Suspension Scaffolds

A suspension scaffold has one or more platforms suspended by ropes or other nonrigid means of support from an overhead structure.

You also probably have had to work on suspension scaffolds on construction jobs. The precautions are different for suspension scaffolds, and you have to be fully aware of the rules and regulations which allow for safe suspension scaffold use. Each part of a suspension scaffold has different requirements. Read the following provisions for each type of suspension scaffold component listed below. Knowing the rules will help you and your coworkers avoid accidents and make a safer work site. Do you and your coworkers follow each of these recommendations?

Outrigger Beams

- Suspension outrigger beams should be made of structural steel and be braced to prevent moving. They can be braced by bolts or by counterweights (but not on a mason's multipoint adjustable suspension scaffold.)
- Outrigger beams should have stop bolts or shackles at both ends.
- Fasten the beams together with flanges turned out on channel iron beams.
- Install bearing supports perpendicular to the centerline of the beam. If it is not possible to install the beams at this angle, use tiebacks for support.
- Install the web in the vertical position.

Counterweight Systems

- Use only items that are specifically designed for counterweight systems.
- Do NOT use materials that are easily moved, such as sand, gravel, blocks, bricks, or rolls of roofing felt.
- Secure counterweights to the outrigger beams so they cannot be moved, and do not remove the counterweights until the scaffold is removed.

Case Report
A 53-year-old painting foreman and a 28-year-old painter were killed when their two-point suspension scaffold collapsed. The scaffold was supported by two steel outriggers. The scaffold manufacturer specified 600 pounds of counterweight for the scaffold and load, but the painters were using only 200 pounds of counterweight (100 pounds per outrigger). The outriggers were not tied off or otherwise secured, and no personal fall protection equipment was being used by either worker. The workers' weight caused the outriggers to slip, and the scaffold, rigging, and victims fell to the ground.

OSHA Construction e-Tool:
http://www.osha.gov/SLTC/etools/scaffolding/accidentreports/an-cw1.html

Tiebacks

- Attach tiebacks to firm anchorage, such as structural parts of a building.
- Do not use standpipes, vents, piping systems, or electrical conduits as tiebacks.
- Install the tiebacks at right angles to the building face. Single tiebacks installed at an angle are prohibited.

Figure 13.6 Parapet hook tieback perpendicular to the building.

Support Devices

- Support devices such as cornice hooks, roof hooks, roof irons, and parapet clamps should be made of steel, wrought iron, or other material that is as strong as the scaffold material.
- Support devices should be supported by bearing blocks.
- Devices should be installed with tiebacks as strong as the hoisting rope.

Case Report
Two workers were killed when their two-point suspension scaffold fell to the ground. They had been sandblasting a 110-ft water tank and working 60-70 feet above ground. The scaffold attachment point failed and the scaffold cables were released. The workers were not tied off independently, and the scaffold had no independent attachment system.

OSHA Construction e-Tool:
http://www.osha.gov/SLTC/etools/scaffolding/accidentreports/an-dc1.html

Winding Drums and Ropes

- Use at least four wraps of suspension rope around the winding drum of a suspension scaffold hoist.
- Suspension ropes should be long enough to prevent the rope end from passing through the hoist.
- Do not use repaired ropes on a suspension scaffold.
- Wire ropes may be joined together only with eye spliced thimbles connected with shackles or coverplates and bolts.
- Replace the ropes if they are damaged or if they have kinks.
- Replace ropes if there are six randomly broken wires in one rope lay.
- If the rope has lost more than one-third its original diameter, it should not be used.
- Heat and electricity damage ropes. Replace as needed.

Case Report
A construction worker was working on the third level of a tubular welded-frame scaffold. The scaffold had little planking, no guard rail, no access ladder, and was covered with ice and snow. The worker slipped and fell headfirst approximately 20 feet to the pavement below.

OSHA Construction e-Tool:
http://www.osha.gov/SLTC/etools/construction/falls/fatexfalls3.html

Clips and U-Bolts

- Install at least three wire rope clips a minimum of six rope diameters apart on suspension scaffolds.
- Tighten the clips again after initial loading.
- Make sure you inspect and retighten the clips at the start of each work shift.
- Do not use U-bolts at the point of suspension for a scaffold hoist. Place the U-bolt over the dead end of the rope.

Figure 13.7 Wire rope with a thimble secured by an eye splice.

Figure 13.8 Adhesive on a wire rope could interfere with a hoist.

Figure 13.9 The birdcaged wire rope should not be used.

Figure 13.10 Constant rotation of this rope as it ran through the hoist caused the free end to twist and split.

Hoists

- Both electrically powered hoists and manual lift hoists should be tested by a qualified testing laboratory.
- Cover the gears and brakes on a powered hoist.
- Both powered and manual hoists should have a braking device that engages automatically if the hoist moves suddenly or if an accelerated over-speed occurs.
- Do not use gas-powered hoists on suspension scaffolds.

Access to Scaffolds

There are quite a few approved ways to access a platform when the platform is more than two feet above or below a point of access. Portable ladders, stairway and hook-on ladders, attachable stairs, stair towers, ramps, walkways, prefabricated scaffold accesses and personnel hoists can be used. Even using another scaffold is an approved method of getting to a scaffold platform. Cross braces, however, are NOT approved for accessing platforms.

Each of the approved methods has safety concerns when used with scaffolds. To make sure that you and your coworkers stay safe on a job with scaffolding, make sure you follow the safety precautions listed below for each type of scaffold access.

Ladders

- Make sure you attach ladders to scaffolding so that they do not tip the scaffold.
- Use a type of ladder that was designed for the type of scaffold used.
- Make sure the bottom rung is no more than 24 inches above the supporting surface.
- The rungs of the ladders should be at least 11½ inches long and no more than 16¾ inches apart.
- Rest platforms should be provided every 35 feet.

Stairways

- Make sure the bottom rung of a stairway unit is no more than 24 inches above the supporting surface.
- Install slip resistant treads on steps and landings.
- The minimum step width should be 16 inches.
- Provide rest platforms every 12 feet.
- Install toprails and midrails on each side of the stairway.
- Use the toprail as a handrail unless another handrail has been provided.
- Handrails should be at least three feet from other objects.
- Inspect stair rails and handrails periodically to make sure that surfaces will not puncture workers or snag clothing, and ensure that ends of rails are not a projection hazard.
- Install stair rails 28-37 inches from the upper surface to the stair tread.
- Provide an 18-inch-by-18-inch landing at each level.
- Stairways should be at a 40-60 degree angle from the horizontal.
- All open sides and ends of landings should have a guardrail.
- Tread depth should be uniform to ¼ inch for each flight of stairs.

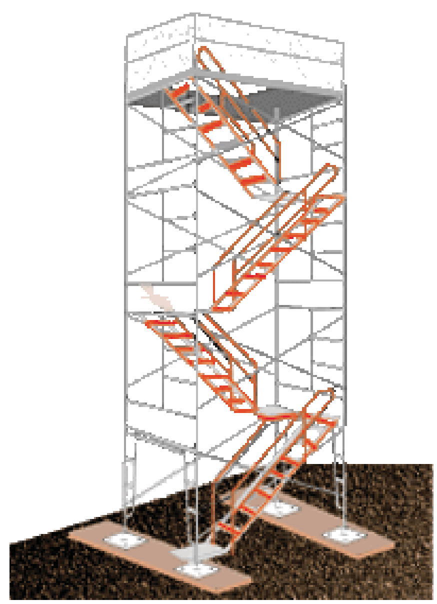


Figure 13.11 Stairway within scaffold.

Ramps and Walkways

- Ramps and walkways must have guardrail systems, and guardrails that are six feet above lower levels must comply with OSHA 29 CFR 1926 Subpart M—Fall Protection.
- Fasten cleats to planks 14 inches apart to improve footing on ramps that are steeper than 1 : 8 (vertical to horizontal).
- The slope of inclined ramps and walkways should be no greater than 1 : 3.

Prefabricated Scaffold Access Frames

- Frames should be specifically designed as ladder rungs that are at least eight inches long.
- Frames should not be used as work platforms if the rungs are less than 11½ inches long unless adequate fall protection or positioning belts are available.
- Scaffold access should be uniformly spaced within each frame section.
- Rest platforms should be available every 35 feet.
- Non-uniform rung spacing from joining frames should be allowed only if the rung spacing is not greater than 16¾ inches.
- Steps and rungs should line up between rest platforms.

OSHA requires that every worker who builds or dismantles scaffolds must have safe access to the scaffold. This includes a provision for ladders that are installed and attached to the scaffold while it is being built, scaffold frames with horizontal members that are no more than 22 inches apart, and good handholds and foot spacing on frames.

Case Report
Scaffolding outside the John Hancock Center in Chicago dropped 40 floors to the ground during a wind storm in 2002, killing three women in cars and injuring eight others.

USA Today: http://www.usatoday.com/news/nation/2002/03/09/scaffolding-chicago.htm

Scaffold Use

Even when scaffolds are constructed with safety provisions, it is important that you keep in mind precautions for using the scaffold safely. Scaffolding accidents are one of the leading causes of work site injuries and deaths. Scaffolding issues—both their construction and use—are the most frequently OSHA-cited construction safety standard violations.

Read and review the following precautions for safe use of scaffolds so that you or your coworkers will not become one of the statistics for scaffold injuries or deaths:

- Do not load a scaffold with more than the maximum intended load.
- Do not use shore scaffolds or lean-to scaffolds.
- Make sure that scaffolds are far enough away from energized power lines.

Clearance of Scaffolds from Energized Power Lines	
Insulated Lines (volts)	**Minimum Distance (feet)**
Less than 300 volts	3 feet
300 volts–50 kilovolts	10 feet
More than 50 kilovolts	10 feet + 0.4 inch / 1 kv over 50 kilovolt
Uninsulated Lines (volts)	**Minimum Distance (feet)**
Less than 50 kilovolts	10 feet
More than 50 kilovolts	10 feet + 0.4 inch / 1 kv over 50 kilovolt

Table 6.1

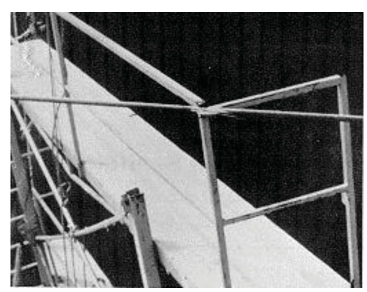


Figure 13.12 This metal scaffold is contacting an overhead power line—a dangerous situation.

- Only put the scaffold and material closer than the precautions listed in the above table if it is absolutely necessary for the work and only if the power company has been notified. The power lines must be de-energized, relocated, or have protective coverings installed.
- Do not work on scaffolds that are covered with snow, ice, or other slipping hazard materials.
- Tag lines should be used to control hoisted swing loads.
- Suspension ropes on scaffolds should be designed to fit the brake and hoist equipment needs and should be protected from heat, acid, and other corrosive substances.
- Do not allow garbage or work debris to collect on a scaffold.
- Do not use makeshift ways of increasing a scaffold's height (for example, stacking boxes or barrels on top).
- Do not use ladders on top of a scaffold unless the ladder is secured, the platform is secured from movement, and the ladder legs are stabilized.

Case Report
A crew of four painters was using a five-tier, tubular, welded-frame scaffold mounted on rubber-clad aluminum wheels. They had just completed painting one side of a three-story building, and the crew decided to move the 28½-foot scaffold to the other side of the structure. The scaffold contacted a 12,000-volt power line that was approximately 27½ feet above the ground. The contact created a path to the ground for the electric current. The four painters were electrocuted, and the crew chief was severely burned.

NIOSH: http://www.cdc.gov/NIOSH/91-110.html

Welding on a Scaffold

Follow these precautions when welding on a scaffold:

- Make sure that excess wire rope and lines are insulated.
- Cover suspension wire ropes with at least four feet of insulating material above the hoist.
- Tail lines below the hoist should be insulated and guided so they do not become grounded.
- Insulate each hoist.
- A grounding conductor should run from the scaffold to the structure.
- The conductor should be at least the same size as the welding work lead.
- The conductor should not be in series with the welding process.
- Immediately shut off any equipment if the scaffold ground lead is disconnected.
- Do not allow an active welding rod to touch the scaffold or suspension system.

Fall Protection While Using Scaffolds

Some fall protection provisions apply to working on any scaffold, and some provisions apply to working on specific types of scaffolds. Read the fall protection precautions listed below. Even if you are not working on a certain type of scaffold right now, you may have to in the future. Knowing the standards for safe scaffold work will help keep you and your co-workers accident free.

Figure 13.13 Working safely on a scaffold.

Type of Scaffold or Work	Safety Provision
Boatswain's chair Catenary scaffold Float scaffold Needle beam scaffold Ladder jack scaffold	Personal fall arrest system.
Single-point adjustable suspension scaffold	Personal fall arrest system and a guardrail.
Chicken ladder (crawling board)	Personal fall arrest system, a guardrail with a 200 pound toprail capacity or a ¾ inch grabline.
Self-contained adjustable scaffold	If supported by frames, use a guardrail. If supported by ropes, use a personal fall arrest system and guardrail system.
A scaffold on a walkway	Guardrail within 9½ inches of one side of the walkway.
Bricklaying on a scaffold	Personal fall arrest system or guardrails on all open sides and ends except the wall being laid.

Table 6.2

Also consider the following safety practices:

- Vertical lifelines should not be used when overhead hazards, such as work platforms, are used.
- If vertical lifelines are being used as part of the fall protection system, they should be secured at safe anchorage points and NOT on standpipes, vents, piping vents, electrical conduits, outrigger beams, or counterweights.
- Do not attach vertical lifelines, independent support lines, and suspension ropes to each other, to the same anchorage point, or to the same point on the scaffold.
- Toprails and posts should be equivalent in strength to 2- by 4-inch lumber. Toeboards should be equivalent in strength to 1- by 4-inch lumber. If other materials are used, they should be as strong as 1¼- by 1¼- by ⅛-inch angle iron, 1-inch (outside diameter) steel tubing, or 2-inch aluminum tubing.

Figure 13.14 The ropes in the picture are vertical lifelines.
Do they follow the regulations for safe practice?

Case Report

A 27-year-old cement finisher and a coworker were working inside a 172-foot high concrete silo. Both men were wearing safety belts with nylon rope lanyards secured to independent lifelines. The victim lost his balance and fell off an unguarded end of the scaffold. The coworker said he saw the victim fall and jerk upward as the lanyard caught him. When the victim's weight dropped back on the lanyard, the lanyard snapped, allowing him to fall to his death on a concrete floor. When the lanyard was inspected, it showed burn damage at several places, including the point of failure. There was no inspection of equipment after use. Equipment was placed in a common work area and workers took equipment as needed. The lanyard had been returned to the storage bin even though it had probably been damaged earlier during cutting and welding operations.

OSHA Construction e-Tools:
http://www.osha.gov/SLTC/etools/scaffolding/accidentreports/f-fa1-3.html

Guardrails

Here are some safety guidelines for guardrails:

Figure 13.15 Guardrails protect these workers on a scaffold.

- Guardrails should be installed on all open sides and ends.
- Guardrails should be installed before workers, other than those working on scaffold construction, start work using the scaffold.
- The toprail should be 39-45 inches about the platform.
- The top edge of the toprails can be greater than 45 inches if the guardrail specifications outlined in the standards are followed.
- Install midrails, screens, mesh, and intermediate vertical parts between the top edge of the toprail and the platform.
- Do not space intermediate parts, such as balusters, more than 19 inches apart.
- Make sure guardrail systems on a single-point or two-point adjustable suspension scaffold can withstand 100 pounds of force.
- Midrails, screens, and mesh should withstand 75 pounds of force.
- Guardrails on scaffolds other than single-point or two-point adjustable suspension scaffolds should be able to withstand 200 pounds of force.
- Make sure surfaces or projections on guardrails cannot puncture or cut workers or snag clothing.
- Do not use steel or plastic banding as a guardrail.
- Cross bracing can be used as a toprail when the crossing point is 38-48 inches above the work platform and as a midrail when the crossing point is 20-30 inches above the work platform.
- Do not use posts or uprights longer than 48 inches.

Falling Object Protection

There are quite a few ways for workers to be protected from falling objects on a construction site. In addition to wearing hardhats, you can use toeboards, screens, guardrail systems, debris nets, catch platforms, and canopy structures that can hold or deflect falling objects.

Anytime falling objects, such as tools, materials, or equipment, can fall on workers, the following precautions should be taken:

- Barricade the area below a scaffold and do not enter the hazard area.
- Build toeboards when platform edges are more than 10 feet above a lower level. Toeboards should be able to withstand 50 lbs of downward force.
- If materials, tools, or other equipment can fall on workers below, install paneling or screening to protect workers.
- Any canopy system or net should be strong enough to protect against the impact of the falling objects.

Other Requirements

Competent Person vs. Qualified Person

OSHA distinguishes between a competent person and a qualified person. A competent person is "one who is capable of identifying existing and predictable hazards in the surrounding area, or working conditions which are unsanitary, hazardous, or dangerous to workers, and who has the authorization to take prompt corrective measures to eliminate them" (OSHA 29 CFR 1926 Subpart L). A qualified person is "one who, by possession of a recognized degree, certificate, or professional standing, or who by extensive knowledge, training, and experience, has successfully demonstrated ability to solve or resolve problems relating to the subject matter, the work or the project" (OSHA 29 CFR 1926 Subpart L).

A qualified person may be a manufacturer or a supplier, a supervisor or a foreman. In order to be a competent person working with scaffolds, a worker must be able to carry out various responsibilities and be thoroughly knowledgeable concerning the OSHA scaffolding rules and regulations.

Training Requirements

Employers are responsible for training all employees to recognize safety hazards on or around scaffolds. Training by a qualified person should include electrical hazards, fall hazards, falling object hazards, the proper use of the scaffold, the proper handling of materials on a scaffold, maximum intended loads, and the load-carrying capacities of the scaffolds used.

Employees who erect, disassemble, operate, repair, or inspect scaffolds must also be trained by a competent person to recognize scaffold hazards, including knowing the design criteria and maximum intended loads and use.

Retraining must occur if it appears that the employee was not trained well enough to understand the safe handling and use of scaffolds.

Common Citations

Here are some common citations that OSHA inspectors issue regarding scaffolds:

- **No guardrails on scaffolds.** This violation is consistently a problem with all types of scaffolds. This is usually more prevalent with smaller employers who purchase equipment without guardrails. Many construction sites are inspected after being referred by a passing OSHA compliance officer who notices the violation.
- **Defective wood planks.** Citations include wood rot, saw marks, and cracks through the whole board.
- **Unsafe access to a scaffold.** Employers do not provide safe stairways or ladders but require workers to climb the cross braces or scaffold frames. This is a serious fall hazard because the frames are not designed as ladders, and the scaffold may tip over. This violation often occurs on sites that also have guardrail citations.
- **No fall arrest equipment on two-point suspended scaffolds.** This often happens when the general contractor does not require a subcontractor to provide 100 percent fall protection. Common contracting operations that receive this citation are tuck pointing, brick cleaning, and window installing.
- **Cross bracing not adequate.** Full cross bracing is generally required on all scaffold sections. If the standard cross bracing cannot be used, horizontal braces must be used. Cross bracing cannot be used as a guardrail unless strict written guidelines are followed.

Figure 13.16 Defective planks can cause serious harm.

Group Discussion Activity

As a group, look at the following images and answer the question for each. Most photos or illustrations ask the question, “What’s wrong with this picture?” (There could be more than one unsafe practice shown in the picture.) Use the images for discussion of violations, unsafe practices, recommendations and examples of safe practices too.

1. What’s wrong with this picture?

Figure 13.17

2. What’s wrong with this picture?

Figure 13.18

3. What's wrong with this picture?

Figure 13.19

4. What's wrong with this picture?

Figure 13.20

5. What's wrong with this picture?

Figure 13.21

6. What's wrong with this picture?

Figure 13.22

7. What's wrong with this picture?

Figure 13.23

8. What's wrong with this picture?

Figure 13.24

9. What's wrong with this picture?

Figure 13.25 Photo courtesy of www.funny-games.biz.

10. What's wrong with this picture?

Figure 13.26

11. What's wrong with this picture?

Figure 13.27

12. What's wrong with this picture?

Figure 13.28

Glossary

adjustable suspension scaffold—a suspension scaffold that has a hoist that can be operated by a worker on the scaffold (shown below).

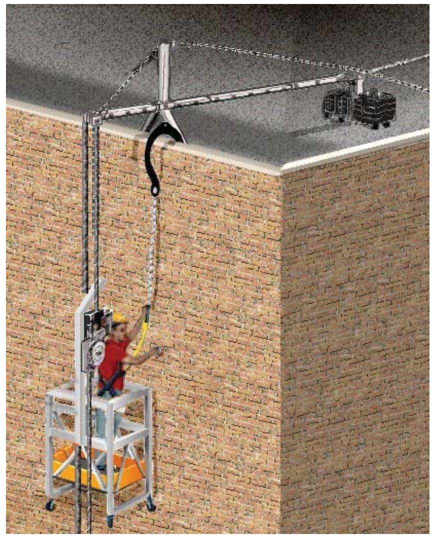


Figure 13.29 Adjustable suspension scaffold.

bearer (putlog)—a horizontal scaffold part upon which the scaffold platform rests and which is connected to the uprights, posts, or poles of the scaffold.

Boatswain's chair—a single-point adjustable suspension scaffold that has a seat or sling for supporting one worker in a sitting position.

body belt (safety belt)—a strap for securing around the worker's waist and for attaching to a lanyard, lifeline, or deceleration device.

body harness—straps that are secured about the worker to distribute fall forces over at least the thighs, pelvis, waist, chest, and shoulders; attaches to other components of a personal fall arrest system.

brace—a rigid connection that holds one scaffold part in a fixed position.

bricklayers' square scaffold—a supported scaffold made up of framed squares which support a platform (shown below).

Figure 13.30 Bricklayers' square scaffold.

carpenters' bracket scaffold—a supported scaffold consisting of a platform supported by brackets attached to building or walls (shown below).

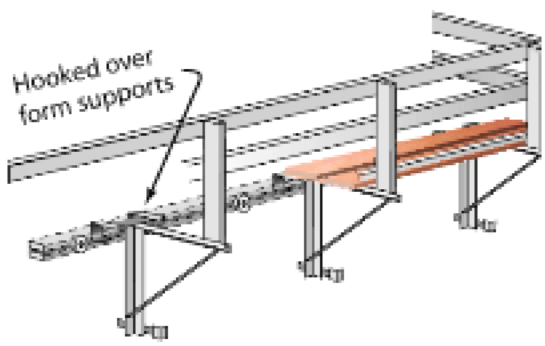


Figure 13.31 Carpenter's bracket scaffold.

catenary scaffold—a suspension scaffold consisting of a platform supported by two horizontal, parallel ropes attached to parts of a building or other structure (shown below).

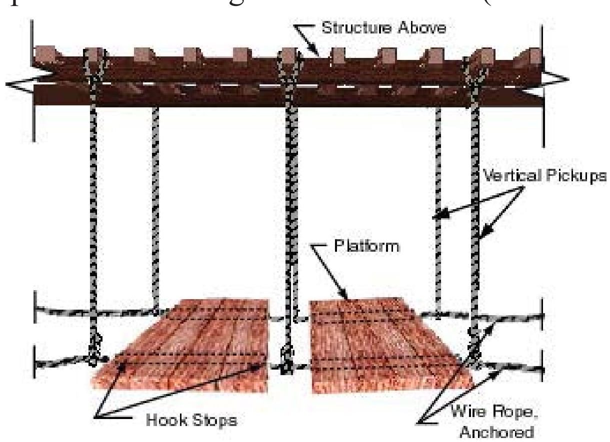


Figure 13.32 Catenary scaffold.

chimney hoist—a multipoint adjustable suspension scaffold used to provide access to work inside a chimney.

cleat—a block used at the end of a platform to prevent the platform from slipping off its supports.

competent person—a person who is capable of identifying existing and predictable hazards in working conditions which are unsanitary, hazardous, or dangerous to employees, and who has authorization to take corrective action to eliminate them.

continuous run scaffold—a multipoint adjustable suspension scaffold constructed using a series of interconnected braced scaffold parts erected to form a continuous scaffold.

coupler—the device that connects the tubes of a tube and coupler scaffold.

crawling board (chicken ladder)—a secured, supported scaffold consisting of a plank with cleats to provide footing for use on sloped surfaces such as roofs (shown below).

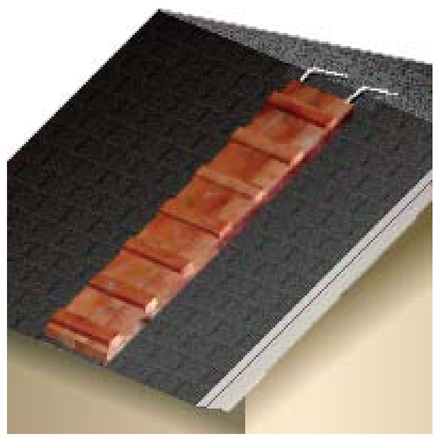


Figure 13.33 Crawling board.

deceleration device—any device, such as a rope grab or lanyard, that reduces a substantial amount of energy during a fall arrest.

double pole (independent pole) scaffold—a supported scaffold consisting of a platform resting on cross beams supported by ledgers and a double row of uprights independent of support (except ties, guys, braces) from any structure.

fabricated decking and planking—manufactured platforms made of wood, metal, or other materials.

fabricated (frame) scaffold—a scaffold consisting of a platform(s) supported on fabricated end frames (shown below).

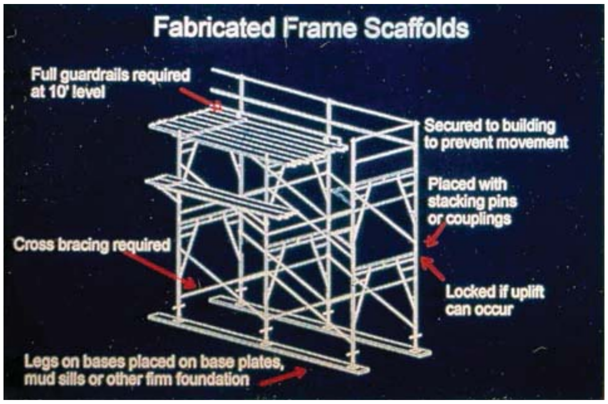


Figure 13.34 Fabricated frame scaffold.

These are the most common types of scaffolds. They are versatile, economical, and easy to use. They can be used with only one or two tiers for residential construction or painting, or they can be stacked several stories for large construction work.

failure—load refusal, breakage, or separation of component parts.

float (ship) scaffold—a suspension scaffold consisting of a braced platform resting on two parallel bearers and hung from overhead supports by ropes of fixed length (shown below).

Figure 13.35 Float scaffold.

form scaffold—a supported scaffold consisting of a platform supported by brackets attached to framework (shown below).

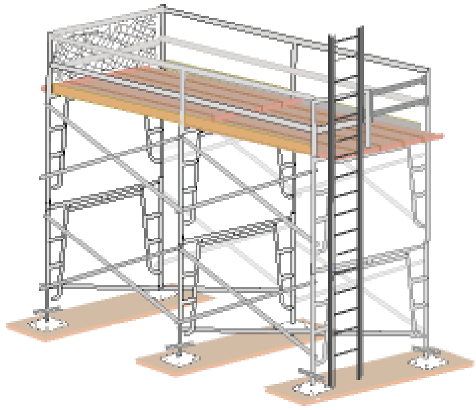


Figure 13.36 Form scaffold.

guardrail system—a vertical barrier of toprails, midrails, and posts erected to prevent workers from falling off a scaffold platform or walkway to lower levels.

hoist—a manual or power-operated device to raise or lower a suspended scaffold.

horse scaffold—a supported scaffold consisting of a platform supported by construction horses (sawhorses). Horse scaffolds constructed of metal are sometimes called trestle scaffolds (shown below).

Figure 13.37 Horse scaffold.

interior hung scaffold—a suspension scaffold consisting of a platform suspended from the ceiling or roof structure by fixed length supports.

ladder jack scaffold—a supported scaffold consisting of a platform resting on brackets attached to ladders (shown below).

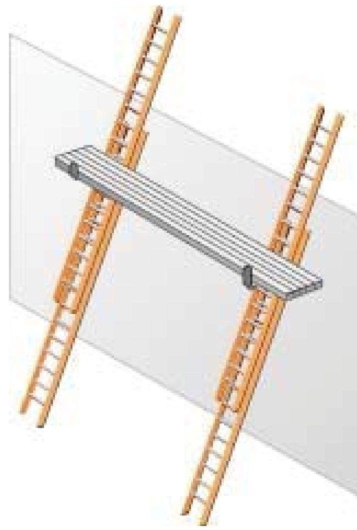


Figure 13.38 Ladder jack scaffold.

ladder stand—a mobile, self-supporting ladder consisting of a wide, flat tread ladder in the form of stairs.

landing—a platform at the end of a flight of stairs.

lean-to scaffold—a supported scaffold that is kept erect by tilting it toward and resting it against a building or structure.

lifeline—a component consisting of a flexible line that connects to an anchorage at one end to hang vertically (vertical lifeline) or that connects to anchorages at both ends to stretch horizontally (horizontal lifeline).

mason's multipoint adjustable suspension scaffold—a continuous run suspension scaffold designed and used for masonry operations.

maximum intended load—the total load of all persons, equipment, tools, and materials expected to be on a scaffold or scaffold component at any one time.

mobile scaffold—a powered or unpowered, portable, caster or wheel-mounted supported scaffold (shown below).

Figure 13.39 Mobile scaffold.

multilevel suspended scaffold—a multipoint adjustable suspension scaffold with a series of platforms at various levels resting on common stirrups (shown below).

Figure 13.40 Multilevel suspended scaffold.

multipoint adjustable suspension scaffold—a suspension scaffold consisting of a platform(s) suspended by more than two ropes from overhead supports and equipped with means to raise and lower the platform (shown below).

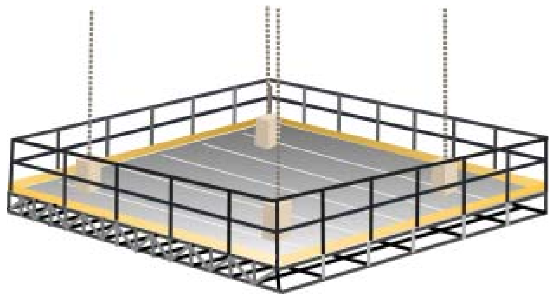


Figure 13.41 Multipoint adjustable suspension scaffold.

needle beam scaffold—a platform suspended from needle beams (shown below).

Figure 13.42 Needle beam scaffold.

outrigger—the structural part of a supported scaffold used to increase the base width of a scaffold in order to provide support and increased stability of the scaffold.

outrigger scaffold—a supported scaffold consisting of a platform resting on outrigger beams (thrustouts) projecting beyond the wall or face of the building or structure while the inboard ends are secured inside the building (shown below).

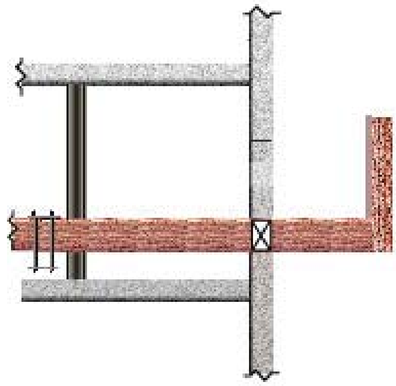


Figure 13.43 Outrigger scaffold.

personal fall arrest system—a system used to stop a worker's fall. It can include an anchorage, connectors, a body belt, or body harness and may include a lanyard, deceleration device, lifeline, or combinations of these.

platform—a work surface elevated above lower levels.

pole scaffold—a type of supported scaffold in which every structural part is made of wood. They are considered somewhat old-fashioned because they have to be built from scratch and cannot be easily reused (shown below).

Figure 13.44 Pole scaffold.

power operated hoist—a hoist that is powered by mechanical means.

pump jack scaffold—a supported scaffold consisting of a platform supported by vertical poles and movable support brackets (shown below).

Figure 13.45 Pump jack scaffold.

rated load—the manufacturer's specified maximum load to be lifted by a hoist or applied to a scaffold.

roof bracket scaffold—a rooftop supported scaffold consisting of a platform resting on angular-shaped supports (shown below).

Figure 13.46 Roof bracket scaffold.

runner (ledger or ribbon)—the lengthwise horizontal spacing or bracing part that supports the bearers.

scaffold—any temporary elevated platform (supported or suspended) and its supporting structure used for supporting workers or materials or both.

self-contained adjustable scaffold—a combination supported and suspension scaffold consisting of an adjustable platform(s) mounted on an independent supporting frame(s) not a part of the object being worked on, and which is equipped with a means to permit the raising and lowering of the platform(s).

float or ship scaffold—a suspension scaffold consisting of a braced platform resting on two parallel bearers and hung from overhead supports by ropes of fixed length (shown below).

Figure 13.47 Float scaffold.

single-point adjustable suspension scaffold—a suspension scaffold consisting of a platform suspended by one rope from an overhead support and equipped with means to permit the movement of the platform to desired work levels (shown below).

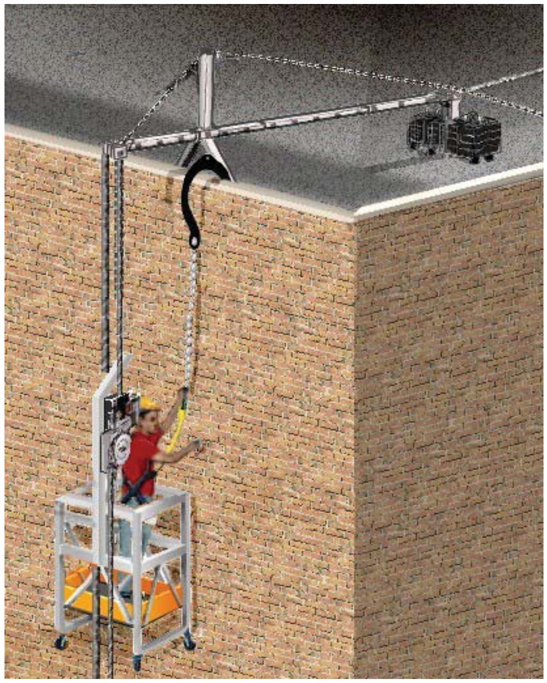


Figure 13.48 Single-point adjustable suspension scaffold.

single-pole scaffold—a supported scaffold consisting of a platform(s) resting on bearers with the outside ends supported on runners secured to a single row of posts or uprights and the inner ends supported on or in a structure.

stair tower—a tower made up of scaffold components and internal stairway units and rest platforms (shown below).

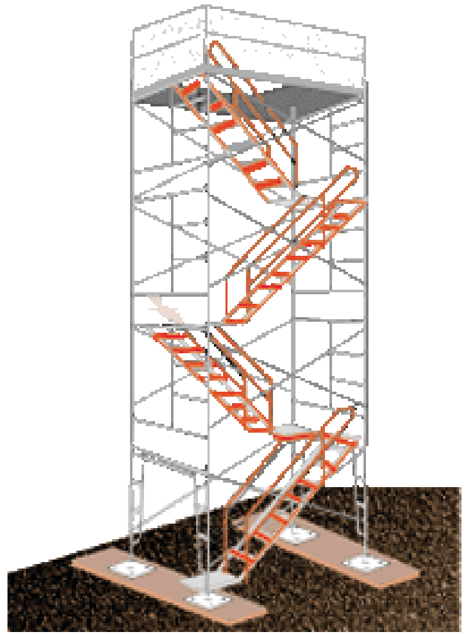


Figure 13.49 Stair tower

stall load—the load at which the prime mover of a power-operated hoist stalls, or the power to the prime mover is automatically disconnected.

step, platform, and trestle ladder scaffold—a platform resting directly on the rungs of stepladders or trestle ladders (shown below).

Figure 13.50 Step scafold.

stonesetters' multipoint adjustable suspension scaffold—a continuous run suspension scaffold designed and used for stonesetters' operations.

supported scaffold—one or more platforms supported by outrigger beams, brackets, poles, legs, uprights, posts, frames, or similar rigid support.

suspension scaffold—one or more platforms suspended by ropes or other nonrigid means from an overhead structure.

tank builders' scaffold—a supported scaffold consisting of a platform resting on brackets that are directly attached to a cylindrical tank.

top plate bracket scaffold—a scaffold supported by brackets that hook over or are attached to the top of a wall.

tube and coupler scaffold—a supported or suspended scaffold consisting of a platform supported by tubing and erected with coupling devices connecting uprights, braces, bearers, and runners (shown below).

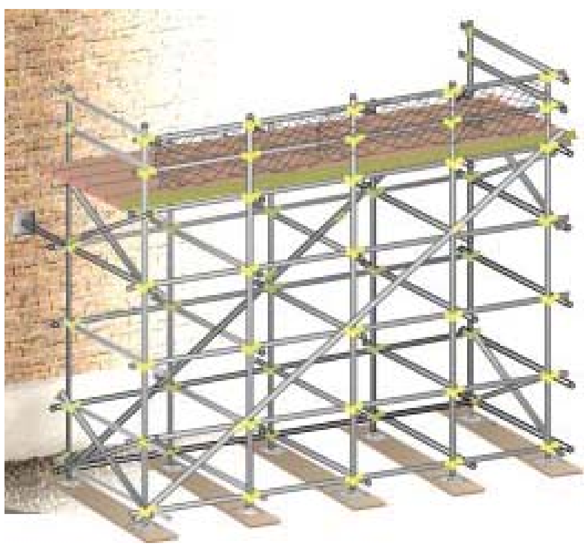


Figure 13.51 Tube and coupler scaffold.

two-point suspension scaffold (swing stage)—a suspension scaffold consisting of a platform supported by hangers (stirrups) suspended by two ropes from overhead supports and equipped with means to permit the raising and lowering of the platform (shown below).

Figure 13.52 Two-point suspension scaffold.

vertical pickup—a rope used to support the horizontal rope in catenary scaffolds.

walkway—a portion of a scaffold platform used only for access and not as a work level.

window jack scaffold—a platform resting on a bracket or jack which projects through a window opening (shown below).

Figure 13.53 Window jack scaffold.

Review Questions

1. How much weight should a scaffold and scaffold components be able to support without failure?

Four times the maximum intended load for the scaffold.

2. What is the safety rule concerning the stall load of any scaffold?

The stall load of any scaffolding should not exceed three times the rated load.

3. Name several safety issues that must be considered when working or constructing supported scaffolds.

- *Legs, posts, frames, or poles should rest on base plates or other firm foundation and should be plumb and braced to prevent slipping.*
- *Footings (or mudsills) should be level, sturdy, and able to support the load.*
- *Unstable objects, such as bricks or blocks, should not be used as support for scaffolds.*
- *If a scaffold has a height to base ratio of more than 4:1, use guys, ties, or braces to prevent tipping.*
- *Braces should be installed at locations where horizontal parts support the inner and outer surfaces of the scaffold.*
- *Install the braces according to the manufacturer's recommendations or at the closest horizontal part to the 4:1 height.*
- *If scaffold platforms are 3 feet wide or less, tie off vertically every 20 feet or less.*
- *If scaffold platforms are more than 3 feet wide, tie off vertically every 26 feet.*
- *Do not use any equipment to support scaffold platforms unless designed for that use by the manufacturer.*

4. Describe how each of the following parts of a suspension scaffold should be constructed or used.

Outrigger Beams

- *Suspension outrigger beams should be made of structural steel and be braced to prevent moving. They can be braced by bolts or by counterweights (but not on a mason's multipoint adjustable suspension scaffold.)*
- *Outrigger beams should have stop bolts or shackles at both ends.*
- *Fasten the beams together with flanges turned out on channel iron beams.*
- *Install bearing supports perpendicular to the center line of the beam. If it is not possible to install the beams at this angle, use tiebacks for support.*

Counterweight Systems

- *Use only items that are specifically designed for counterweight systems.*
- *Do NOT use materials that are easily moved, such as sand, gravel, blocks, bricks, or rolls of roofing felt.*
- *Secure counterweights to the outrigger beams so they cannot be moved, and do not remove the counterweights until the scaffold is removed.*

Tiebacks

- *Attach tiebacks to firm anchorage, such as structural parts of a building.*
- *Do not use standpipes, vents, piping systems, or electrical conduits as tiebacks.*
- *Install the tiebacks at right angles to the building face. Single tiebacks installed at an angle are prohibited.*

Support Devices

- *Support devices such as cornice hooks, roof hooks, roof irons, and parapet clamps should be made of steel, wrought iron, or other material that is as strong as the scaffold material.*
- *Support devices should be supported by bearing blocks.*
- *Devices should be installed with tiebacks as strong as the hoisting rope.*

Winding Drums and Ropes

- *Use at least four wraps of suspension rope around the winding drum of a suspension scaffold hoist.*
- *Suspension ropes should be long enough to prevent the rope end from passing through the hoist.*
- *Do not use repaired rope on a suspension scaffold.*
- *Wire ropes may be joined together only with eye spliced thimbles connected with shackles or coverplates and bolts.*
- *Replace the ropes if they are damaged or if they have kinks.*
- *Replace ropes if there are six randomly broken wires in one rope lay.*
- *If the rope has lost more than one-third its original diameter, it should not be used.*
- *Heat and electricity damage ropes. Replace as needed.*

Clips and U-Bolts

- *Install at least three wire rope clips a minimum of six rope diameters apart on suspension scaffolds.*
- *Tighten the clips again after initial loading.*
- *Make sure you inspect and retighten the clips at the start of each work shift.*
- *Do not use U-bolts at the point of suspension for a scaffold hoist. Place the U-bolt over the dead end of the rope.*

Hoists

- *Both electrically powered hoists and manual lift hoists should be tested by a qualified testing laboratory.*
- *Cover the gears and brakes on a powered hoist.*
- *Both powered and manual hoists should have a braking device that engages automatically if the hoist moves suddenly or if an accelerated over-speed occurs.*
- *Do not use gas-powered hoists on suspension scaffolds.*

5. How far away should you put a scaffold from an energized power line? Give the minimum distances for varying voltages.

For insulated lines:

a. less than 300 volts—3 feet
b. 300 volts–50 kilovolts—10 feet
c. more than 50 kilovolts—10 feet + 0.4 inch/over 50 kilovolts

For uninsulated lines:

a. less than 50 kilovolts—10 feet
b. more than 50 kilovolts—10 feet + 0.4 inch/over 50 kilovolts

6. What safety items should you use to protect yourself from falling objects on a construction site?

Hardhats, toeboards, screens, debris nets, catch platforms, canopy structures.

7. What do you consider to be the most important safety practice for your job?

Answers will vary.

8. What training concerning scaffolds are employers responsible for providing employees?

Employers are responsible for training all employees to recognize safety hazards on or around scaffolds. Training by a qualified person should include electrical hazards, fall hazards, falling object hazards, the proper use of the scaffold, the proper handling of materials on a scaffold, maximum intended loads, and the load-carrying capacities of the scaffolds used.

Employees who erect, disassemble, operate, repair, or inspect scaffolds must also be trained by a competent person to recognize scaffold hazards, including knowing the design criteria and maximum intended loads and use.

Retraining must occur if it appears that the employee was not trained sufficiently to understand the safe handling and use of scaffolds.

9. Describe a work experience that was difficult because of scaffolding being used on the job. (This could be because you had to construct the scaffolds for a number of different job site conditions, because you had a difficult time getting the materials to construct a safe scaffold, or for other job site factors.) Include a description of what you did to work through the task.

Answers will vary.

10. Have you met the training requirements for your job?

Answers will vary.

Other Resources

OSHA Standards—Scaffolding
http://www.osha.gov/SLTC/scaffolding/standards.html

ANSI/OSHA Scaffolding—EZ Facts: Safety Info Online
http://www.labsafety.com/refinfo/ezfacts/ezf133.htm

Compliance and Safety
http://complianceandsafety.com/shop/index.php?l=product_list&c=172
http://www.labsafety.com/refinfo/ezfacts/ezf133.htm

Compliance Assistance Quick Start: Construction Industry
http://www.osha.gov/dcsp/compliance_assistance/quickstarts/construction/index_construction.html

OSHA Construction e-Tool—Scaffolding
http://www.osha.gov/SLTC/etools/scaffolding/index.html

IUOE National Training Fund National HAZMAT Program. (2007). *Construction Industry Outreach*. Publication no.: M-18-2007.

OSHA: Stairways and Ladders: A Guide to OSHA Rules
http://www.osha.gov/Publications/osha3124.pdf

Laborers-AGC Education and Training Fund. (2003). *OSHA Construction Safety and Health.*

OSHA 3071. Job Hazard Analysis (2002 revised.)
http://www.osha.gov/Publications/osha3071.pdf

OSHA QUICKCARD—Supported Scaffold Safety Tips
http://www.docstoc.com/docs/9690/OSHA-QUICK-CARD-SUPPORTED-SCAFFOLD-SAFETY-TIPS

OSHA Safety and Health Topics—Scaffolding
http://www.osha.gov/SLTC/scaffolding/

OSHA Worker Safety Series—Construction
http://www.osha.gov/Publications/OSHA3252/3252.html

OSHA: Safety Requirements for Scaffolding
http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=9720&p_table=STANDARDS

OSHA: Scaffolds—Hazards and Possible Solutions
http://www.osha.gov/SLTC/scaffolding/recognition.html

Instructor Lesson Plan

Highlights of OSHA's New Steel Erection Rule

OSHA: 29 CFR Part 1926.750

Key Concepts

The highlights presentation contains a Microsoft PowerPoint® Presentation and script, which provide a brief summary of OSHA's new steel erection regulation. The objective of this slide presentation is to present some of the key provisions of the new rule. At the end of the training session, the audience should be familiar with major elements of the new regulation. This presentation should take approximately one hour.

Purpose: This presentation is intended to assist you in providing an overview of the new rule to audiences with a broad knowledge of OSHA's former rule. It does not discuss the rule in detail and does not describe all the requirements or changes in the new regulation.

Instructions for Use: Before the presentation, review the latest information on the steel erection rule, which will be posted on OSHA's website. In addition, print copies of OSHA's main Steel Erection page as a handout to inform audience members of the latest information available on the website. For consistency of message on steel erection, follow the script.

Required Software: PowerPoint® 2000 or PowerPoint® Viewer

These materials are intended to be a resource document for presenters and are not a substitute for any of the provisions of the Occupational Safety and Health Act of 1970 or for any regulations or standards issued by the US Department of Labor. The Department of Labor, OSHA is providing this information as a public service. You should be aware that, while we try to keep the information timely and accurate, there will often be a delay between official publication of the materials, and updates, and their appearance on the website.

You should also review the OSHA standard, 29 CFR Part 1926.750 of the Code of Regulations, and all handouts before any training session

Module 14

Highlights of OSHA’s New Steel Erection Rule

OSHA: 29 CFR Part 1926.750

Lesson Outline

The New Steel Erection Rule: Highlights
Steel Erection Final Rule
Scope
Exclusions
Steel Erection Decision Tree
Key Provisions of the Rule:

Site Layout

Hoisting and Rigging

Column Anchorage

Beams and Columns

Open Web Steel Joists

Structural Steel Assembly

Falling Object Protection

Training

Specific Controlling Contractor Duties

OSHA’s Website

Overview

This module provides a brief summary of OSHA's new steel erection regulation. The objective is to present some of the key provisions of the new rule. This module is intended to provide an overview of the new rule to audiences with a broad knowledge of OSHA's former rule. It does not discuss the rule in detail and does not describe all the requirements or changes in the new regulation.

Objectives

After completing this chapter, you should be able to:

Know

- Describe major elements of the new regulation.

The New Steel Erection Rule: Highlights

Steel Erection Final Rule


Figure 14.1 Steel erection.

The Steel Erection Rule was published on January 18, 2001, and became effective on January 18, 2002. This rule is the first OSHA safety standard developed under the Negotiated Rulemaking Act of 1990 and the Department of Labor’s negotiated rulemaking policy. It was developed in conjunction with industry and union groups.

The new rule addresses the most serious hazards in the steel erection industry and emphasizes maintaining the stability of the structure during construction. Some of the rule’s provisions are being phased in. These are the “component requirements” — provisions that affect the design of components.

Example: columns must have 4 anchor bolts.

Components provisions will not apply if the building permit was obtained (or contract date, for bridges) before January 18, 2001, or steel erection began on or before September 16, 2001.
A requirement for slip-resistant coatings on painted steel surfaces does not go into effect until July 18, 2006.

Scope

In general, the scope of the standard is based on activities — not the type of structure. There are two lists of activities — a Primary List and an Ancillary list.

To determine if an activity is covered by the standard, see if it fits in one of two lists. If it is in the Primary List (.750(b)(1)), then it is covered by the standard. These include activities such as hoisting, placing, connecting, bracing, bolting, etc.

If it is in the Ancillary list (.750(b)(2)), then it is covered ONLY IF it meets a test — the test is whether it is done "during and as a part of" an activity in the Primary list.

For example, there are standing seam metal roofing systems that incorporate a layer of insulation under the metal roof. In the installation process, a row of insulation is installed, which is then covered by a row of metal roofing. Once that row of roofing is attached, the process is repeated, row by row, until the roof is completed. Is the installation of the insulation covered by the standard?

The installation of the row of insulation is not in the Primary list. However, it does fit within the Ancillary list. And the insulation is installed "during and as a part of" the installation of the metal roofing — which is in the Primary list. So, the insulation work is covered.

Exclusions

The new rule does not apply to electrical transmission towers, communication and broadcast towers, or tanks.

- Electrical transmission towers are covered in 29 CFR, Part 1926.950, Subpart V
- Communication and broadcast towers and tanks are covered under 29 CFR, Part 1926.105, Subpart E.

The rule describes a tank as, "a container for holding gases, liquids, or solids." The final rule, however, does apply to the construction of the steel structure that supports a tank.

Steel Erection Decision Tree

Once you determine that none of the exclusions apply, the decision tree for whether the standard applies looks like this. First, is this a Primary activity — one listed in section .750(b)(1)? If it is, then the standard applies. If it isn't, then check to see if the activity in question is in the Ancillary list — section .750(b)(2). If it is also not in that list, then the standard does not apply. If it is in the Ancillary list, then check to see if it meets the test for coverage — is that ancillary activity being done "during and as a part of" a Primary list activity? If it is, then the standard applies. If it is not, then the standard does not apply.

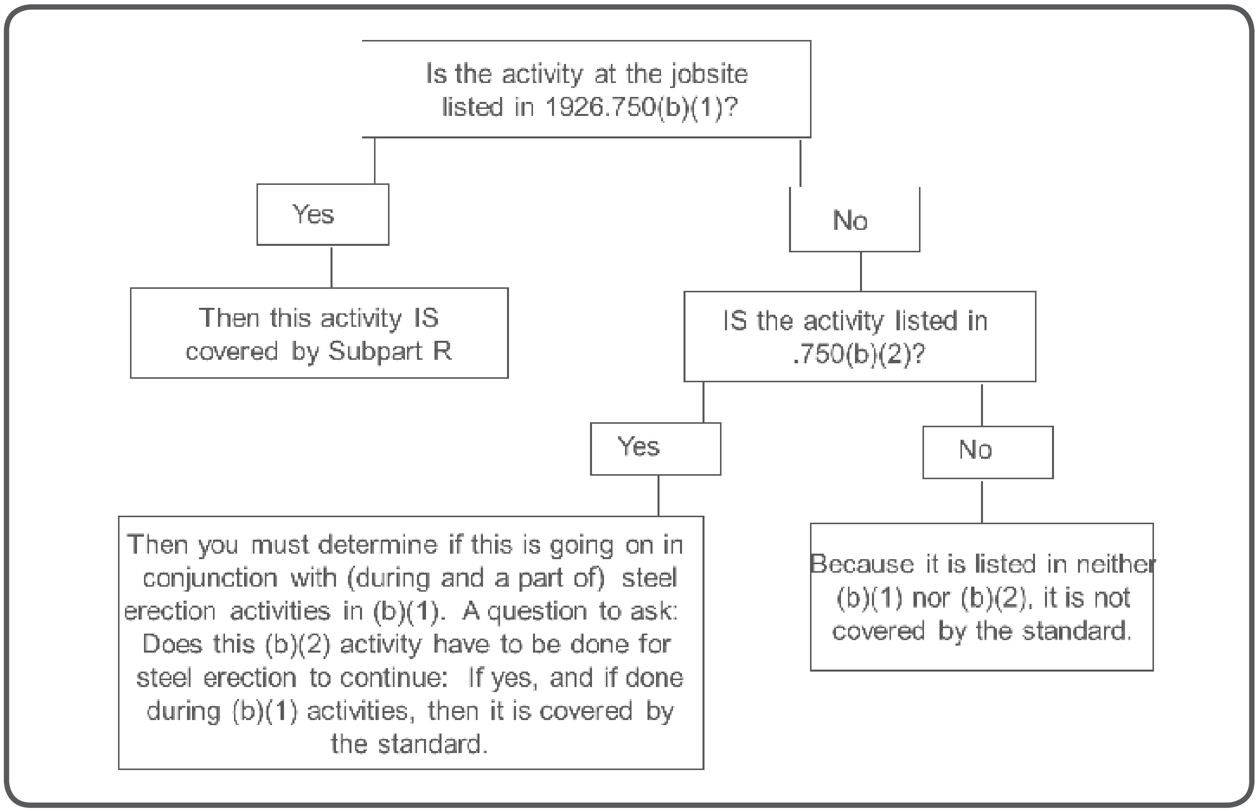


Figure 14.2 Steel Erection Decision Tree

Key Provisions of the Rule:

The new rule addresses seven key concepts.

1. **Site Layout:** The controlling contractor must provide the erector with a safe site layout and on site access roads.
2. **Hoisting and Rigging:** The rule provides additional crane safety for steel erection. It minimizes employee exposure to overhead loads through pre-planning and work practice requirements, and prescribes proper procedures for multiple lifts (Christmas-treeing).
3. **Structural Steel Stability Requirements:** Many of the provisions in the new standard are designed to increase the stability of the structure during construction.
4. **Column Anchorage:** The new rule requires a minimum of four anchor bolts per column, along with other column stability requirements, and adequate procedures for anchor bolts that have been modified in the field.
5. **Beams and Columns:** The rule addresses collapse hazards associated with beams and columns, and sets specific requirements for making double connections safely.
6. **Open Web Steel Joists:** The rule minimizes the risk of collapse of lightweight steel joists by requiring anchored erection bridging and specifying criteria for attachment of joists to the structure before releasing the hoisting cable. It adds new requirements to minimize the risk of collapse when placing loads on steel joists. Illustrations and drawings are provided in a non-mandatory appendix.
7. **Structural Steel Assembly:** The new rule provides for safer walking/working surfaces by eliminating tripping hazards and minimizing slips through new slip resistance requirements.

Specific work practices have also been added for landing deck bundles and promoting the prompt protection from fall hazards in interior openings.

- **Systems-Engineered Metal Buildings:** The final rule addresses requirements to minimize the risk of collapse in the erection of these specialized structures, which account for a major portion of steel erection in this country.
- **Falling Object Protection:** The rule addresses hazards of falling objects in steel erection.
- **Fall Protection:** Fall protection is required for most workers above 15 feet, although there are exceptions for connectors and deckers.
- Connectors must be provided fall protection between 15 and 30 feet, but do not have to be tied off.
- Deckers can work in a Controlled Decking Zone (CDZ) without fall protection between 15 and 30 feet.
- Fall protection is required for all workers above 30 feet, without exception.
- **Training:** The new rule requires that a qualified person train exposed workers in fall protection, and in special, high-risk activities.

Site Layout

Figure 14.3 Site Layout

Requires the controlling contractor to supply the erector with a safe site layout: The new rule requires that adequate access roads and a drained and graded area be provided and maintained by the controlling contractor.

These conditions enable the erector to move around the site and perform necessary operations in a safe manner. They ensure the site is readily accessible to the work area, and gives the erector adequate space for the safe storage of materials and safe operation of the erector's equipment.

Hoisting and Rigging

Figure 14.4 Hoisting and Rigging

Provides additional crane safety for steel erection: The new rule contains requirements for pre-shift inspections of cranes and rigging used in steel erection. It requires that a competent person perform a pre-shift visual inspection of the cranes to be used for steel erection. The visual inspection must be performed before each shift. The competent person typically will be the operator or oiler of the hoisting equipment or, on a large project, the master mechanic who checks each crane.

Minimizes employee exposure to overhead loads through pre-planning and work practice requirements: All hoisting operations in steel erection must be pre-planned to eliminate overhead exposure in most instances. The purpose of the final rule is to address the hazards associated with overhead loads.

These hazards may include failure of the lifting device, or items falling from a load which would create a crushing hazard, or struck-by hazard.

Routes for suspended loads must be pre-planned and employees are prohibited from working under a hoisted load except for those engaged in initial connection activities or employees who are necessary for unhooking the load. For these exceptions to apply, the materials must be rigged by a qualified rigger to prevent unintentional displacement, and hooks with self closing safety latches must be used to prevent components from slipping out of the hook.

Prescribes proper procedures for multiple lifts (Christmas-treeing). The new rule now contains procedures for performing multiple lifts. The procedures apply when a steel erector chooses to lift multiple pieces of steel at one time as an alternative to hoisting individual structural members.

This procedure includes the following requirements:

- Use a multiple lift rigging assembly with a certified 5 to 1 safety factor for capacity.
- Limit the lift to five members.
- Lift only beams and similar structural members.
- Train employees engaged in the lift operation.
- Ensure that the crane has controlled load-lowering capability whenever loads are over connectors.

The multiple lift rigging assembly must be rigged with the members attached at their center of gravity, kept reasonably level, rigged from the top down, and have a distance of at least seven feet between the members.

Column Anchorage

Figure 14.5 Column Anchorage

Requires four anchor bolts per column: All columns must now be anchored by a minimum of four anchor rods/bolts. There is also a strength requirement for the anchorage: it must be designed to resist a minimum eccentric gravity load on the column of 300 pounds.

Also, all columns must be evaluated by a competent person to determine whether they need to be guyed or braced.

Requires written notification of proper curing of concrete in footings, piers, etc., for steel columns: The controlling contractor must ensure that written notifications are provided to the steel erector indicating that the concrete in footings, piers, and walls and the mortar in the masonry piers and walls have cured sufficiently to provide the necessary strength to support the column during steel erection. The concrete has to pass an ASTM field-cure test.

Requires written notification of adequacy of anchor bolt repairs: The controlling contractor must also notify the erector that anchor bolts that have been repaired, replaced or modified, meet the approval of the project structural engineer of record. This addresses the problem that the erector cannot always tell when an anchor bolt has been repaired and thus may not be aware of a repair unless notified that a repair has been made. If an anchor bolt has been improperly repaired, replaced or modified, it could lead to a collapse.

Beams and Columns


Figure 14.6 Beams and columns

Two bolts per connection before releasing the hoisting line: During the final placing of solid web structural members, the load must not be released from the hoisting line until the members are secured with at least two bolts, per connection, of the same size and strength as shown in the construction documents.

The bolts must be drawn up wrench tight or secured by an equivalent connection as specified by the project structural engineer of record. The requirement for bolts of the same strength and size will prevent collapses caused by the use of lesser strength/size bolts.

Safe procedures for making double connections at columns: A double connection is a type of attachment where the ends of two steel members join to opposite sides of a central (carrying) member — such as a beam, girder or column web — using the same bolts.

After the first member is bolted, a second member is connected to the opposite side of the existing connection. This second member is attached using the same bolts (going through the same holes) used to attach the first member. To attach the second member, the nuts on the first beam’s bolts must be removed and the bolts backed most of the way out. The ends of the bolts must be flush with the surface of the central member so that the second member can be lined up with the existing holes. Only fractions of an inch are now preventing the first beam from falling. Once the holes in the connection plate of the second member are lined up with the first beam’s bolts, the bolts are pushed back through all the holes and the nuts are put back on the bolts and tightened to secure the three pieces of steel together.

This maneuver is extremely dangerous, and often takes place with a worker sitting on the first beam. If the first beam collapses, the worker falls. The risk of collapse is high because of the tenuous grip of the loosened bolts and the possibility that the connector’s spud wrench, which is used to align the second member, may slip.

The new rule requires that when making a double connection at or near a column, the first member must remain connected to a supporting member by at least one connection bolt at all times unless a connection seat or equivalent connection device is supplied with the members to secure the first member.

Open Web Steel Joists

Figure 14.7 Open Web Steel Joists

Minimize the risk of collapse of lightweight steel joists by addressing the need for anchored erection bridging and methods of attachment: The final rule requires certain open web joists to have erection bridging installed and anchored before the hoisting cable is released. Tables are supplied in the rule to identify which type and length of joist must have this erection bridging.

The standard also sets the maximum number of workers that may be on the joist before all bridging is installed and anchored. "Anchored" erection bridging is bolted diagonal bridging that is anchored back to a terminus point, as shown in the lower picture on the slide.

There are also requirements and specifications for both the initial attachment of joists and their final attachment. For example, some joists must be supplied with holes and initially attached by bolting.

New requirements to minimize collapse in placing loads on steel joists: The new rule establishes work practices regarding landing and placing loads on steel joists. In general, loads are prohibited on steel joists until all bridging is installed and anchored and all joist bearing ends are attached. There are specific requirements for landing joist bundles and decking bundles.

Structural Steel Assembly


Figure 14.8 Structural Steel Assembly

Specific work practices regarding hoisting deck bundles: The new rule restricts the use of bundle straps for hoisting. Unless designed for hoisting, they can break apart or loosen, create a falling object hazard or, if a structural member is hit by the bundle or its contents, cause the structure to collapse.

Minimizing fall hazards: Trip hazards are reduced by requiring shear connectors to be field-installed rather than shop-installed. That will eliminate this trip hazard by ensuring that workers have a clear surface to walk on while members are being erected.

There are work practice requirements to minimize the number of interior holes and openings:

- All openings should be decked over if possible.
- Large openings (elevator shafts, stairwells, etc.) must be otherwise protected if not decked over.
- Cut holes and openings only when the equipment or structures that will fill them are ready to be installed.
- Gaps around columns must be covered.

The slip hazard caused by painted coatings on skeletal structural steel is addressed by a new slip resistance requirement. To give the industry time to complete development of coatings that will meet the requirement, this provision will not go into effect until July 18, 2006.

Systems-Engineered Metal Buildings


Figure 14.9 Systems-Engineered Metal Buildings

Minimize the risk of collapse in erection of Systems-Engineered Buildings: Systems-engineered metal buildings are often used for anything from sheds to larger structures such as warehouses, gymnasiums, airplane hangars, and arenas. These buildings use different types of steel members and a different erection process than typical steel erection.

Falling Object Protection

Figure 14.10 Falling Object Protection

Provisions that address hazards of falling objects in steel erection: The new rule requires that employees be protected from falling objects. This is a real everyday hazard, as loose items that have been placed aloft that can fall and strike employees working below. All materials, equipment, and tools that are not in use while aloft must either be secured against accidental displacement, or the controlling contractor must bar operations below steel erection.

When it is necessary to work below ongoing steel erection activities (other than hoisting), overhead protection must be provided. If protection is not provided, work by other trades is not permitted below steel erection work. One way a controlling contractor can reduce these hazards is by scheduling work so employees are not exposed.

This part of the standard does NOT deal with the hazard of hoisted materials falling. That hazard is dealt with in the Hoisting and Rigging section.

Fall protection requirements: Fall protection means systems and devices that either physically prevent a worker from falling or arrest a worker's fall. Under the new standard, all workers must be protected at heights greater than 30 feet (or two stories, whichever is less) including connectors and deckers.

However, between 15 and 30 feet/two stories, all workers must be protected with two exceptions. The exceptions are for connectors and for leading edge deckers working in a controlled access zone.

Connectors between 15 and 30 feet/ two stories: At heights between 15 and 30 feet/ two stories, the steel erector must provide conventional fall protection equipment. However, connectors are not required to actually tie-off. So, unless protected by nets or other passive devices, the employer must provide an anchor point and all associated fall arrest equipment. The connector must wear all equipment necessary to tie-off. But that connector need not attach the lanyard to the anchor.

Deckers between 15 and 30 feet (or two stories): The CDZ is an alternative to fall protection for leading edge decking workers between 15 and 30 feet/two stories above a lower level. If an employer establishes a CDZ in this height range, employees authorized to be in the CDZ do not have to be provided with or use a fall protection system.

An important aspect of a CDZ is controlled access. Data indicates that some employees who suffered fatal falls from areas that were being decked were not engaged in leading edge work.

The rule therefore limits access to the CDZ exclusively to those employees who are actually engaged in and trained in the hazards involved in leading edge work.

The CDZ boundaries must be clearly marked to restrict access to the area. The CDZ can be no more than 90 feet wide and 90 feet deep from any leading edge. There can be no more than 3,000 square feet of unsecured decking in a CDZ.

Employees working in a controlled decking zone must be trained to recognize the hazards associated with working in a (CDZ). They must be trained in the establishment, access, safe installation techniques and effective work practices required by the CDZ and Metal Decking provisions.

Training

Figure 14.11 Training

Requires a qualified person to train exposed workers in fall protection: Due to the new requirements involving more widespread use of personal fall protection equipment and special procedures in steel erection, a qualified person is now required to train all exposed workers in fall protection.

The employer can choose the provider, and method and frequency of training for the employees being trained. The provider may be an outside, professional training organization, or other qualified entity, or the employer may develop and conduct the training in-house. Each employee, however, must be provided the training before exposure to the hazard.

Requires qualified person to train exposed workers in special, high-risk activities: Additional training is also required for employees engaged in special high-risk activities such as multiple lift rigging procedures, connecting activities, and work in controlled decking zones. At a minimum the training must cover the nature of the hazards, proper procedures, and work practices required when engaged in these activities.

Specific Controlling Contractor Duties

Four specific duties in the standard are placed specifically on the controlling contractor. They are:

1. Written notification to the steel erector: The new rule is designed to ensure proper communication and pre-planning between contractors pouring concrete footings, contractors making repairs to anchor bolts, the controlling contractor, and the steel erector.

This communication must take place before the beginning of steel erection. The written notifications can be transmitted electronically.

2. Provide adequate layout areas and on-site access roads: The final rule requires that the controlling contractor provide and maintain the access roads and a drained and graded area. These conditions enable the steel erector to move around the site and perform necessary operations in a safe manner. The provision does not apply to roads outside of the construction site.

3. Preclude work below steel erection unless there is overhead protection: When it is necessary to have work performed below on-going steel erection activities (other than hoisting), effective overhead protection must be provided by the employer to those workers to prevent injuries from falling objects.

If this protection is not provided, the controlling contractor must not permit work by other trades below the steel erection work.

4. Choose whether to accept responsibility for fall protection left by the erector: The new rule addresses the need to ensure that fall protection equipment is maintained even after steel erectors have completed their work. Typically, perimeter safety cables are initially installed and maintained by the steel erector, but the cables are still there after steel erection work is completed.

Under the new standard, the controlling contractor must choose either to accept responsibility for this fall protection equipment — and make sure that it is maintained — or have it removed.

OSHA's Website

You can view the complete standard at www.osha.gov

OSHA is developing an electronic tool with training presentations, a handbook with technical links, and frequently asked questions that will provide further help in explaining the standard.

Should you have any further questions, do not hesitate to view the steel erection information web site at www.osha.gov/doc/steelerection/index.html.

Instructor Lesson Plan

Tools-Hand and Power

Lesson Plan – CIO 223-323

Key Concepts

- Basic safety rules for hand and power tools.
- Powder-actuated tools.
- Dangers associated with electric tools.
- Classification of power tools by power sources.

Presentation and Materials

- Allow 30 minutes to present this chapter.
- Use Tools-Hand and Power PowerPoint slides.
- Use Review Questions at the end of the chapter to facilitate discussion.
- Use 30-Hour Construction Outreach course manual.

Standards

Safety and Health Regulations for Construction

- 29 CFR 1926 Subpart I—Tools—Hand and Power

Module 15

Tools—Hand and Power

OSHA: 29 CFR 1926 Subpart I – CIO 223 - 323

Lesson Outline

Hand and Power Tool Safety
Five Basic Safety Rules
Personal Protective Equipment
Hand Tools
Power Tools

General Requirements
Condition of Tools
Guards and Safety Switches
Electric Tools
Pneumatic Tools
Fuel-powered Tools
Powder-actuated Tools
Hydraulic Tools

Common Citations

Review Questions

Other Resources

Overview

What's the difference between a tool that can help you and a hazard that can hurt you? Not a darned thing. Use a tool wrong, and it has just as much chance of injuring you as the bigger, more obvious dangers you face at a construction site. This chapter will teach you about using both hand and power tools safely.

Objectives

After completing this chapter, you should be able to:

Know

- State basic safety rules for hand and power tools.
- Describe a powder-actuated tool.

Apply

- Identify dangers associated with electric tools.
- Classify power tools according to their power sources.

Analyze

- Differentiate between hand and power tools.
- Compare safety precautions of hand tools and power tools.

Hand and Power Tool Safety

You face hazards all around you on a construction site—moving equipment, ladders, airborne contaminants, falling objects—the list goes on. Some of the bigger potential dangers you have to be aware of are your tools. You work with both hand and power tools on the site. Each comes with its own set of hazards. Knowing how to use tools properly and protect yourself and others is important for everyone's safety.

Five Basic Safety Rules

The following five rules can keep everyone safe when working with hand and power tools:

1. Keep all tools in good condition with regular maintenance.
2. Use the right tool for the job.
3. Examine each tool for damage before use.
4. Operate the tool according to the manufacturer's instructions.
5. Use the right protective equipment for the tool.

Follow those five basic rules and you'll have a good start toward a safe work environment.

Personal Protective Equipment

No matter the job, there's a level of personal protective equipment (PPE) you should don to protect yourself. Working with hand and power tools is no different. The PPE you choose will depend on the equipment you're working with and the hazards you'll face at the job site. Your PPE might be as simple as safety glasses or goggles, leather gloves, and safety-toed shoes. You also might need to use respirators, hard hats, leather aprons, coveralls, and bump caps.

Hand Tools

Figure 15.1 Hammers should be used properly.

By definition hand tools are nonpowered; they're powered manually. Hammers, axes, wrenches, screwdrivers, crowbars, chisels—these are hand tools. When you think of the dangers of tools, you probably think more of power tools. However, hand tools come with their own set of hazards:

- Use a screwdriver as a chisel and the tip might break and fly away or the handle might shatter, hitting you or others.
- Work with a handle that's loose, splintered, or cracked on a hammer or axe and the head of the tool might fly off.
- Use an impact tool, such as chisels, wedges, or drift pins, when their heads are mushroomed from wear and tear and the heads might shatter on impact, sending sharp fragments flying.
- Pull on a wrench when its jaws are sprung and it might slip.

The greatest hazard that hand tools present is misuse and improper maintenance. The employer is responsible for providing you with safe tools and equipment as well as making sure you don't use unsafe hand tools. The most important person, though, in ensuring your safety is you. Here are some safety tips for working with hand tools:

- **Inspect tools before using.** Tools that appear to be damaged or have broken handles should be marked unsafe. Remove the tool from service and follow the manufacturer's recommendations. Replace or fix worn out tools or ones needing to be repaired. If you can't fix it immediately, mark it DO NOT USE so others don't use it.
- **Keep knives and scissors sharp.** Dull tools can be more hazardous than sharp ones because they require more force to make them cut.
- **Take care of your tools and use them for the purpose they were intended.** Forcing a small tool to do the job of a large one is asking for trouble. Never use a screwdriver to see if electrical circuits are hot. Never use a machinist's hammer in place of a carpenter's hammer. Do not strike a steel surface, such as an anvil, with a steel hammer because a small piece of steel may break off and injure someone. Pull on wrenches, don't push. When sawing, secure the material in the saw vise.
- **Grip tools firmly.** Hold hand tools securely so they don't slip and hit someone. Don't wear gloves if not necessary because they are bulky and make gripping tools difficult.
- **Direct saw blades, knives, or other hand tools away from aisle areas or coworkers nearby.**

- **Watch your fingers.** Take special care when hammering. Keep your eyes on the nail.
- **Keep your work area, tools, and the floor clean.** Dirty, greasy, and oily tools and floors can cause accidents. Clean and put away all unneeded tools and materials. Clean up spills and scraps from the floor and equipment. Keep paths to exits clear.
- **Wear a filter-type respirator if conditions are dusty.**
- **Wear approved eye protection.**
- **Wear proper clothing.** Don't wear loose, baggy, or highly flammable clothes. To protect against burns, wear clothing such as coveralls, high-top shoes, leather aprons, and leather gloves. Remove all paper from pockets and wear cuffless pants. When working with heavy metals, wear hard-toed shoes with non-skid soles. Avoid wearing synthetic clothing because it has low flashpoints. Don't wear jewelry.
- **Protect your hair, scalp, and head.** Pull back long hair in a band or cap. Be extremely careful with long hair when using a drill or drill press. When handling carpentry materials, wear a hard hat or bump cap to protect your head.
- **Keep your mind on your work.** Avoid horseplay and loud talk. Loud talking as well as pushing, running, and scuffling while working with hand tools can cause serious accidents. Be alert and work defensively.
- **Carry and store tools properly.** Carry any sharp-edge tool or chisel with the cutting edge down. Never carry sharp tools in a pocket. Store all sharp-edge cutting tools with the sharp edges down.

Remember, just because the tool isn't powered doesn't mean it can't hurt you or someone else.

Power Tools

Power tools are any tools that aren't manually powered. They're classified according to their power source: electric, pneumatic, fuel, hydraulic, or powder actuated.

Figure 15.2 The operator of the machine is wearing a hard hat and face shield and keeping the other worker a safe distance away from the radial saw.

Obviously, power tools can be very dangerous if you don't handle or use them properly. Here are some general precautions:

- **Maintain your power tools.** Keep them sharp and clean. Follow the instructions in the user's manual for lubricating and changing accessories.
- **Remove from use all damaged portable electric tools.** Tag them DO NOT USE.
- **Keep all observers a safe distance away from the work area.** Note the picture at right for an example of this.
- **Protect the electrical cord.** Keep the power cord out of the line of the cut. Serious shock may result if the cord is cut. Never carry a tool by the cord or hose. Never yank or pull the cord or hose to disconnect it from a receptacle. Keep cords and hoses away from heat, oil, and sharp edges.
- **Avoid accidental starting.** Keep your fingers away from the switch button when you're carrying a plugged-in tool.
- **Keep guards in place.** They can't protect you if they're not in place and in working order.
- Secure your work with clamps or a vise, freeing both of your hands to work with the tool.
- **Know the machine.** Read the operator's manual and learn the applications, limitations, and potential of each power tool before you begin to use it.
- **Know the switch locations.** That way you can turn off the machine quickly in an emergency.
- **Use safe blades.** Never use cracked or kinked saw blades. Keep saw blades sharp and properly set.
- **Remove nails, staples, and loose knots before sawing.**
- **Provide proper ventilation.** For example, when you use a paint gun in a confined area, it's important to ventilate the hazardous vapors.
- **Keep good footing and maintain your balance.**
- **Work only at operating speed.** Do not use a power tool before it has reached operating speed or while it is coming to a stop. Never force a tool while applying too much pressure.
- **Use both hands.** Use both hands to hold and guide material being sawed.

- Stand in a safe location. Position yourself to avoid being hit if the tool kicks back. Do not stand directly behind the equipment.
- **Never stop moving parts abruptly.** Once a power tool has been turned off, allow it to coast to a stop. Never force an object into moving parts to stop a machine. Be sure the tool has come to a complete stop before laying it down.
- **Wear proper clothing for the type of work performed.** Don't wear loose clothing, ties, or jewelry that can get caught in moving parts. When using a grinder, don't wear gloves. Don't roll up long sleeves. Don't wear highly flammable clothes. Wear safety-toed shoes to protect your feet and toes.
- **Wear a filter-type respirator if conditions are dusty.**
- **Wear approved eye protection.** Safety glasses should have the Z87.1 logo on them to ensure they are industrial quality.
- **Protect your hair, scalp, and head.** Pull back long hair in a band or cap. When handling carpentry materials, wear a hard hat or bump cap to protect your head. Pay attention to where your hair is around moving parts. Even short hair can get caught.
- **Avoid distractions.** Keep your mind on your work. Talking, running, pushing, and scuffling can lead to accidents.
- **Keep your work area, tools, and the floor clean.** Dirty, greasy, and oily tools and floors can cause accidents. Clean and put away all unneeded tools and materials. Clean up spills and scraps from the floor and equipment. Keep paths to exits clear.
- **Never leave a machine unattended.** Make sure all moving parts have come to a complete stop before you leave the work area or before you make minor adjustments.
- **Disconnect tools when you're not using them, before you service them, and when changing accessories such as blades, bits, and cutters.**

General Requirements

In addition to the commonsense tips to follow for using hand and power tools safely, you and your employer also have some general OSHA requirements to follow to ensure your safety at the job site. These requirements are listed beginning in CFR 1926.300, Subpart I. Remember, OSHA requirements were written to protect you against serious injuries in the workplace.

Condition of Tools

Whether you furnish your hand and power tools or any other equipment to work with them or your employer does, the equipment must be in safe working condition. The tools must be maintained, and if they need to be repaired, they shouldn't be used at the job site.

Guards and Safety Switches

Figure 15.3 This saw is properly guarded.

OSHA requires the parts, functions, or processes of any powered machine that may cause injury to be guarded. These mechanical hazards can occur in three basic areas: at the point of operation, the power transmission apparatus, and operation controls. The point of operation is where work, like cutting or drilling, is performed. The power transmission apparatus are parts which transmit energy to the machine. And operation controls refer to moving parts that reciprocate, rotate, and transverse other moving parts.

The purpose of machine guarding is to protect you from hazards caused by nip points, rotating parts, or flying chips and sparks. Belts, gears, shafts, pulleys, sprockets, flywheels, spindles, drums, chains ,or other reciprocating, rotating, or moving parts require a guard.. These guards should never be removed when using a tool.

The easiest way to avoid injury is to use only properly guarded tools. Avoid loose-fitting clothes and long hair that might become entangled in a power tool and remove rings, watches, neck chains, and other jewelry.

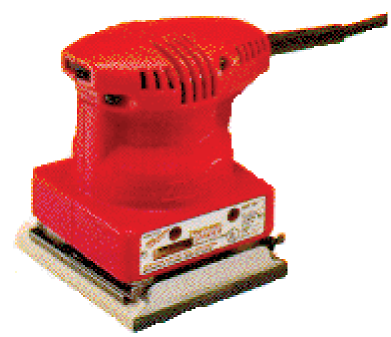


Figure 15.4 A power sander.

Power tools also must have a momentary contact on-off switch to kill the power quickly. The tools also can have a lock-on control. The momentary contact on-off switch requirement applies to power tools with wheels larger than two inches wide (drills, drivers, fasteners, grinders, disc sanders, belt sanders, reciprocating saws, and saber saws).

Sanders and grinders with discs and wheels two or less inches wide may be equipped with a constant pressure switch that kills the power when the pressure is released. Tools with quarter-inch wide or less blades may also have this kind of switch. These tools include routers, planners, trimmers, nibblers, shears, scroll saws, and jigsaws.

Electric Tools

When you work with electric tools, the most common dangers are burns and slight shocks. Don't take these risks lightly. They can lead to injuries and even heart failure. Even a small jolt of current can send your heart into an irregular rhythm. The shock might also make you lose your grip on a ladder or your balance on an elevated work surface. And, of course, the most serious risk with electric tools is electrocution.

To protect yourself from shock, always use a three-wire cord with ground fault circuit interrupters (GFCI) or a two-prong cord with a double insulated tool and a GFCI. Three-wire cords contain two current-carrying conductors and one grounding conductor. Never remove the third prong from the plug.

Figure 15.5 Three-wire cord.

Double insulation protects you and the tools by normal insulation on the wires inside and a housing that can't conduct electricity on the outside.

Follow these rules when using electric tools:

- Operate electric tools within their design limitations.
- Use gloves and safety footwear.
- Store tools in a dry place.
- Do not use electric tools in wet or damp locations.
- Keep work areas well lighted.
- Keep cords under control so you don't trip on them.

Abrasive Wheel

The biggest danger that powered abrasive grinding, cutting, polishing, and wire buffing wheels pose is the flying fragments they can shoot off. Obviously eye protection is paramount.

Before you mount an abrasive wheel, inspect it closely for cracks and defects. Try sound or ring testing it. Tap it gently with a screwdriver handle (image at left). An undamaged wheel gives off a clear sound, or "ring."

Figure 15.6 Abrasive wheel test.

To prevent a wheel from cracking, make sure it fits freely on the spindle. Tighten the spindle nut enough to hold the wheel in place without distorting the flange. Make sure the spindle wheel rotation speed does not exceed the abrasive wheel rotation specifications. Never stand directly in front of the wheel on a powered abrasive tool when in use because the wheel might disintegrate or explode. Guards should be in place to protect you from the moving wheel and from flying fragments.

If you're using a power grinder, turn off the power when not in use. Never clamp a handheld grinder in a vise.

Pneumatic Tools

Compressed air powers pneumatic tools. These include chippers, drills, hammers, and sanders. Wearing the proper PPE is vital because of the tremendous air pressure some of these tools use. Your two biggest dangers with pneumatic tools are being struck by an attachment, such as a hose, or by the fastener the tool might be driving, such as a nail. Eye and face protection is a must when working with pneumatic tools. You also might need ear protection, especially because pneumatic tools such as jackhammers and pavement breakers produce a tremendous amount of noise. Safety shoes are also imperative with jackhammers to protect your feet in case the jackhammer slips.

Pneumatic tools that shoot nails, staples, or fasteners and operate at pressures more than 100 psi must be equipped with a special device to keep fasteners from being ejected unless the muzzle is depressed against a work surface. And of course, NEVER point a compressed air gun toward anyone.

Figure 15.7

Screens must be set up to protect nearby workers from being struck by flying fragments around chippers, riveting guns, staplers, or air drills.

You also must make sure that the connection between the pneumatic tool and air hose is secure to prevent them from disconnecting. A short wire or locking device can attach the air hose to the tool. Air hoses over a half inch in diameter are required to have a safety excess flow valve to shut off the air supply in case the hose breaks.

A safety clip or retainer must be installed to prevent attachments, such as chisels on a chipping hammer, from being shot in the barrel.

Also, never used compressed air to blow down or clean off workers. This could result in an air bubble being forced underneath the skin, which is very dangerous. An air bubble could be injected into the bloodstream and cause serious problems, including blockages of the blood flow to lungs, brains, or other organs. At worst, these blockages could result in a serious stroke or death.

Fuel-powered Tools

Fuel-powered tools usually run on gasoline. As a result, the most serious hazards you face with them are dangerous exhaust fumes, combustible vapors, and explosive gases.

Before refilling a fuel-powered tool tank, shut down the engine and let it cool to prevent accidental ignition of hazardous vapors. If you’re using a fuel powered tool in a closed area, you need effective ventilation or atmosphere supplying respirators to avoid breathing carbon monoxide. Fire extinguishers also have to be available.

Powder-actuated Tools

Figure 15.7 A powder-actuated fastener.

Powder-actuated tools are nail guns used in the construction and manufacturing industries to join materials to hard substrates like steel and concrete. Also known as “direct fastening,” this technology relies on a controlled explosion created by igniting a small chemical propellant charge, similar to the process that activates a firearm.
Because they operate like a loaded gun, not surprisingly, extreme caution must be exercised when using them. In fact, a person must be thoroughly instructed certified in the use of one of these tools by a competent person before operating it, according to OSHA.

If you use a powder-actuated tool, you must wear ear, eye, and face protection.

These tools can shoot a fastener at either low or high velocity. You choose the powder level necessary for doing the work without excessive force.

The muzzle end of the tool must have a protective shield or guard to protect against flying fragments. A tool containing a high-velocity load must be designed not to fire unless it has this kind of safety device.

To prevent the tool from firing accidentally, two separate motions are required for firing. The first motion is to bring the tool into the firing position against a surface, and the second motion is to pull the trigger. The tool must not be able to operate until it is pressed against the work surface.

If a powder-actuated tool misfires, you must hold the tool in the operating position for at least 30 seconds before trying to fire it again. If it still will not fire, you must hold the tool in the operating position for another 30 seconds and then carefully remove the load according to the manufacturer’s instructions. This procedure will make the faulty cartridge less likely to explode. The bad cartridge should then be put in water immediately after removal. If the tool develops a defect during use, it should be tagged and must be taken out of service immediately until it is properly repaired.

Here are safety tips for using powder-actuated nail guns:

- Do not use the tool in an explosive or flammable atmosphere.
- Inspect the tool before using it to determine that it is clean, that all moving parts operate freely, and that the barrel is free from obstructions and has the proper shield, guard, and attachments recommended by the manufacturer.
- Do not load the tool unless it is to be used immediately.
- Do not leave a loaded tool unattended, especially where it would be available to unauthorized persons.
- Keep hands clear of the barrel end.
- Never point the tool at anyone.

When using powder-actuated tools to apply fasteners, several additional procedures must be followed:

- Do not fire fasteners into material that would allow the fasteners to pass through to the other side.
- Do not drive fasteners into very hard or brittle material that might chip or splatter or make the fasteners ricochet.
- Always use an alignment guide when shooting fasteners into existing holes.
- When using a high-velocity tool, do not drive fasteners more than 3 inches from an unsupported edge or corner of material, such as brick or concrete.
- When using a high-velocity tool, do not place fasteners in steel any closer than a half inch from an unsupported corner edge unless a special guard, fixture, or jig is used.

Hydraulic Tools

Hydraulic tools put fluid under pressure to drive the tool. The fluid itself must be fire resistant and able to operate at extreme temperatures. Hydraulic tools range from jacks, hammers, ratchets, levers and rescue equipment.

When using hydraulic powered tools, never exceed the manufacturer's recommended safe operating pressure for hoses, valves, pipes, filters, and other fittings.

All jacks must have a device that stops them from jacking up too high. Also, the manufacturer's load limit must be permanently marked in a prominent place on the jack, and that limit must never be exceeded.

Never use a jack to support a lifted load. Once the load has been lifted, it must immediately be blocked up. Put a block under the base of the jack when the foundation is not firm, and place a block between the jack cap and load if the cap might slip.

Figure 15.8
Hydraulic jack.

To set up a jack, make certain:

- The base of the jack rests on a firm, level surface.
- The jack is correctly centered.
- The jack head bears against a level surface.
- The lift force is applied evenly.

Proper maintenance of jacks is essential for safety. All jacks must be lubricated regularly. In addition, each jack must be inspected on a regular schedule.

Common Citations

Here are some common citations given by OSHA for violations relating to hand and power tools:

Figure 15.9 Grinder with guard.

- **No guards on grinder.** Common injuries occur while grinding welds, and the grinder slips, hitting you in the leg.
- **Grinder wheel not rated for speed of grinder.** Grinding wheels are rated for certain speeds. Using a faster grinding speed may cause the wheel to explode. This also applies to abrasive cutting blades used to cut concrete.
- **No protection for rotating parts.** All tools must guard rotating shafts and parts to prevent you or your clothing from getting caught in them. Equipment usually comes with a guard, and replacements can be ordered from the manufacturer.
- **No training for powder-actuated tools.** You must be trained in the use of these types of tools and wear appropriate PPE. Most manufacturers of these tools will provide training.
- **Mortar mixer is not fully guarded.** Fatalities have occurred when operators have caught their clothing in the mixer blades and been pulled in. This often occurs during the cleaning operation.

Review Questions

1. State the five basic safety rules for hand and power tool use.

- *Keep all tools in good condition with regular maintenance.*
- *Use the right tool for the job.*
- *Examine each tool for damage before use.*
- *Operate the tool according to the manufacturer's instructions.*
- *Use the right protective equipment on the tool.*

2. Give an example of a hand tool.

Hand tools are tools powered manually, like hammers, axes, wrenches, screwdrivers, crowbars, and chisels.

3. Give an example of a power tool.

Power tools need electric, pneumatic, fuel, hydraulic, or powder-actuated sources to run. Examples are chippers, drills, sanders, jackhammers, nail guns, and saws.

4. How are power tools classified?

Tools are classified by their power source—electric, pneumatic, fuel, hydraulic, or powder-actuated.

5. If a chipper is powered by compressed air, what is the classification of that tool?

Compressed air makes this a pneumatic power tool.

6. Compare the safety precautions for hand tools with safety precautions for power tools.

The five basic rules (see question #1) apply for both hand and power tools. Additional safety precautions for power tools are to protect the electrical cord, know the switch locations, avoid accidental starts, work at an operating speed, never stop moving parts abruptly, never leave a machine unattended, and disconnect tools when they are not in use or when servicing them.

7. Explain the protection provided by guards and safety switches on power tools.

Guards protect you from contacting rotating parts or being hit by debris. Safety switches kill the power quickly.

8. What are the most common dangers when working with electric tools?

Burns and shocks are the most common dangers when working with electric tools.

9. List the six rules for using electric tools safely.

- *Operate electronic tools within their design limitations.*
- *Use gloves and safety footwear.*
- *Store tools in a dry place.*
- *Do not use electric tools in wet or damp locations.*
- *Keep work areas well lighted.*
- *Keep cords under control so you don't trip on them.*

10. What is the biggest danger for each of the following tools:

a. abrasive wheel

Flying fragments

b. pneumatic tools

Being struck by an attachment or by a fastener

c. fuel-powered tools

Exhaust fumes, combustible vapors, and explosive gases

11. Describe how a powder-actuated tool works.

These nail guns use a controlled explosion to join materials to hard substrates like steel and concrete. A small chemical propellant charge is ignited similar to the process that activates a firearm.

12. Is the following statement true or false?
You must be certified before operating a powder-actuated tool.

True. Because these tools operate like a loaded gun, a person must be certified in its use before operating it.

Other Resources

OSHA Standard – Subpart I – Tools – Hand and Power
http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10688

OSHA Hand and Power Tools Booklet
http://www.osha.gov/Publications/osha3080.html

OSHA Standard – Guarding of Portable Powered Tools
http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9850

OSHA Standard – Power-operated Hand Tools
http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10690

OSHA QUICKCARD – Electrical Safety
http://www.osha.gov/OshDoc/data_Hurricane_Facts/electrical_safety.pdf

Agricultural Engineering Safety Lesson Plan: Hand Tool Safety
http://www.cdc.gov/nasd/docs/d000701-d000800/d000790/d000790.html

Agricultural Engineering Safety Lesson Plan: Power Tool Safety
http://www.cdc.gov/nasd/docs/d000701-d000800/d000783/d000783.html

Instructor Lesson Plan

Welding and Cutting

OSHA: 29 CFR 1926. Subpart J– CIO 333

Key Concepts

- Welding Health Hazards
- Gas Welding and Cutting
- Arc Welding and Cutting
- Fire Prevention
- Ventilation
- Welding, Cutting, and Heating – Preservative Coatings

Presentation and Materials

- Allow 60 minutes to present this chapter.
- Use Fire Welding and Cutting PowerPoint slides.
- Use Review Questions at the end of the chapter to facilitate discussion.
- Use 30-Hour Construction Outreach course manual.

Standards

Safety and Health Regulations for Construction, Subpart J, Welding and Cutting

- 29 CFR 1926 Subpart J

Module 16

Welding and Cutting

OSHA: 29 CFR 1926. Subpart J– CIO 333

Lesson Outline

Welding, Cutting, and Brazing

Welding Health Hazards
Chemical Agents
Physical Agents

Gas Welding and Cutting – 29 CFR 1926.350
Transporting, Moving, and Storing Compressed Gas Cylinders
Placing Cylinders
Treatment of Cylinders
Use of Fuel Gas
Fuel Gas and Oxygen Manifolds
Hose
Torches
Regulators and Gauges
Oil and Grease Hazards
Additional Rules

ARC Welding and Cutting – 29 CFR 1926.351
Manual Electrode Holders
Welding Cables and Connectors
Ground Returns and Machine Grounding
Operating Instructions
Shielding

Fire Prevention – 29 CFR 1926.352

Ventilation – 29 CFR 1926.353
Mechanical Ventilation
Welding, Cutting, and Heating in Confined Spaces
Welding, Cutting, or Heating of Metals of Toxic Significance
Inert-Gas Metal-Arc Welding
General Welding, Cutting, and Heating

Welding, Cutting, and Heating – Preservative Coatings - 29 CFR 1926.354

Review Questions

Overview

OSHA Reference: 29 CFR 1926.350 - Subpart J

Objectives

After completing this chapter, you should be able to:

Know

- Describe the following:
    - Welding Health Hazards
    - Gas Welding and Cutting
    - Arc Welding and Cutting
    - Fire Prevention
    - Ventilation
    - Welding, Cutting, and Heating – Preservative Coatings

Welding, Cutting, and Brazing

Welding, cutting, and brazing are hazardous activities which pose a unique combination of both safety and health risks to over 500,000 workers in a wide variety of industries. The risk from fatal injuries alone is more than four deaths per thousand workers over a working lifetime. OSHA is developing an action plan which will reduce worker exposures to these hazards but is not initiating rulemaking at this time.

Welding Health Hazards

CHEMICAL AGENTS

Zinc
Zinc is used in large quantities in the manufacture of brass, galvanized metals, and various other alloys. Inhalation of zinc oxide fumes can occur when welding or cutting on zinc-coated metals. Exposure to these fumes is known to cause metal fume fever. Symptoms of metal fume fever are very similar to those of common influenza. They include fever (rarely exceeding 102o F), chills, nausea, dryness of the throat, cough, fatigue, and general weakness and aching of the head and body. The victim may sweat profusely for a few hours, after which the body temperature begins to return to normal. The symptoms of metal fume fever have rarely, if ever, lasted beyond 24 hours. The subject can then appear to be more susceptible to the onset of this condition on Mondays or on weekdays following a holiday than they are on other days.

Cadmium
Cadmium is used frequently as a rust-preventive coating on steel and also as an alloying element. Acute exposures to high concentrations or cadmium fumes can produce severe lung irritation, pulmonary edema, and in some cases, death. Long-term exposure to low levels of cadmium in air can result in emphysema (a disease affecting the ability of the lung to absorb oxygen) and can damage the kidneys. Cadmium is classified by OSHA, NIOSH, and EPA as a potential human carcinogen.

Beryllium
Beryllium is sometimes used as an alloying element with copper and other base metals. Acute exposure to high concentrations of beryllium can result in chemical pneumonia. Long-term exposure can result in shortness of breath, chronic cough, and significant weight loss, accompanied by fatigue and general weakness.

Iron Oxide
Iron is the principal alloying element in steel manufacture. During the welding process, iron oxide fumes arise from both the base metal and the electrode. The primary acute effect of this exposure is irritation of nasal passages, throat, and lungs. Although long-term exposure to iron oxide fumes may result in iron pigmentation of the lungs, most authorities agree that these iron deposits in the lung are not dangerous.

Mercury
Mercury compounds are used to coat metals to prevent rust or inhibit foliage growth (marine paints). Under the intense heat of the arc or gas flame, mercury vapors will be produced. Exposure to these vapors may produce stomach pain, diarrhea, kidney damage, or respiratory failure. Long-term exposure may produce tremors, emotional instability, and hearing damage.

Lead
The welding and cutting of lead-bearing alloys or metals whose surfaces have been painted with lead-based paint can generate lead oxide fumes. Inhalation and ingestion of lead oxide fumes and other lead compounds will cause lead poisoning. Symptoms include metallic taste in the mouth, loss of appetite, nausea, abdominal cramps, and insomnia. In time, anemia and general weakness, chiefly in the muscles of the wrists, develop. Lead adversely affects the brain, central nervous system, circulatory system, reproductive system, kidneys, and muscles.

Fluorides
Fluoride compounds are found in the coatings of several types of fluxes used in welding. Exposure to these fluxes may irritate the eyes, nose, and throat. Repeated exposure to high concentrations of fluorides in air over a long period may cause pulmonary edema (fluid in the lungs) and bone damage. Exposure to fluoride dusts and fumes has also produced skin rashes.

Chlorinated Hydrocarbon Solvents
Various chlorinated hydrocarbons are used in degreasing or other cleaning operations. The vapors of these solvents are a concern in welding and cutting because the heat and ultraviolet radiation from the arc will decompose the vapors and form highly toxic and irritating phosgene gas. (See Phosgene.)

Phosgene
Phosgene is formed by decomposition of chlorinated hydrocarbon solvents by ultraviolet radiation. It reacts with moisture in the lungs to produce hydrogen chloride, which in turn destroys lung tissue. For this reason, any use of chlorinated solvents should be well away from welding operations or any operation in which ultraviolet radiation or intense heat is generated.

Carbon Monoxide

Carbon monoxide is a gas usually formed by the incomplete combustion of various fuels. Welding and cutting may produce significant amounts of carbon monoxide. In addition, welding operations that use carbon dioxide as the inert gas shield may produce hazardous concentrations of carbon monoxide in poorly ventilated areas. This is caused by a “breakdown” of shielding gas. Carbon monoxide is odorless, colorless and tasteless and cannot be readily detected by the senses. Common symptoms of overexposure include pounding of the heart, a dull headache, flashes before the eyes, dizziness, ringing in the ears, and nausea.

Ozone

Ozone (O3) is produced by ultraviolet light from the welding arc. Ozone is produced in greater quantities by gas metal arc welding (GMAW or short-arc), gas tungsten arc welding (GTAW or heli-arc), and plasma arc cutting. Ozone is a highly active form of oxygen and can cause great irritation to all mucous membranes. Symptoms of ozone exposure include headache, chest pain, and dryness of the upper respiratory tract. Excessive exposure can cause fluid in the lungs (pulmonary edema). Both nitrogen dioxide and ozone are thought to have long-term effects on the lungs.

PHYSICAL AGENTS

Ultraviolet Radiation

Ultraviolet radiation (UV) is generated by the electric arc in the welding process. Skin exposure to UV can result in severe burns, in many cases without prior warning. UV radiation can also damage the lens of the eye. Many arc welders are aware of the condition known as “arc-eye,” a sensation of sand in the eyes. This condition is caused by excessive eye exposure to UV. Exposure to ultraviolet rays may also increase the skin effects of some industrial chemicals (coal tar and cresol compounds, for example).

Infrared Radiation

Exposure to infrared radiation (IR), produced by the electric arc and other flame cutting equipment may heat the skin surface and the tissues immediately below the surface. Except for this effect, which can progress to thermal burns in some situations, infrared radiation is not dangerous to welders. Most welders protect themselves from IR (and UV) with a welder’s helmet (or glasses) and protective clothing.

Intense Visible Light

Exposure of the human eye to intense visible light can produce adaptation, pupillary reflex, and shading of the eyes. Such actions are protective mechanisms to prevent excessive light from being focused on the retina. In the arc welding process, eye exposure to intense visible light is prevented for the most part by the welder’s helmet. However, some individuals have sustained retinal damage due to careless “viewing” of the arc. At no time should the arc be observed without eye protection.

Nitrogen Oxides

The ultraviolet light of the arc can produce nitrogen oxides (NO, NO2), from the nitrogen (N) and oxygen (O2) in the air. Nitrogen oxides are produced by gas metal arc welding (GMAW or short-arc), gas tungsten arc welding (GTAW or heli-arc), and plasma arc cutting. Even greater quantities are formed if the shielding gas contains nitrogen. Nitrogen dioxide (NO2), one of the oxides formed, has the greatest health effect. This gas is irritating to the eyes, nose and throat but dangerous concentrations can be inhaled without any immediate discomfort. High concentrations can cause shortness of breath, chest pain, and fluid in the lungs (pulmonary edema).

Gas Welding and Cutting - 29 CFR 1926.350

TRANSPORTING, MOVING, AND STORING COMPRESSED GAS CYLINDERS


Figure 16.1 Compressed gas cylinders.

- Valve protection caps shall be in place and secured.
- When cylinders are hoisted, they shall be secured on a cradle, sling board, or pallet. They shall not be hoisted or transported by means of magnets or choker slings.
- Cylinders shall be moved by tilting and rolling them on their bottom edges. They shall not be intentionally dropped, struck, or permitted to strike each other violently.
- When cylinders are transported by powered vehicles, they shall be secured in a vertical position.
- Valve protection caps shall not be used for lifting cylinders from one vertical position to another. Bars shall not be used under valves or valve protection caps to pry cylinders loose when frozen. Warm, not boiling, water shall be used to thaw cylinders loose.
- Unless cylinders are firmly secured on a special carrier intended for this purpose, regulators shall be removed and valve protection caps put in place before cylinders are moved.
- A suitable cylinder truck, chain, or other steadying device shall be used to keep cylinders from being knocked over while in use.
- When work is finished, when cylinders are empty, or when cylinders are moved at any time, the cylinder valve shall be closed.
- Compressed gas cylinders shall be secured in an upright position at all times, if necessary, for short periods of time while cylinders are actually being hoisted or carried.
- Oxygen cylinders in storage shall be separated from fuel-gas cylinders or combustible materials (especially oil or grease), a minimum distance of 20 feet (6.1 m) or by a noncombustible barrier at least 5 feet (1.5 m) high having a fire-resistance rating of at least one-half hour.
- Inside of buildings, cylinders shall be stored in a well-protected, well-ventilated, dry location, at least 20 feet (6.1 m) from highly combustible materials such as oil or excelsior. Cylinders should be stored in definitely assigned places away from elevators, stairs, or gangways. Assigned storage places shall be located where cylinders will not be knocked over or damaged by passing or falling objects, or subject to tampering.
- The in-plant handling, storage, and utilization of all compressed gases in cylinders, portable tanks, rail tank cars, or motor vehicle cargo tanks shall be in accordance with Compressed Gas Association Pamphlet P-1-1965.

PLACING CYLINDERS

- Cylinders shall be kept far enough away from the actual welding or cutting operation so that sparks, hot slag, or flame will not reach them. When this is impractical, fire resistant shields shall be provided.
- Cylinders shall be placed where they cannot become part of an electrical circuit. Electrodes shall not be struck against a cylinder to strike an arc.
- Fuel gas cylinders shall be placed with valve end up whenever they are in use. They shall not be placed in a location where they would not be subject to open flame, hot metal, or other sources of artificial heat.
- Cylinders containing oxygen or acetylene or other fuel gas shall not be taken into confined spaces.

TREATMENT OF CYLINDERS

- Cylinders, whether full or empty, shall not be used as rollers or supports.
- No person other than the gas supplier shall attempt to mix gases in a cylinder. No one except the owner of the cylinder or person authorized by him shall refill a cylinder. No one shall use a cylinder's contents for purposes than those intended by the supplier. All cylinders used shall meet the Department of Transportation requirements published in 49 CFR Part 178, Subpart C, Specification for Cylinders.
- No damaged or defective cylinder shall be used.

USE OF FUEL GAS

The employer shall thoroughly instruct employees in the safe use of fuel gas, as follows:

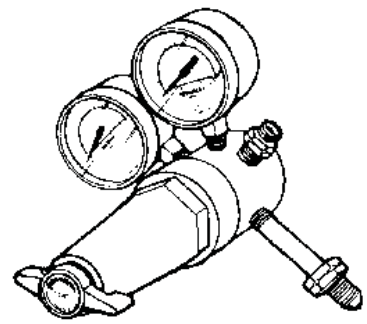


Figure 16.2 Regulator

- Fuel gas shall not be used from cylinders through torches or other devices which are equipped with shutoff valves without reducing the pressure through a suitable regulator attached to the cylinder valve or manifold.
- Before a regulator to a cylinder valve is connected, the valve shall be opened slightly and closed immediately. (This action is generally termed "cracking" and is intended to clear the valve of dust or dirt that might otherwise enter the regulator.) The person cracking the valve shall stand to one side of the outlet, not in front of it. The valve of a fuel gas cylinder shall not be cracked where the gas would reach welding work, sparks, flame, or other possible sources of ignition.
- The cylinder valve shall always be opened slowly to prevent damage to the regulator. For quick closing, valves of fuel gas cylinders shall not be opened more than 1-1/2 turns. When a special wrench is required, it shall be left in position on the stem of the valve while the cylinder is in use so that the fuel gas flow can be shut off quickly in case of an emergency. In the case of manifold or coupled cylinders, at least one such wrench shall always be available for immediate use. Nothing shall be placed on top of a fuel gas cylinder, when in use, which may damage the safety device or interfere with the quick closing of the valve.

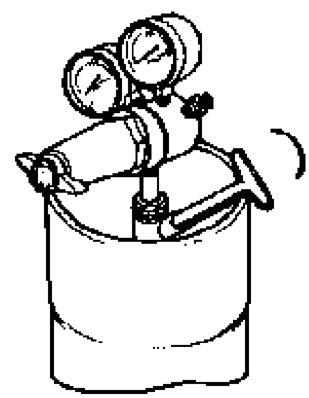


Figure 16.3 1 -1/2 turns max.

- Before a regulator is removed from a cylinder valve, the cylinder valve shall always be closed and the gas released from the regulator.
- If, when the valve on a fuel gas cylinder is opened, there is found to be a leak around the valve stem, the valve shall be closed and the gland nut tightened. If this action does not stop the leak, the use of the cylinder shall be discontinued, and it shall be properly tagged and removed from the work area. In the event that fuel gas should leak from the cylinder valve, rather than from the valve stem, and the gas cannot be shut off, the cylinder shall be properly tagged and removed from the work area. If a regulator is attached to a cylinder valve will effectively stop a leak through the valve seat, the cylinder need not be removed from the work area.
- If a leak should develop at a fuse plug or other safety device, the cylinder shall be removed from the work area.
-

FUEL GAS AND OXYGEN MANIFOLDS

- Fuel gas and oxygen manifolds shall bear the name of the substance they contain in letters at least 1-inch high which shall be either painted on the manifold or on a sign permanently attached to it. These manifolds shall be placed in safe, well ventilated, and accessible locations and not be located within enclosed spaces.
- Manifold hose connections, including both ends of the supply hose that lead to the manifold, shall be such that the hose cannot be interchanged between fuel gas and oxygen manifolds and supply header connections. Adapters shall not be use to permit the interchange of hose. Hoses connections shall be kept free of grease and oil.
- When not in use, manifold and header hose connections shall be capped.
- Nothing shall be placed on top of a manifold, when in use, which will damage the manifold or interfere with the quick closing of the valves.

HOSE

- Fuel gas and oxygen hose shall be easily distinguishable from each other. The contrast may be made by different colors or by surface characteristics readily distinguishable by the sense of touch.
- Oxygen and fuel gas hoses shall not be interchangeable. (See accompanying figure for example.) A single hose having more than one gas passage shall not be used.

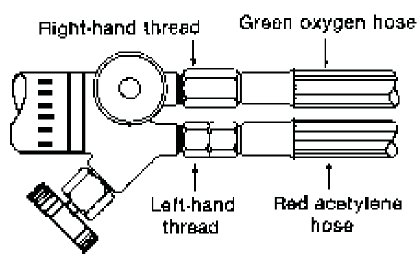


Figure 16.4 Oxygen and fuel gas hoses shall not be interchangeable.

- When parallel sections of oxygen and fuel gas hose are taped together, not more than 4 inches out of 12 inches shall be covered by tape.
- All hose in use, carrying acetylene, oxygen, natural or manufactured fuel gas, or any gas or substance which may ignite or enter into combustion, or be in any way harmful to employees, shall be inspected at the beginning of each working shift. Defective hose shall be removed from service.
- Hose which has been subject to flashback, or which shows evidence of severe wear or damage, shall be tested to twice the normal pressure to which it is subject, but in no case less than 300 p.s.i. Defective hose, or hose in doubtful condition, shall not be used.
- Hose couplings shall be of the type that cannot be unlocked or disconnected by means of a straight pull without rotary motion.
- Boxes used for the storage of gas hose shall be ventilated.
- Hoses, cables, and other equipment shall be kept clear of passageways, ladders, and stairs.

TORCHES

- Clogged torch tip openings shall be cleaned with suitable cleaning wires, drills, or other devices designed for such purpose.
- Torches in use shall be inspected at the beginning of each working shift for leaking shutoff valves, hose couplings, and tip connections. Defective torches shall not be used.
- Torches shall be lighted by friction lighters or other approved devices, and not by matches or from hot work.

REGULATORS AND GAUGES

Oxygen and fuel gas pressure regulators, including their related gauges, shall be in proper working order while in use.

OIL AND GREASE HAZARDS

Oxygen cylinders and fittings shall be kept away from oil or grease. Cylinders, cylinder caps and valves, couplings, regulators, hose, and apparatus shall be kept free from oil or greasy substances and shall not be handled with oily hands or gloves. Oxygen shall not be directed at oily surfaces, greasy clothes, or within a fuel oil or other storage tank or vessel.

ADDITIONAL RULES

For additional details not covered in this subpart, applicable technical portions of American National Standards Institute, Z49.1-1967, *Safety in Welding and Cutting*, shall apply.

Arc Welding and Cutting - 29 CFR 1926.351

MANUAL ELECTRODE HOLDERS

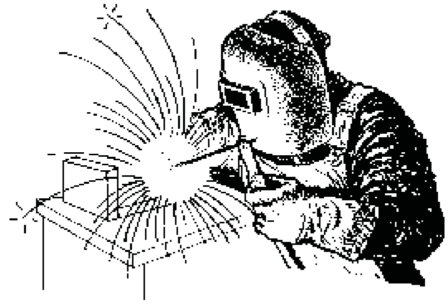


Figure 16.5 Manual electrode holder.

- Only manual electrode holders which are specifically designed for arc welding and cutting, and are of a capacity capable of safely handling the maximum rated current required by the electrodes, shall be used.
- Any current-carrying parts passing through the portion of the holder which the arc welder or cutter grips in his hand, and the outer surfaces of the jaws of the holder, shall be fully insulated against the maximum voltage encountered to ground.

WELDING CABLES AND CONNECTORS

- All arc welding and cutting cables shall be of the completely, insulated, flexible type, capable of handling the maximum current requirements of the work in progress, taking into account the duty cycle under which the arc welder or cutter is working.
- Only cable free from repair or splices for a minimum distance of 10 feet from the cable end to which the electrode holder is connected shall be used, except that cables with standard insulated connectors or with splices whose insulating quality is equal to that of the cable are permitted.
- Cables in need of repair shall not be used. When a cable, other than the cable lead referred to above, becomes worn to the extent of exposing bare conductors, the portion thus exposed shall be protected by means of rubber and friction tape or other equivalent insulation.
- When it becomes necessary to connect or splice lengths of cable one to another, substantial insulated connectors of a capacity at least equivalent to that of the cable shall be used. If connections are effected by means of cable lugs, they shall be securely fastened together to give good electrical contact, and the exposed metal parts of the lugs shall be completely insulated.

GROUND RETURNS AND MACHINE GROUNDING

- A ground return cable shall have a safe current-carrying capacity equal to or exceeding the specified maximum output capacity of the arc welding or cutting unit which it services. When a single ground return cable services more than one unit, its safe current-carrying shall exceed the total specified maximum output capacities of the all the units which it services.
- Pipelines containing gases or flammable liquids, or conduits containing electrical circuits, shall not be used as a ground return.
- When a structure or pipeline is employed as a ground return circuit, it shall be determined that the required electrical contact exists at all joints. The generation of an arc, sparks, or heat at any point shall cause rejection of the structures as a ground circuit.
- When a structure or pipeline is continuously employed as a ground return circuit, all joints shall be bonded, and periodic inspections shall be conducted to ensure that no condition of electrolysis or fire hazard exists by virtue of such use.
- The frames of all arc welding and cutting machines shall be grounded either through a third wire in the cable containing the circuit conductor or through a separate wire which is grounded at the source of the current. Grounding circuits, other than by means of the structure, shall be checked to ensure that the circuit between the ground and the grounded power conductor has resistance low enough to permit sufficient current to flow to cause the fuse or circuit breaker to interrupt the current.
- All ground connections shall be inspected to ensure that they are mechanically strong and electrically adequate for the required current.
-

OPERATING INSTRUCTIONS

Employers shall instruct employees in the safe means of arc welding and cutting as follows:

- When electrode holders are to be left unattended, the electrodes shall be removed and the holders shall be so placed or protected that they cannot make electrical contact with employees or conducting objects.
- Hot electrode holders shall not be dipped in water; to do so may expose the arc welder or cutter to electric shock.
- When the arc welder or cutter has occasion to leave his work or to stop work for any appreciable length of time, or when the arc welding or cutting machine is to be moved, the power supply switch to the equipment shall be opened.
- Any faulty or defective equipment shall be reported to the supervisor.
- A disconnecting means shall be provided in the supply circuit for each motor generated arc welder, and for each AC transformer and DC rectifier arc welder which is not equipped with a disconnect mounted as an integral part of the welder.
- A switch or circuit breaker shall be provided by which each resistance welder and its control equipment can be isolated from the supply circuit. The ampere rating of this disconnecting means shall not be less than the supply conductor ampacity.

SHIELDING

Whenever practicable, all arc welding and cutting operations shall be shielded by noncombustible or flameproof screen which will protect employees and other persons working in the vicinity from the direct rays of the arc.

Fire Prevention - 29 CFR 1926.352

- When practical, objects to be welded, cut, or heated shall be moved to a designated safe location or, if these objects cannot be readily moved, all movable fire hazards in the vicinity shall be taken to a safe place, or otherwise protected. If these objects cannot be moved and if all the fire hazards cannot be removed, positive means shall be taken to confine the heat, sparks, and slag, and to protect the immovable fire hazards from them.
- No welding, cutting or heating shall be done where the application of flammable paints, or the presence of other flammable compounds, or heavy dust concentrations creates a hazard.
- Suitable fire extinguishing equipment shall be immediately available in the work area and shall be maintained in a state or readiness for instant use.
- When the welding, cutting, or heating operation is such that normal fire prevention precautions are not sufficient, additional personnel shall be assigned to guard against fire while the actual welding, cutting, or heating operation is being performed, and for a sufficient period of time after completion of the work to ensure that no possibility of fire exists. Such personnel shall be instructed as to the specific anticipated fire hazards and how the firefighting equipment provided is to be used.
- When welding, cutting, or heating is performed on walls, floors, and ceilings, since direct penetration of sparks or heat transfer may introduce a fire hazard to an adjacent area, the same precautions shall be taken on the opposite side as are taken on the side on which the welding is being performed.
- For the elimination of possible fire in enclosed spaces as a result of gas escaping through leaking or improperly closed torch valves, the gas supply to the torch shall be positively shut off at some point outside the enclosed space whenever the torch is not to be used or whenever the torch is left unattended for a substantial period of time, such as during the lunch period.
- Overnight and at the change of shifts, the torch and hose shall be removed from the confined space. Open end fuel gas and oxygen hoses shall be immediately removed from enclosed spaces when they are disconnected from the torch or other gas-consuming device.
- Except when the contents are being removed or transferred, drums, pails, and other containers which contain or have contained flammable liquids shall be kept closed. Empty containers shall be removed to a safe area apart from hot work operations or open flames.
- Drums, containers, or hollow structures which have contained toxic or flammable substances shall, before welding, cutting, or heating is undertaken on them, either be filled with water or thoroughly cleaned of such substances and ventilated and tested.
- Before heat is applied to a drum, container, or hollow structure, a vent or opening shall be provided for the release of any built-up pressure during the application of heat.

Ventilation and Protection - 29 CFR 1926.353

MECHANICAL VENTILATION

- Mechanical ventilation shall consist of either general mechanical ventilation systems or local exhaust systems.
- Ventilation shall be deemed adequate if it is of sufficient capacity and so arranged as to remove fumes and smoke at the source and keep their concentration in the breathing zone within safe limits as defined in Subpart D of Part 1926, Occupational Health and Environmental Controls.
- Contaminated air exhausted from a working space shall be discharged clear of the source of intake air.
- All air replacing that withdrawn shall be clean and respirable.
- Oxygen shall not be used for ventilation purposes, comfort cooling, blowing dust from clothing, or for cleaning the work area.

WELDING, CUTTING, AND HEATING IN CONFINED SPACES

- Except where air line respirators are required or allowed as described below, adequate mechanical ventilation meeting the requirements described above shall be provided whenever welding, cutting, or heating is performed in a confined space.
- When sufficient ventilation cannot be obtained without blocking the means of access, employees in the confined space shall be protected by air line respirators in accordance with the requirements of Subpart E of Part 1926, Personal Protective and Life Saving Equipment. An employee on the outside of the confined space shall be assigned to maintain communication with those working within it and to aid them in an emergency.
- Where a welder must enter a confined space through a small opening, means shall be provided for quickly removing him in case of emergency. When safety belts and lifelines are used for this purpose they shall be so attached to the welder's body that his body cannot be jammed in a small exit opening. An attendant with a pre-planned rescue procedure shall be stationed outside to observe the welder at all times and be capable of putting rescue operations into effect.

WELDING, CUTTING, OR HEATING OF METALS OF TOXIC SIGNIFICANCE

Welding, cutting, or heating in any enclosed spaces involving the following metals shall be performed with adequate mechanical ventilation as described above:

- Zinc-bearing base or filler metals or metals coated with zinc-bearing materials;
- Lead base metals;
- Cadmium-bearing filler materials;
- Chromium-bearing metals or metals coated with chromium-bearing materials.

Welding, cutting, or heating in any enclosed spaces involving the following metals shall be performed with adequate local exhaust ventilation as described above or employees shall be protected by air line respirators in accordance with the requirements of Subpart E:

- Metals containing lead, other than as an impurity, or metals coated with lead-bearing materials;
- Cadmium-bearing or cadmium-coated base metals;
- Metal coated with mercury-bearing metals;
- Beryllium-containing base or filler metals. Because of its high toxicity, work involving beryllium shall be done with both local exhaust ventilation and air line respirators.

Employees performing such operations in the open air shall be protected by filter-type respirators in accordance with the requirements of Subpart E, except that employees performing such operations on beryllium-containing base or filler metals shall be protected by air line respirators in accordance with the requirements of Subpart E.

Other employees exposed to the same atmosphere as the welders or burners shall be protected in the same manner as the welder or burner.

INERT-GAS METAL-ARC WELDING

Since the inert-gas metal-arc welding process involves the production of ultra-violet radiation of intensities of 5 to 30 times that produced during shielded metal-arc welding, the decomposition of chlorinated solvents by ultraviolet rays, and the liberation of toxic fumes and gases, employees shall not be permitted to engage in, or be exposed to the process until the following special precautions have been taken:

- The use of chlorinated solvents shall be kept at least 200 feet, unless shielded, from the exposed arc, and surfaces prepared with chlorinated solvents shall be thoroughly dry before welding is permitted on such surfaces.
- Employees in the area not protected from the arc by screening shall be protected by filter lenses meeting the requirements of Subpart E. When two or more welders are exposed to each other's arc, filter lens goggles of a suitable type, meeting the requirements of Subpart E, shall be worn under welding helmets. Hand shields to protect the welder against flashes and radiant energy shall be used when either the helmet is lifted or the shield is removed.
- Welders and other employees who are exposed to radiation shall be suitably protected so that the skin is covered completely to prevent burns and other damage by ultraviolet rays. Welding helmets and hand shields shall be free of leaks and openings, and highly reflective surfaces.
- When inert-gas metal-arc welding is being performed on stainless steel, adequate local exhaust ventilation as described above or air line respirators in accordance with the requirements of Subpart E shall be used to protect against dangerous concentrations of nitrogen dioxide.

GENERAL WELDING, CUTTING, AND HEATING

Welding, cutting, or heating not involving conditions or toxic materials described above may normally be done without mechanical ventilation or respiratory protective equipment. These protections shall be provided, however, where an unsafe accumulation of contaminants exists because of unusual physical or atmospheric conditions.

Employees performing any type of welding, cutting, or heating shall be protected by suitable eye protective equipment in accordance with the requirements of Subpart E.

Welding, Cutting, and Heating – Preservative Coatings – 29 CFR 1926.354

Before welding, cutting, or heating is commenced on any surface covered by a preservative coating whose flammability is not known, a test shall be made by a competent person to determine its flammability. Preservative coatings shall be considered to be highly flammable when scrapings burn with extreme rapidity.

When coatings are determined to be highly flammable, they shall be stripped from the area to be heated to prevent ignition.

Protection against toxic preservative coatings:

- In enclosed spaces, all surfaces covered with toxic preservatives shall be stripped of all toxic coatings for a distance of at least 4 inches from the area of heat application, or the employees shall be protected by air line respirators meeting the requirements of Subpart E.
- In the open air, employees shall be protected by a respirator, in accordance with the requirements of Subpart E.

The preservative coatings shall be removed a sufficient distance from the area to be heated to ensure that the temperature of the unstripped metal will not be appreciably raised. Artificial cooling of the metal surrounding the heating area may be used to limit the size of the area required to be cleaned.

Review Questions

1. When cylinders are transported by powered vehicles, they shall be secured in a:

   A. horizontal position
   B. vertical position
   C. diagonal position
   D. pallet

   B. vertical position

2. Oxygen cylinders in storage shall be separated from fuel-gas cylinders or combustible materials, a minimum distance of 20 feet or by a noncombustible barrier at least 5 feet high having a fire-resistance rating of at least 1/2 hour. True or False?

   True

3. Fill in the blank.
   Fuel gas cylinders shall be placed with the ____*valve*____ end up when in use.

4. Valves of fuel gas cylinders should not be opened more than:

   A. 3/4 turn
   B. 2 - 3 turns
   C. 1/4 turn
   D. 1-1/2 turns

   D. 1-1/2 turns

5. Hot electrode holders should be dipped in water to cool them down. True or False?

   True

6. Torches shall be lighted by friction lighters or other approved devices, and not by:

matches or hot work

7. Oxygen shall not be used for:

A. ventilation
B. comfort cooling
C. blowing dust from clothing
D. all of the above

D. all of the above

Document Legacy Log

Status (Baseline/ Revision/ Canceled)	**Document** **Revision** **Control Number** M/C/D/F-XXX-20XX.XX	**Effective Date** Month/Year	**Description of Changes**
Baseline	M-068-2014	3/2014	Updated Instructor Notes, Updated Appendices with New Releases from OSHA
Revision	M-068-2014.ST & IN	5/2014	Updated 6-42 Mobile Crane Bullet

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