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OSH Technical Reference Manual

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MASTER

Preface

In an evaluation of the Department of Energy (DOE) Occupational Safety and Health programs for government-owned contractor-operated (GOCO) activities, the Department of Labor's Occupational Safety and Health Administration (OSHA) recommended a technical information exchange program. The intent was to share written safety and health programs, plans, training manuals, and materials within the entire DOE community. The OSH Technical Reference (OTR) helps support the secretary's response to the OSHA finding by providing a one-stop resource and referral for technical information that relates to safe operations and practice. It also serves as a technical information exchange tool to reference DOE-wide materials pertinent to specific safety topics and, with some modification, as a training aid. The OTR bridges the gap between general safety documents and very specific requirements documents. It is tailored to the DOE community and incorporates DOE field experience.

The OTR provides a one-point referral source for information on various safety related topics such as robotics, lockout/tagout, electrical shock, etc. Each topic is addressed in a separate chapter. All chapters basically have the same format for easy reference, and they discuss the following general topics:

- DOE incidence of injuries.
- Unsafe acts and unsafe conditions that would result in injury or property damage.
- Personal protective equipment.
- Good work practices.
- Training.
- Hazards associated with equipment and work tasks.

In addition, each chapter:

- Lists pertinent codes and standards.
- Includes a bibliography.
- Includes a safety checklist.

Users can make comprehensive self-assessments of their work area. By combining the appropriate questions from each chapter, a detailed self-inspection checklist can be tailored to the work area. For example, parts of walking/working surfaces, electrical shock, personal protective equipment, and machine guarding chapters can be applied to a carpentry shop.

To provide the safest and most productive environment for both DOE and contractor personnel, both DOE mandatory standards and nonmandatory standards were used to develop these chapters, including safety checklists. However, it is important to note that these chapters are not safety requirement documents but do set minimums for good practice.

The following terminology is used throughout the OTR:

- "Shall" indicates a mandatory requirement.
- "Must" also indicates a mandatory requirement and in addition expresses a declaration of intent, probability, or determination.
- "Should" indicates a preferred method of accomplishment.
- "May" indicates an acceptable or satisfactory method of accomplishment.

This regulatory information is correct at the time of issuance, however, please refer to current OSHA regulations. This document is a "living" document and may be changed in the future to meet the technical and professional needs of the Department of Energy and to reflect technological change. Current recipients will receive all changes.

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DISCLAIMER

Chapter 1
Industrial Robots

1. Introduction

1.1 Incidence of Robotic Accidents

Studies in Sweden and Japan indicate that many robot accidents occur during programming, program touchup, maintenance, repair, testing, setup, or adjustment rather than under normal operating conditions. The operator, programmer, or corrective maintenance worker may temporarily be within the robot's working envelope where unintended operations can result in injury. For example:

- A robot's arm functioned erratically during a programming sequence and struck the operator.
- A materials-handling-robot operator entered a robot's work envelope during operations and was pinned between the back end of the robot and a safety pole.
- A fellow employee accidentally tripped the power switch while a maintenance worker was servicing an assembly robot. The robot's arm struck the maintenance worker's hand.

1.2 Causes of Robotic Accidents

Unsafe Acts

- Placing oneself in hazardous positions while programming or performing maintenance within the robot's work envelope.
- Inadvertently entering the envelope because of unfamiliarity with the safeguards in place or not knowing if they are activated.
- Making errors in programming, interfacing peripheral equipment, and connecting input/output sensors.

Unsafe Conditions

- Mechanical failure.
- Safeguards deactivated.
- Intrinsic faults within the control system of the robot, errors in software, electromagnetic interference, and radio-frequency interference.
- Hazards from pneumatic, hydraulic, or electrical power that can result from malfunction of control or transmission elements of the robot's power system such as control valves, voltage variations, or voltage transients disrupting the electrical signals to the control and/or power supply lines.
- High temperature ignition that can result from electrical overloads or from the use of flammable hydraulic oil.
- Electrical shock and release of stored energy from accumulating devices that can result in injury to personnel.

1.3 Prevention Overview

System components must be designed, installed, and secured so that the hazards associated with stored energy are minimized. Adequate room must be provided for a robot's movement as well as for workers. There must be a means for controlling the release of stored energy in all the robotic systems and for shutting off power from outside the restricted envelope.

A detailed risk assessment should be performed to ensure the safety of workers who operate, service and maintain the robotics system.

1.4 Scope

Generally, robots are used to perform unsafe, hazardous, highly repetitive, and unpleasant tasks. They have many different functions such as material handling, assembly, arc welding, resistance welding, machine tool load/unload functions, and painting/spraying.

This chapter includes information on how to properly and safely operate fixed industrial robots and robot systems with other peripheral equipment.

Appendix A contains an overview of robotics, including illustrations of maximum, restricted, and operating envelopes, the components of a robot system, and a robot with six degrees of freedom.

1.5 Basic Terms

Industrial robots. Reprogrammable, multifunctional, mechanical devices designed to move materials, parts, tools, or specialized devices through various programmed motions to perform a variety of tasks.

Industrial robot system. The system includes not only industrial robots but also any devices and/or sensors required for the robot to perform its tasks, including communication interfaces for sequencing or monitoring the robot. See Appendix B for more detailed definition.

2. Standards and Codes

Group	Standard	Subject
1. ANSI/RIA	R1506-1986	American national standards for industrial robots and robot systems
2. BSR/RIA	BSR/RIA R15-06-19XX	Proposed standard for industrial robots and robot systems
3. ANSI/RIA	R15.02-1990	American national standard human engineering design criteria for hand-held robot control pendants
4. OSHA	Pub. 2254 (revised)	Training requirements in standards and training guidelines
5. NIOSH	Pub. 88-108	Safe maintenance guidelines for robotics workstations
6. OSHA	Pub. 8-1.3, 1987	Guidelines for robotics safety
7. OSHA	29 CFR 1910. 147	Control of hazardous energy source (lockout/tagout final rule)
8. AFOSH	127-12, 1991	Occupational safety machinery

ANSI/RIA = American National Standards Institutes/Robotics Industrial Association.
BSR/RIA = Bureau of Standards Review/Robotics Industrial Association.
NIOSH = National Institute for Occupational Safety and Health.
OSHA = Occupational Safety and Health Administration.
AFOSH = Department of the Air Force.

Table 2.1. Standards and codes for industrial robots.

3. Protective Devices

The proper selection of an effective robotics safeguarding system should be based upon a hazard analysis of the robotics system application and required operations. Prior to safeguarding a robot or robot system, it is recommended that a risk assessment (see Appendix C) be performed and appropriate safeguards employed to reduce or eliminate the risks of injury from potential hazards. Among the factors to be considered are tasks a robot is programmed to perform, start-up and programming procedures, environmental conditions, locations and installation requirements, possible human errors, scheduled and unscheduled maintenance, possible robot and system malfunctions, normal mode of operation functions, and all personnel functions and duties.

Safeguarding of personnel with varying job functions requires special considerations as far as the types of safeguards that can be employed. Robot operators who oversee the robot and its system in the automatic mode are usually exposed to fewer hazards because all safeguarding devices employed are activated, and their operators are usually outside the robot's restricted envelope (space) and the safeguarded area. Personnel who teach or perform programming and maintenance functions or attend continuous operation functions are working with robot system safeguards deactivated and with the robot in the manual or teach mode.

An effective safeguarding system protects not only operators but also engineers, programming and maintenance personnel, and any others who, by nature of their function, could be exposed to the hazards associated with a robot's operation. A combination of safeguarding methods may be used. Redundancy and backup systems are especially recommended, particularly if a robot or a robot system is operating under hazardous conditions or handling hazardous materials. The safeguarding devices employed should not constitute or act as a hazard or obstruct the vision of operators.

Personnel should be safeguarded from the hazards associated with the restricted envelope through the use of limiting devices and one or more of the safeguarding devices listed below:

- Mechanical limiting devices, such as emergency stop buttons and enabling switches.
- Non mechanical limiting devices.
- Presence sensing safeguarding devices.
- Fixed barriers (recommended at least 2 meters in height).
- Interlock barriers.

Awareness devices are usually used with other safeguarding devices. Typical awareness devices are chalk or roped barriers with supporting stations or flashing lights, signs, whistles, or horns.

An amber light should be installed on the robot to be conspicuous from anywhere around the robot. This light is on while the robot is energized signifying it is "live" even during periods when the robot is not moving.

4. Work Practices

4.1 Safeguarding Methods

The operating envelope of the robot should be physically restricted. This is accomplished by using some form of mechanical stop(s) able to withstand the force of momentum of the robot traveling at maximum speed and carrying a full load.

Safeguarding the teacher or the robot programmer requires special consideration to minimize as many hazards as possible. During the teach mode of an operation, the teacher is responsible for controlling the robot and associated equipment and for being familiar with the operations to be programmed, system interfacing, and the control functions of the robot and other equipment. When systems are large and complex, it can be easy for improper functions to be activated or sequenced. Because the teacher can be within the robot's restricted envelope, mistakes in programming can result in unintended movement or actions. For this reason, a restricted speed of 150 millimeters/second (6 inches/second) has been placed on any part of the robot. This slower speed would minimize potential injuries to teacher if an inadvertent action or movement occurred. Several other safeguards are suggested to reduce the hazards associated with how training personnel use the robots. (See Section 6.5 of the ANSI/RIA R15.06-1986 standard.)

To prevent hazards to the system, the robot systems operator should ensure that all appropriate safeguards are established for all robot operations. Because the robot will be in the automatic mode of operation, all safeguarding devices will be activated. At no time should any part of the operator's body be within the robot's safeguarded area. For additional information on operator safeguarding, see Section 6.6 of the ANSI/RIA R15.06-1986 standard.

The attended continuous operation mode permits a person to be in or near the robot's restricted envelope to evaluate or check the robot's motion or other operations being performed. The robot should be moving at a slow speed, and the operator should have the robot in the teach mode and be in full control of all operations being performed. Other safeguarding requirements are suggested. (See Section 6.7 of the ANSI/RIA R15.06 1986 standard.)

The job functions of safeguarding, maintenance, and repair personnel are difficult for many reasons. These personnel are exposed to unknown hazards because part of their responsibilities includes troubleshooting faults or problems with the robot, controller, tooling, or other associated equipment.

During maintenance and repair, the robot is placed in the manual or teach mode, and maintenance personnel perform their work within the safeguarded area and the robot's restricted envelope.

4.2 Maintenance

The user of a robot or robot system should establish a regular and periodic inspection and maintenance program to ensure safe equipment operations. This program should include, but not be limited to, the recommendations of the robot manufacturer and the manufacturers of other associated robot system equipment such as conveyer mechanisms, part feeders, tooling, gages, and sensors. These recommended maintenance programs are essential for minimizing the hazards that can result from component malfunction, breakage, and unpredicted movements or actions of the robot or other system equipment.

To ensure that robots are safely and adequately maintained, it is recommended that periodic maintenance be conducted and documented, including the names of the personnel who perform maintenance and the names of the independent verifiers.

5. Training

5.1 Technical Training

Robotic system safety depends on passive and active barriers and restraints, built-in enabling and disenabling subsystems, procedures, and adherence to procedures by personnel. For safe and effective use of the systems, management should ensure that personnel who program, operate, maintain, or repair robots or robot systems are adequately trained to perform their assigned functions. This training must include the safety aspects of the subject systems and their individually assigned functions. Technical training may be conducted at robotic system supplier's facilities or at the user's facility. Technical training may be provided on the job by formally trained personnel and documented in the employee's training record.

Supervised on-the-job training is recommended after all technical training. Performance based on training is recommended.

5.2 Initial Safety Training

Safety training is required in addition to technical training. Safety training is tailored to the actual installation and facility and to the functions that are performed at that installation. This same training should be provided for all personnel responsible for robotic system's. Management should maintain a list of individuals who have successfully completed the safety training and the dates thereof.

The robotic facility must be made available for safety training, which must include the following:

- Understanding of the robot system's maximum, restricted, and working envelopes, and zones or areas where access is limited and/or controlled.
- A review of hazards and their potential consequences.

- Review of safeguards: passive barriers and features limiting robot system movement, passive and active warning systems, and integral features of the system.
- Use and location of emergency stops.
- Safe use of any teach pendant or other controls that operate within the maximum envelope.
- Review of safety-related procedures and manufacturer's safety recommendations.
- A description of the system's operational functions and the need for hazard and system reassessment if changes are made to these functions.
- Recognition of off-normal and emergency situations and appropriate responses.
- Individual responsibilities by name and position (including management, operational, technical, and maintenance and repair personnel), emergency contacts, and location where these are posted.
- Identification of documentation associated with safety, and locations of reference copies available to personnel at the facility.

5.3 Refresher Training

Refresher safety training shall be provided to personnel who program, operate, maintain, or repair robots or robot systems. At minimum, this training should be (1) provided annually (2) when operational or safeguarding systems change or (3) when management determines that additional training is required. All training materials must be updated to reflect the robotic system in its current configuration. Refresher training should cover the same material as the initial safety training.

6. Hazards

6.1 Energy

Robots are capable of high-energy movements through a large volume of work space beyond the base dimensions of the robots. The pattern and initiation of movement of the robot arm are difficult to predict and can vary because of variables in the product and environmental conditions.

6.2 Contact/Injury

Injury from the robot's arm or peripheral equipment can result from unpredicted movements, component malfunctions, or unpredicted program changes.

6.3 Crushing or Trapping

Part of the body can be trapped between the robot's arm and other peripheral equipment if the proper precautions are not taken.

6.4 Mechanical Components

Mechanical hazards can result from the mechanical failure of components associated with the robot or its power source, drive components, tooling or end effector, and/or peripheral equipment. The failure of gripper mechanisms can result from the release of parts and/or the failure of end-effector power tools such as grinding wheels, buffing wheels, deburring tools, power screwdrivers, and nut runners to name a few.

6.5 Other Hazards

Equipment that provides power and control to the robot system and represents potential electrical and pressurized fluid hazards. Ruptured hydraulic lines could create dangerous high-pressure cutting streams or whipping hose hazards. Environmental hazards are associated with arc flash, metal spatter, dust, or electromagnetic or radio-frequency interference. In addition, cables on the floor present tripping hazards.

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Appendix A. Robotics Overview

1.1 Types and Classification of Robots

Industrial robots vary widely in size, shape, number of axes, degrees of freedom, and design configuration. Each factor influences the dimensions of the robot's working envelope or the volume of space within which it can move and perform its designated task. Figures 1 through 4 show examples of robot design configurations.

Industrial robots can be classified as either servo or nonservo controlled. Servo robots are controlled through the use of sensors that continually monitor the robot's axes for positional and velocity feedback information. This feedback is different from pretaught information, which is programmed and stored in the robots memory.

Nonservo robots use a system of mechanical stops and/or limit switches to control their axes; they do not use the feedback from position sensors.

1.2 Types of Paths Generated

Industrial robots can be programmed to move over paths generated with different types of control. Three different types of paths generation are outlined below. Movement of the robot refers to movement of the end effector or the wrist to which robotic tooling is attached.

1.2.1 Point-to-Point Path

With point-to-point programming, the robot moves from one discrete point to another within its working envelope. Motion between the points is typically not in a straight line, and the orientation of held objects may vary as the joint actuators operate independently to arrive at their new positions. Robot movement between points can result in a safety hazard for personnel and equipment because is difficult to predict the exact path.

1.2.2 Controlled Path

With controlled-path programming, the robot is moved along a computer-generated, predictable path as the robot travels from point to point. The computer-generated path may be a straight line with end-effector orientation or it may involve curved paths through successive points and/or gradual orientation changes. Coordinate transformations that control these precise movements are calculated by the robot's control system computer. The robot movements are more precise than with point-to-point programming and are less likely to present a hazard to personnel and equipment.

1.2.3 Continuous Path

With continuous-path programming, the robot's path is controlled by storing a large number or close succession of spatial points in the robot's memory during the teach sequence. During teaching, and while the robot is being moved, the coordinate points in space of each axis are continually monitored and placed into the control system's computer memory. When the robot is placed in the automatic mode, the program is replayed from memory and the original path is duplicated.

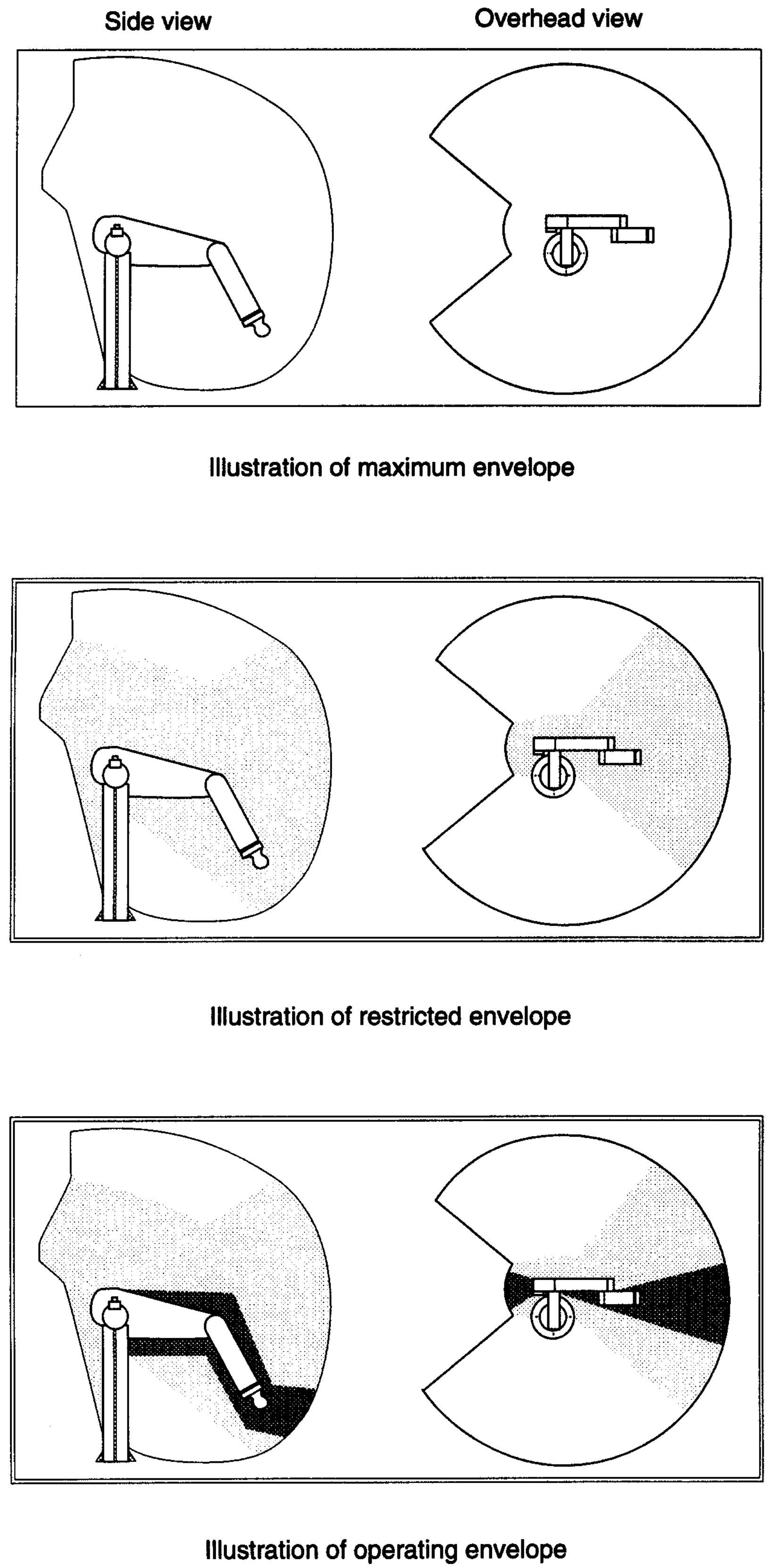


Figure 1. Illustrative articulated arm robot.

Side view Overhead view

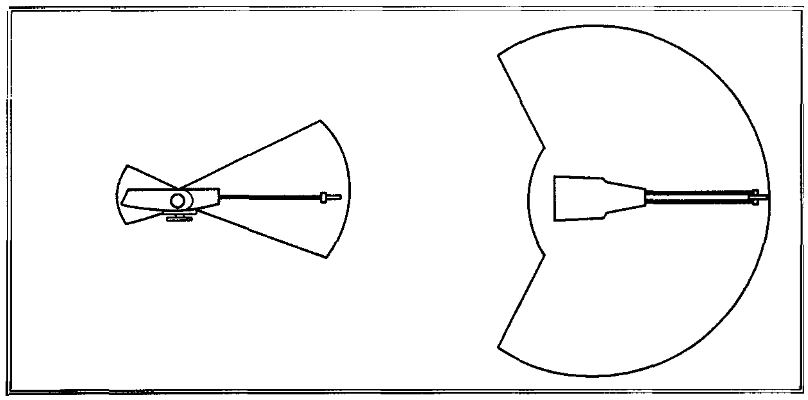


Illustration of maximum envelope

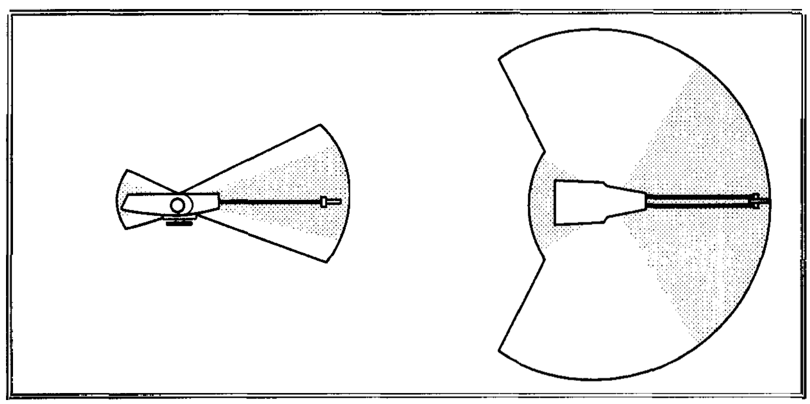


Illustration of restricted envelope

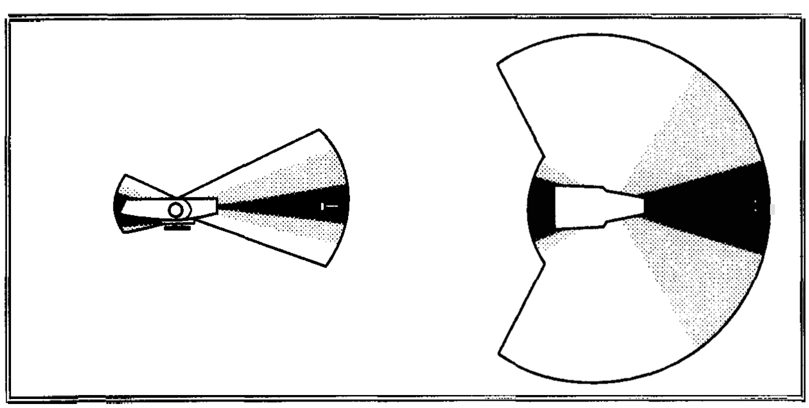


Illustration of operating envelope

Figure 2. Illustrative telescoping arm robot.

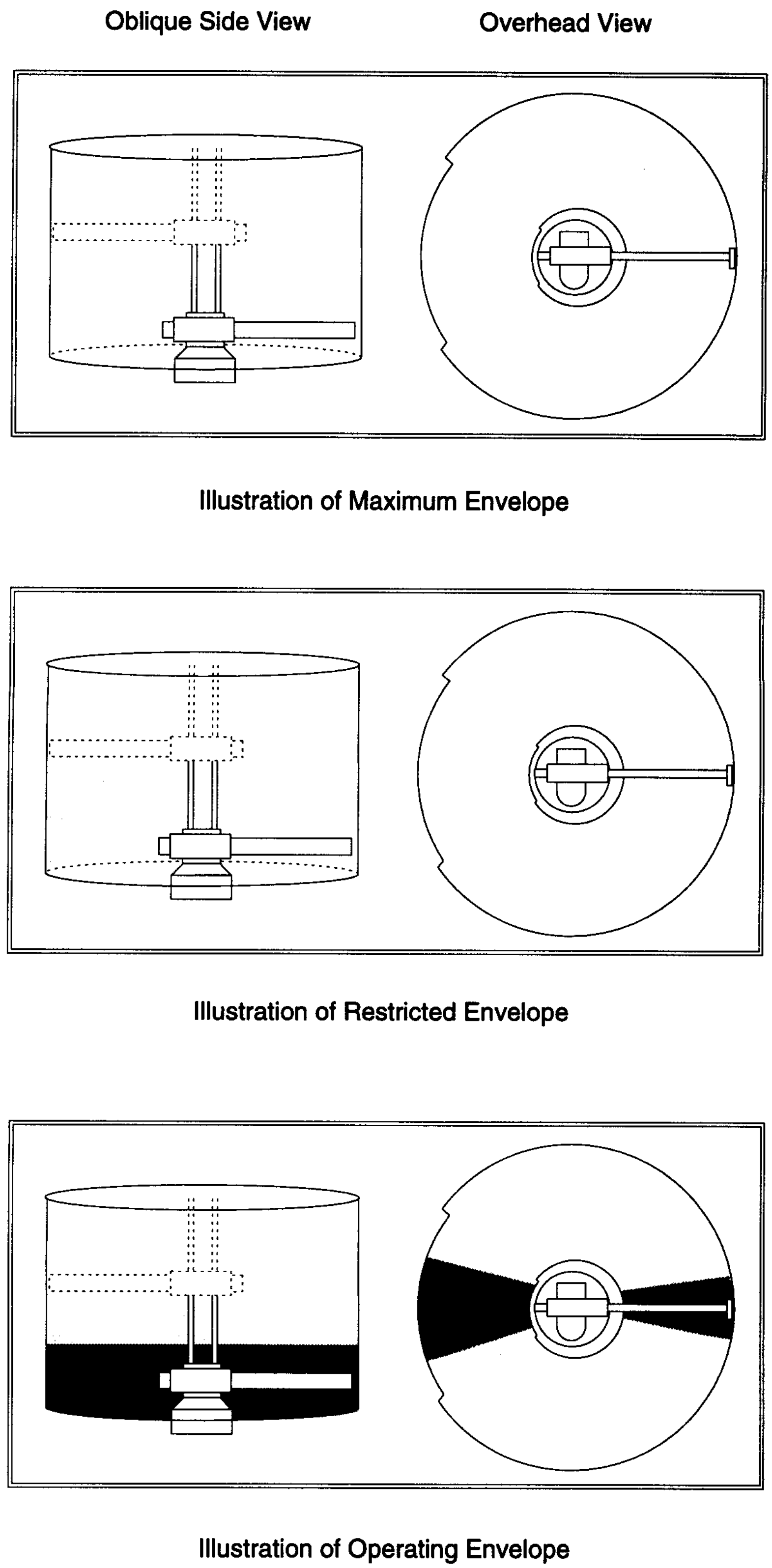
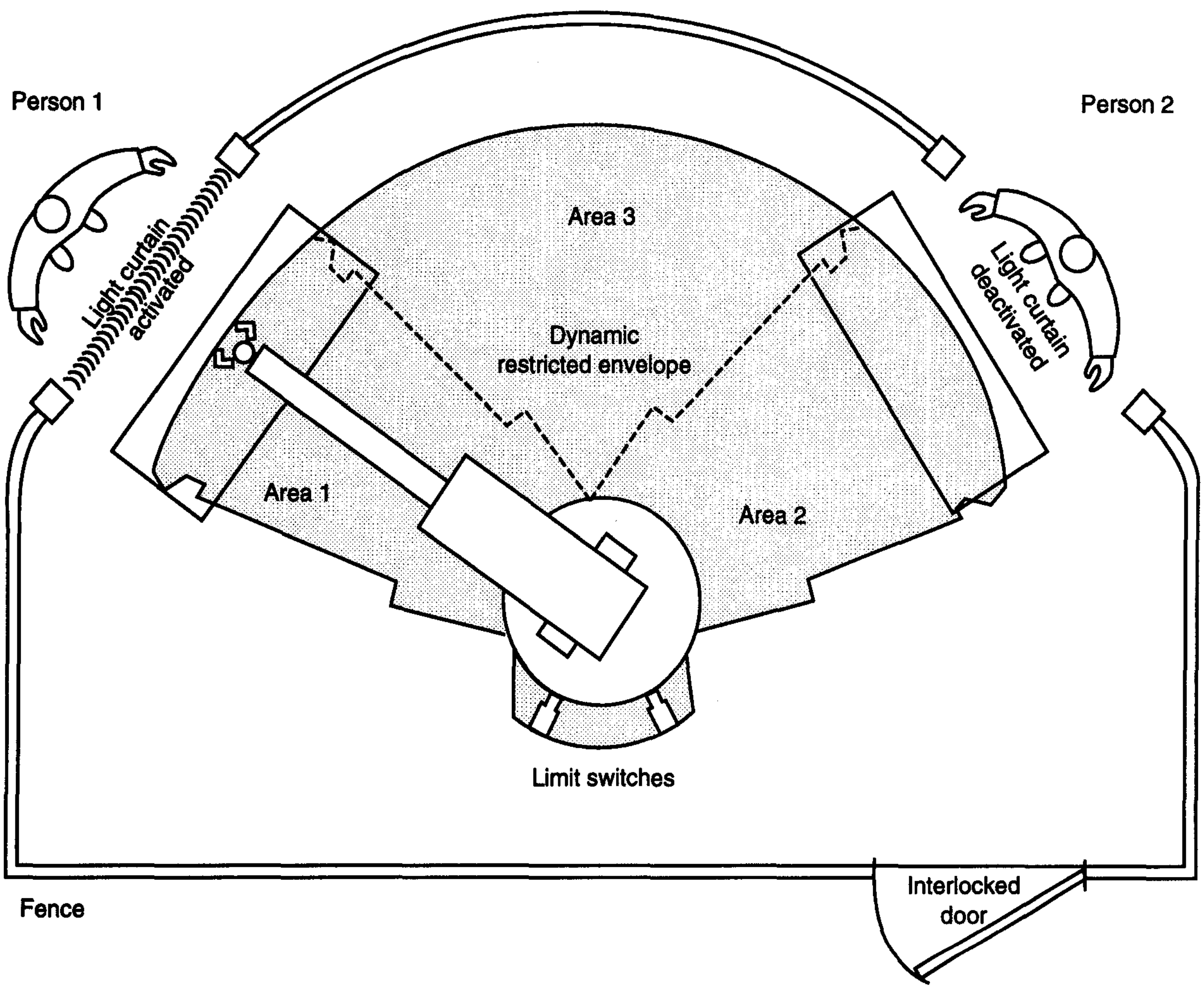


Figure 3. Illustrative cylindrical coordinate robot.



Robot installation with shifting workstations can have dynamic restricted envelopes. The light curtains are electrically monitored while the robot performs its programmed operations and shifts from Area 1 to Area 2. The dynamic restricted envelope would shift from Area 1 to include Areas 1, 3, and 2, and then to Area 2. The light curtains and the two limit switches are designed so that the robot is stopped if it tries to enter into an area in which a light curtain beam is deactivated or if a person or object tries to enter into an area with an active light curtain beam.

Figure 4. Illustration of dynamic restricted envelope.

1.3 Robot Components

Industrial robot systems consist of four major subsystems: the mechanical unit, drive, control system, and tooling. A short description of each is provided below. An example of the four major robot subsystems is illustrated in Figure 5.

1.3.1 Mechanical Unit

The mechanical unit refers to the robot's manipulative arm and its base. Tooling such as end effectors, tool changers, and grippers are attached to the wrist-tooling interface. The mechanical unit consists of a fabricated structural frame with provisions for supporting mechanical linkage and joints, guides, actuators, control valves, limiting devices, and sensors. The physical dimensions, design, and loading capability of the robot depend upon the application requirements.

1.3.2 Drive

Most new robots use electric drives. Pneumatic drives have been used for high speed, nonservo robots and are often used for powering tooling such as grippers. Hydraulic drives have been used for heavier lift systems, typically where accuracy was not also required. Electric drive systems can provide both lift and/or precision, depending on the motor and servo system selection and design. An ac- or dc-powered motor may be used depending on the system design and applications.

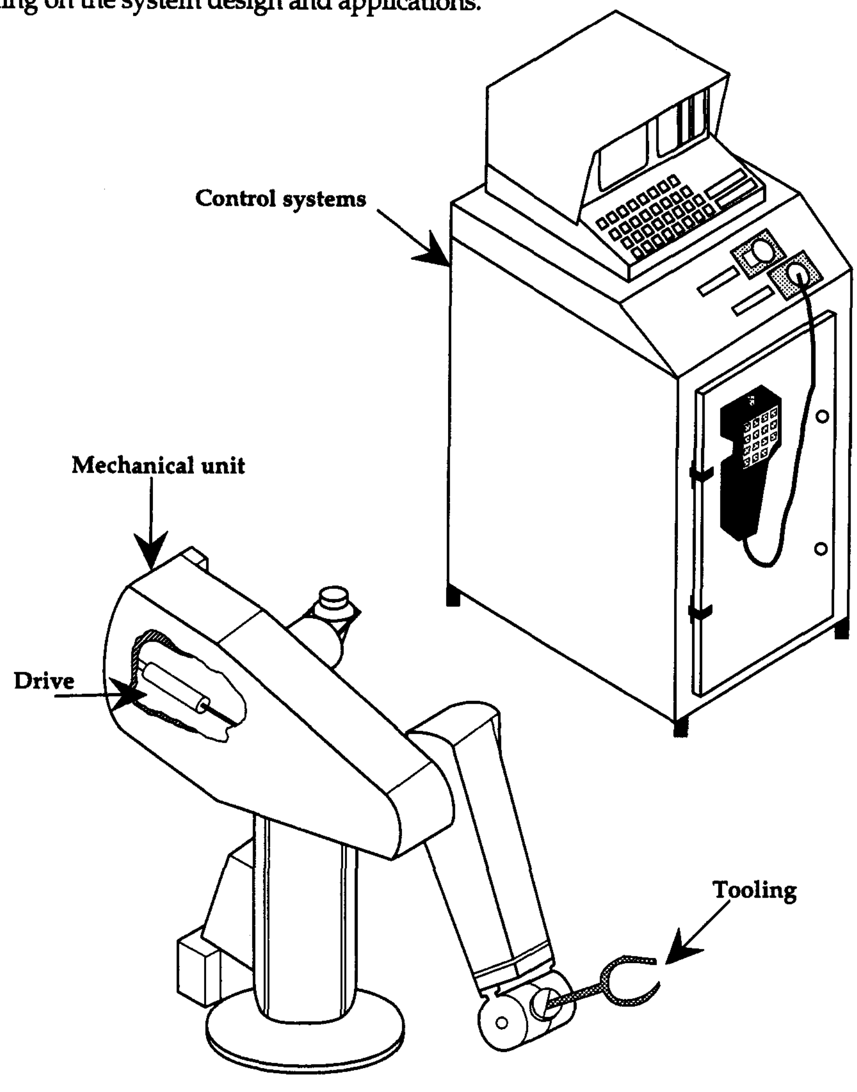


Figure 5. Illustration of robot system components.

1.3.3 Control Systems

Most industrial robots incorporate computer or microprocessor-based controllers. These perform computational functions and interface with and control sensors, grippers, tooling, and other peripheral equipment. The control system also performs sequencing and memory functions associated with communication and interfacing for on-line sensing, branching, and integration of other equipment.

Controller programming may be done on-line or from remote, off-line control stations. Programs may be on cassettes, floppy disks, internal drives, or in memory; and may be loaded or downloaded by cassettes, disks, or telephone modem. Robot controllers can have self-diagnostic capability, which can reduce the downtime of robot systems. Some robot controllers have sufficient computational ability, memory capacity, and input/output capability to serve as system controllers for other equipment and processes. In addition, the robot controller may be in a control hierarchy in which it receives instructions and reports positions or gives directions. Robot manufacturers typically use proprietary languages for programming robot controllers and systems.

1.3.4 Tooling

Tooling is manipulated by the robot to perform the functions required for the application. Depending on the application, the robot may have one functional capability, such as making spot welds or spray painting. These capabilities may be integrated with the robot's mechanical system or may be attached at the robot's wrist-end effector interface. Alternatively, the robot may use multiple tools that may be changed manually (as part of set-up for a new program) or automatically during a work cycle.

Tooling and objects that may be carried by a robot's gripper can significantly increase the envelope in which objects or humans may be struck. Tooling manipulated by the industrial robot and carried objects can cause more significant hazards than motion of the bare robotic system. The hazards added by the tooling should be addressed as part of the risk assessment.

1.4 Robot Programming by Teach Methods

Robots perform tasks for a given application by following a programmed sequence of directions from the control system. The robot's program establishes a physical relationship between the robot and other equipment. The program consists of a sequence of positions for the axes of movement and any end-effector operation, path information, timing, velocities, sensor data reading, external data-source reading, and commands or output to externally connected systems. The program may be taught by manually commanding the robot to learn a series of positions and operations (such as gripper closing) that collectively compose the work cycle. The robot converts these positions and operations into its programming language. Alternatively, the robot programming can be input directly in its programming language at a terminal, which may be the robot's controller or a separate computer. Robot programming generally needs verification and some modifications. This procedure is called program touchup. It is normally done in the teach mode of operation with the teacher manually leading the robot through the preprogrammed steps.

Three different teaching or programming techniques are lead-through, walk-through, and off-line programming. A description of each is provided below.

1.4.1 Lead-Through Programming/Teaching

Lead-through programming usually uses a teach pendant. This allows the teacher to direct the robot through a series of positions and to enter associate commands and other information, such as velocities. The human teaches the positions. The robot's controller generates the programming commands to move between positions when the program is played. When using this programming technique, the teacher may need to enter the robot's working envelope. This introduces a high potential for accidents because safeguarding devices may have to be deactivated to permit such entry.

Only the teach pendant may be used to program a robot, or it may be used with an additional programming console and/or the robot's controller.

1.4.2 Walk-Through Programming/Teaching

The teacher physically moves ("walks") the robot through the desired positions within the robot's working envelope. During this time, the robot's controller may scan and store coordinate values on a fixed-time interval basis. These values and other functional information are replayed in the automatic mode. This may be at a different speed than that used in the walk-through.

This type of walk-through programming uses triggers on manual handles that move the robot. When the trigger is depressed the controller remembers the position. The movement between these points when the program is played would then be generated by the controller.

The walk-through methods of programming require the teacher to be within the robot's working envelope with the robot's controller energized at least in the position sensors. This may also require that safeguarding devices be deactivated.

1.4.3 Off-line Programming

Off-line programming uses a remote programming computer. The programmer establishes the required sequence of functional and positional steps. The program is transferred to the robot's controller by disk, cassette, or network link. Typically, positional references are established on the robot to calibrate or transform the coordinates used in the remote programming for the actual setup.

1.5 Degrees of Freedom

"Degrees of freedom" refer to the directions of motion inherent in the design of robot mechanical systems (Figure 6).

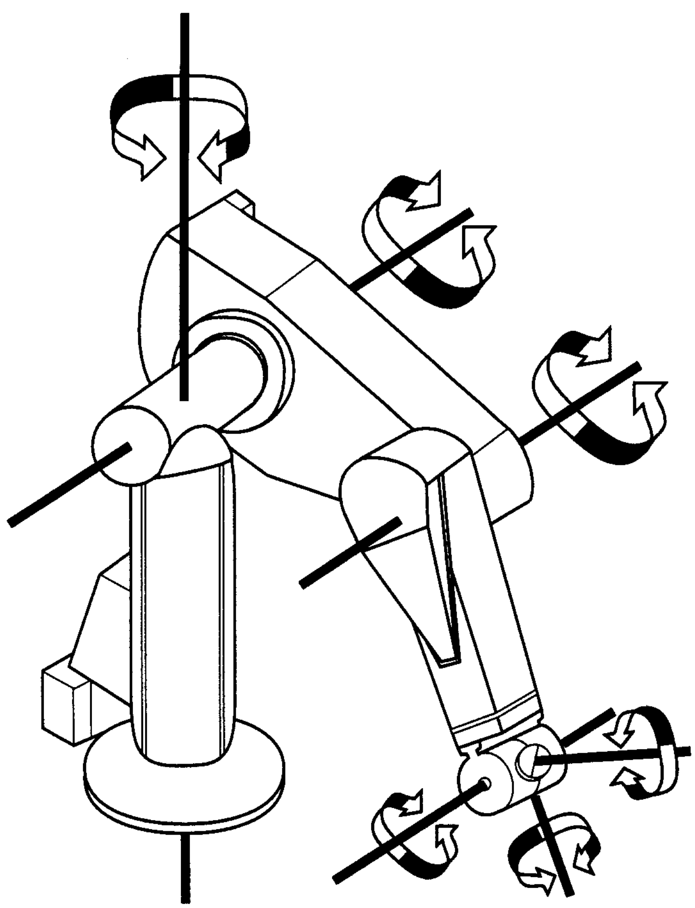


Figure 6. Robot with 6 degrees of freedom.

Each actuator usually causes rotary or linear motion along an axis. The number of axes is normally the same as the number of degrees of freedom of the robot. Motions of actuators in the end effector, such as closing grippers or the motion of a drill, do not constitute additional degrees of freedom. Depending on the robot's geometry, motion of one or more axes may be required for the robot to move to a new location in space.

There are usually three axes used to move the robot's wrist-end effector interface to a position in space. Additional axes provide for rotation at that point to permit flexibility in orientation. One, two, or three rotating axes at the wrist may be used, depending on the needs of the application or the robotic system sophistication. Six degrees of freedom are commonly available with articulated arm and gantry robots. Four degrees of freedom are typical with the selective compliance assembly robot arm (SCARA) configuration. Seven or more axes are used for some special applications. An example is an articulated arm-welding robot required to work on the far side of an auto body. A seventh degree of freedom is also added by putting a six-degree-of-freedom robot on ways or rails, allowing for an extended longitudinal range.

Appendix B. Definitions

Actuator—A power mechanism used to effect motion of the robot or a device that converts electrical, pneumatic, or hydraulic energy into robot motion.

Application program—The instruction set that defines the specific tasks of robots and robot systems. This program may be originated and/or modified by the robot operator.

Attended continuous operation—The time when robots are performing production tasks at a speed no greater than slow speed through attended program execution.

Attended program verification—The time when a person within the restricted envelope verifies the robot's programmed tasks at programmed speed.

Automatic mode—The state of the robot in which automatic operation can be initiated.

Automatic operation—The time during which robots are performing programmed tasks through unattended program execution.

Awareness barrier —Physical and/or visual means that warn a person of an approaching or present hazard.

Awareness signal—A device that warns a person of an approaching or present hazard by means of audible sound or visible light.

Backfit —A change either to the hardware or design applied to systems, structures, and components; to a procedure or organization used to design, construct, or operate a facility; or to any contractually agreed to activity that may be required because of new or other safety requirements.

Barrier —A physical means of separating persons from the restricted envelope.

Control device—A control hardware providing a means for human intervention in the control of a robot or robot system, such as an emergency stop button, start button, or selector switch.

Control program—An inherent set of control instructions that defines the actions and responses of the robot system. This program is usually not intended to be modified by the user.

Controller—An information-processing device whose inputs are both desired and measured positions, velocity or other variables in a process, and whose output is a drive signal to a controlling motor or actuator. (See Appendix A.)

Degrees of freedom—The directions of motion inherent in the design of the robot mechanical system. Robot systems can have up to six degrees of freedom or types of movement. These are:

- Vertical traverse—up and down motion of the robot arm caused by pivoting the entire arm about a horizontal axis or moving the arm along a vertical slide.
- Radial traverse—retraction and extension of the arm (in and out movements).
- Rotational traverse—rotation about the vertical axis (right or left swivel of the robot arm).
- Wrist pitch—up and down movement of the wrist.
- Wrist yaw—right and left swivel of the wrist.
- Wrist roll—rotation of the wrist. (See Appendix A.)

Emergency stop—The operation of a circuit with hardware-based components that overrides all other robot controls, removes drive power from the robot actuators, and causes all moving parts to stop.

Enabling device—A manually operated device that, when continuously activated, permits motion. Releasing pressure on this device stops robot motion and motion of associated equipment that may present a hazard.

End effector—An accessory tool or device specifically designed for attachment to the robot wrist or tool-mounting plate to enable the robot to perform its intended task. (See Appendix A.) (Examples may include gripper, spot-weld gun, arc-weld gun, spray paint gun, or any other application tools.)

Hazard— A situation that could cause physical harm or have adverse safety consequences.

Hazardous motion—Any motion that could cause physical harm to personnel or equipment.

Human engineering—The application of available knowledge that defines the nature and limits of human capabilities as they relate to checkout, operation, maintenance, or control of systems or equipment in engineering design.

Industrial equipment—A physical apparatus used to perform industrial tasks (e.g., welders, conveyors, turntables, positioning tables, machine tools, fork trucks, or robots).

Industrial robot—A reprogrammable, multifunctional-manipulator designed to move material, parts, tools, or specialized devices through variable programmed motions. This includes industrial robot systems, end effectors, and devices and sensors .

Interlock—A situation in which the operation of one control or mechanism causes or prevents the operation of another.

Limiting device—A device that restricts the maximum envelope by causing all robot motion to stop and is independent of the control and application programs.

Maximum envelope—The volume of space-encompassing the maximum-designed movements of all robot parts. This includes the workpiece, end effector, and attachments. (See Figures 1–3 in Appendix A.)

Mobile robot—A self-propelled and self-contained robot that can move over a mechanically unconstrained course.

Muting—The deactivation of a presence-sensing safeguarding device during part of the robot cycle.

Operating envelope—That part of the restricted envelope (space) used by the robot while performing its programmed motions. (See Figures 1–3 in Appendix A.)

Operator—A person designated to start, monitor, and stop the intended operation of a robot or robot system.

Pendant—Any portable control device, including teach pendants, that permits an operator to control the robot from within or without the restricted envelope of the robot.

Presence-sensing safeguarding device—A device designed, constructed, and installed to create a sensing field or area to detect an intrusion into such field or area by personnel, robots, or other objects.

Rebuild—To restore, to the extent possible, the robot to the original manufacturers' specifications.

Repair—To restore robots and robot systems to operating condition after malfunction, damage, or wear.

Restricted envelope—That part the maximum envelope to which a robot is restricted by limiting devices. The boundaries of the restricted envelope are defined by the maximum distance that the robot and associated tooling can travel after the limiting device is actuated. (See Figures 1–3 in Appendix A.) Note: The safeguarding interlocking logic and the robot program may allow the restricted envelope to be continually redefined (dynamic restricted envelope) while the robot performs its application program. (See Figure 4 in Appendix A.)

Robot manufacturer—An entity involved in either the design, building, or sale of robots, robot tooling, robotic peripheral equipment or controls, and/or associated process equipment.

Robot system integrator—An entity that either directly or through subcontractors assumes responsibility for the design, building, and/or integration of the robot or ancillary equipment for a robotic application.

Safeguard—A barrier guard, device, or safety procedure designed for the protection of personnel. "Safeguard" is not used in its nuclear material security sense in this chapter.

Safety procedure—Documented instructions designed for the protection of personnel and equipment.

Selective compliance assembly robot arm (SCARA)—A robot manipulator geometry, typically with four degrees of freedom that includes two deep arms connected by vertical pin hinges to provide X-Y (horizontal plane) motion with high rigidity. The first and second links of the base allow for rotation along the horizontal plane, while vertical plane motion is typically provided by a mast which the robot travels up and down on.

Service or personal robots—Robots that are typically used for educational purposes or for the training of industrial robot operators and maintenance personnel.

Single point of control—The ability to operate the robot such that initiation or robot motion from one source of control is only possible from that source and cannot be overridden by another source.

Slow speed control—A mode of robot motion control in which the velocity of the robot is limited to 6 inches (150 millimeters) per second to allow personnel sufficient time to either withdraw from the hazardous motion or stop the robot.

Startup—Routine application of drive power to the robot or robot system.

Startup, initial—Initial drive-power application to the robot or robot system after one of the following events:

- Manufacture or modification.
- Installation or reinstallation.
- Programming or program editing.
- Maintenance or repair.

Teach—The generation and storage of a series of positional data points affected by moving the robot arm through a path of intended motions.

Teach mode—The control state that allows for the generation and storage of positional data points affected by moving the robot arm through a path intended for the robot.

Teacher—A person who provides the robot with a specific set of instructions.

User—An entity, experimenter, or person that uses robots or contracts, hires, or is responsible for the personnel associated with the robot operation.

Appendix C. Risk Assessment

A risk assessment (also termed "hazard analysis") is required for robotic installations in nuclear facilities owned or operated by DOE. Risk assessments will be part of the safety analysis documentation preparation or update of the technical safety requirements when robotic installations have nuclear safety implications (per DOE 5480.22 and 5480.23).

Risk assessments for nuclear and nonnuclear installations are based on the satisfaction of current criteria, regardless of the age of the basic facility or the date of the design of the equipment to be installed. Although closely linked to system design and preparation for use, the risk assessments must be done independently using a systematic approach to identifying and assessing hazards. Designers and users would be involved in identifying approaches to reduce risks, but the assessment of residual risk must be performed independently and objectively. Note: "Current criteria" include all applicable federal regulations and implementing regulations and orders issued by federal departments and other federal activities; DOE orders; the most recent standards, specifications, or criteria cited in those documents or incorporated by reference in this chapter; and state laws and regulations applicable to the facility. The criteria contained in guidance documents issued or cited by federal activities or contained in requirements that would be applicable if the facility were not exempt due to its status as a DOE facility, must be identified, and any failure to also comply with this must be discussed and justified.

Preparation of a preliminary risk assessment early in the conceptual design is desirable to meet safety objectives most effectively. Needed remediation and mitigation measures can determine the choices among significantly different concepts. These choices will also further affect design definition, layout, and component selection. Safety-related sensors, switches, and interlocks must be used where the hazards are not reduced sufficiently by system and facility design. Safe operating procedures are required to complement the passive and active safety systems.

The assessment of residual risk is based on the sum of the benefits provided by the multiple approaches to meeting safety objectives. Management must review the risk assessment and approve the means of safeguarding. The following factors that must be addressed in a risk assessment of robotic systems:

- The size, capacity, and speed of the robot.
- The specific application and associated processes.
- The anticipated tasks required for continued operation.
- The hazards associated with identified tasks, applications, and associated processes.
- Anticipated failure modes, including human errors and system malfunctions.
- The probability of occurrence of potential failures and estimated severity of injury associated with these anticipated failures.
- The capability of meeting the levels of expertise required for personnel.

Other factors that may be appropriate to consider during a risk assessment are:

- Adequacy of testing and start-up procedure.
- Adequacy of training program.
- Satisfaction of installation criteria.
- Environmental considerations.
- Satisfaction of occupational safety and health criteria.

- Maintenance and inspection activities.

- The system stage(s) of development.

Safeguarding requirements vary for different stages of robot system development. The probability of occurrence of hazards can be dependent on factors such as numbers of people present, levels of experience, and types of robot application. Nonroutine use is typically more hazardous than routine use. Extended application engineering and setups involving multiple tools and robot system interfaces add to the probability of hazards.

The stages of development for a new system can include testing, research, and design up through and including productive use. The risk assessment shall recognize the different situations and the safeguarding measures shall be designed accordingly. For example, frequent access to the restricted envelope may be anticipated. If safety depended on a system of fixed barriers, the probability that the barrier may not be replaced and that interlocks will be muted must be considered. These may be considered by development personnel as unnecessarily restricting essential tasks. The safeguarding system, the training, procedures, and managerial oversight would all need to recognize the situation.

Risk assessment must address the current stage of system development and must be revised as system hazards or the stage of development changes.

Appendix D. System Design Features

The features that give a modern industrial robot its value can also be principal sources of hazards. The robot achieves flexibility in application through the variety of motions that can be programmed, the ease with which the programming can be changed, the speed of movement, and the large working volume. These same features can also cause human entry into the robot's envelope to be hazardous. Human entry into this space has been the primary cause of robot-related deaths and injuries. Design for safety therefore becomes a compromise between functional capabilities and hazard minimization.

The majority of accidents involving robots could be prevented if robot installation layouts and procedures followed guidance outlined in the robot safety standards.

Industrial robots are available (new, used, and rebuilt) that do not meet industrial robot safety standards or installation requirements. Management is responsible for ensuring that robot systems are procured and installed to meet the following safety requirements:

- To incorporate shielding, filtering, or suppression. This will prevent hazardous motion caused by radio frequency or electromagnetic interference and electrostatic discharge.
- To allow each axis to be moved without using drive power. This feature permits correction of a pin or pinch accident after deenergizing the robot. This feature also allows for maintenance or testing of tasks without having to energize the robot where movement of the robot arm is required.
- The robot must have slow speed capabilities, where the maximum speed of any part of the robot is less than 150 millimeters (6 inches) per second. This speed has been determined appropriate to allow personnel to react in adequate time to avert the hazard. The capability of operating at this or a slower speed is mandatory for any robot where there is to be any human access to the restricted envelope with the robot energized.
- All incorporated and installed mechanical stops must be capable of stopping robot motion under rated load and maximum speed conditions. In the absence of adequate stops, the robot's maximum envelope must be used as the restricted envelope to prevent human access.
- Provisions for lifting the robot and associated equipment must be provided and must be adequate for handling the anticipated load.
- All electrical connectors that could cause a hazardous situation if disconnected must be specially marked and labeled and guarded against unintended separation or mismating.
- Robots and their associated system components must be designed and constructed so that loss of electrical power, voltage surges, or changes in oil or air pressure do not result in hazardous motion. Any hoses incorporated in the system must be secured or protected to minimize hazard that may be caused by if the hose is from hose failure or disconnected.

Personnel involved with the installation must have knowledge of and access to information on the robotic system as necessary. The following documentation shall be provided by the robot manufacturer or created by the user:

- Function and location of all controls.
- Lifting procedures and precautions.
- Manufacturer's system-specific safety related information.
- Operating instructions.
- Maintenance and repair procedures, including lockout/tagout procedures.

- Robot system testing and start-up procedures, including initial start-up procedures.
- Installation instructions.
- Information on special environmental requirements.
- Electrical requirements.
- System-specific safety documentation, including risk assessment documentation.
- System-specific robot safety training lesson plans and associated materials.
- System-specific maintenance, failure, mishap, and training records, including calibration checking and calibration procedures.

Appendix E. Industrial Robotics Safety Checklist

The robotics safety checklist assists authorized employees in determining that procedures and equipment are available and personnel are trained in the control of hazardous energy sources. This checklist only addresses the minimum required standards. Where appropriate, it may be supplemented with local site or shop requirements.

Design, Modify, and Rebuild *(Reference: See Section 2, Standards and Codes No. 1 and 2)*	**OK**	**Action Needed**
Have hazards associated with moving parts been eliminated by design, or has protection been provided?	____	____________
Have robot components been designed, installed, manufactured, or secured to eliminate hazards caused by breaking, loosening, or releasing of stored energy?	____	____________
Has a means for isolating sources of energy been provided for the robot?	____	____________
Does the means for isolating sources of energy have lockout/tagout capabilities?	____	____________
Has a means for the controlled release of stored energy been provided for the robot?	____	____________
Installation *(Reference: See Section 2, Standards and Codes No. 1, 2, 6, and 8)*		
Is the robot installed in accordance with the manufacturer's specifications?	____	____________
If the answer to the previous question was no, is the installation specifications documented?	____	____________
If the robotic system was not installed in accordance with the manufacturer's specifications, did the installation receive an engineering review?	____	____________
If the robotic system was not installed in accordance with the manufacturer's specifications, did the installation receive management approval?	____	____________
Have procedures, layouts, zones, and use of safeguards been incorporated in the plans for startup?	____	____________
Is the robotic installation properly grounded in accordance with the manufacturer's specification or applicable codes?	____	____________
Is the provided power source in accordance with the manufacturer's specification or applicable codes?	____	____________
Are all controls or equipment requiring access during automatic operation located outside of the restricted envelope?	____	____________
Is the robot system installed to avoid interference with structures, equipment, and utilities; or other obstructions or workspaces where it may create a hazardous condition?	____	____________

	OK	Action Needed
Does the robotic installation have a means to shut off power to the robot that is located outside of the restricted envelope?	____	________
Does the robotic installation have a means to shut off power to the robot that has lockout/tagout capabilities?	____	________
Do all incorporated limiting devices reduce the hazards to personnel inside of the restricted envelope?	____	________
Is the robot system installed so that shutdown of associated equipment does not result in hazardous motion of the robot?	____	________
Is the robot system installed so that shutdown of associated equipment does not allow the creation of a condition that is hazardous to associated personnel?	____	________
Is the restricted envelope conspicuously identified?	____	________
Are all warning signs and labels visible, understandable, and appropriate for the level of hazard they address?	____	________
Risk Assessment *(Reference: See Section 2, Standards and Codes No. 1 and 2)*		
Is the robotic installation's safeguarding system based on a documented risk assessment?	____	________
Does the documented risk assessment address all of the following points:		
• The size, capacity, and speed of the robot?	____	________
• The specific application and associated processes?	____	________
• The anticipated tasks required for continued operation?	____	________
• Anticipated failure modes, including human errors and system malfunctions?	____	________
• The probability of occurrence of possible failures and estimated severity of injury associated with them?	____	________
• The levels of expertise of robot system personnel and estimates on frequency and duration of time spent at the system?	____	________
• Testing and start-up procedure?	____	________
• Environmental considerations (e.g., temperature and noise)?	____	________
• Robot system technical and safety training?	____	________
• Robot system stage(s) of development?	____	________
• Level of experience of robot system personnel?	____	________
• Maintenance and inspections?	____	________
• System associated personnel functions and responsibilities?	____	________

	OK	Action Needed
System Design Features *(Reference: See Section 2, Standards and Codes No. 1 , 2, 4, 5, 6, 7, and 8)*		
Is shielding, filtering, or suppression provided to prevent hazardous robot motions caused by radio frequency or electromagnetic interference and electrostatic discharge?	____	________
Does the robot design allow each axis to be moved without using drive power?	____	________
Does the robot have slow speed capabilities where the maximum speed of any part of the robot is less than 150 millimeters (6 inches) per second?	____	________
Are all incorporated mechanical stops capable of stopping robot motion under rated load and maximum speed conditions?	____	________
Are provisions for lifting the robot and associated equipment provided and adequate for handling the anticipated load?	____	________
Are all electrical connectors that could cause a hazardous situation if disconnected, uniquely marked, or labeled and guarded against unintended separation or mismating?	____	________
Are all hoses protected to minimize the whipping hazard if a hose was to fail or become disconnected?	____	________
Are the robot and associated system components designed and constructed so that the loss of electrical power, voltage surges, or changes in oil or air pressure will not result in a hazardous motion of the robot?	____	________
Is the following documentation maintained and made available, upon request, to personnel associated with the robotic system:		
• Function and location of all controls?	____	________
• Robot specifications, including range and load capacity?	____	________
• Lifting procedures and precautions?	____	________
• Manufacturer's system-specific safety-related information?	____	________
• Operating instructions?	____	________
• Maintenance and repair procedures, including lockout/tagout procedures?	____	________
• Robot system testing and start-up procedures, including initial start-up procedures?	____	________
• Installation instructions?	____	________
• Information on special environmental requirements?	____	________
• Electrical requirements?	____	________

	OK	Action Needed
• System-specific safety documentation, including risk assessment documentation?	____	__________
• System-specific robot safety training lesson plans and associated materials?	____	__________
• System-specific maintenance, failure, mishap, and training information and records?	____	__________

Emergency Stop *(Reference: See Section 2, Standards and Codes No. 1, 2, 3, 4, 5, and 6)*

	OK	Action Needed
Is the robot equipped with a hardware-based emergency stop circuit that, when depressed, will override all other robot controls?	____	__________
Is the robot equipped with a hardware-based emergency stop circuit that, when depressed, will remove drive power from robot actuators?	____	__________
Is the robot equipped with a hardware-based emergency stop circuit that, when depressed, will cause all moving parts to stop?	____	__________
Does each robot operator control station, including pendants, have a readily accessible emergency stop device?	____	__________
Are all emergency stop buttons red and of the palm or mushroom type? (Note: Pendant emergency stop buttons should, but do not need to be, of the palm or mushroom type.)	____	__________
Are all emergency stop buttons unobstructed?	____	__________
Are robot systems red, palm type, or mushroom head buttons only used for emergency stop purposes?	____	__________
Are all emergency stop buttons of the type that require manual resetting after activation?	____	__________
Is a prescribed start-up procedure used by the operator to restart the robot following an emergency stop?	____	__________
Following an emergency stop, is the robot restarted from outside the restricted envelope?	____	__________
Is the emergency stop circuit provided with capabilities to include additional emergency stop devices?	____	__________

Actuating Controls *(Reference: See Section 2, Standards and Codes No. 1, 2, 3, 5, and 6)*

	OK	Action Needed
Are all robot-actuating controls constructed in a manner that will protect against inadvertent activation?	____	__________
Are all robot-actuating controls designed to indicate operational status?	____	__________
Are all robot-actuating controls adequately labeled to indicate function?	____	__________

	OK	Action Needed
Are robots that can be controlled from remote locations equipped with a means that, when used, will prevent initiation of robot movement from another remote location?	____	____________

Pendant *(Reference: See Section 2, Standards and Codes No. 1, 2, and 3)*

Is it possible to place the robot into automatic mode without using the pendant exclusively?	____	____________
Are all buttons or other devices on the pendant of the type that when released will cause robot motion to stop?	____	____________
Does the pendant have a red emergency stop button?	____	____________
Is the emergency stop button on the pendant easily accessible and physically isolated?	____	____________
When the robot is under pendant control, does the system design prevent initiation of robot motion from all other sources?	____	____________
Is all robot motion initiated from the pendant at slow speed? (Note: A permitted exception is when full programmed speed is provided for attended program verification on a pendant with an operational enabling device.)	____	____________
Do pendants with enabling devices only allow robot movement in the teach mode with constant activation of the enabling device?	____	____________
Does releasing the enabling device stop all robot motion?	____	____________
Does releasing the enabling device stop the motion of all associated equipment that may present a hazard?	____	____________
Does the pendant have convenient control and display characteristics?	____	____________
Are critical and frequently used controls or the pendant clearly marked and easily accessible?	____	____________
Does the pendant include design features that discourage operator fatigue and error?	____	____________
Do visual displays provide the user with a clear indication of equipment and system conditions?	____	____________
Do visual displays provide the user with clear operational information?	____	____________
Do all pendant labels facilitate proper operation by being legible and nonambiguous?	____	____________

Safeguarding System *(Reference: See Section 2, Standards and Codes No. 1, 2, 5, 6, and 8)*

Is the safeguarding system based on the results of a documented risk assessment?	____	____________

	OK	Action Needed
Does the safeguarding system effectively control the robotic system hazards?	____	________
Are all incorporated presence-sensing devices interfaced with the control system?	____	________
Are all incorporated presence-sensing devices designed, constructed, and installed so that any single component failure, including failure of output devices, does not prevent the normal stopping action of the robot?	____	________
Are all incorporated presence-sensing devices designed, constructed, and installed so that any single component failure, including failure of output devices, does not inhibit commands from being sent to the robot?	____	________
Are all incorporated presence-sensing devices designed, constructed, and installed so that any single component failure, including failure of output devices, prevents automatic operation of the robot until the failure has been corrected?	____	________
Are all incorporated presence-sensing safeguarding devices designed, constructed, and installed so that environmental factors do not adversely affect proper operation?	____	________
Does the resumption of robot motion, after a violation of the presence-sensing field, require removal of the sensing field violation when no continuous violation of the sensing field is caused during entry into the restricted envelope?	____	________
Does the resumption of robot motion, after a violation of the presence-sensing field, require a deliberate activation of the controls when no continuous violation of the sensing field is caused during entry into the restricted envelope?	____	________
If muting of the presence-sensing device is required, is it done so that no single component failure can prevent the normal stopping action of the robot?	____	________
If muting of the presence-sensing device is required, is it done so that no single component failure can inhibit commands from being sent to the robot?	____	________
If muting of the presence-sensing device is required, is it done so that no single component failure can allow further robot motion until the failure is corrected?	____	________
Do all incorporated barriers and interlocking barriers prevent personnel from reaching over, around, under, or through the barrier to access the restricted envelope?	____	________
Do all incorporated barriers require the use of tools to remove or adjust the barrier to gain access to the restricted envelope?	____	________
Do all incorporated interlocking barriers prevent personnel access to the restricted envelope except through opening an interlocked gate?	____	________
Does the opening of interlocked gates remove drive power to the robot actuators?	____	________
Does the opening of interlocked gates stop automatic operation of the robot and associated equipment that may cause a hazardous condition?	____	________

	OK	Action Needed
Does returning to automatic operation after a system shutdown (caused by an interlock violation) require deliberate activation of controls from outside the restricted envelope after safeguards required for automatic operation are restored?	____	________
Does all incorporated perimeter guarding meet the following criteria:		
• Provide sufficient warning to prevent inadvertent entry into the restricted envelope?	____	________
• Allow entry into the work space by authorized personnel without first entering the restricted envelope?	____	________
• Have posted warning signs identifying the hazard and providing information to avert the hazard?	____	________
Are awareness barriers constructed and installed to prevent inadvertent entry into the restricted envelope?	____	________
Are all incorporated awareness signals constructed and installed to provide a recognizable audible or visual signal to notify personnel of inadvertent entry into the restricted envelope?	____	________
Is an awareness signal provided when the robot fails to reach its intended location if this condition is hazardous?	____	________
Is an awareness signal provided when the envelope is breached by misdirected motion of the robot?	____	________
Safeguarding the Operator *(Reference: See Section 2, Standards and Codes No. 1 and 2)*		
Are robot operators prevented from being in the restricted envelope during robot operation?	____	________
Is robot motion prevented while any part of an operator's body is within the restricted envelope?	____	________
Safeguarding the Teacher *(Reference: See Section 2, Standards and Codes No. 1, 2, 3, and 6)*		
Do personnel who teach the robot visually check the robot and work area to identify hazardous conditions before teaching the robot?	____	________
Are identified hazardous conditions resolved before teaching the robot?	____	________
Do personnel entering the restricted envelope ensure that all safeguards are in place and functioning as intended before performing their task in the restricted envelope?	____	________
Are emergency stop devices and motion controls of the pendant function tested before teaching the robot?	____	________

	OK	Action Needed
Are identified deficiencies on emergency stop devices and motion controls of the pendant resolved before teaching the robot?	____	________
When the teach mode is selected and the teacher enters the restricted envelope, are all of the following conditions met:	____	________
• Is the robot system under the sole control of the teacher?	____	________
• Is slow speed control in effect? (An exception to this is when full programmed speed is provided for attended program verification and requires constant activation of a pendant enabling device.)	____	________
• Are all emergency stop devices functional?	____	________
• Will the robot respond to any remote interlocks or signals that would cause motion?	____	________
• Is movement of other equipment in the work envelope under the sole control of the teacher if such movement would present a hazard?	____	________
Does the teacher exit the restricted envelope prior to initiating automatic operation?	____	________
Are personnel prevented from accessing the restricted envelope when the robot is in the automatic mode?	____	________

Safeguarding During Attended Continuous Operation *(Reference: See Section 2, Standards and Codes No. 2 and 6)*

When the attended continuous operation mode is selected, is the robot under slow speed control?	____	________
Is selection of the attended continuous operation mode only possible from outside of the restricted envelope?	____	________
Does attended continuous operation require constant activation of an enabling device that, when released, stops robot motion?	____	________
Does attended continuous operation require constant activation of an enabling device that, when released, stops motion and operation of associated equipment that may create a hazardous condition?	____	________
Are the following conditions met when attended continuous operation is selected:		
• The person has single point of control of the robot and equipment that may present a hazard?	____	________
• All emergency stop and motion control devices are functional?	____	________
Does initiation of the pendant emergency stop device meet all of the following criteria		
• Override all other robot and associated controls?	____	________
• Remove drive power from the robot and associated equipment actuators?	____	________

	OK	Action Needed
• Cause all functions to stop if continued operation may cause a hazardous condition?	____	__________
Do personnel exit the restricted envelope and restore all safeguards prior to restoration of automatic operation following attended continuous operation?	____	__________
Must personnel initiate a deliberate start-up procedure prior to restoration of automatic operation following attended continuous operation?	____	__________
Safeguarding Maintenance and Repair Personnel *(Reference: See Section 2, Standards and Codes No. 1, 2, 5, 6, and 7)*		
Is there a procedure that maintenance and repair personnel follow when performing their assigned tasks?	____	__________
Does this procedure include information on lockout/tagout of power sources?	____	__________
Does this procedure include information on blocking of potentially hazardous stored energy?	____	__________
When the lockout/tagout procedure cannot be used, are other effective safeguards or safeguarding procedures established and used to prevent injury and equipment damage?	____	__________
When the lockout/tagout procedure cannot be used, are other effective safeguards or safeguarding procedures approved by management?	____	__________
When drive power is on, maintenance and repair personnel shall check the following before entering the restricted envelope:		
• Are the robot and work area visually checked and all identified hazardous conditions corrected before working on the robot?	____	__________
• Are safeguards checked and in place prior to performing the tasks in the restricted envelope?	____	__________
• Are pendant emergency stop and enabling devices verified to be functioning as intended prior to performing the tasks in the restricted envelope?	____	__________
• Are all identified deficiencies with the emergency stop devices and motion controls of the pendant resolved before entry into the restricted envelope?	____	__________
• Are all emergency stop devices and motion controls of the pendant that had deficiencies retested before working on the robot?	____	__________
The following conditions are to be met before maintenance and repair personnel enter the restricted envelope while the drive power is on:		
• Is control of the robot removed from automatic mode?	____	__________
• Do maintenance and repair personnel have a single point of control of the robot and equipment that may present a hazard?	____	__________
• Are all emergency stop devices functional?	____	__________

	OK	Action Needed
Must maintenance and repair personnel exit the restricted envelope and initiate a deliberate start-up procedure before restoring automatic operation?	_____	___________
Must maintenance and repair personnel exit the restricted envelope and restore all safeguards before restoring automatic operation?	_____	___________
If it is necessary to bypass safeguards during maintenance and repair activities, is the bypass method identified and approved by management?	_____	___________
If it is necessary to bypass safeguards during maintenance and repair activities, are other safeguarding means implemented?	_____	___________

Maintenance and Inspections *(Reference: See Section 2, Standards and Codes No. 1, 2, and 5)*

Has a regular and periodic maintenance and inspection program been established?	_____	___________
Is the periodic maintenance and inspection program based on the manufacturer's specifications and/or best established management practices?	_____	___________
Is there a system in place to document problems found during inspections?	_____	___________
Is there a system in place to correct problems found during inspections?	_____	___________
Is there a system in place to prevent use of the robot until the problems are corrected?	_____	___________

Testing and Start-Up *(References: See Section 2, Standards and Codes No. 1, 2, 5, 6, and 8)*

Is there a documented testing and start-up or restart procedure that covers the following criteria:

• New or relocated installations?	_____	___________
• Modified installations?	_____	___________
• Cases where there have been changes in software or hardware?	_____	___________
• After maintenance and repair activities that could affect safe operations?	_____	___________
Does the procedure outline the means of safeguarding for testing and starting robots?	_____	___________
Is safeguarding in place and are personnel restricted from the work envelope prior to testing and starting robots?	_____	___________
Are manufacturer's instructions followed for testing and starting robots and robot systems?	_____	___________

Is there a documented initial start-up procedure in place that provides for verification of the following before applying power:

• Mechanical mounting and stability?	_____	___________
• Electrical, communication, and utility connections?	_____	___________

	OK	Action Needed
• Necessary peripheral equipment and systems?	____	________
• Identification and evaluation of limiting devices for restricting the work envelope?	____	________
• All personnel to exit the restricted envelope?	____	________
Is there a documented initial start-up procedure in place that provides for the verification of the following after applying power:		
• Each axis is able to move and is restricted as intended?	____	________
• All emergency stop devices and drive power disconnects are operational?	____	________
• All interlocks and safeguarding devices function as intended?	____	________
• The program executes as intended?	____	________
• Slow speed and automatic operation function as intended?	____	________
Do these procedures address checks for changes or additions to the hardware system?	____	________
Are these procedures approved by management?	____	________
Technical Training *(Reference: See Section 2, Standards and Codes No. 1, 2, 4, and 7)*		
Are personnel who program, teach, operate, maintain, or repair robots or robot systems adequately trained in the technical functions, tasks, and operations?	____	________
Are personnel who program, teach, operate, maintain, or repair robots or robot systems able to demonstrate technical competency in performing their assigned functions?	____	________
Are records maintained of all robot technical training?	____	________
Are controls in place to prevent untrained personnel from programming, teaching, operating, maintaining, or repairing robots or robotic systems?	____	________
Initial Safety Training *(Reference: See Section 2, Standards and Codes No. 1, 2, and 4)*		
Is there a management-approved lesson plan for robot safety training?	____	________
Have the personnel who program, teach, operate, maintain, or repair robots or robot systems received safety training?	____	________
Are personnel who program, teach, operate, maintain, or repair robots or robot systems able to demonstrate competency in safely performing their assigned functions?	____	________
Are all authorized employees whose job requires them to perform service/maintenance on machines, systems, or equipment trained on lockout/tagout procedures?	____	________

	OK	Action Needed
Does the robot safety training include identification and illustration of the robot system's maximum, restricted, and working envelopes?	____	____________
Does the robot safety training include identification and illustration of the robot system's zones or areas where access is limited and/or controlled?	____	____________
Does the robot safety training include a review of hazards and their potential consequences?	____	____________
Does the robot safety training include identification, discussion, and demonstration of the robot system's barriers and features that limit robot system movement?	____	____________
Does the robot safety training include identification, discussion, and demonstration of integral features of the safeguarding system?	____	____________
Does the robot safety training include identification, discussion, and demonstration of the robot systems warning labels and devices?	____	____________
Does the robot safety training include description, discussion, and illustration of safety-related procedures and the manufacturer's safety recommendations?	____	____________
Does the robot safety training include discussion and illustration of other procedures that have safety ramifications (e.g., facility emergency response procedures)?	____	____________
Does the robot safety training include a description of the system's operational functions?	____	____________
Does the robot safety training include the identification of need for risk and system reassessment upon change or extension of functions?	____	____________
Does the robot safety training include recognition of off-normal and emergency situations?	____	____________
Does the robot safety training include identification of appropriate responses to off-normal and emergency situations?	____	____________
Does the robot safety training include identification of locations of emergency stop devices?	____	____________
Does the robot safety training include a demonstration of the use of emergency stops devices?	____	____________
Does the robot safety training include how to safely use any teach pendant or other controls operable within the maximum envelope?	____	____________
Is robot safety-related documentation made available to personnel?	____	____________
Are records maintained of all robot safety training?	____	____________
Are controls in place to prevent untrained personnel from programming, teaching, operating, maintaining or repairing robots or robotic systems?	____	____________

	OK	Action Needed
Are the individuals responsible for operating robot systems identified by name and position (including management, operational, technical, and maintenance and repair personnel)?	____	________
Are emergency contacts identified in the training?	____	________
Are the names of emergency contacts posted at or near the robot system?	____	________

Retraining and Refresher Training *(Reference: See Section 2, Standards and Codes No. 1)*

	OK	Action Needed
Are personnel provided additional formal and on-the-job technical training in their job functions when the equipment is modified and replaced?	____	________
Are personnel given refresher safety training comparable to the initial safety training annually or as needed?	____	________
Are training materials revised, and are personnel provided refresher training when operating or safeguarding systems change?	____	________

Chapter 2
Electrical Shock Control

1. Introduction

1.1 Incidences of Electrocution

The Department of Energy's (DOE's) May 1991 Tiger Team Assessments summary states that 36% of standards noncompliances were electrical violations. More than 2300 Occupational Safety and Health Administration (OSHA) electrical safety findings were documented by Tiger Team Assessments. From 1983 to 1992, approximately 130 DOE or contractor personnel reported shocks or burns from contact with electricity in the workplace. Electrocution killed four people during these years. The four deaths resulted from direct contact with high voltage circuits. All but one of the victims were aware that they were working on energized circuits.

Risk from electric shock is greatest for electricians and technicians. They receive over 50% of the reported shocks and burns. Other workers at higher risk include mechanics, welders, laborers, machinists, and those that use portable electric tools. Personnel in occupations that require standing in water (e.g., firefighters and janitors) experience more shocks than others.

1.2 Causes of Electrocution

Unsafe Acts

- Accidentally slipping with wrenches, screwdrivers, etc., while working on or near electrical equipment with "live" parts (over 50 volts).
- Switching off the wrong circuit and then failing to verify that the circuit is deenergized before beginning work.
- Failing to implement lockout/tagout procedures or use adequate protective equipment.
- Using noninsulated tools.
- Wearing metal jewelry while working on live circuits.
- Using instruments/meters/tools not designed for the system voltage.
- Nonelectrical personnel working too close to live equipment (e.g., power lines), usually with cranes or lifting equipment or handling metallic material.

Unsafe Conditions

- Improper grounding, loose connections, defective parts, ground faults, unguarded live parts or faulty insulation in equipment.
- Inadequate maintenance.
- Hazardous environments, e.g., corrosive or flammable atmospheres, wet or damp locations.
- Inadequate working clearance.

A study by Suruda (1988) showed that contact with high-voltage power lines was the leading cause of electrocution. Electrocution rates were high among electrical workers and construction trades, especially steel erecting. In fact, 60 percent of all deaths were not caused by electrical work but by contact with power lines. Alternatively, the main cause of death in workers involved with low voltage ac (under 600 volts ac) was the failure to disconnect power or to use lockout procedures while working on wiring or equipment. Young workers (probably inadequately trained) were found to be at increased risk of electrocution.

1.3 Prevention Overview

Preventing low-voltage electrocutions relies on locking/tagout (see Figure 1) or on disconnecting or otherwise isolating the power. Ground fault circuit interrupters should also be used to prevent electric shock and/or electrocution from damaged or defective tools. To prevent high-voltage electrocutions, electrical engineers should use appropriate personal protective equipment and deenergize grounded lines prior to working near them. Electrocutions also result from the inadvertent contact of equipment with overhead power lines. However, proximity warning devices and radar devices that detect electric current flow in crane booms have not been proven in the field.

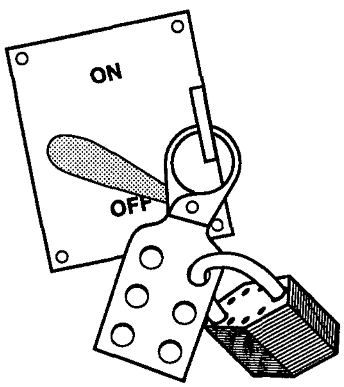


Figure 1. Lockout device.

1.4 Scope

This chapter does not cover the design and construction specifications found in the Code of Federal Regulation (CFR) Title 29. Proper initial installation and selection of wiring, electrical equipment, and electrical system parts, using approved or listed components, is assumed. This chapter is not meant as a substitute for knowledge of the OSHA regulations in the CFR. Wiring and equipment over 600 volts are not discussed. The primary audience for this chapter are persons who use plant machinery and equipment energized by electricity. They are at risk from faults in electric equipment or the misuse of such equipment.

1.5 Basic Terms

Current. The "flow" of electricity, similar to the volume of water flowing past a certain point in a given length of time. Electric current is measured in amperes.

Voltage. The "pressure" behind the electricity, which is measured in volts. Low voltage in this chapter refers to 600 volts or less.

Resistance. Any condition that slows the current flow. It is measured in ohms.

1.6 National Codes

All electrical work must conform to the National Electric Code (NEC) and relevant OSHA regulations.

2. Standards and Codes

Organization	Standard	Subject
OSHA	29 CFR 1910 subpart S	Electrical
OSHA	29 CFR 1910.303 - .333	Electrical safety
OSHA	29 CFR 1910.147	Lockout/tagout
OSHA	29 CFR 1910.268	Telecommunications
OSHA	29 CFR 1926.400	Construction
OSHA	29 CFR 1926.950	Power transmission
DOE	6430.1A Div. 16	Criteria for electrical design
ANSI	C2	National Electric Code
ANSI	C84.1	Electric power systems and equipment voltage
ANSI	C73	Dimensions on attachment plugs
ANSI/ISA	582.01,.02,.03	Electrical test, measuring, controlling, and related equipment

ANSI = American National Standards Institute
DOE = Department of Energy
OSHA = Occupational Safety and Health Administration

Table 2.1. Standards and codes for electric shock control.

3. Protective Devices

3.1 Grounding in Outlets

Outlets should accommodate three-wire grounded plugs to prevent electric shock.

3.2 Disconnects

It may be necessary to quickly deenergize electrical equipment in an emergency. Delaying, or worse, deenergizing the wrong circuit could endanger rescue personnel and prevent rescue of the victim. Therefore, circuit breakers and disconnects should be identified by their circuit number and the function that is being disconnected. Also, switches should be installed with their handles in the down position when the switch is off and with provision for a lockout and tagout device.

3.3 Overcurrent Devices

Overcurrent devices protect facility wiring and equipment. They open the circuit automatically in case of excessive current flow from accidental grounds, short circuits, or overloads. Excessive current flow can lead to overheating and resultant fires. Overcurrent devices should interrupt the current flow when it exceeds the wire's capacity.

3.3.1 Fuses

Using the wrong type or size fuse may cause injury to personnel and damage to equipment. Never insert fuses in a live circuit.

3.3.2 Circuit Breakers

Circuit breakers can be either thermal or magnetic. The thermal circuit breaker operates according to the rise in temperature. Therefore, room temperature variations can affect the point at which the breaker interrupts the circuit. The magnetic circuit breaker operates on the amount of current passing through the circuit.

3.4 Ground Fault Circuit Interrupters

3.4.1 Function

Ground fault circuit interrupters or (GFCIs) (see Figure 2), are designed to protect grounded workers from electric shock when they touch an electrically charged object. When a worker touches the "hot" side, the GFCI detects a very small difference (nominally 5 milliamps) between the hot-side current and return current and shuts off power to the circuit. It is important to note that the GFCI does not protect against shock if a person touches the hot-side and neutral wire simultaneously.

3.4.2 Applications

GFCIs are required by local building codes in all restroom areas, kitchens, outdoors, and other damp locations. GFCIs are also available in portable models for outdoor work where electrical equipment and tools are used.

3.4.3 Use

In construction activities, locate the GFCIs as close as possible to the electrical equipment it protects. Tripping of the GFCI can result from:

- Wet or defective power tools.
- Defective or damaged GFCIs.
- Poorly installed GFCIs.
- Too many power tools on a GFCI branch.

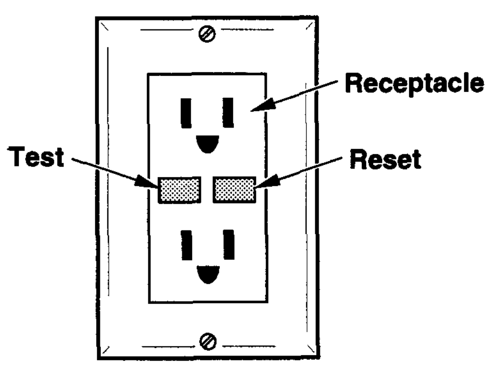


Figure 2. Ground fault circuit interrupters.

3.5 Safety Protection at Installation

3.5.1 Interlocks

Interlocks are safety devices on panels, doors, and other entryways that are designed to deenergize electrical circuits when someone is entering an electrical hazard area. Interlocks should:

- Be equipped with fail-safe features.
- Have a visible disconnect or opening in the primary power circuit.
- Have a locking arrangement that makes attempts to go around the interlock impractical.

3.5.2 Guarding/Barriers/Insulation

Electrical hazards that cannot be eliminated should be mitigated by guarding, isolating, or rendering inert by:

- Installing fences, guardrails, or enclosures to prevent unintentional contact with energized conductors.
- Installing sensors, such as infrared motion detectors, high-frequency sound detectors, light barriers, radar, and pressure sensors to give alert or disable equipment.
- Insulating hazards so that physical contact with energized conductors is rendered harmless.
- Locating hazards 8 feet or more above work space.

3.5.3 Warning Signs

Warning signs should be displayed near exposed current-carrying parts and in hazardous areas, such as high-voltage installations. When a hazard cannot be eliminated by design or guarding, active or passive means of warnings can be used.

An active warning system that gives an audible or visual warning or both can be installed whenever practical. Examples are bells, horns, and flashing lights. Warning systems must be a standard design so that the meaning of warnings is clearly understood.

Passive warnings must be very explicit and state what the hazard is, what harm could result, and how to avoid the hazard (see Figure 3).

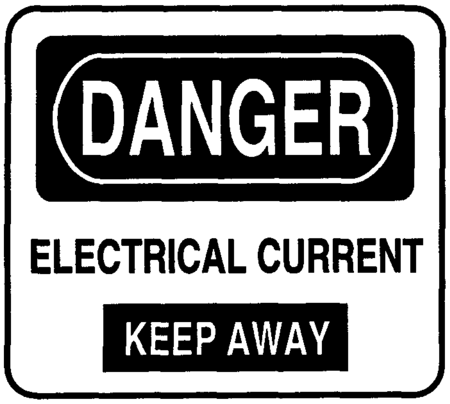


Figure 3. Warning signs.

3.5.4 Insulation

All conductors used for general wiring must be insulated unless specifically exempted by the NEC. When selecting wiring for a job, operating temperature, color, and location of use should be considered.

3.6 Proximity Warning Devices for Hoisting and Rigging

Proximity warning devices and radar devices that detect electric current flow in crane booms have not been proven effective in the field, and should not be used.

3.7 Test Equipment

Qualified technicians should periodically check electrical systems and equipment by using appropriate test equipment. Electrical testing equipment includes multimeters, clipon current meters, megohmmeters, battery testers, ground wire impedance testers, 120 volts (ac) receptacle testers, ground fault circuit interrupter testers, electrostatic meters and ac voltage detectors. Multimeters can check ac leakage, proper line voltage, batteries, continuity, ground connection, integrity of shielded connections, and fuses. Other specialized equipment, such as oscilloscopes and cable testers, are also available.

3.8 Mats

Standard rubber floor mats are not suitable for use as protection against electric shock. Special rubber floor mats (conforming to ANSI/ASTM J6.7) may be used but only under controls listed in a safety procedure that allows their use. The safety procedure must specify where the mats may be used, maximum voltage levels permitted, and the testing program that must be followed to verify their protection levels.

4. Work Practices

4.1 General Practices

General practices should include:

- Allow only authorized, competent, and qualified (e.g., by training) persons to work on or around electrical equipment and/or wiring.
- Follow a lockout/tagout program.
- Know emergency procedures in the event of an accident.
- Do not enter a hazard area alone.

4.2 Lockout/Tagout

A lockout/tagout program is essential to safe electrical maintenance and installation. The basic program provides energy control procedures, employee training, and periodic inspections. When electrical repairs or modifications are required, open the circuit and padlock the switch in the off position. Unless otherwise directed, tag the switch with a description of the work being done and the name of the person and the department involved.

4.3 Grounding

4.3.1 Need for Grounding

A high percentage of electrical shock injuries are caused by poorly grounded or ungrounded electrical equipment. In addition, ungrounded metallic electrical enclosures present a serious hazard when they are installed in locations that are likely to have explosive gases or dust present.

4.3.2 Requirements

The NEC requires that all metallic enclosures and framework of electrical equipment be grounded. A conductor used for grounding should be permanent and of continuous length. It should have the capacity to safely conduct any fault current likely to be imposed.

Some experimental conditions require that certain equipment not be grounded. In those situations, appropriate barriers, shields and/or warnings should be provided.

4.4 Power Tools/Portable Equipment

Faulty portable electric tools such as hand saws, drills, and portable sanders can cause electric shock and other injuries. These tools and their cords are susceptible to abuse with undetected electrical faults causing serious problems. Before using, always inspect portable electric equipment or tools for defects. Any defective tools should be removed from service until they are repaired. With the exception of double-insulated (indicated by sign in Figure 4) power tools, all portable electric equipment and tools that require 60 Hz must use a three-conductor grounded cable for their power feed. When using portable equipment or tools outdoors or in damp locations, use a GFCI.

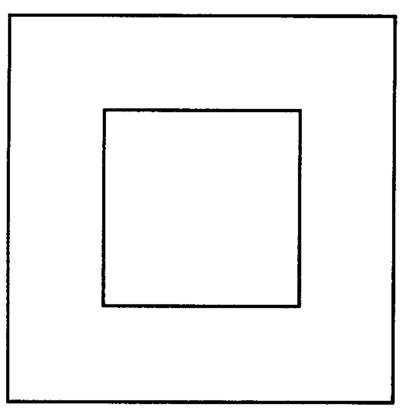


Figure 4. Sign for double-insulated tools.

Four safety rules for dead electrical equipment:

1. See that the electric supply has been shut off.
2. Ensure that supply cannot be turned on.
3. Verify that the circuit is dead.
4. Apply personal protective grounds.

4.5 Extension Cords

The need for extension cords should be minimized by reducing the distance between outlets. Only three-wire cords listed by Underwriters Laboratories or other recognized testing laboratories should be used. Those cords that are necessary should be taped down or otherwise secured to avoid a tripping hazard. If cords cannot be dropped from overhead and must cross the floor, they should be covered with rubber channels. They should never be exposed to excessive heat, sharp surfaces, or other conditions that could adversely affect the insulation of the cord. Multiple extension cords increase the resistance in an electric circuit, thus increasing the heating of conductors, receptacles, and plugs. High-visibility orange or yellow extension cords should be used outdoors. Misuse of extension cords, faulty extension cords, or using cords with missing or broken grounding pins can result in serious electric shock and fire.

4.6 Work Space

Working on electrical equipment in cramped spaces, in awkward or uncomfortable positions, or in poorly illuminated areas increases the worker's potential for electric shock. A minimum work space around electrical equipment is specified according to the voltage and the NEC.

4.7 Confined Spaces

Special hazards, such as heat and toxic substances, can be encountered during work in confined spaces. Relevant standards and guidelines for work in confined spaces should be followed.

4.8 Overhead Clearance

Cranes, derricks, and other vehicles should maintain safe working clearances from overhead electric wires. The required clearance can be found in the NEC.

4.9 Temporary Wiring

Temporary wiring may be permitted during periods of construction, remodeling, maintenance, repair, or demolition of equipment or structures. All temporary wiring should conform with NEC article 305 and be protected from accidental damage. Temporary wiring is no substitute for permanent wiring and should be removed as soon as the construction or remodeling is completed.

4.10 Hazardous Locations

Specialized wiring methods and electrical equipment are required in locations classified as hazardous where there are (1) flammable liquids; (2) combustible liquids operating at a temperature above their flash point; or (3) gases or combustible dusts that may be present in flammable, explosive, or combustible concentrations. Use intrinsically safe equipment, as required in hazardous locations.

5. Training and Personal Protective Equipment

5.1 General Training

All employees who work with electrical and electronic equipment should be trained in the hazards of electricity, emergency procedures, cardiopulmonary resuscitation, safety-related work practices (29 CFR 1910.331-.335), and the use of warning signs, guards, and other protective devices. They should never work alone with hazardous electrical equipment. The training program should address the specific electrical system and electronic equipment in use. A course should be provided for office workers and another more comprehensive course for shop personnel and craftsmen.

5.2 Supervisor Training

Supervisors should also know about existing and possible electrical hazards. They should encourage employees to report any electrical defects immediately.

5.3 Specialized Training

Formal standardized courses on electrical safety and on-the-job training should be provided to electricians and others who work closely with electricians (see Figure 5). The training should provide a thorough review of the hazards associated with electrical equipment, the procedures to deenergize and lockout equipment prior to work, and any other pertinent safety procedures. The degree of training should be determined by the risk to the individual employee.

TYPICAL OCCUPATIONAL CATEGORIES OF EMPLOYEES FACING A HIGHER THAN NORMAL RISK OF ELECTRICAL ACCIDENT

Occupation

Blue Collar supervisor[1]
Electrical and Electronic engineers[1]
Electrical and electronic equipment assemblers[1]
Electrical and electronic technicians
Electricians
Industrial Machine operators[1]
Material handling equipment operators[1]
Mechanics and repairers[1]
Painters[1]
Riggers and roustabouts[1]
Stationary engineers[1]
Welders

[1]Workers in these groups do not need to be trained if their work or the work of those they supervise does not bring them or the employees they supervise close enough to exposed parts of electric circuits operating at 50 volts or more to ground for a hazard to exist.

Figure 5. Employees facing risk of electric accident.

5.4 Personal Protective Equipment

Protective equipment or apparel shall meet criteria established by the American Standard for Testing Materials (ASTM) and the American National Standards Institute (ANSI). Table 5.1 lists the standards and equipment.

Organization	Standard	Protective equipment
ANSI	Z87.1	Eye and face protection
ANSI	Z89.1	Nonconductive hard hats
ASTM	D120	Rubber gloves
ASTM	D178	Rubber matting
ASTM	D1048	Rubber blankets
ASTM	D1049	Rubber covers
ASTM	D1050	Rubber line hose
ASTM	D1051	Rubber sleeves
ASTM	F696	Leather protectors for rubber gloves

Table 5.1. Personal protective equipment.

6. Hazards/Effects

6.1 Electric Shock

6.1.1 Biological Effects

If a direct contact is made with an electrically energized part while a similar contact is made simultaneously with another conductive surface that is maintained at a different electrical potential, a current will flow through the body. The effects of electric current on the human body can vary, depending on the following:

- Circuit characteristics (current, resistance, frequency, and voltage) (60 Hz is the worst frequency).
- Contact and internal resistance of the body.
- The current's pathway through the body.
- Duration of the contact.
- Environmental conditions affecting the body's contact resistance.

In electrocution, the most damaging route of electricity is through the chest cavity or brain. Ventricular fibrillation of the heart (stopping of rhythmic pumping action) can be initiated by a current flow of 75 milliamps or greater for 5 seconds or more through the chest cavity of a 150 pound (68.2 kg) person. Nearly instantaneous fatalities can result from either direct paralysis of the respiratory system, failure of rhythmic pumping action, or immediate heart stoppage. Even if the current does not pass through the vital organs or nerve center, severe injuries, such as deep internal burns, can still occur.

Burns suffered in electrical accidents can be of three basic types: electrical burns, arc burns, and thermal contact burns. In electrical burns, tissue damage (whether skin deep or deeper) is caused by the heat from the current flow. The body is unable to dissipate this heat. Typically, electrical burns are slow to heal. Arc burns, caused by electric arcs, are heat burns similar to burns from high-temperature sources. The temperatures generated by electric arcs can melt material nearby, vaporize metal in close vicinity, and burn flesh and ignite clothing at distances up to 10 feet (3 meters). Lastly, thermal contact burns are those normally experienced from the skin's contact with hot surfaces of overheated electric conductors.

Electric shock currents, even at 3 to 10 milliamps, can also cause injuries of an indirect or secondary nature through involuntary muscle reactions. In this case, the involuntary muscle reaction to the electric shock can cause bruises, bone fractures, and even death resulting from collisions or falls.

6.1.2 Delayed Effects

Damage to the internal tissues may not be immediately apparent after contact with the current. Internal tissue swelling and irritation are also possible. Prompt medical attention can help minimize these effects and avoid possible death.

6.2 Hazards Associated with Electricity

Most electrical systems use the earth to establish a voltage reference system by connecting a portion of the system to ground. Since these systems use conductors that have voltages to the ground, a shock hazard exists for workers who are in contact with the earth and are exposed to the conductors. If people come in contact with an ungrounded conductor while they are in contact with the ground, they become part of the circuit and current passes through their bodies.

Electricity, also, poses other hazards. When a short circuit occurs or current flow is interrupted, an arc is often created. If the current involved is great enough, these arcs can cause injury or can start a fire. Fires can also be caused by overheating equipment or by conductors carrying too much current. Extremely high-energy arcs can damage equipment causing fragmented metal to fly in all directions. In explosive or combustible atmospheres, even low-energy arcs can cause violent explosions.

Some studies suggest health effects are associated with long term exposure to low level electromagnetic fields that are commonly associated with electricity.

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Appendix A. Electrical Shock Control Safety Checklist

This safety checklist will help employees and supervisors to follow minimal safety practices. This list is not meant to be comprehensive, nor as is, is it meant to form part of any official self assessment practice. Where appropriate, local safety offices and supervisors are encouraged to add to these checklists. Relevant references are noted after each question.

These regulations apply only to electrical installations or equipment used on the jobsite both temporary and permanent.

General	OK	Action Needed
Are your electricians familiar with the requirements of the National Electrical Code (NEC)? 29 CFR 1910.332	____	________
Do you specify compliance with the NEC and other appropriate standards for all contract electrical work and equipment? 29 CFR Subpart S, Appendix A	____	________
Work Practices		
If you have electrical installations in hazardous dust or vapor areas, do they meet the NEC for hazardous locations? 29 CFR 1910.307	____	________
Is the electrical system checked periodically by someone knowledgeable in the NEC? 29 CFR 1910.303 (b)	____	________
Is all conduit, cable, etc., properly attached to all supports and tightly connected to junction and outlet boxes? 29 CFR 1910.304(f)(5)	____	________
Are all electrical cords strung so they do not hang on pipes, nails, hooks, etc.? (NSC)	____	________
Are electric cords in good condition and not frayed? (NSC)	____	________
Are electrical cords kept free of grease, oil, and chemicals? (NEC 430-11)	____	________
Are metallic cable and conduit systems properly grounded? 29 CFR 1910.304(f)(3)	____	________
Are grounding circuits checked to make sure that the circuit between the ground and the grounded power conductor has a resistance low enough to permit sufficient current to flow to cause the fuse or circuit breaker to interrupt the current? 29 CFR 1910.304(f)	____	________
Are switches free from evidence of overheating? 29 CFR 1910.303(b)(iv)	____	________

	OK	Action Needed
Is it verified that controls will not operate and all hazardous energy (including stored energy) is dissipated, blocked out, or rendered safe before work is started on equipment or systems? 29 CFR 1910.333	____	________
Do all personnel follow the general lockout and tagout procedures for their facility? 29 CFR 1910.333	____	________
Is a clear working space maintained around electrical enclosures that require personnel access? 29 CFR 1910.303 (h)(3)(i)	____	________
Are all fuses free of "jumping" (or shorting) with pennies or metal strips? (NSC)	____	________
Are switches mounted in clean metal boxes with all openings tightly closed? 29 CFR 1910.304(f)(5)	____	________
Are all fuses and circuit breakers the right type and size for the load on each circuit? 29 CFR 1910.304(e)	____	________
Are all electrical switches marked to show their purpose? 29 CFR 1910.303(f)	____	________
Electrical Equipment		
Are portable electric tools and appliances grounded or double insulated? 29 CFR 1910.304(5)(v)	____	________
Are all ground connections clean, tight, permanent, and continuous? 29 CFR 1910.304(f)(3)	____	________
Are motors clean and kept free of excessive grease and oil? (NEC 430 11)	____	________
Are motors properly maintained and provided with adequate overcurrent protection? (NSC)	____	________
Are portable lights equipped with proper guards? 29 CFR 1910.305(a)(2)(f)	____	________
Is sufficient space provided and maintained in the area of electrical equipment so as to permit safe operation and maintenance of such equipment? 29 CFR 1910.303(g)(1)	____	________
Is the path from circuits, equipment, structures, and conduit or enclosures to ground permanent and continuous? 29 CFR 1910.304(f)	____	________

Training and Personnel Protective Equipment	OK	Action Needed
Are insulated protective gloves provided, tested and used when employees are working in the vicinity of hidden underground electric power lines? 29 CFR 1910.137, 1926.416(a)	____	________
Before an employee begins work near electric power circuits, has the employer determined whether any part of the circuit has exposed live parts or near exposed circuits? 29 CFR 1926.416(a)	____	________
Does protective equipment or apparel meet the acceptance and testing criteria established by ASTM and ANSI? 29 CFR 1910.137	____	________
Does the supervisor ensure the use and testing prior to use of appropriate personal protective equipment and apparel specified for a job? 29 CFR 1910.335 (a)(ii)	____	________
Do personnel always use protective equipment or apparel while working with electrical equipment? 29 CFR 1910.335	____	________
Do personnel who work on electrical equipment receive on the job training? 29 CFR 1910.332(c)	____	________
Do employees receive basic life support training and certification (CPR)? 29 CFR 1910.332(c)	____	________

29 CFR = Code of Federal Regulations Title 29
NSC = National Safety Council. 1992 Accident Prevention Manual for Business and Industry: Administration and Programs.
NEC = National Electric Code

Chapter 3
Lockout/Tagout

1. Introduction

1.1 Incidence of Injuries

Approximately 39 million workers are protected by lockout/tagout in general industry. OSHA estimates that adherence to the requirements will eliminate nearly 2 percent of all workplace deaths. Within the DOE community, over 100 incidents have been reported since 1990.

1.2 Causes of Injuries

Unsafe Acts

- Accidentally activating an energy source that should have been locked or tagged out.
- Failing to lockout/tagout all energy sources before work begins.
- Turning off the wrong source of energy.
- Not testing an energy source before work begins.
- Not relieving stored secondary energy.

Unsafe Conditions

- No written procedures.
- Improper labeling and identification of lockout/tagout devices.
- Inadequate training/inspections.
- Energy isolation devices not identified.

1.3 Application

Lockout/tagout is used to control energy sources during the service and maintenance of machinery or equipment when unexpected energization, start up, or release of stored energy may occur. Its purpose is to safeguard employees from injury or death. This procedure also applies when:

- Employees are required to remove or bypass any guard, interlock, or other safety device.
- Employees are required to place any part of their body into an area on a machine or equipment where work is being performed.

1.4 Basic Terms

Affected employee. Employees whose jobs require them to operate or use machinery or equipment that is being serviced or maintained or whose jobs require them to work in areas where service or maintenance is being performed.

Authorized employee. A person who locks out or tags out machinery or equipment in order to perform service or maintenance on that machinery or equipment.

Energy isolating device. A mechanical device that physically prevents the transmission or release of energy. (Note: push buttons, selector switches, and other control circuit-type devices are not energy-isolating devices.)

Energy source. Any source of electrical, mechanical, hydraulic, pneumatic, chemical, thermal, or other energy.

Lockout device. A device that uses a positive means (such as a key or combination lock) to hold an energy-isolating device in a safe position.

Tagout device. A prominent warning device, such as a tag, with means of attachment that can be securely fastened to an energy-isolating device (see Figure 1). Refer to (OSHA) 29 CFR 1910. 147, "Control of Hazardous Energy"; the American National Standard

Figure 1. Tagout.

Institute (ANSI) Z244.1-1982, "Lockout/Tagout of Energy Sources"; and the Department of Energy Manual 5480.19, Chapter 9, "Lockouts and Tagouts" for additional information and definitions.

1.5 Exemptions

There are three exemptions to lockout/tagout procedures. First, lockout/tagout does not apply to minor tool changes, adjustments, and other minor servicing activities that take place during normal operations. The changes also have to be routine, repetitive, and integral to the use of the equipment. Second, lockout/tagout procedures do not apply on cord and plug-connected electrical equipment if exposure to unexpected start-up is controlled by unplugging it from its energy source. The plug must also be under the exclusive control of the employee performing the servicing or maintenance. Third, hot-tap operations involving transmission and distribution systems for utilities such as water, gas, or electrical power, do not require lockout/tagout if employers can demonstrate that (1) continuity of services is essential, (2) shutdown of the system is impractical, (3) documented procedures are followed, and (4) special equipment is used that will provide proven effective protection for employees.

2. Standards and Codes

Group	Standard	Subject
OSHA	29 CFR 1910.147	Control of hazardous energy (lockout/tagout)
OSHA	29 CFR 1910.333	Lock and tag requirements for electrical systems
ANSI	Z244.1-1982	For personnel protection—lockout/tagout of energy sources—minimum safety requirements
DOE	Manual 5480.19	Lockouts and tagouts
DOE	STD 1030-92	Guide to good practices for lockouts and tagouts
AFOSH	STD 127-45	Signs and tags
AFOSH	STD 127-66	General industrial operations

OSHA = Occupational Safety and Health Administration.
ANSI = American National Standards Institute.
DOE = Department of Energy.
AFOSH = Air Force Occupational Safety and Health.

Table 2.1 Standards and codes for lockout/tagout.

3. Protective Devices

3.1 Selection

Facilities should identify the requirement for tags, locks, and lockout/tagout attachment hardware and ensure an adequate supply is maintained and distributed as needed. In addition, all energy isolating devices must be adequately labeled or marked to indicate their function. The only exception is when isolating devices are located or arranged so that their purpose is evident.

3.2 Minimum Requirements

When attached to an energy-isolating device, both lockout and tagout devices protect employees from hazardous energy. The lockout device holds the energy-isolating device in a safe position to prevent the machine or equipment from unexpected start-up. The tagout device does this by identifying the energy-isolating device as a source of potential danger and indicating that the energy-isolating device and the controlled equipment may not be operated until the tagout device is removed. Whichever devices are used, they must be singularly identified, be the only devices used for controlling hazardous energy, and meet the following requirements:

Durable. Lockout and tagout devices must withstand the environment to which they are exposed for the maximum duration of the expected exposure. Tagout devices must be constructed and printed so that they do not deteriorate or become illegible, especially when used in corrosive (acid and alkali chemicals) or wet environments.

Standardized. Both lockout and tagout devices must be standardized according to either color, shape, or size. Tagout devices must also be standardized according to print and format.

Substantial. Lockout and tagout devices must be substantial enough to minimize accidental removal except by excessive force of special tools such as bolt cutters or other metal cutting tools. Tag attachments must be nonreusable, attachable by hand, self-locking, and nonreleasable, with a minimum unlocking strength of no less than 50 pounds.

The device for attaching the tag also must have the general design and basic characteristics equivalent to a one-piece nylon cable that will withstand all environments and conditions.

Identifiable. Locks and tags must clearly identify the employee who applies them. Tags must warn against hazardous conditions if the machine or equipment is energized. They should also include a legend such as: DO NOT START, DO NOT OPEN, DO NOT CLOSE, DO NOT ENERGIZE, or DO NOT OPERATE.

4. Work Practices

4.1 Energy Source Survey

An initial survey must identify all energy sources and related exposures in the equipment, systems, and machines. The survey will determine if adequate and appropriately located energy-isolating devices are available for positive protection. Additionally, the potential for accidents will be reduced if employees are not expected to rely on memory to determine which energy-isolating devices apply to which machines or to trace the equipment complexity.

4.2 No Lockout Provisions

OSHA has determined that lockout is a more reliable means of deenergizing equipment than tagout and that it should always be the preferred method used by employees. DOE believes that, except for limited situations, the use of lockout devices will provide a more secure and effective means of protecting employees from the unexpected release of hazardous energy or startup of machines and equipment. However, if an energy-isolating device cannot be locked out, a tagout system may be used if all three of the following provisions are met:

- It can be demonstrated that the use of a tagout system will afford the same protection as lockout.
- The tagout device is attached at the same location that the lockout would have been.
- An additional means of protection is provided, such as, isolating a circuit element or blocking a control switch.

4.3 Lockout/Tagout Sequence

Prior to implementation, all affected employees must be notified of the work to be performed under lockout/tagout. Special operating problems, unusual equipment/process modes, and factors affecting equipment/process release should be discussed. A mutual understanding with respect to scope and lockout/tagout time should exist.

4.4 Lockout/Tagout Application

Simple lockout/tagout applications, such as one employee and one energy source, do not need a prepared plan. However, it is advisable to have available written listings of all equipment and the specific locations of their energy-isolating devices. For other situations,

- Use the appropriate equipment shutdown procedures; turn off all operating controls.
- Locate all equipment energy-isolating devices, and isolate the machine from the energy sources.
- Use an approved lockout/tagout device to isolate each hazardous energy source (see Figure 2).
- Examine the equipment to detect and relieve any stored hazardous energy.
- Verify that the energy-isolating device has produced the required results.

4.5 Lockout/Tagout Removal

Before energy is restored to the equipment, an authorized employee should inspect the work area and make a personnel count. The procedure will verify that equipment components are operationally intact and the work is complete. The procedure should also ascertain that personnel are physically clear of the work area. Afterwards, each lockout/tagout device will be removed by the authorized employee who applied it. When this employee is not available, another employee, under the direction of the supervisor, may remove the device if:

- The supervisor verifies that the authorized employee who applied the device is not at the facility.
- The supervisor makes a reasonable effort to contact the authorized employee to inform him or her that the lockout/tagout device has been removed.
- The supervisor must ensure the authorized employee is informed that his or her lockout/tagout device was removed as soon as he or she arrives at work.

4.6 Documentation of Lockout/Tagout

Lockout/tagout placement, activation, and removal should be recorded, including any information relevant to their occurrence. This record should be maintained by the supervisor to ensure accuracy, completeness, and continuity of lockout/tagout protection.

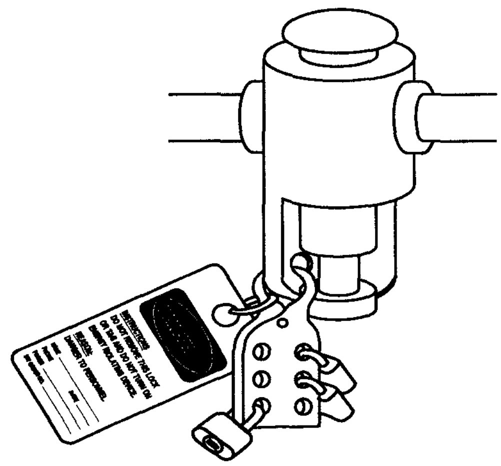

Figure 2. Lockout/tagout of energy source.

4.7 Testing Considerations

In situations where the energy-isolating devices are locked and tagged and the equipment must be tested or positioned, the following sequence must be performed:

- Clear the machine or equipment of all tools and materials.
- Make sure all authorized and affected personnel are clear.
- Remove the lock or tag according to procedures for lockout/tagout removal.
- Energize and proceed with equipment testing.
- Deenergize all systems and reapply energy control measures when the testing or positioning is complete.

4.8 Inspections

The supervisor must ensure that periodic inspections have been performed. The audit must identify the machine or equipment where the energy-control procedure was used, the date of the inspection, the employees included in the inspection, and the name of the person who performed the inspection. For lockout/tagout procedures, the periodic inspection must include a review between the inspector and each authorized employee (including affected employees when reviewing tagout procedures) of that employee's responsibilities under the energy control procedure being inspected.

4.9 Group Lockout/Tagout

The scope of the job, the complexity of the equipment/system, or the number of personnel involved may produce situations where a more functional and practical method of lockout/tagout is used. However, when service and maintenance is performed by a crew, department, or other group, it must use a lockout/tagout procedure that still affords the employees of the group protection equal to what a single employee would receive.

5. Training

5.1 General Training

All lockout/tagout training programs must ensure that all employees understand the purpose, function, and restrictions of the energy control program. The supervisor shall provide training and retraining as necessary and shall certify the training has been given to all employees. There are three classifications of employees for lockout/tagout training: **authorized, affected,** and **other.** The amount and kind of training that each employee receives is based on (1) the relationship of that employee's job to the machine or equipment being locked or tagged out, and (2) the degree of knowledge relevant to hazardous energy that he or she must possess. For example, the training program for **authorized** employees (those who are charged with the responsibility for implementing the energy control procedures and performing the servicing or maintenance) must cover, at minimum, the following areas:

- Details about the type and magnitude of the hazardous energy sources present in the workplace.
- The methods and means necessary to isolate and control those energy sources (i.e., the elements of the energy-controls procedure[s]).

By contrast, **affected** employees (usually the machine operators or users) and **other employees** (people who may be in the area) need only be able to (1) recognize when the control procedures are being implemented, and (2) understand the purpose of the procedure and the importance of not attempting to start up or use the equipment that has been locked or tagged out.

5.2 Retraining

Employees should be provided retraining whenever there is a change in a job assignment or in machines, equipment, or processes that present new hazards.

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American National Standard Institute (ANSI) 244.1. 1982. *For Personnel Protection—Lockout/Tagout of Energy Sources—Minimum Safety Requirements.* ANSI: New York.

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Appendix A. Lockout/Tagout Safety Checklist

This safety checklist assists authorized employees in determining that procedures and equipment are available and personnel are trained in the control of hazardous energy sources. This checklist only addresses the minimum required standards. Where appropriate, it may be supplemented with local site or shop-unique requirements. Relevant references are noted after each question.

Training OK Action Needed	OK	Action Needed
Are all authorized employees whose job requires them to perform service/maintenance on machines, systems, or equipment trained on lockout/tagout procedures? 29 CFR 1910.147 (c)(7)(i)	____	__________
Is lockout/tagout training sufficient to ensure recognition of applicable hazardous energy sources? 29 CFR 1910.147 (c)(7)(i)	____	__________
Do authorized employees know the adequate methods and means of isolating hazardous energy sources? 29 CFR 1910.147 (c)(7)(i)(A)	____	__________
Are affected employees instructed by their supervisor on the purpose and use of energy control procedures? 29 CFR 1910.147 (c)(7)(i)(B)	____	__________
Are all employees whose duties require them to be in an area where energy control procedures are used, instructed on their purpose, the prohibitions of lockout/tagout, and about a change in equipment that presents a new hazard? 29 CFR 1910.147 (c)(7)(iii)(A)	____	__________
If random lockout/tagout inspections reveal problems, is retraining accomplished? 29 CFR 1910.147 (c)(7)(iii)(B)	____	__________
If a supervisor has reason to suspect there are inadequacies in the employee's knowledge of lockout/tagout procedures, is retraining accomplished? 29 CFR 1910.147 (c)(7)(iii)(B)	____	__________
Is lockout/tagout retraining sufficient to provide employee proficiency and introduce new or revised procedures? 29 CFR 1910.147 (c)(7)(iii)(B)	____	__________
As a minimum, is lockout/tagout training recorded with the employee's name, class attendance date, and their work area? 29 CFR 1910.147 (c)(7)(iii)(C)	____	__________
Lockout/Tagout Procedures		
Are lockout/tagout devices capable of withstanding the environment to which they are exposed? 29 CFR 1910.147 (c)(5)(ii)(A)(1)	____	__________

	OK	Action Needed
Are lockout/tagout devices easily recognizable and clearly visible? 29 CFR 1910.147 (c)(5)(ii)	____	__________
Do locks have substantial strength to prevent removal without applying excessive force such as bolt cutters? 29 CFR 1910.147 (c)(5)(ii)(C)(1)	____	__________
Are lockout/tagout devices standard in either shape, color, or format? 29 CFR 1910.147 (c)(5)(ii)(B)	____	__________
Are tags, tag attachments, and lock attachment mechanisms designed so that the probability of accidental removal is minimized? 29 CFR 1910.147 (c)(5)(ii)(C)(2)	____	__________
Are tag attachments self-locking and attachable by hand? 29 CFR 1910.147 (c)(5)(ii)(C)(2)	____	__________
Have facilities identified their requirements for tags, locks, and attachment hardware, and do they have an adequate supply on-hand? 29 CFR 1910.147 (c)(5)(i)	____	__________
Has an initial survey been completed to identify all primary and secondary equipment energy sources? 29 CFR 1910.147 (d)(1)	____	__________
Are drawings, prints, and actual inspections used to assist in identifying all sources of equipment energy? 29 CFR 1910.147 (d)(1)	____	__________
If an energy isolating device is not capable of being locked out, can it be demonstrated that a tagout affords the adequate protection? 29 CFR 1910.147 (c)(3)(ii)(B)	____	__________
If using a tagout, can an additional means of protection be provided, such as blocking a control switch? 29 CFR 1910.147 (c)(3)(ii)(B)	____	__________
Are all energy isolating devices adequately labeled or marked to indicate their function? 29 CFR 1910.147 (d)(1)	____	__________
Is all new or replacement equipment able to accept a lock device? 29 CFR 1910.147 (c)(2)(iii)	____	__________
Prior to lockout/tagout implementation, are all affected employees notified of the work to be performed? 29 CFR 1910.147 (c)(9)	____	__________
If equipment complexity warrants, is a special lockout/tagout plan developed? 29 CFR 1910.147 (c)(4)(i)	____	__________

	OK	Action Needed
Do affected employees review the plan of lockout/tagout sequences of complex operations? 29 CFR 1910.147 (c)(7)(i)(A)	____	__________
Is there a written listing of all energy isolating devices on shop equipment? 29 CFR 1910.147 (c)(4)	____	__________
During lockout/tagout, are all operating controls turned off by an authorized employee? 29 CFR 1910.147 (d)(1)	____	__________
Is an approved lock or tag used to isolate each hazardous energy source? 29 CFR 1910.147 (d)(4)(i)	____	__________
Are tagouts located in such a position that they will be immediately obvious to anyone attempting to operate an energy isolating device? 29 CFR 1910.147 (c)(7)(ii)(C)	____	__________
Is the equipment or system examined to detect and relieve any stored hazardous energy? 29 CFR 1910.147 (d)(5)(ii)	____	__________
Is the equipment or system tested to determine if the operation of the energy isolation device is working? 29 CFR 1910.147 (d)(6)	____	__________
Before energy is restored, is a visual inspection and personnel count of the work area conducted by an authorized employee? 29 CFR 1910.147 (e)(1)	____	__________
Is each lockout/tagout device removed by the authorized employee who applied it? 29 CFR 1910.147 (e)(2)(ii)	____	__________
Does the supervisor maintain a record of placement and removal of lockouts/tagouts? 29 CFR 1910.147 (c)(4)(ii)(B)	____	__________
Special Lockout/Tagout Considerations		
If a group lockout/tagout system exists, does the procedure provide the same protection that a single employee would receive? 29 CFR 1910.147 (f)(3)(i)	____	__________
Is responsibility for a number of personnel working under the protection of a particular lockout/tagout vested with an authorized employee or supervisor? 29 CFR 1910.147 (f)(3)(ii)(A)	____	__________
Are specific procedures established for lockout/tagout utilization during shift change? 29 CFR 1910.147 (f)(4)	____	__________

	OK	Action Needed
If outside contractors are working on-site, do our personnel ensure compliance with lockout/tagout procedures? 29 CFR 1910.147 (f)(2)	___	___

Periodic Inspections

	OK	Action Needed
Are periodic inspections of lockout/tagout procedure conducted at least annually? 29 CFR 1910.147 (c)(6)(i)	___	___
Are inspections conducted by a supervisor or authorized employee, other than the person using the lockout/tagout procedure? 29 CFR 1910.147 (c)(6)(i)(A)	___	___
Does the inspection include a review between the inspector and the authorized/affected employees of their responsibilities under the lockout/tagout program? 29 CFR 1910.147 (c)(6)(i)(D)	___	___
Are inspections certified and recorded? 29 CFR 1910.147 (c)(6)(ii)	___	___
As a minimum, do the inspections include the date of inspection, the employee and inspector names, and the equipment on which the lockout/tagout procedures are being used? 29 CFR 1910.147 (c)(6)(ii)	___	___

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29 CFR = Code of Federal Regulations Title 29

Chapter 4
Confined-Space Entry

1. Introduction

1.1 Incidence of Fatalities

Work in confined space presents unusual and severe hazards to a sizable portion of the Department of Energy (DOE) and maintenance and operations (M&O) contractors' work forces. Common tasks, such as welding, use of solvents and adhesives, live electrical work, or painting can quickly become lethal in a confined space. The National Institute for Occupational Safety and Health (NIOSH) reports that about 63 occupational fatalities per year in the United States are caused by improper confined space entries. The Occupational Safety and Health Administration (OSHA) reports that over 60 percent of the fatalities were would-be rescuers and estimates that 85 percent of deaths and injuries in confined spaces could be prevented if industry would fully implement sound confined-space entry permit programs.

1.2 Causes of Fatalities

Many fatalities occur because victims do not fully understand the threat of airborne hazards that they cannot see, smell, or feel. Additional fatalities occur when untrained persons enter unknown atmospheres to rescue fallen co-workers.

Unsafe Acts and Omissions

- Failure to test the atmosphere in a confined space before entry.
- Failure to continuously monitor the atmosphere in a permit-required confined space.
- Failure to lock out hazardous fluids, mechanical equipment, and electrical power to equipment inside the confined space.
- Failure to follow approved entry procedures.
- Failure to preplan rescue and retrieval efforts.
- Failure to use adequate respirators.

Unsafe Conditions

- Lack of training.
- Fall hazards.
- Oxygen deficient atmosphere.
- Oxygen enriched atmosphere.
- Poor lighting.
- Flammable atmosphere.
- Lack of a communication system when entrants are out of sight.
- Toxic atmosphere.
- Electrical shock hazards.
- Presence of an engulfing or drowning medium.
- Entrapping mechanisms.
- Grinding, crushing, or mixing mechanisms.
- Contact with hazardous chemicals.

1.3 Prevention Overview

From previous incidents, a few preventive measures have been established:

- Be able to identify confined spaces.
- Always follow official procedures for confined space entry.
- Always have a co-worker (attendant) to watch when working in confined spaces.
- Never attempt a rescue unless you are trained to do so and have a qualified attendant to watch.
- Ensure proper confined space ambient air testing is conducted by trained Industrial Hygiene (IH) personnel.

1.4 Scope and Purpose

This chapter addresses working in confined spaces. It includes initial identification and risk assessment of confined spaces, entry procedure development and approval, self-help, and emergency rescue. Two categories of confined spaces are covered in this chapter: permit-required confined spaces (PRCS) and non-permit-required confined spaces (NPRCS).

1.5 Basic Terms

Confined Space. A space that is large enough and so configured that an employee can bodily enter and perform work. Confined spaces have limited or restricted means for entry or exit and are not designed for continuous occupancy. Confined spaces include storage tanks, bins, boilers, ventilation and exhaust ducts, pits, manholes, vats, and reactor vessels.

Entry. Confined-space entry begins when any part of the employee's body breaks the plane of any opening of the confined space and continues until the employee exits the confined space.

IDLH. Any condition that would pose an immediate or delayed threat to life, cause irreversible health effects, or interfere with an individual's ability to escape unaided from a permit space.

Isolation. A process of interrupting and/or disconnecting pipes, lines, and energy sources from the confined space. The space is removed from service, and complete protection from release of energy or substances into the space is provided.

Lower explosive limit/lower flammability limit (LEL/LFL). The lowest percentage of a substance in the air that leads to fire or explosion.

Non-permit-required confined space (NPRCS). A space that meets the definition of a confined space but, which after evaluation, does not contain or have potential to contain any hazard capable of causing death or serious physical harm.

Permit-required confined space (PRCS). A confined space that has one or more of the following characteristics:

- Potential to contain a hazardous atmosphere.
- Material that has potential for engulfing an entrant.
- An internal configuration that could trap or asphyxiate an entrant such as inwardly converging walls or a floor that slopes downward and tapers to a smaller cross-section.
- Any other recognized serious safety or health hazard.

2. Standards and Codes

Group	Standard	Subject
OSHA	29 CFR 1910.146	Permit required confined spaces
OSHA	29 CFR 1910.147	The control of hazardous energy (lockout/tagout)
OSHA	29 CFR 1910.268 (o)	Telecommunications: underground lines
OSHA	29 CFR 1910.333	Selection and use of (electrical) practices; paragraph (b) (2) lockout and tagging paragraph (c) (5) confined work spaces
OSHA	29 CFR 1910.353	Ventilation and protection in welding, cutting, and heating.
OSHA	29 CFR 1910 Subpart Z	Toxic substance standards
ANSI	Standard Z117.1-1989	Safety requirements for confined space
ACGIH	-------------	Threshold limit values and biological indices

OSHA = Occupational Safety and Health Administration.
ACGIH = American Congress of Governmental Industrial Hygienists.
ANSI = American National Standards Institute.

Table 2.1. Standards and codes for confined-space entry.

3. Protective Devices and Controls

3.1 Air Testing Equipment

All air-testing equipment should be calibrated in accordance with the manufacturer's instruction.

3.1.1 Oxygen Meters and Monitors.

The oxygen content of the air in a confined space is the first and most important constituent to measure before entry is made. The acceptable range of oxygen is between 19.5 and 23.5 percent. This content is measured before flammability is tested because rich mixtures of flammable gases or vapors give erroneous measurement results. For example, a mixture of 90 percent methane and 10 percent air will test nonflammable because there is not enough oxygen to support the combustion process in the flammability meters. This mixture will not support life and will soon become explosive if ventilation is provided to the space. Before entry, spaces must be ventilated until both oxygen content and flammability are acceptable.

3.1.2 Flammability Meters

Flammability meters are used to measure the amount of flammable vapors or gases in the atmosphere as a percent of the LEL/LFL. The oxygen content must be near 21 percent for results to be meaningful.

3.1.3 Toxic Air Contamination Testers

Tests for toxic contaminants must be specific for the target toxin. The instrument manufacturer should be consulted for interferences. Therefore, it is important to know the history of the confined space so proper tests can be performed. Part of hazard assessment is to identify all possible contaminants that could be in the confined space.

3.2 Protective Devices

3.2.1 Fall-Protection Equipment

Fall-protection equipment for confined spaces should be the chest-waist harness type to minimize injuries from uncontrolled movements when it arrests a worker's fall. This type of harness also permits easier retrieval from a confined space than a waist belt. Adjustable lanyards should be used to limit free fall to two feet before arrest.

3.2.2 Respirators

An industrial hygienist should select respirators on the basis of his or her evaluation of possible confined-space hazards. NIOSH-approved respirators should be identified in the approved procedure required by the confined-space entry permit. It is important to note that air-purifying respirators cannot be used in an oxygen deficient atmosphere.

3.2.3 Lockout/Tagout Devices

Lockout/tagout devices permit employees to work safely on deenergized equipment without fear that the devices will be accidentally removed. Lock and tag devices are required to withstand a 50-pound pull without failure. Devices used to block or restrain stored mechanical energy devices must be engineered for safety.

3.2.4 Safety Barriers

Safety barriers separate workers from hazards that cannot reasonably be eliminated by other engineering controls. Required barriers will be identified in the approved confined-space entry procedure.

3.2.5 Ground Fault Circuit Interrupters

Ground fault circuit interrupter must be used for all portable electrical tools and equipment in confined spaces because most workers will be in contact with grounded surroundings.

3.3 Emergency Response Equipment

3.3.1 Fire Extinguishers

"Hot work" inside a confined space requires that an approved fire extinguisher and a person trained in its use be stationed in the confined space or in a suitable vantage point where he or she could effectively suppress any fire that might result from the work.

3.3.2 First Aid Equipment

Blankets, first-aid kit, Stokes stretchers, and any other equipment that may be needed for first-response treatment must be available just outside the confined space. Medical and safety professionals should select equipment on the basis of their evaluations of the potential hazards in the confined space.

3.3.3 Retrieval Equipment

A tripod or another suitable anchorage, hoisting device, harnesses, wristlets, ropes, and any other equipment that may be needed to make a rescue must be identified in the confined-space safe-entry procedures. It is important that this equipment be available for immediate use. Harnesses and retrieval ropes must be worn by entrants unless they would increase hazards to the entrants or impede their rescue.

4. Work Practices

4.1 Confined-Space Program

4.1.1 Key Elements

- Written program.
- Identification of confined spaces.
- Establishment and full implementation of a written entry permit system.
- Air monitoring.
- Selection and training of key personnel.
- Protective equipment.
- Provisions for attendants and emergency response.

Personnel selection, training, and motivation are the three most important aspects of a confined-space safe entry program. This program should be established through close oversight by health and safety professionals and strong support by management.

4.1.2 Identification of Confined Spaces

All confined spaces should be identified and classified as non-permit-required confined spaces or permit-required confined spaces. The degree of hazards that confront entrants determines the classification of the confined space. A hazard assessment should be performed and documented by industrial safety and hygiene personnel for each confined space. Permit-required confined spaces shall be posted:

DANGER PERMIT-REQUIRED CONFINED SPACE, DO NOT ENTER Responsible Supervisor ________________ Entry Procedure XXXXX

4.1.3 Entry Permits

The key elements that a permit must contain are:

- Time, date, and place.
- Names and signatures of entrants, attendants, and entry supervisor.
- Hazards of the space.
- Measures used to eliminate or control hazards.
- Acceptable entry conditions.
- Results of initial and periodic monitoring.
- Equipment available at time of entry.

Confined-space entry permit programs need to be evaluated annually to ensure that personnel, procedures, and equipment components of the program are maintained in a high state of readiness. Confined-space entry permits should be retained for one year after each job completion in a central location. There should also be a feedback system so that problems encountered during confined-space entries can be brought to management's attention.

4.1.4 Safe Entry Procedures

Safe entry procedures must be developed for permit-required spaces before personnel are allowed to enter these spaces. It is important to include any emergency that could occur in the confined space in the safe entry procedure emergency response and rescue procedures. The maximum number of authorized entrants should be kept to a minimum. This number should be spelled out in the approved confined-space safe entry procedure required to obtain the permit. The duration of the permit may not exceed the time required to complete the assigned task or job. All lockout/tagout provisions, as well as preparations for entry and emergency response, need to be rechecked. All safeguards in the approved procedure must be in place before the second crew enters the confined space.

4.1.5 Lockout/Tagout

A lockout/tagout program is essential to safeguard personnel during confined-space entry operations. Lockout/tagout procedures are used to permit persons to work safely on deenergized equipment, without fear that the equipment will be reenergized while they are at work. Locking devices must be secure enough to ensure that they are not accidentally removed. Devices used to block or restrain stored mechanical energy sources must be engineered to do so safely. Lines and pipes that could carry flammable, toxic, or injurious substances into the confined space must be blocked by positive means, such as valves, to ensure that the atmosphere in the confined space is not contaminated or rendered inert.

4.1.6 Key Personnel Roles

Supervisor. The supervisor has overall responsibility for the safety of all persons involved with entry operations into confined spaces under his or her control. This includes authorized entrants, safety attendants, and emergency rescue personnel. The supervisor authorizes entry into a confined space, approves procedures for entry, and coordinates efforts of all other key personnel. The supervisor ensures that all safety requirements identified in the permit are met, all required equipment is readily available, and all persons involved in the entry are fully aware of their roles and responsibilities. The supervisor's responsibilities also include canceling the permit when the entry is complete and retaining the permit for one year for audit purposes.

Safety Attendant. The safety attendant continuously observes authorized entrants working in a confined space. The safety attendant must be trained to recognize early symptoms of oxygen depletion (anoxia), toxic effects, and behavioral changes. The attendant must not be exposed to the same hazard as the entrants and must be trained, equipped, and physically able to render immediate and effective aid. He or she will keep track of the number of people entering and leaving the confined space to avoid exposing rescue personnel to grave risks by searching for a person who has previously left the confined space. Where entrants are out of sight of the safety attendant, a means of communications must be provided.

Authorized Entrant. An authorized entrant is selected and trained to safely enter, work in, and exit confined spaces. Training includes a physical examination, classroom training, and on-the-job training in self-help techniques.

Industrial Hygienist. The industrial hygienist reviews and approves procedures to satisfy confined-space entry permit requirements. The industrial hygienist defines the types of respiratory protection needed in the confined space and samples air to determine that oxygen content is neither deficient nor enriched and that the atmosphere is nonflammable, nonexplosive, and nontoxic.

Industrial Safety Engineer. The industrial safety engineer inspects the confined space to determine if there are physical, engulfment, electrical, fall, or fire hazards that could injure entrants. The industrial safety engineer inspects lockout/tagout provisions to determine if they prevent entry of harmful substances into the confined space. He or she takes steps to prevent movement of machinery because of gravity, springs, or trapped compressed gases and reviews and approves procedures for entry, emergency response plans, and preparations for the confined-space entry.

4.2 Preentry

One should never enter a permit-required confined space without a safety attendant on duty and adequate air testing. To the extent practicable, provisions should be made to expedite entry and exit from the confined space.

Permit-required confined spaces should be inspected by a supervisor, industrial hygenist and/or safety engineer prior to work entry.

4.2.1 Air Sampling

Air in the confined space should be tested for oxygen content, flammability, and toxic contamination. If no dangerous air contamination, oxygen deficiency, or enrichment is found and no other hazard exists, the space can be safely entered. Under no circumstances should an ignition source be introduced into the confined space until test measures have ensured that no flammable or explosive atmosphere exists or will occur during entry operations.

4.2.2 Ventilation

If the confined space has contained hazardous substances, it is important for the confined space to be emptied and thoroughly flushed or purged before entry. In addition, where air sampling indicates a need, supplemental mechanical ventilation must be provided.

4.2.3 Crew Briefing

The crew supervisor or lead man should always give a safety briefing covering all protective measures, emergency response plans and preparations, and each person's role and responsibilities at the start of each entry or shift change. He or she must perform a final inspection and complete a checklist to ensure that all items required by the permit are in place before an entry is made.

4.2.4 Oxygen-Consuming Devices

Whenever combustion devices are used in a confined space, steps must be taken to ensure that combustion air is supplied, and combustion products are exhausted from the confined space.

4.2.5 Fire-Suppression Systems

Automatic fire-suppression systems using harmful concentrations of toxic or oxygen-displacing gases or total foam flooding should be deactivated. Self-contained breathing apparatus (SCBA) has to be used where it is not practical or safe to deactivate such systems.

4.3 Confined-Space Operations

4.3.1 Protective Equipment

Appropriate NIOSH-approved respiratory protection and other protective equipment must be provided and worn in confined space areas when required.

4.3.2 Top Entry

Confined spaces with top and side openings should be entered from the side whenever practicable. When entry must be made into a confined space through a top opening, the following requirements apply: (1) A harness-type safety belt that supports a person in an upright position must be used, and (2) A hoisting device with a minimum mechanical advantage of 4 to 1 must be provided for lifting workers out of the confined space.

4.3.3 Hot Work

Work using flames, arcs, sparks, or other sources of ignition is prohibited within a confined space. It is also prohibited in a space having a common surface with a confined space that contains or is likely to develop dangerous air contamination due to the presence of flammable or explosive substances.

4.3.4 Inert Atmospheres

Whenever inert gases such as nitrogen are used to create an inert atmosphere to prevent ignition of flammable gases or vapors, no ignition source is permitted unless the atmosphere is kept below 10% of LEL/LFL. Ventilation is required before entry to ensure the atmosphere is acceptable before an entry permit is issued. Testing the oxygen content must be done every 20 minutes, and written records of test results must be kept at the job site for the duration of the job.

4.3.5 Electrical Equipment

Only U.L. or equivalent approved lighting and electrical equipment should be used in confined spaces that are subject to dangerous air contamination from flammable or explosive substances. Portable electric tools used in a confined space must be protected by a ground fault circuit interrupter.

4.3.6 Corrosives

Employees working in confined spaces that have last contained substances corrosive to the skin or substances that can be absorbed by the skin, are required to wear appropriate protective clothing and equipment, unless the space has been decontaminated prior to entry.

4.3.7 Communications

An effective means of communications between employees inside a confined space and the safety attendant must be used whenever conditions in the space require use of respirators or whenever entrants are out of sight of the safety attendant at any time. It is important that the communication system be tested before each use, and frequently thereafter, to ensure that it is working properly.

4.3.8 Rescue Operations

An approved harness and an attached line must be used. The free end must be secured outside the confined space. The line should be at least 0.5 inches in diameter and able to withstand a 2,000 pound test. Exception: A line may be eliminated in situations where it would further endanger the worker or not contribute to rescue. At least one other employee who may have other duties must be within calling distance to assist the safety attendant in an emergency. If required by the entry procedure, the safety attendant must have an appropriate, NIOSH-approved, SCBA respirator available for immediate use. The safety attendant may enter the confined space, but only in case of emergency and after notifying another employee. This employee will then become the safety attendant and assume all duties outside of the confined space. The safety attendant must wear appropriate protective equipment, including self-contained breathing apparatus, during the emergency entry and ensure that another employee is standing by outside.

5. Training and Personal Protective Equipment

5.1 General Training

Training must emphasize preventing hazardous conditions during confined-space entries and preparing for emergency response, both self-help and emergency rescue. The following training is required for all key personnel:

- American Red Cross Cardio-Pulmonary Resuscitation (CPR) Course or equivalent.
- American Red Cross Advanced First Aid Course (Basic) or equivalent.
- Confined-Space-Entry Safety Course.
- Fire Extinguisher Use Course.
- Lockout/Tagout Course.

Training should emphasize that serious emergencies can develop quickly in confined spaces. Trained personnel, preplanned responses, and preplaced rescue equipment are important for immediate and effective action when emergencies occur.

Training must be conducted annually for confined-space-entry and emergency rescue courses. Support courses such as Red Cross First Aid and Cardiopulmonary Resuscitation must be conducted in accordance with Red Cross requirements to keep certifications current.

5.1.1 Authorized Entrant Training

Authorized entrants must be trained to recognize possible hazards in confined spaces and to know what countermeasures are available. They also need to be familiar with lockout/tagout procedures, air sampling techniques, use of protective equipment, and know the limitations of the protective equipment. It is also important they know how to recognize in themselves early symptoms of oxygen deprivation or intoxication such as dizziness, slurred speech, drowsiness, weakness, and loss of balance. Training should emphasize the importance of immediate evacuation at the first sign that the atmosphere is not safe. Training in methods and equipment used in self-help is also important. The employer should certify that employees have had all training necessary for performing safe entry into confined spaces.

5.1.2 Safety Attendant Training

Safety attendants must be able to recognize symptoms such as behavioral changes, slurred speech, dizziness, clumsiness, weakness or fatigue and other signs of distress in entrants. It is important that safety attendants be aware that the confined space must be immediately evacuated if such symptoms are observed.

5.1.3 Supervisor Training

Supervisors who are responsible for personnel who enter confined spaces must receive all training that other key personnel receive. Supervisor training must emphasize the importance of strict adherence to all rules established in approved procedures required by the permit system.

5.1.4 Emergency Rescue Team Training

Emergency response team training includes all training required for key personnel plus annual practical training in removing dummies, mannequins, or actual persons from actual or representative permit spaces.

5.2 Personal Protective Equipment

(Respirators)

Air purifying respirators can remove some contaminants from the air, but they do not protect from oxygen deficient atmospheres. For oxygen deficient atmosphere, supplied air respirators should be used. Supplied air respirators can be either self-contained or airline supplied types. All respirators must be selected by an industrial hygienist, fitted to the user, and the user trained in its use and limitations. A self-contained breathing apparatus is the only approved respiratory protection for IDLH environments. It is important to note that air purifying respirators cannot be used in an oxygen deficient atmosphere.

6. Hazards

6.1 Hazardous Atmosphere

A hazardous atmosphere means an atmosphere that may expose employees to the risk of death, incapacitation, impairment of ability to self-rescue (that is to escape unaided from a permit space), injury, or acute illness from one or more of the following causes:

- **Oxygen deficient atmosphere.** When the oxygen content is below 19.5 percent, it is too low to provide enough oxygen for a working person.
- **Oxygen enriched atmosphere.** Oxygen content above 23.5 percent causes combustible substances to burn more vigorously than in normal atmosphere. For instance, in an oxygen enriched atmosphere, a person's hair, clothing, and even skin will burn rapidly if ignited.
- **Flammable explosive atmosphere.** Flammable gases, vapors, or dusts are dangerous in concentrations above 10 percent of the lower flammable explosive limit.
- **Toxic atmosphere.** Dangerous air contamination caused by a toxic substance is the concentration immediately dangerous to life and health. This definition does not preclude the requirement to control the concentrations to below the permissible exposure limit for persons working without respiratory protection.
- **Airborne combustible dust at a concentration that exceeds its LFL.** In a concentration above LFL, dust obscures vision at a distance of 5 feet or less.

- **IDLH.** Any other atmospheric condition that is immediately dangerous to life or health is considered a hazardous atmosphere.

6.2 Electrical/Mechanical Hazards

Electrical power that could shock workers or move mechanical equipment must be locked or tagged out prior to entry into a confined space. Machinery that could move under the influence of gravity, spring loads, or other forces must be mechanically blocked or immobilized before work is started in a confined space.

6.3 Engulfment/Drowning

Grain, dusts, powders, liquids, or slurries pose serious hazards to persons entering confined spaces. Persons engulfed in sawdust or grain cannot breathe and become asphyxiated in a very short time. Lifelines attached to an approved harness, mechanical lifting aids, and an alert safety attendant are needed to prevent deaths in this work environment.

6.4 Fall Hazards

Fall hazards are serious because it is difficult to retrieve an injured person in confined spaces. Free-fall distance must be limited to 2 feet (0.61 meters) before the fall is arrested.

7. Bibliography

National Institute for Occupational Safety and Health (NIOSH). NIOSH Alert. *Request for Assistance in Preventing Occupational Fatalities in Confined Spaces.* NIOSH: Morgantown, WV.

U.S. Department of Labor, Occupational Safety and Health Administration (OSHA). 29 CFR Part 1910.146. *Permit-Required Confined Spaces for General Industry.* Final Rule. OSHA: Washington, DC.

U.S. Department of Labor Occupational Safety and Health Administration (OSHA). 1993. *Permit-Required Confined Spaces (Permit Spaces) OSHA 3138.* OSHA: Washington. D.C.

Appendix A. Confined-Space Preentry Checklist

Checklist must be filled out whenever workers enter a permit required space. A copy of the safe entry procedure must be available at the entry point to the confined space.

	OK	Action Needed
Did you survey the surrounding area to show it to be free of hazards such as drifting vapors from tanks, piping, or sewers?	____	__________
Does your knowledge of industrial or other discharges indicate this area is likely to remain free of air contaminants while occupied?	____	__________
Are you certified in operation of the gas monitor to be used?	____	__________
Has a gas monitor functional test been performed this shift on the gas monitor to be used?	____	__________
Did you test the atmosphere of the confined space prior to entry?	____	__________
(a) Was oxygen content between 19.5 percent and 23.5 percent ?	____	__________
(b) Was flammable vapor less than 10 percent of LEL/LFL?	____	__________
(c) Were tests for toxic materials less than TLV/PEL?	____	__________
Have all sources of hazards been isolated from the confined space?	____	__________
(a) Have all pipes been blanked?	____	__________
(b) Have electrical and mechanical hazards been locked and blocked?	____	__________
Is all rescue equipment called out in the safe entry procedure available outside the confined space?	____	__________
Will the atmosphere be continuously monitored while the space is occupied, if required by entry procedure?	____	__________
Have the facility emergency and rescue services been notified that a confined space entry is about to be made?	____	__________

NOTICE: If any of the above questions are answered "Action Needed," do not enter the confined space until the conditions are corrected.

Supervisor/Lead Man ____________________________

Appendix B. Confined-Space-Entry Safety Work Permit

1. General Information

(a) Identify permit space to be entered. ____
(b) Purpose of entry. ____
(c) Time of authorized entry. ________ am/pm
(d) Authorized duration: Start Time ______am/pm End Time _____am/pm
(e) Entrants' names and employee numbers:

________________________________ ____________________________
________________________________ ____________________________
________________________________ ____________________________
________________________________ ____________________________

(f) Work Location: ____

(g) Equipment to be worked on: ______________________________________

(h) Description of job: ____
____
____

(i) Hazards of the permit space:
____
____
____
____

2. Measures Used To Isolate the Permit Space:

(a) Are electrical sources secured per Lockout/Tagout Chapter? _____
(b) Mechanical lockout/blockout _____
(c) Blanking/disconnect _____

3. Acceptable Entry Conditions:

(a) Acceptable oxygen content is between 19.5 and 23.5 percent.
Make and model of oxygen tester ______________________________ Calibration Date________________
Measured oxygen content ______ percent.
Person performing test____

(b) Acceptable flammable gas, vapor, and dust concentrations are less than 10 percent LEL/LFL.
Make and model of flammability tester: ______________________________ Calibration Date__________
Measured flammability ______ percent of LEL/LFL.
Person performing test____.

(c) Acceptable toxicity levels are those listed in the approved entry procedure.
Make and model of toxicity testers:__________________________________ Calibration Date__________
Person performing test____.

(d) Ventilation: Powered fresh air ventilation is functioning properly ____

(e) Temperature: There is safe working temperature in the confined space: ____

(f) Exhaust air is directed away from work areas ____

(g) Hot Work Permit is required for open flame torches, electric heater, arc, or flame welders, flame, or spark-producing devices.

4. Power Tool Use

(a) Are portable electric tools double insulated or GFCI protected? ______

(b) Are electrical power cords routed so that personnel
working in the confined space will not trip over them? ______

5. Personal Protective Equipment

Are the following items below used as required by entry procedure?

Air-purifying respirator _____ Air-supplied respirator _____

Head/eye protection _____ Hand/foot protection _____

Protective clothing _____ Hearing protection _____

Portable shower/eyewash _____ Harness/rope _____

Continuous personal monitor _____ Rescue equipment _____

6. Rescue (Call 911)

(a) Name of safety attendant ______________________________________

(c) Means of communication with emergency rescue services: Phone _____ Radio _____

(d) Means of communication with entrant(s): Voice ____ Radio _____

(e) Continuous visual contact with entrants _____

7. Special Restrictions / Instructions

____

____

8. Approvals

Signatures below indicate that all entrants and safety attendants have current training, physical examinations, and that all requirements of this permit are fulfilled.

________________________________ ________________________________

Supervisor/Lead Man Safety Attendant

Appendix C. Confined-Space-Entry Safety Checklist

This safety checklist is provided to help employees and supervisors to follow minimal safety practices. This list is neither meant to be comprehensive nor to form part of any official self-assessment practice. Where appropriate, local safety offices and supervisors are encouraged to add to these checklists. Relevant references are noted after each question.

General Requirements	OK	Action Needed
Have all confined spaces at this facility been evaluated and classified as permit-required spaces or non-permit-required confined spaces? 29 CFR 1910.146 (c) (1)	____	____________
Are all permit-required confined spaces posted "DANGER, PERMIT-REQUIRED CONFINED SPACE, DO NOT ENTER"? 29 CFR 1910.146 (c) (2)	____	____________
Is a written and implemented confined-space entry program in place? 29 CFR 1910.146 (c) (4)	____	____________
Is the written program available for inspection by employees or their authorized representatives? 29 CFR 1910.146 (c) (4)	____	____________
Are there effective measures in place to prevent unauthorized entry into confined spaces? 29 CFR 1910.146 (c) (5)	____	____________
Are acceptable entry conditions spelled out in the safe entry procedure? 29 CFR 1910.146 (f) (9)	____	____________
Are results of initial and periodic tests documented and initialed with an indication of the time and location noted where samples were taken? 29 CFR 1910.146 (f) (10)	____	____________
Are procedures and equipment (including phone numbers) to summon rescue and emergency services called out on the entry permit? 29 CFR 1910.146 (f) (11)	____	____________
Are communication procedures used by authorized entrants and safety attendants included in the entry permit? 29 CFR 1910. (f) (12)	____	____________
Is personal protective equipment, testing equipment, alarm systems, and rescue equipment identified in the entry permit? 29 CFR 1910.146 (f) (14)	____	____________
Are other permits, such as for hot work, posted with the entry permit? 29 CFR 1910.146 (f) (15)	____	____________

Training	OK	Action Needed
Does the employer provide training to all employees involved in confined-space entry operations so they acquire the understanding, knowledge, and skills necessary to perform their duties safely? 29 CFR 1910.146 (g) (1)	____	____________
Is training provided before the employee is assigned to confined-space entry duties? 29 CFR 1910.146 (g) (2) (i)	____	____________
Is training provided when there is a change in assigned duties? 29 CFR 1910.146 (g) (2) (ii)	____	____________
Is training provided before there is a change in permit space operations that presents a hazard about which the employee has not been trained? 29 CFR 1910.146 (g) (2) (iii)	____	____________
Is additional training provided whenever the employer has reason to believe that there are deviations from safe entry procedures, or that there are inadequacies in the employee's knowledge of the procedures? 29 CFR 1910.146 (g) (2) (iv)	____	____________
Does training establish employee proficiency in the duties necessary to comply with this chapter? 29 CFR 1910.146 (g) (3)	____	____________
Does the employer certify that training required by this chapter has been accomplished? 29 CFR 1910.146 (g) (4)	____	____________
Duties of Authorized Entrants		
Does the authorized entrant know the hazards that may be faced during entry, including information on the mode, signs or symptoms, and consequences of exposure? 29 CFR 1910.146 (h) (1)	____	____________
Do all authorized entrants know how to use equipment required by the safe entry procedure? 29 CFR 1910.146 (h) (2)	____	____________
Do all authorized entrants understand the importance and methods of communications with the safety attendant and the importance of evacuating the space promptly if ordered to do so? 29 CFR 1910.146 (h) (3)	____	____________
Are entrants trained to alert the safety attendant whenever the entrant recognizes any warning sign or symptom of exposure to a dangerous situation, or detects a prohibited condition? 29 CFR 1910.146 (h) (4)	____	____________

	OK	Action Needed
Are entrants trained to exit from the permit space as quickly as possible whenever the order is given to evacuate by the safety attendant or supervisor, they recognize any warning sign or symptom of exposures to a dangerous situation, they detect a prohibited condition, or an evacuation alarm is activated? 29 CFR 1910.146 (h) (5)	____	____

Duties of Safety Attendants

	OK	Action Needed
Does the safety attendant know the hazards that may be faced during entry, including information on the mode, signs or symptoms, and consequences of exposure? 29 CFR 1910.146 (i) (1)	____	____
Are safety attendants trained to be aware of possible behavioral effects of hazard exposure in authorized entrants? 29 CFR 1910.146 (i) (2)	____	____
Are safety attendants required to maintain an accurate count of authorized entrants? 29 CFR 1910.146 (i) (3)	____	____
Is a roster or tracking system used to maintain an accurate count of authorized entrants, by name, for the entire duration of the permit? 29 CFR 1910.146 (f) (4)	____	____
Are safety attendants trained to remain outside the permit space until relieved by another safety attendant? 29 CFR 1910.146 (i) (4)	____	____
Are safety attendants trained to communicate with authorized entrants to monitor entrant status and to alert entrants of the need to evacuate the space if conditions warrant? 29 CFR 1910.146 (i) (5)	____	____
Are safety attendants trained to monitor activities inside and outside the space to determine if it is safe for entrants to remain in the space and to order evacuation of the space immediately if the attendant detects a prohibited condition, detects behavioral effects of hazard exposure, detects a situation outside the space that could endanger entrants, or if the safety attendant cannot perform all the duties required herein? 29 CFR 1910.146 (i) (6)	____	____
Are safety attendants trained to summon rescue personnel as soon as the attendant determines that entrants may need assistance to escape from permit space hazards? 29 CFR 1910.146 (i) (7)	____	____
Are safety attendants trained to warn unauthorized personnel that they must stay out of and away from the permit space? 29 CFR 1910.146 (i) (8)	____	____
Are supervisors and authorized entrants notified if unauthorized persons have entered the permit space? 29 CFR 1910.146 (i) (8) (iii)	____	____

	OK	Action Needed
Are safety attendants trained to perform nonentry rescues as specified in the safe entry procedure? 29 CFR 1910.146 (i) (9)	____	____________
Are safety attendants prohibited from performing duties that might interfere with their primary duty to monitor and protect authorized entrants? 29 CFR 1910.146 (h) (1)	____	____________

Duties of Entry Supervisors

	OK	Action Needed
Are entry supervisors trained to recognize hazards that may be faced during entry, including the mode, signs, or symptoms, and consequences of exposure? 29 CFR 1910.146 (j) (1)	____	____________
Do supervisors verify by checking entries made on the permits that all tests have been conducted and all tests specified by the permit are in place before endorsing the permit and allowing the entry to begin? 29 CFR 1910.146 (j) (2)	____	____________
Does the entry supervisor terminate entry and cancel the entry permit when the entry operations have been completed? 29 CFR 1910.146 (e) (5) (i)	____	____________
Does the entry supervisor terminate entry and cancel the permit when a condition that is not allowed under the entry permit arises in or near the permit space? 29 CFR 1910.146 (e) (5) (ii)	____	____________
Does the entry supervisor verify that rescue services are available and that means for summoning them are operable? 29 CFR 1910.146 (j) (4)	____	____________
Do supervisors remove unauthorized persons who enter or attempt to enter the permit space? 29 CFR 1910.146 (j) (5)	____	____________
Does the entry supervisor determine that operations within the confined space remain consistent with terms of the entry permit at reasonable intervals and whenever responsibilities are transferred to another supervisor? 29 CFR 1910.146 (j) (6)	____	____________

Rescue and Emergency Services

	OK	Action Needed
Does the employer ensure that each member of the rescue service is provided with, and trained to use properly, the personal protective equipment and rescue equipment necessary for making rescues from permit spaces? 29 CFR 1910.146 (k) (1) (I)	____	____________
Has each member of the rescue service been trained to perform the assigned rescue duties and trained as an authorized entrant? 29 CFR 1910.146 (k) (1) (ii)	____	____________
Do all members of rescue services practice making rescues of dummies or actual persons from actual permit spaces at least every 12 months? 29 CFR 1910.146 (k) (1) (iii)	____	____________

	OK	Action Needed
Is each member of the rescue service trained in basic first-aid and in cardiopulmonary resuscitation (CPR)? 29 CFR 1910.146 (k) (1) (iv)	____	____________
Is at least one member of the rescue service holding a current certification in first aid and CPR required to be available? 29 CFR 1910.146 (k) (1) (iv)	____	____________
Are all rescue personnel briefed to inform them of hazards they may confront while performing a rescue from confined space? 29 CFR 1910.146 (k) (2) (i)	____	____________
Does the employer provide access for rescue services to all permit confined spaces from which rescue may be necessary so that the rescue service can develop appropriate rescue plans and practice rescue operations? 29 CFR 1910.146 (k) (2) (ii)	____	____________
Are nonentry rescue and retrieval systems or methods used whenever an authorized entrant enters a confined space, except when retrieval equipment would increase overall risk or would not contribute to the rescue of the entrant? 29 CFR 1910.146 (k) (3)	____	____________
Is each authorized entrant required to wear a full body harness with a retrieval line attached at the center of the back near shoulder level or above the entrant's head? 29 CFR 1910.146 (k) (3) (i) **Note:** Wristlets may be used in lieu of chest or full body harness if the employer can show that the use of a chest or full body harness is not feasible or creates a greater hazard, and the use of wristlets is the safest and most effective alternative.	____	____________
Is the other end of the retrieval line required to be attached to a mechanical device or fixed point outside the permit space in such a manner that rescue can begin as soon as the rescuer becomes aware that rescue is necessary? 29 CFR 1910.146 (k) (3) (ii) **Note:** A mechanical device shall be available to retrieve personnel from vertical type permit spaces more than 5 feet deep.	____	____________
Is the requirement highlighted, if an injured entrant is exposed to a substance for which a Material Safety Data Sheet (MSDS) or other similar written information is required to be kept at the worksite, that MSDS or written information must be made available to the medical facility treating the exposed entrant? 29 CFR 1910.146 (k) (4)	____	____________

29 CFR = Code of Federal Regulations Title 29

Chapter 5
Personal Protective Equipment

1. Introduction

1.1 Incidence of Personal Protective Equipment Violations

In May 1991, the DOE Tiger Team assessment found 114 Personal Protective Equipment (PPE) violations out of 2,772 other violations at nine DOE sites and 79 PPE violations out of 2,211 violations at the DOE production facility.

1.2 Causes of Violations

Unsafe Acts

- Not wearing proper PPE.
- Lack of adequate training in using PPE.
- Hurrying—either using convenient but not proper PPE or not using PPE at all to get the task finished.

Unsafe Conditions

- Not eliminating or controlling hazards as much as practicable either through engineering and/or administrative controls before employing PPE.
- Poor housekeeping and lack of a physical barriers (e.g., items fall on workers, layout of machinery is not adequate for work situations).
- Protective shields and sound barriers not in place.
- Poor maintenance of protective equipment.

1.3 Purpose and Scope

This chapter discusses the types of equipment most commonly used for protection of the head (including eyes and ears), the torso, arms, hands, and feet. The use of equipment to protect against life-threatening hazards is also discussed.

Respiratory protection is not addressed. Information on respiratory protective equipment may be found in Title 29, CFR, Part 1910.134. This standard should be consulted for information on specialized equipment such as that used by firefighters.

1.4 Human Factors

The use of protective clothing and equipment is frequently resisted by the worker because it is uncomfortable and inconvenient. Particular effort should be made to ensure this equipment is the correct type and size and that it provides maximum comfort and minimum inconvenience. It must also ensure safe job performance. Dissatisfaction or resistance to using PPE can be minimized by proper on-the-job counseling. Failure to locate or store PPE in a prominent and convenient place can contribute to its misuse or nonuse.

2. Standards and Codes

Group	Standard	Subject
OSHA	29 CFR 1910.132	PPE general requirements
OSHA	29 CFR 1910.133	Eye and pace protection
OSHA	29 CFR 1910.135	Occupational head protection
OSHA	29 CFR 1910.95	Occupational noise exposure—audiometric test rooms
OSHA	29 CFR 1910.136	Occupational footwear
OSHA	29 CFR 1926.28	Head protection
OSHA	29 CFR 1910.137	Electrical protective devices
OSHA	29 CFR 1926.100	Head protection
OSHA	29 CFR 1923.101	Hearing protection
OSHA	29 CFR 1926.XXX	Eye and face protection
OSHA	29 CFR 1926.104	Fall protection—safety belts, lifelines, and lanyards
OSHA	29 CFR 1926.959	Fall protection—lineman's body belts, safety straps, and lanyards
ANSI	Z41	Men's safety toe footwear
ANSI	Z87.1	Eye and face protection
ANSI	Z89.1	Requirements for head protection
ANSI	A10.14	Fall protection—safety belts, lifelines, and harnesses
ASTM	J6.7	Rubber matting around electrical apparatus
ASTM	J6.6	Rubber insulating gloves
ASTM	J6.4	Rubber insulating blankets
ASTM	J6.2	Rubber insulating hoods
ASTM	J6.1	Rubber insulating line hose
AFOSH	127-31	Personal protective equipment
ASTM	J6.5	Rubber insulating sleeves

OSHA = Occupational Safety and Health Administration.
AFOSH = Air Force Occupational Safety and Health.
ANSI = American National Standards Institute.
ASTM = American Society for Testing Materials.

Table 2.1. Standards and codes for personal protective equipment.

3. Protective Equipment

3.1 Head Protection

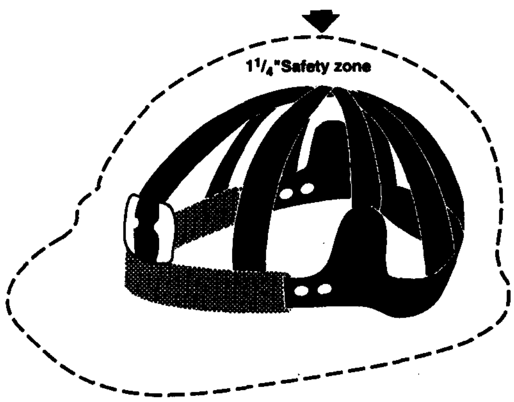
3.1.1 Incidence of Inadequate Protection

In 1980, a survey by the Bureau of Labor Statistics (BLS) showed that most employers of injured workers did not require them to wear head protection. Of those wearing hard hats, all but 5 percent indicated that it was an employer requirement. The vast majority who wore hard hats all or most of the time at work felt the hats were practical. In almost half of the accidents involving head injuries, employees knew of no actions taken by employers to prevent such injuries from recurring, according to the report.

The BLS survey noted that more than one-half of the workers were struck on the head while they were looking down and almost three-tenths were looking straight ahead. While a third of the unprotected workers were injured when bumping into stationary objects. Such actions injured only one-eighth of hard hat wearers.

3.1.2 Causes of Injuries

Head injuries are caused by falling or flying objects, or by bumping the head against a fixed object. Protective hats resist penetration and absorb the shock of a blow. The shell of the hat must be hard enough to resist a blow and a shock-absorbing lining composed of headband and crown straps to keep the shell away from the wearer's skull must be used.



Safety hat suspension system

Figure 1. Hard hats.

3.1.3 Types

Protective hats are made in the following types and classes: Type 1—helmets with full brim, not less than 1.25 inches (3.2 centimeters) wide; and Type 2—brimless helmets with a peak extending forward from the crown (see Figure 1). Liners and hoods are available for cold weather use.

For firefighters, head protection must consist of a protective head device with ear flaps and chin straps that meet the performance, construction, and testing requirements stated in Title 29 CFR, 1910.156 (e)(5).

3.1.4 Industrial Classes

For industrial purposes, three classes are recognized:

Class A—general service, limited voltage protection impact hazards.

Class B—utility service, high-voltage helmets.

Class C—special service, no voltage protection.

They are used in mining, building construction, shipbuilding, tunneling, lumbering, and manufacturing.

Class B utility service hats and caps protect the head from falling or flying objects and high-voltage shock and burn. They are used extensively by electrical workers.

Class C safety hats or caps are designed for lightweight comfort and impact protection. This class is usually manufactured from aluminum. Class C helmets are used in certain construction and manufacturing occupations, oil fields, refineries, and chemical plants where there is no danger from electrical hazards or corrosion. They are also used in work where the head may bump against fixed objects.

3.1.5 Minimum Requirements

Materials used in helmets should be water-resistant and slow burning. Each helmet consists of a shell and suspension. Ventilation is provided by a space between the headband and the shell. Each helmet should be accompanied by instructions explaining the proper method of adjusting and replacing the suspension and headband. The internal cradle of the headband and sweatband forms the suspension. The wearer should be able to identify the type of helmet by looking inside the shell for the manufacturer's name, ANSI designation, and class.

When the headband is adjusted to the right size, it provides sufficient clearance between the shell and the headband. The removable-replaceable sweatband should cover at least the forehead portion of the headband. The shell should be of one-piece seamless construction and designed to resist impact from falling material. Any part that comes in contact with the wearer's head should not be irritating to normal skin.

3.1.6 Inspection

Safety hats should be inspected prior to each use. Any one of the following defects is cause for immediate removal from service:

- Suspension systems that show evidence of material cracking, tearing, fraying, or other signs of deterioration. Suspensions should provide a minimum clearance of 1 to 1.25 inches (2.5 to 3.2 centimeters) between the top of the wearer's head and the inside crown of the hat.

- Any cracks or perforations of brim or shell, deformation of shell, or evidence of exposure to excessive heat, chemicals, or radiation. Shells constructed of polymer plastics are susceptible to damage from ultraviolet light and gradual chemical degradation. This degradation first appears as a loss of surface gloss called chalking. With further deterioration, the surface will begin to flake away.

- Any accumulation of conductive material on or inside the shell that cannot be removed prior to use. This applies to hats used in electrically hazardous environments.

3.1.7 Maintenance

Manufacturers should be consulted regarding paint or cleaning materials for their helmets because some paints and thinners may damage the shell and reduce protection by weakening it or negating electrical resistance.

A common method of cleaning shells is to dip them for at least a minute, in hot water (approximately 140°F) that contains a good detergent. Shells should then be scrubbed and rinsed in clear hot water. After rinsing, the shell should be carefully inspected for any signs of damage. All components, shells, suspensions, headbands, sweatbands, and any accessories should be inspected daily for signs of dents, cracks, penetration, or any other damage that might reduce the original safety.

Users are cautioned that if unusual conditions occur (such as higher or lower extreme temperatures described in the standards) or if there are signs of abuse or mutilation of the helmet or any component, the margin of safety may be reduced. If damage is suspected, helmets should be replaced or representative samples tested according to procedures in ANSI Z89.1 1986.

Helmets should not be stored or carried on the rear-window shelf of an automobile because sunlight and extreme heat may decrease the degree of protection.

3.1.8 Use

Objects should not be placed inside the safety hat between the shell and the suspension device. This space is designed so an impact will not be transmitted to the head of the wearer.

Safety hats should be kept free of abrasions, scrapes, and nicks and should not be deliberately dropped, thrown, or otherwise abused because they will lose their protective qualities.

Ventilation holes should not be drilled in safety hats.

3.1.9 Chin Straps

Chin straps prevent the safety hat from falling off or being bumped off and must be made of nonconductive material. The chin strap must be worn at all times when working aloft to prevent the safety hat from falling and creating a hazard. Chin straps must also be worn when the worker is working over at the edge of a pit and there are people below.

3.1.10 Bump Caps

Bump caps are constructed of lightweight materials and are designed for minimal protection against bump hazards or minor blows to the head. They do not adequately protect workers from high-impact forces or penetration by falling objects. Therefore, bump caps must not be used as substitutes for hard hats. Their use must be determined by supervisors in conjunction with the safety office.

3.1.11 Hair Protection

Personnel who work around chains, belts, rotating devices, suction devices, and blowers, must cover their long hair (generally, over 4 inches in length). While such devices are normally guarded, long hair can fall between the mesh of guards and be drawn into the moving machine parts.

Bandannas, hair nets, and turbans may be used if they cover the hair completely and do not themselves present a hazard to the wearer. Soft caps may also be used but should completely cover the hair.

3.2 Eye and Face Protection

3.2.1 Causes of Eye and Face Injuries

A 1980 BLS study found that about 60 percent of workers who suffered eye injuries were not wearing eye protective equipment. When asked why they were not wearing face protection, workers indicated that face protection was not normally used in their type of work or that it was not required for the type of work performed at the time of the accident. The survey noted that the typical injury was caused by flying or falling blunt metal objects. Lacerations, fractures, broken teeth, and contusions were common types of injuries reported.

3.2.2 Eye Washes

The National Society to Prevent Blindness recommends that emergency eye washes be placed in all hazardous locations. First-aid instructions should be posted close to potential danger spots since any delay to immediate aid or an early mistake in dealing with an eye injury can result in lasting damage.

3.2.3 Minimum Requirements

Eye protectors must meet the following minimum requirements:

- Provide adequate protection against the particular hazards for which they are designed.
- Be reasonably comfortable when worn under the designated conditions.
- Fit snugly without interfering with the movements or vision of the wearer.
- Be durable.
- Be capable of being disinfected.
- Be easily cleanable.
- Be kept clean and in good repair.

Design, construction, testing, and use of eye and face protection must be in accordance with ANSI Z87.1-1989. The fitting of goggles and safety spectacles should be performed by someone skilled in the procedure. Prescription safety spectacles should be fitted only by a qualified optical person. Safety spectacles require special frames. Combinations of normal street wear frames with safety lenses are not in compliance.

3.2.4 Selection

In selecting the proper protector, consideration should be given to the kind and degree of hazard. Where a choice of protectors is given and the degree of protection required is not an important issue, worker comfort may be a deciding factor. The BLS survey showed that few workers ever complained about poor vision or discomfort with personal eye protection equipment. Employees who work on or near exposed energized electrical circuits or in flammable explosive atmospheres must not wear conductive frame eye/face protection. Tables A.1, A.2, and A.3 in Appendix A should guide the selection of face and eye protection for the hazards and operations noted.

Goggles come in a number of different styles: eye cups, flexible or cushioned goggles, plastic eye shield goggles, and foundry men's goggles. Goggles are manufactured in several styles for specific uses such as protecting against dust and splash, and in chipper's, welder's, and cutter's models.

3.2.5 Corrective Lenses

Persons using corrective spectacles and those who are required by OSHA to wear eye protection should wear face shields, goggles, or spectacles of one of the following types:

- Spectacles with protective lenses providing optical correction.
- Goggles worn over corrective spectacles without disturbing the adjustment of the spectacles.
- Goggles that incorporate corrective lenses mounted behind the protective lenses.

3.2.6 Face Shields

Face shields should only be used as eye and face protection in areas where splashing or dusts, rather than impact resistance, is the problem. In the case of grinding operations (plus other operations), a face shield is only secondary protection to other protective devices, such as safety goggles.

3.2.7 Contact Lenses

Contact lens wearers are required to wear the appropriate eye and face protection for the job, as determined by the supervisor. The supervisor must coordinate with the safety office to determine if contact lenses may be worn.

3.2.8 Inspection and Maintenance

It is essential that the lenses of eye protectors be kept clean. Continuous vision through dirty lenses can cause eye strain—often an excuse for not wearing the eye protectors. Daily inspection and cleaning of the eye protector with soap and hot water, or with a cleaning solution and tissue, is recommended. Pitted lenses, like dirty lenses, can be a source of reduced vision. They should be replaced. Deep scratches or excessively pitted lenses are apt to break more readily.

Slack, worn-out, sweat-soaked, or twisted headbands do not hold the eye protector in proper position. Visual inspection can determine when the headband elasticity is reduced to a point beyond proper function.

Goggles should be kept in a case when not in use. Spectacles, in particular, should be given the same care as one's own glasses because the frame, nose pads, and temples can be damaged by rough usage.

Personal protective equipment that has been previously used should be disinfected before being issued to another employee. Even when each employee is assigned protective equipment for extended periods, it is recommended that such equipment be cleaned and disinfected regularly.

Several methods for disinfecting eye-protective equipment are acceptable. The most effective method is to disassemble the goggles or spectacles and thoroughly clean all parts with soap and warm water. Carefully rinse all traces of soap and replace defective parts with new ones. Swab completely and immerse all parts for 10 minutes in a solution of germicidal deodorant fungicide. Remove parts from the solution and suspend them in a clean place for air drying at room temperature or with heated air. Do not rinse after removing parts from the solution because this will remove the germicidal residue which retains its effectiveness after drying. Ultraviolet disinfecting equipment or spray type disinfecting solutions may be used in conjunction with the washing procedure.

The dry parts or items should be placed in a clean, dust-proof container, such as a box, bag, or plastic envelope to protect them until reissue.

3.3 Ear Protection

The prevention of excessive noise exposure is the only way to avoid hearing damage. Engineering and administrative controls must be used if the sound levels listed in Appendix B are exceeded. If such controls fail to reduce the sound levels within the level specified in Table B.1, personal hearing protection must be used. Plain cotton is ineffective as protection against hazardous noise. Preformed or molded ear plugs should be individually fitted by a professional. Waxed cotton, foam, or fiberglass wool ear plugs are self-forming. When properly inserted, they work as well as most molded ear plugs. (See Appendix B)

Some ear plugs are disposable, to be used one time and then thrown away. The nondisposable type should be cleaned after each use for proper protection.

Earmuffs must make a perfect seal around the ear to be effective. Glasses, long sideburns, long hair, and facial movements, such as chewing, can reduce protection. Special equipment is available for use with glasses or beards.

3.4 Torso Protection

Many hazards can threaten the torso: heat, splashes from hot metals and liquids, impacts, cuts, acids, and radiation. A variety of protective clothing, such as vests, jackets, aprons, coveralls, and full body suits are available.

Wool and specially treated cotton are two natural fibers that are fire resistant and comfortable because they adapt well to changing work place temperatures.

Duck, a closely woven cotton fabric, is good for light duty protective clothing. It can protect against cuts and bruises on jobs where employees handle heavy, sharp, or rough material.

Heat-resistant clothing such as leather is often used to guard against dry heat and flame. Rubber and rubberized fabrics, neoprene, and plastics give protection against some acids and chemicals.

Disposable suits of paper-like material are particularly important for protection from dusty materials or materials that can splash. If the substance is extremely toxic, a completely enclosed suit may be necessary. The clothing should be inspected to assure proper fit and function for continued protection.

Night workers and flagmen who might be struck by moving vehicles need suits or vests designed to reflect light. Reflectors also include reflective fabrics, cloths, threads, paints, tapes, buttons, discs, cones, and posts.

3.5 Arm and Hand Protection

Examples of injuries to arms and hands are burns, cuts, electrical shock, amputation, and absorption of chemicals.

3.5.1 Selection of Protective Devices

Protective devices should be selected to fit the job. For example, some gloves are designed to protect against specific chemical hazards. Employees may need to use gloves that have been tested and provide insulation from burns and cuts such as wire mesh, leather, and canvas. Metal mesh gloves are used by employees who work with knives. They protect against cuts and blows from sharp or rough objects and edged tools (see Figure 2). Heat-resistant gloves should be used to protect against burns as well as discomfort where there is sustained heat. The employee should become acquainted with the limitations of the clothing. Glove selection material is discussed in Appendix C.

Certain occupations call for special protection. For example, electricians need special protection from shocks and burns. Rubber is considered the best material for insulating gloves and sleeves.

Rubber, plastic, or synthetic rubber gloves for work with oils, grease, solvents, and other chemicals, protect against burns, irritation, and dermatitis (see Table C.1). Cleaning crews also find them useful.

Leather work gloves are more durable. They resist sparks, moderate heat, chips, and rough objects, and provide some cushioning against blows. A welder requires a better type than the ordinary leather glove.

Cotton or fabric gloves are suitable for protection against dirt, slivers, chafing, or abrasion. They are not heavy enough for use with rough, sharp, or heavy materials.

Coated fabric gloves, for use with moderate concentrated chemicals, are recommended for laboratory tasks such as handling bricks and wire rope.

Gauntlet type gloves should be used where the wrists and forearms may be injured. Finger covers for one or more fingers are designed for certain hazards. Hand pads of leather or other materials protect the palm of the hand. Their application is limited.

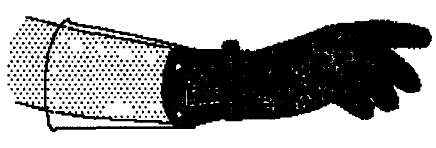


Figure 2. Metal mesh gloves.

3.5.2 Additional Precautions

Gloves should be long, leaving no gap between the glove and coat or shirt sleeve. Long flaring gauntlets should be avoided unless they are equipped with locking devices for a snug wrist fit. Sleeves should be worn outside gauntlets when caustic substances are being poured from large containers into smaller ones. Extra-long cuffs, which have a ridge near the top edge, can be folded back to form a trough for trapping liquids running down the wrist or forearm. Hand wear with metal parts should not be worn around electrical equipment. Gloves should not be worn around moving machinery (drills, saws, or grinders that could catch the glove and pull the worker's hand into the danger area.

3.6 Foot and Leg Protection

According to a 1981 BLS survey, most of the workers in selected occupations who suffered foot injuries were not wearing protective footwear. Furthermore, most of their employers did not require them to wear safety shoes. The typical foot injury was caused by objects falling fewer than 4 feet (1.2 meters) and the median weight of the object was about 65 pounds (29.6 kilograms). Again, most workers were injured while performing their normal job activities at their work sites.

For protection of feet and legs from falling or rolling objects, sharp objects, molten metal, hot surfaces, and wet slippery surfaces, workers should use appropriate foot guards, safety shoes, boots, and leggings.

3.6.1 Selection

Leggings protect the lower leg and feet from molten metal or welding sparks. Safety snaps permit their rapid removal.

3.6.2 Metatarsal Guards

Metatarsal guards may be strapped to the outside of the shoe to add protection to the instep area of the foot (see Figure 3). The guard material may be aluminum, steel, fiber, or plastic. Any metatarsal guard must meet the requirements of ANSI Z41.

3.6.3 Toe Guards

Toe guards are removable steel, aluminum, or plastic caps that fit over the toe of regular shoes (see Figure 4). The toe guard rim rests on the ground or floor. The guard is held on the foot by a steel spring that permits easy removal. A combination foot and shin guard is also available when greater protection is necessary.

3.6.4 Safety Shoes

Safety shoes should be sturdy and with an impact-resistant toe. In some shoes, metal insoles protect against puncture wounds. Heat-resistant soles protect against hot surfaces like those found in the roofing, paving, and hot metal industries (see Figure 5).

Safety footwear is classified according to its ability to meet minimum requirements for both compression and impact tests. Those requirements and testing procedures may be found in ANSI Z41-1991. Those meeting ANSI Z41 standards are clearly identified by the manufacturer by a label or stamp placed on the inside surface of the tongue or quarter lining.

3.6.5 Foot Protection—Extreme Cold Weather Operations

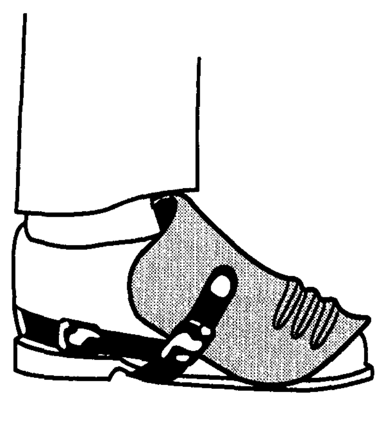
When working in weather colder than 10 degrees below zero Fahrenheit, workers should wear arctic footwear, not steel-toe safety shoes. Such cold weather is more of a risk to the feet than any potential crushing hazard.

3.6.6 Conductive Shoes

Conductive shoes protect against the buildup of static electricity or equalize the electrical potential between personnel and the ground. Personnel must avoid wearing 100 percent silk, wool, or nylon hose or socks with conductive shoes because these materials are static producers. These shoes should be worn only for the specific task(s) for which they are designed and should be removed at task completion and not used as general purpose footwear. This type of shoe must not be used by personnel working near exposed energized electrical circuits. Foot powders must be avoided because they are insulators and interfere with electrical conductivity.

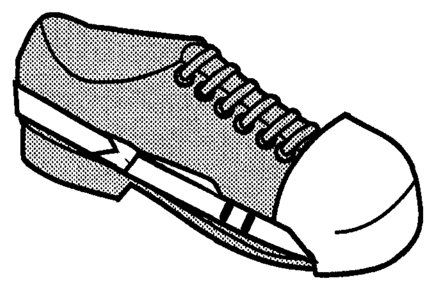
3.6.7 Electrical-Hazard Safety-Toe Shoes

Electrical-hazard safety-toe shoes are nonconductive and protect against open circuits of 600 volts or less under dry conditions. The insulating qualities may be compromised if the shoe is wet, the rubber sole is worn through, or metal particles are embedded in the sole or heel. Electrical-hazard shoes are not intended for use in explosive or hazardous locations where conductive footwear is required. This footwear should be used in conjunction with insulated surfaces.

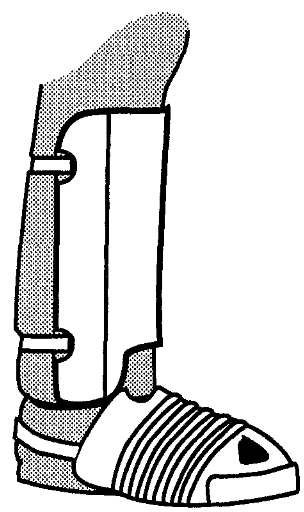


Safety Shoe with Metatarsal Guard

Figure 3. Metatarsal guards.



Toe guard



Combination foot and shin guard

Figure 4. Toe guards.

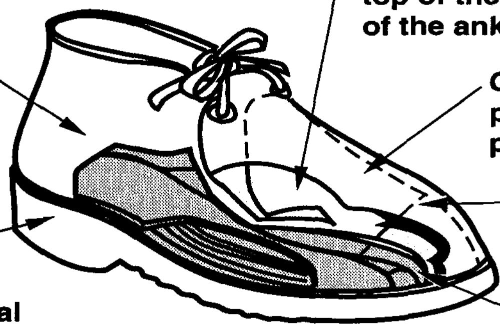


Figure 5. Safety Shoes.

3.6.8 Foundry Shoes

Foundry shoes protect the feet of foundry workers when handling or pouring molten metal. They are made so that hot metal cannot lodge in crevices made by eyelets, tongues, or other parts. The shoes fit snugly at the ankle and are made of leather or leather substitutes. The soles are either leather or rubber, and heels are rubber. Foundry shoes must always have safety-toes built in.

3.6.9 Explosive Operations

Spark-resistant shoes prevent sparks in areas such as storage of explosives or petroleum tank cleaning where a spark might ignite the atmosphere with catastrophic results. They should not be worn outside the work area because they are not general purpose footwear.

3.7 Cryogenics Handling

Liquid oxygen (LOX) and liquid nitrogen (N2) are the most commonly used cryogenics. Liquid hydrogen, helium, and liquefied petroleum gas are also used but in more limited applications.

Protective clothing that is used when transferring and handling cryogenics is listed below:

- Face shield.
- Gloves.
  - — Leather welder's gauntlet cuff with cotton knit insert.
  - — Leather with wool insert.
  - — Aramid (Kevlar).
- Apron.
- Head covering.
- Cuffless trousers and long sleeve shirt or jacket or coveralls.
- Shoes, which fit closely around the top, that have conductive rubber soles and heels.

All items must be clean and free of grease, oil, and fuel.

Caps made of a loosely woven material that have a space and fastener at the back to loosen or tighten the cap, shall not be worn. These caps (frequently called baseball caps) leave a portion of the head uncovered and do not provide adequate protection. Personnel engaged in fuel operations must have a clean change of clothes available at cryogenic storage areas in case their clothing is contaminated (which could present a hazard).

3.8 Safety Belts, Lifelines, and Lanyards

Lifelines, safety belts, and lanyards are 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 other structural member. Lifelines used on rock-scaling operations or in areas where the lifeline may be subjected to cutting or abrasion should be a minimum of 7/8-inch (2.2-centimeter) wire core manila rope.

All safety belt and lanyard hardware except rivets must be capable of withstanding a tensile loading of 4,000 pounds (1,812 kilograms) without cracking, breaking, or taking a permanent deformation.

All fabric and leather used for safety straps should withstand an ac (alternating current) dielectric test and be tested for leakage current.

A Coast Guard-approved life jacket or buoyant work vest should be used if there is danger of falling into water while working. For emergency rescue operations, boats and ring buoys with at least 90 feet (27.4 meters) of line should be provided.

4. Work Practices

4.1 Program Elements

- Written program on usage of PPE.
- Training program for use and maintenance of PPE.
- Proper selection and fitting of equipment.
- Proper enforcement of the use of PPE.
- Periodic program evaluation.
- Provision for inspection, cleaning, maintenance, and storage of PPE.
- Medical examination, where required.
- Work area surveillance.

4.2 Role of Supervisors

Supervisors must ensure that the proper PPE required for the job is obtained and inform each employee of the hazards to which they might be exposed, the PPE required, and how to use and maintain it.

5. Training

5.1. Suggested Training Elements

- Hazards and/or conditions.
- Controls for those hazards and/or conditions.
- Capabilities and limitations of PPE.
- How to use, adjust, and fit PPE.
- What to do in an emergency.
- Selection of proper PPE.
- Maintenance and repair of PPE.
- DOE policy and enforcement.
- Practical PPE practice.

5.2 Pointers

Employees must be aware that the equipment does not eliminate the hazard. If the equipment fails, exposure will occur. To reduce the possibility of failure, equipment must be properly fitted and maintained in a clean and serviceable condition. The equipment must not be altered or removed even though an employee may find it uncomfortable. (Sometimes equipment may be uncomfortable simply because it does not fit properly.)

6. Hazards

DOE and maintenance and operation (M&O) contractor personnel encounter a range of hazards in their daily work such as excessive noise, arc flashes, grinding sparks, falling objects, and hot or sharp objects. These hazards can be mitigated by judicious selection and use of protective equipment such as hard hats, eye protection, ear protection, coveralls, aprons, gloves, and safety shoes.

Numerous hazards exist that can damage the human body. They vary from those that result in hand injuries, dropping tools or objects from overhead, falls from heights, to in-running pinch points.

Head injuries are caused by falling or flying objects or bumping the head against fixed objects. Hard hats protect by resisting the blow and by using a shock-absorbing liner to keep the shell away from the wearer's head. Certain hard hats protect the wearer against electrical shocks to the head.

Eye injuries are caused by flying objects, liquid splashes or mists, or intense light sources such as lasers or welding arcs. Various eye and face protectors (safety glasses, goggles, face shields) are available to prevent these objects or light sources from injuring the eyes.

Hearing loss or impairment can be caused by excessive noise exposure. Ear plugs and muffs provide protection against excessive noise.

Many hazards threaten the torso: cold or heat, splashes from hot liquids or molten metal, cuts, or chemical splashes. A variety of protective clothing is available to protect the torso: vests, jackets, aprons, coveralls, and full body suits. Life jackets prevent drowning. Certain clothing reflects light so that night workers are more visible to operators of motor vehicles.

Injuries to hands and arms such as thermal burns, cuts, electrical shocks, and chemical burns are possible. Various gloves, hand pads, sleeves, and wristlets protect from various situations.

Typical foot injuries are caused by objects falling on toes. Safety shoes and toe guards prevent injury caused by such occurrences.

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Appendix A. Types of Eye and Face Protectors

1. **Safety spectacles.** Protective eye glasses are made with safety frames, corrective or plano impact resistant glass or plastic lenses, and temples, and may be obtained with or without sideshields. Glasses without sideshields have a limited application since they provide frontal protection only, and most eye hazards require both frontal and side protection. Combinations of frames and lenses that do not meet ANSI Z87.1 criteria should not be used.

1.1 **Impact resistant spectacles.** If eye protection from moderate impact from particles encountered in job tasks such as carpentry, woodworking, grinding or scaling is required, impact-resistant spectacles shall be used.

1.2 **Sideshields.** If flying particles may enter the eye from the side, sideshields made of wire screen or perforated or nonperforated plastic shall be used. Eyecup type sideshields are the preferred type and shall be requested when ordering new glasses. Flat-fold sideshields, if used, shall be securely attached to the spectacles. Snap on or clip on types are not acceptable.

2. **Goggles.** Goggles are designed to provide protection from impact or dust or splashing liquids. They protect the eyes, eye sockets, and the facial area immediately adjacent to and surrounding the eyes. When required, goggles that fit over corrective spectacles worn by the individual should be obtained. Because of the many types of goggles available, care must be exercised when selecting to ensure that they are designed to provide the required protection.

3. **Face shields.** Face shields are designed to provide secondary protection from flying particles and sprays or splashes of hazardous liquids to the face and the frontal portion of the neck. Additionally, they may provide antiglare protection. Face shields can be used as primary eye and face protection only if they are used for splash or nuisance dust protection. If used in areas where an impact hazard exists, they will be used in conjunction with safety goggles.

4. **Welding shields.** These assemblies consist of vulcanized fiber or fiberglass body, a ratchet/button type adjustable headgear or cap attachment, and a filter and cover plate holder. Hand-held shield assemblies are also available.

   a. Welding shields and helmets protect the worker's eyes and face from infrared or radiant light burns, flying sparks, metal spatter, and slag chips encountered during welding brazing, soldering, and cutting operations. Shields are normally nonconductors. Metal parts are usually insulated for protection of the wearer.

   b. Filter lenses of required filtration capacity must be selected and used according to job requirements. Refer to Table A.1 for selection of the proper shade number for welding operations.

   c. Welding shield headgear should be kept clean and cover plates changed if metal spatter accumulations cause vision impairment. Users should wash headgear with a mild soap and water or sanitizer solution to remove dust, dirt, perspiration, and skin oil residue.

5. **Laser safety goggles.** Selection of the proper laser safety goggles is dependent upon the specific equipment and operating conditions. Refer to Table A.3 and the Laser chapter for guidance. The selection of approved laser protective eye wear is the responsibility of the supervisor.

6. **Protection against radiant energy.** Selection of shade numbers for welding filters. Table A.2 shall be used as a guide for the selection of the proper shade numbers of filter lenses or plates used in welding. Shades more dense than those listed may be used to suit the individual's needs.

7. **Laser protection.** Employees whose occupation or assignment requires exposure to laser beams shall be furnished suitable laser safety goggles, that will protect for the specific wavelength of the laser and be of optical density (O.D.) adequate for the energy involved. Table A.3 lists the maximum power or energy density for which adequate protection is afforded by glasses of optical densities from 5 through 8.

Table A.1. lists types of eye and face protection for specific operations and hazards. The table is followed by a list of recommended eye and face protectors. Figure A.1. illustrates the choices.

Applications		
Operation	**Hazards**	**Recommended protectors: (see Figure A.1)**
Acetylene-burning Acetylene-cutting Acetylene-welding	Sparks, harmful rays, molten metal, flying particles	7, 8, 9
Chemical handling	Splash, acid burns, fumes	2, 10 (For severe exposure add 10 over 2)
Chipping	Flying particles	1, 3, 4, 5, 6, 7A, 8A
Electric (arc) welding	Sparks, intense rays, molten metal	9, 11 (11 in combination with 4, 5, 6 in tinted lenses advisable)
Furnace operations	Glare, heat, molten metal	7, 8, 9 (For severe exposure add 10)
Grinding-light	Flying particles	1. 3, 4, 5, 6, 10
Grinding-heavy	Flying particles	1, 3, 7A, 8A (For severe exposure add 10)
Laboratory	Chemical splash, glass	2 (10 when in breakage combination with 4, 5, 6)
Machining	Flying particles	1, 3, 4, 5, 6, 10
Molten metals	Heat, glare, sparks, splash	7, 8 (10 in combination with 4, 5, 6 in tinted lenses)
Spot welding	Flying particles, sparks	1, 3, 4, 5, 6, 10

Table A.1. Eye and face protector selection guide.

Recommended Eye and Face Protectors

Eye and face protectors are identified below by number and type. Refer to Table A.1 for recommended usage applications. Also refer to Figure A.1.

1. GOGGLES, Flexible Fitting, Regular Ventilation
2. GOGGLES, Flexible Fitting, Hooded Ventilation
3. GOGGLES, Cushioned Fitting, Rigid Body
4. SPECTACLES, Metal Frame, Without Sideshields
5. SPECTACLES, Plastic Frame, With Sideshields
6. SPECTACLES, Metal-Plastic Frame, With Flat Fold Sideshields
7. WELDING GOGGLES, Eyecup Type, Tinted Lenses

7a. CHIPPING GOGGLES, Eyecup Type, Clear Safety Lenses (not illustrated)

8. WELDING GOGGLES, Eyecup Type, Tinted Plate Lens

8a. CHIPPING GOGGLES, Coverspec Type, Clear Safety Lenses (not illustrated)

9. WELDING GOGGLES, Coverspec Type, Tinted Plate Lens
10. FACESHIELD (Available With Plastic or Mesh Window, Tinted/Transparent)
11. WELDING HELMETS

*These are also available without sideshields for limited use requiring only frontal protection.

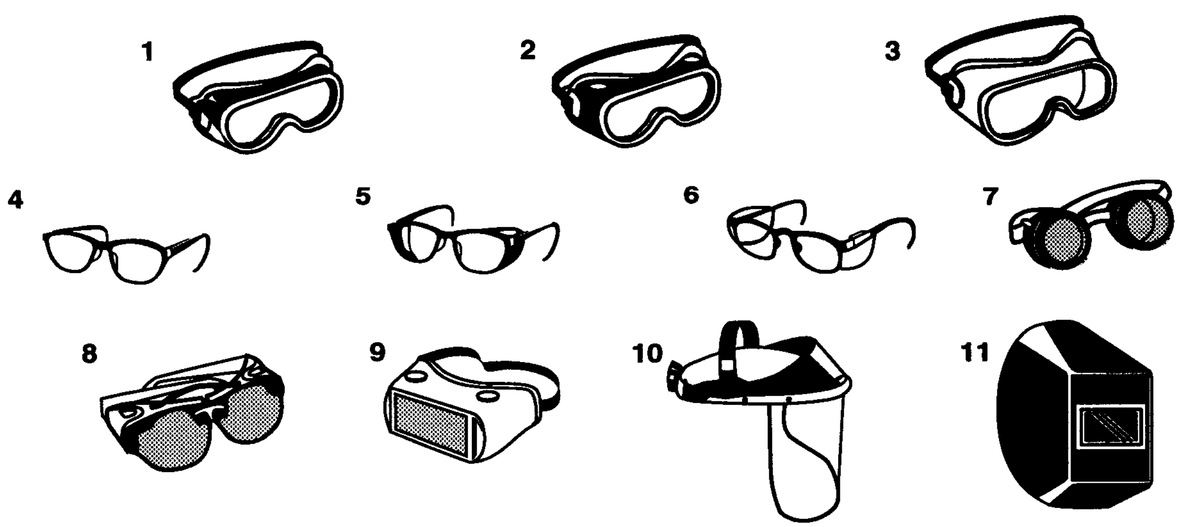


Figure A.1. Recommended eye and face protectors.

Welding operation	Shade number
Shielded metal-arc welding 1/18-, 3/32-, 1/8-, 5/32-inch-diameter electrodes	10
Gas-shielded arc welding (nonferrous) 1/16-, 3/32-, 1/8-, 5/32-inch-diameter electrodes	11
Gas-shielded arc welding (ferrous) 1/16-, 3/32-, 1/8-, 5/32-inch-diameter electrodes	12
Shielded metal-arc welding 3/16-, 7/32-, 1/4-inch-diameter electrodes	12
5/16-, 3/8-inch-diameter electrodes	12
Atomic hydrogen welding	10–14
Carbon-arc welding	14
Soldering	2
Torch brazing	3 or 4
Light cutting, up to 1 inch	3 or 4
Medium cutting, 1 inch to 6 inches	4 or 5
Heavy cutting, over 6 inches	5 or 6
Gas welding (light), up to 1/8 inch	4 or 5
Gas welding (medium), 1/8 inch to 1/2 inch	5 or 6
Gas welding (heavy), over 1/2 inch	6 or 8

Table A.2. Filter lens shade numbers for protection against radiant energy.

Intensity, CW maximum power density (watts/cm3)	Optical density (O.D.)	Attenuation factor
10^{-2}	5	10^5
10^{-1}	6	10^6
1.0	7	10^7
10^{+1}	8	10^8

Table A.3. Selecting laser safety glass.

Output levels falling between lines in Table A.3 shall require the higher optical density. All protective goggles shall bear a label identifying the following data:

- The laser wavelengths for which use is intended.
- The optical density of those wavelengths.
- The visible light transmission.

Appendix B. Occupational Noise Exposure

Protection against the effects of noise exposure must be provided when the sound levels exceed those shown in Table B.1 when measured on the A-scale of a standard sound level meter at slow response.

When employees are subjected to sound levels exceeding those listed in Table B.1, feasible administrative or engineering controls must be used. If such controls fail to reduce sound levels within the levels of the table, personal protective equipment must be provided and used to reduce sound levels within the levels of the table.

Duration per day, hours	Sound level dBA slow response
8	90
6	92
4	95
3	97
2	100
1-1/2	102
1	105
1/2	110
1/4 or less	115

Table B.1. Permissible noise exposures.

If the variations in noise level involve maxima at intervals of 1 second or less, it is to be considered continuous. In all cases where the sound levels exceed the values shown herein, a continuing, effective hearing conservation program shall be administered.

When the daily noise exposure is composed of two or more periods of noise exposure of different levels, their combined effect should be considered rather than the individual effect of each. Exposure to different levels for various periods of time shall be computed according to Equation 1.

$$F_e = (T_1/L_1) + (T_2/L_2) + \ldots(T_n/L_n) \quad (1)$$

where

F_e = the equivalent noise exposure factor, T = the period of noise exposure at any essentially constant level, and L = the duration of the permissible noise exposure at the constant level (from Table B.1).

If the value of F_e exceeds unity, the exposure exceeds permissible levels.

A sample computation that shows an application of Equation 1 follows. An employee is exposed at these levels for these periods:

110 db A 1/4 hour.

100 db A 1/2 hour.

90 db A 1-1/2 hours.

$F_e = (1/4 / 1/2) + (1/2 / 2) + (1\text{-}1/2 / 8)$

$F_e = 0.500 + 0.25 + 0.188$

$F_e = 0.938$

Since the value of F_e does not exceed unity, the exposure is within permissible limits. Exposure to impulsive or impact noise should not exceed 140 dB peak sound pressure level.

Appendix C. Glove Selection Material

Frequently used industrial gloves are listed below. Descriptions are provided to make selection easier. Table C.1 is a chemical resistance chart for gloves.

1. **Asbestos Gloves.** Prohibited. Kevlar and Zetex are substitutes. Refer to paragraph five below.

2. **Aluminized Gloves.** Offer both reflective and insulating protection. The insert shall NOT be made of asbestos. Kevlar and Zetex are satisfactory asbestos substitutes. These gloves are generally used for welding, furnace, and foundry work.

3. **Coated Fabric Glove.** Normally made from cotton flannel with napping on one side. The unnapped side is coated with a plastic material. This type glove is a general-purpose protector offering slip-resistant qualities. They are used in laboratory tasks and for handling bricks and wire rope.

4. **Chemical and Liquid Resistant Gloves.** Made from rubber (latex, nitrile, or butyl) or a synthetic composition such as neoprene. Frequently used gloves are described below:

4.1 **Butyl Rubber Gloves.** Provide protection from nitric acid, sulfuric acid, hydrofluoric acid, red fuming nitric acid, rocket fuels, and peroxide. These gloves have a high impermeability to gases, chemicals, and water vapor, and resistance to oxidation and ozone attack. They have high abrasion resistance and remain flexible at low temperatures.

4.2 **Natural Latex or Rubber Gloves.** Provide protection from most water solutions of acids, alkalis, salts, and ketones. Plus, they are resistant to abrasions occurring in sandblasting, grinding, and polishing. These gloves have excellent wearing qualities, pliability, and comfort and are a good general-purpose glove.

4.3 **Neoprene Gloves.** Provide good protection from hydraulic fluids, gasoline, alcohols, organic acids, and alkalis. They have good pliability and finger dexterity, high density and tensile strength, plus high fear resistance.

4.4 **Nitrile Rubber Gloves.** Provide protection from chlorinated solvents (trichloroethylene, perchloroethylene). They are intended for jobs requiring dexterity and sensitivity, yet they stand up under mechanical use even after prolonged exposure to substances that cause other glove materials to deteriorate. They also resist abrasion, puncturing, snagging, and tearing.

5. **Substitutes for Asbestos Gloves.** Gloves made out of the fabrics listed below are substitutes for asbestos gloves.

5.1 **Kevlar.** Provides protection against heat and cold. Kevlar is a synthetic material and is used by a variety of manufacturers in their gloves. Gloves made of Kevlar material are cut and abrasion resistant and wear well.

5.2 **Zetex.** Provides protection against heat and cold. It is also a synthetic material and is used by several manufacturers in their gloves. Gloves made of Zetex material are cut and abrasion resistant and also withstand diluted acids (except hydrofluoric, alkalis, and solvents).

Chemical	Neoprene gloves	Latex or rubber gloves	Butyl gloves	Nitrile latex gloves
*Acetaldehyde	VG	G	VG	G
Acetic acid	VG	VG	VG	VG
*Acetone	G	VG	VG	P
Ammonium hydroxide	VG	VG	VG	VG
*Amyl acetate	F	P	F	P
Aniline	G	F	F	P
*Benzaldehyde	F	F	G	G
*Benzene	P	P	P	F
Butyl acetate	G	F	F	P
Butyl alcohol	VG	VG	VG	VG
Carbon disulfide	F	F	F	F
*Carbon tetrachloride	F	P	P	G
Castor oil	F	P	F	VG
*Chlorobenzene	F	P	F	P
*Chloroform	G	P	P	E
Chloronaphthalene	F	P	F	F
Chromic acid (50%)	F	P	F	F
Citric acid (10%)	VG	VG	VG	VG
Cyclohexanol	G	F	G	VG
*Dibutyl phthalate	G	P	G	G
Diesel fuel	G	P	P	VG
Diisobutyl ketone	P	F	G	P
Dimethylformamide	F	F	G	G
Dioctyl phthalate	G	P	F	VG
Diaxane	VG	G	G	G
Epoxy resins, dry	VG	VG	VG	VG
*Ethyl acetate	G	F	G	F
Ethyl alcohol	VG	VG	VG	VG
*Ethyl ether	VG	G	VG	G
*Ethylene dichloride	F	P	F	P
Ethylene glycol	VG	VG	VG	VG
Formaldehyde	VG	VG	VG	VG

Table C.1. Gloves chemical resistance selection chart

Formic acid	VG	VG	VG	VG
Freon 11	G	P	F	G
Freon 12	G	P	F	G
Freon 21	G	P	F	G
Freon 22	G	P	F	G
*Furfural	G	G	G	G
Gasoline, leaded	G	P	F	VG
Gasoline, unleaded	G	P	F	VG
Glycerin	VG	VG	VG	VG
Hexane	F	P	P	G
Hydrazine (65%)	F	G	G	G
Hydrochloric acid	VG	G	G	G
Hydrofluoric acid (48%)	VG	G	G	G
Hydrogen peroxide (30%)	G	G	G	G
Hydroquinone	G	G	G	F
Isooctane	F	P	P	VG
Kerosene	VG	F	F	VG
Ketones	G	VG	VG	P
Lacquer thinners	G	F	F	P
Lactic acid (85%)	VG	VG	VG	VG
Lauric acid (36%)	VG	F	VG	VG
Lineoleic acid	VG	P	F	G
Linseed oil	VG	P	F	VG
Maleic acid	VG	VG	VG	VG
Methyl alcohol	VG	VG	VG	VG
Methylamine	F	F	G	G
Methyl bromide	G	F	G	F
*Methyl chloride	P	P	P	P
*Methyl ethyl ketone	G	G	VG	P
*Methyl isobutyl ketone	F	F	VG	P
Methyl methacrylate	G	G	VG	F
Monoethanolamine	VG	G	VG	VG
Morpholine	VG	VG	VG	G
Naphthalene	G	F	F	G
Naphthas, alyphatic	VG	F	F	VG

Naphthas, aromatic	**G**	**P**	**P**	**G**
***Nitric acid**	**G**	**F**	**F**	**F**
Nitric acid, red and white fuming	**P**	**P**	**P**	**P**
Nitromethane * (95.5%)	**F**	**P**	**F**	**F**
Nitropropane (95.5%)	**F**	**P**	**F**	**F**
Octyl alcohol	**VG**	**VG**	**VG**	**VG**
Oleic acid	**VG**	**F**	**G**	**VG**
Oxalic acid	**VG**	**VG**	**VG**	**VG**
Palmitic acid	**VG**	**VG**	**VG**	**VG**
Perchloric acid (60%)	**VG**	**F**	**G**	**G**
Perchloroethylene	**F**	**P**	**P**	**G**
Petroleum distillates (naphtha)	**G**	**P**	**P**	**VG**
Phenol	**VG**	**F**	**G**	**F**
Phosphoric acid	**VG**	**G**	**VG**	**VG**
Potassium hydroxide	**VG**	**VG**	**VG**	**VG**
Propyl acetate	**G**	**F**	**G**	**F**
Propyl alcohol	**VG**	**VG**	**VG**	**VG**
Propyl alcohol (iso)	**VG**	**VG**	**VG**	**VG**
Sodium hydroxide	**VG**	**VG**	**VG**	**VG**
Styrene	**P**	**P**	**P**	**F**
Styrene (100%)	**P**	**P**	**P**	**F**
Sulfuric acid	**G**	**G**	**G**	**G**
Tannic acid (65%)	**VG**	**VG**	**VG**	**VG**
Tetrahydrofuran	**P**	**F**	**F**	**F**
***Toluene**	**F**	**P**	**P**	**F**
Toluene diisocyanate (TDI)	**F**	**G**	**G**	**F**
***Trichloroethylene**	**F**	**F**	**P**	**G**
Triethanolamine (85%)	**VG**	**G**	**G**	**VG**
Tung oil	**VG**	**P**	**F**	**VG**
Turpentine	**G**	**F**	**F**	**VG**
*** Xylene**	**P**	**P**	**P**	**F**

***Limited Service**

VG = Very Good **G = Good** **F = Fair** **P = Poor (not recommended)**

Appendix D. Personal Protective Equipment Safety Checklist

This personal protective equipment (PPE) safety checklist will help employees and supervisors follow minimal safety practices. This list is not meant to be comprehensive, or form part of any official self-assessment practice. Where appropriate, local safety offices and supervisors are encouraged to add to these checklists. Relevant references are noted after each question.

Application	OK	Action Needed
Is proper PPE provided, used, and maintained in a sanitary and reliable condition? 29 CFR 1910.132(a)	____	____________
Responsibilities		
Is PPE used to protect personnel against hazards after engineering and administrative controls have been applied? AFOSH 127-31 5.b.(1)	____	____________
Do supervisors inform each employee of the hazards to which they might be exposed, the PPE required, and how to use and maintain PPE? AFOSH 127-31 5.b.(1)	____	____________
Do supervisors ensure that PPE is readily available, clearly identified, used for the purpose intended, fits correctly, and is properly worn? AFOSH 127-31 5.b.(1)	____	____________
Does the employee PPE not interfere with the task? AFOSH 127-31 5.b.(1)	____	____________
Do employees ensure that the PPE is cleaned, repaired, stored, and disposed of as applicable? AFOSH 127-31 5.b.(4)	____	____________
Do personnel who wear contact lenses notify their supervisors of this fact, and do supervisors know which employees wear contact lenses? AFOSH 127-31 5.b.(3)	____	____________
Head Protection		
Do employees wear safety hats when required? 29 CFR 1926.100	____	____________
Are safety hats with any defects or damage immediately removed from service? AFOSH 127-31 5.c.(4)	____	____________
Are personnel who work around chains, belts, rotating devices, suction devices, and blowers required to cover long hair? AFOSH 127-31 c.(8)	____	____________

Eye and Face Protection — **OK** — **Action Needed**

Is protective eye and face equipment required and provided where there is a reasonable probability of injury that can be prevented by such equipment?
29 CFR 1910.153 (a)(1), 29 CFR 1926.102

Does the facility provide proper eye and face protection for the work to be performed?
29 CFR 1910.133 (a)(1)

If needed, do employees use eye and face protection?
29 CFR 1910.133 (a)(1); 29 CFR 1926.102

Does eye protection meet the following minimum requirements?
29 CFR 1910.133 (a)(2)(ii) through (vii)

- Provide adequate protection against the particular hazards for which they are designed.
- Fit snugly and not unduly interfere with the movements of the wearer.
- Look durable, clean, and in good repair.

Are employees provided with goggles or spectacles of one of the following methods when their vision requires corrective lenses or spectacles?
29 CFR 1910.133 (a)(3)(i) through (iii)

- Spectacles whose protective lenses provide optical correction.
- Safety goggles that can be worn over corrective spectacles without disturbing the adjustment of the spectacles.
- Safety goggles that incorporate corrective lenses mounted behind the protective lens.

Is eye protection distinctly marked to identify the manufacturer?
29 CFR 1910.133 (a)(4)

Does eye protection meet the requirements of ANSI Z87.1 - 1968?
29 CFR 1910.133 (a)(6); 29 CFR 1926.102 (a)(2)(a)

Are face shields used as primary eye and face protection in areas where splashing or dust, rather than impact resistance, is the problem?
AFOSH 127-31 5.d.(4)

Is it prohibited for personnel to wear contact lenses when the work environment exposes the individual to toxic or chemical fumes and vapors, splash hazards, intense heat, molten metal, or highly particulate atmospheres?
AFOSH 127-31 5.d.(5)

Is it prohibited for employees who work on or near energized electrical circuits or in flammable/explosive atmospheres to wear conductive frame eye/face protection?
AFOSH 127-31 5.d.(6)

Hand Protection	OK	Action Needed
Is proper hand protection required for employees whose work may involve hand injury or impairment? 29 CFR 1926.28, AFOSH 127-31 5.f.(1) through (7) **Exception:** Hand protection shall not be required where there is a danger of the hand protection becoming caught in moving machinery or materials.	____	________
Are sleeves worn outside glove gauntlets when caustic substances are being poured? AFOSH 123-31, Attachment 8	____	________

Foot and Leg Protection

Is protective foot wear provided and worn when needed? ANSI 241-1983, AFOSH 127-31 5.g.(1)	____	________
Are requirements for protective footwear determined by supervision with assistance from safety? AFOSH 127-31 5.g.(3)	____	________
Are conductive shoes provided to protect employees against the buildup of static electricity? AFOSH 127-31 5.g.(6). Note: This type of shoe must not be used by personnel working near exposed energized electrical circuits.	____	________
Are electrical-hazard safety shoes provided for employees exposed to electrical hazards? AFOSH 127-31 5.g.(7)	____	________
Are spark-resistant shoes provided in working areas for explosive storage, petroleum tank cleaning, etc.? AFOSH 127-31 5.g.(9) **Note:** These shoes should not be worn outside the work area since they are not general purpose footwear.	____	________

Light Reflective Products

Are traffic directors and others exposed to vehicular traffic equipped with reflective vests or light-reflective clothing? AFOSH 127-31 5.b.(1)	____	________

Cryogenics Handling

Are employees exposed to cryogens provided with and do they use required protective clothing? AFOSH 127-31 5.j.(2)	____	________

Safety Belts, Lifelines, and Lanyards

Are lifelines, safety belts, and lanyards used only for their intended purpose? ANSI A10.14-1975, 29 CFR 1926.104(a)	____	________

	OK	Action Needed
Are lifelines secured above the point of operation to an anchorage or structural member capable of supporting a minimum dead weight of 5,400 pounds (2,455 kilograms)? 29 CFR 1926.104(b)	____	__________
Are lifelines that are subjected to cutting or abrasion a minimum of 7/8-inch (2.2-centimeter) wire core manila rope? 29 CFR 1926.104(c)	____	__________
Are safety belt lanyards a minimum of 0.5-inch (1.27-centimeter) nylon, or quivalent, with a maximum length to provide for a fall of no greater than 6 feet (1.8 meters)? 29 CFR 1926.104(d)	____	__________
Does the cushion part of the body belt meet the following conditions? 29 CFR 1926.959(b)(2)	____	__________
• Contain no exposed rivets on the inside;	____	__________
• Be at least 3 inches (7.6 centimeters) in width;	____	__________
• Be at least 5/32 inch (0.39 centimeter) thick, if made of leather; and	____	__________
• Have pocket tabs that extended at least 1.5 inches (3.8 centimeters) down and three 3 inches (7.6 centimeters) back of the inside of circle of each D ring for riveting on pliers or tool pockets. On shifting D belts this measurement for pocket tabs shall be taken when the D ring section is centered.	____	__________

ANSI = American National Standards Institute

AFOSH = Air Force Occupational Safety and Health Manual

29 CFR = Code of Federal Regulations Title 29

Chapter 6
Powered Industrial Trucks

1. Introduction

1.1 Incidence of Lift-Truck Injuries

Each year, it is estimated that more than 37,000 forklift-related injuries occur in U.S. industry (*Professional Safety,* January 1993). Injuries involve employees being struck by lift trucks or falling while standing or working from elevated pallets and tines. Many employees are injured when lift trucks are inadvertently driven off loading docks or when the lift falls between a dock and an unchocked trailer. For each employee injured, there are probably numerous incidents that are unnoticed or unreported to supervision. All mishaps—no matter how small—cost. Most incidents also involve property damage. Damage to overhead sprinklers, racking, pipes, walls, machinery, and various other equipment occurs all too often. In fact, millions of dollars are lost in damaged equipment, destroyed products, or missed shipments. Unfortunately, a majority of employee injuries and property damage can be attributed to lack of procedures, insufficient or inadequate training, and lack of safety-rule enforcement.

1.2 Causes of Lift-Truck Injuries

Unsafe Acts

- Inadequately trained maintenance personnel and inspectors and operators.
- Wrong truck selected for the job (too big, too small, wrong for hazardous location).
- Hurrying, taking shortcuts, not paying attention, fatigue, boredom, or not following the rules.
- Overloading trucks.
- Improper selection and installation of dockboards and bridge plates.

Unsafe Conditions

- Forks or other load-handling attachments cracked or bent.
- Gouges or large chunks missing from solid tires.
- Blind corners.
- Leaky connectors and hydraulic cylinders.
- Too much free play in the steering.
- Unsafe refueling or recharging practices.

1.3 Prevention Overview

Whether the operator is new to the job or experienced he or she should visually check forklift trucks every day. Good prevention consists mainly of proper maintenance, trained operators, and adherence to established safety procedures. Special attention should be given to the following areas:

- Proper truck selection (size, load-carrying capacity, hazardous location).
- Condition and inflation of pressure lines.
- Battery, lights, and warning devices.

- Controls, including lift and tilt system and limit switches.
- Brakes and steering mechanism.
- Fuel system.

1.4 Scope

This chapter contains safety information relating to fire protection, design, maintenance, and use of fork trucks, tractors, platform lift trucks, motorized hand trucks, and other specialized industrial trucks powered by electric motors or internal combustion engines. It does not apply to compressed-air or nonflammable, compressed-gas-operated industrial trucks, farm vehicles, or vehicles intended primarily for earth moving or over-the-road hauling.

1.5 Basic Terms

Attachments—Devices (other than conventional forks or load backrest extensions) mounted permanently or temporarily on the elevating mechanism of the truck. Popular types include fork extensions, clamps, booms, rams, baskets, and personnel platforms.

Capacity—Used to designate the weight-handling ability of a particular truck as equipped.

Dockboard—A portable or fixed device for spanning the gap or compensating for the differences in the level between loading platform and carrier.

Environment—Locations are classified as hazardous or nonhazardous when considering the type of industrial truck required (see Appendix A.1).

Forklift Truck—A self-loading truck, equipped with load carriage and forks for transporting and tiering loads (see Figure 1).

Forks—Horizontal, tine-like projections, normally suspended from the carriage, that engage and support loads.

Operator—A trained and authorized person who controls any function(s) of a powered industrial truck.

Tiering—The process of placing one load on or above another.

Truck-type designations—See Appendix A.2.

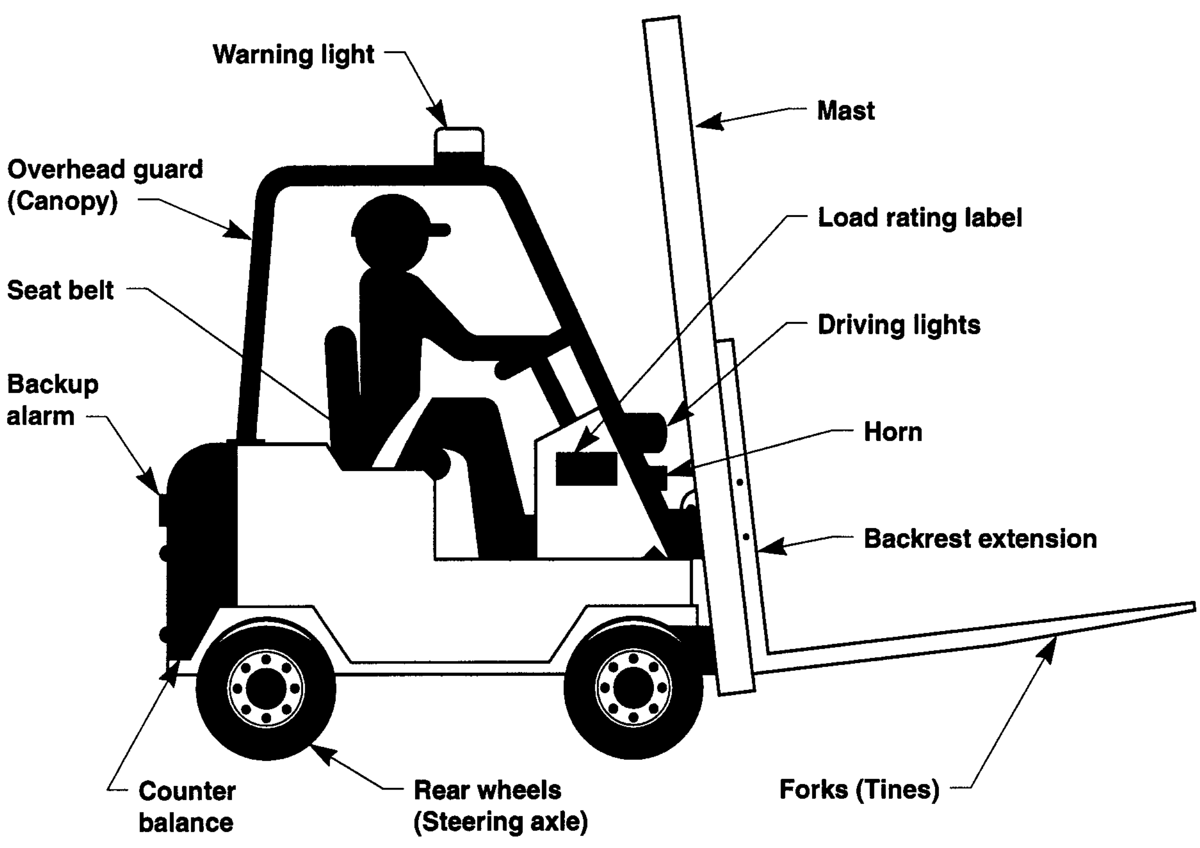


Figure 1. Fork Truck

2. Standards and Codes

Organization	Standard	Title
OSHA	29 CFR 1910.178	Powered industrial trucks
OSHA	29 CFR 1910.1000	Air contaminants
ANSI	B56.1-1988	American national standard for powered industrial trucks
NFPA	NFPA No. 30-1969	NFPA flammable and combustible liquids code
NFPA	NFPA No. 58-1969	NFPA storage and handling of liquefied petroleum gases
NFPA	NFPA No. 505-1969	Powered industrial trucks
UL	583	Standard for safety for electric or battery-powered i ndustrial trucks
UL	558	Standard for safety for internal combustion or engine-powered industrial trucks
ANSI/NFPA	30-1987	Flammable and combustible liquid code
ANSI/NFPA	58-1986	Storage and handling of liquefied petroleum gases
ANSI/NFPA	505-1987	Fire safety standard for powered industrial trucks—type designations, areas of use, maintenance and operation

OSHA = Occupational Safety and Health Administration
ANSI = American National Standards Institute
NFPA = National Fire Protection Association
UL = Underwriters Laboratory

Table 2.1 Standards and codes for powered industrial trucks.

3. Protective Devices

The use of protective devices is an important factor in safe forklift operation. Safety specialists can assist supervisors in determining what protective devices are necessary. Although forklifts need not be equipped alike, there are some similarities such as lights. Also, manufacturers are required by federal standards to equip forklifts with certain mandatory features such as back-up alarms. The requirement exists to warn others when the truck is reverse. Some other protective devices include:

- Overhead protection to guard the operator from falling objects.
- Wheel plates to protect the operator from objects picked up and thrown by tires.
- On-board fire extinguishers.
- Horns to warn others when the truck is moving forward.

Other protective devices that might be seen in the work area or specifically designed for the operator include:

- Signs—such as stop, caution, danger, and speed limits—to inform operators of conditions.
- Gloves and safety shoes.
- Eyewash stations.
- Concave mirrors.
- Eye protection devices.
- Hardhats to protect operators when there is an overhead hazard.

4. Work Practices

4.1 Selection and Inspection of Trucks

The proper truck (size, load capacity, and use) must be selected and inspected to ensure that all controls and safety features are working properly.

4.2 Maintenance and Repair of Trucks

It is required that trained and authorized personnel maintain and inspect fork trucks. All work should be done in accordance with the manufacturer's specifications. Because of everyday use of these vehicles, it is particularly important for personnel to follow the maintenance, lubrication, and inspection schedules. Special attention should be given to forklift control and lifting features such as brakes, steering, lift overload devices, and tilt mechanism.

4.3 Safety Tips for Operating Forklifts

Safe Operation. Operators must follow all safety rules related to speed, parking, fueling, loading, and moving loads. While the forklift is in operation keep the forks low with the mast tilted slightly back. Too tall or "top-heavy" loads can change the forklift's center of gravity and cause it to tip over. Follow safe speed limits. Loaded forklifts should travel at low speeds. Without loads, forklifts are not weighted and are especially unstable. Avoid sharp turns. Forklifts can turn over if turns are made too fast. When parking on a hill, always chock the forklift's wheels, lower the tines, and set the parking brake (see Figure 1). Also, to avoid tipping, always carry loads up a grade and back down ramps. Never turn on grades (see Figure 2). Keep safe visibility. If a load blocks forward vision, drive backwards. Always use the horn at intersections. Be cautious around uneven surfaces; chuckholes and other uneven ground can cause forklifts to tip.

Co-worker safety. Never carry hitchhikers—they can easily fall off and become injured. If co-workers are on a safety platform, always ensure that the platform is securely attached to the forklift and personnel are wearing proper personal protective equipment (e.g., hardhat and safety belt). Never travel with co-workers on the platform. Watch out for overhead obstructions.

Pedestrian safety. Pedestrians working nearby should be sure to keep a safe distance from forklifts. That means staying clear of the forklift's turning radius and making sure the driver knows where you are.

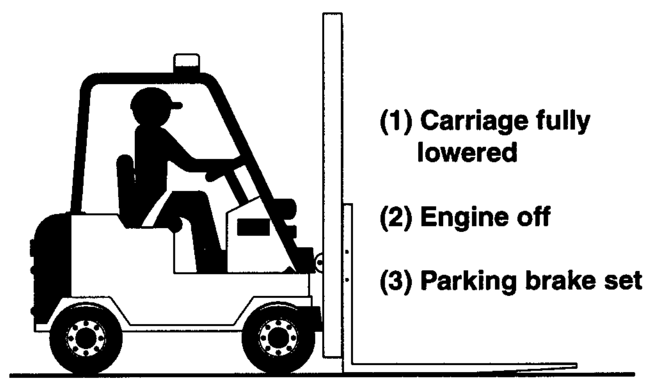
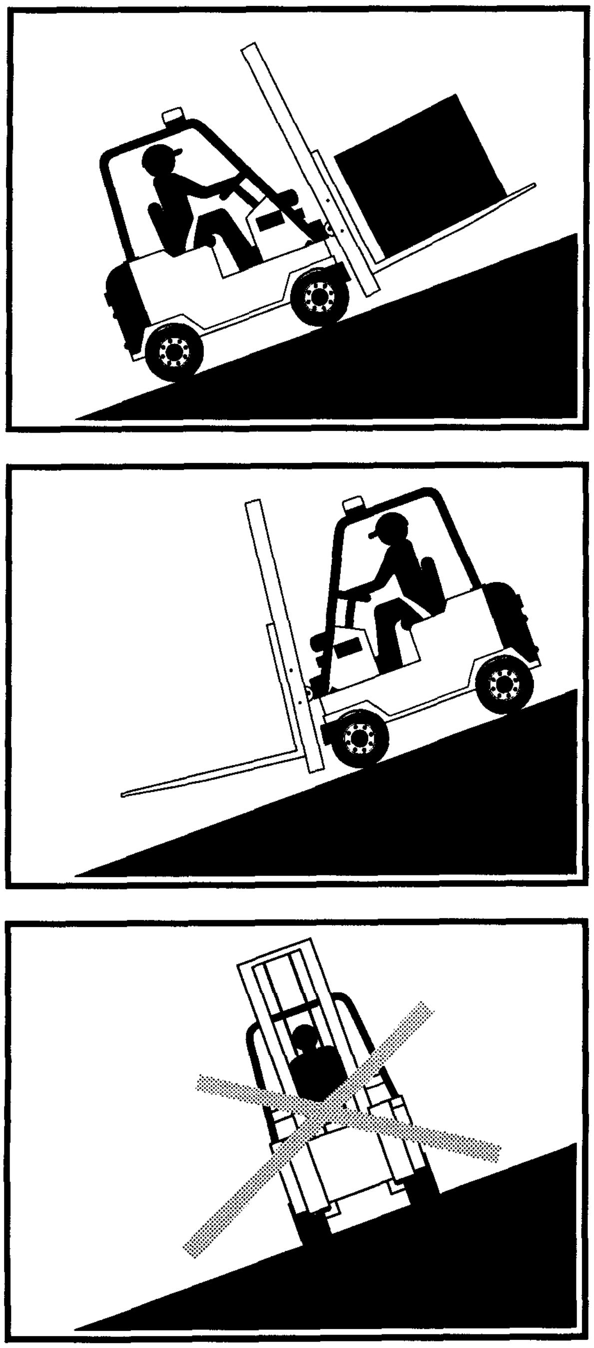


Figure 1. Properly set forklift.



1. Always ensure the load is against the backrest. Drive a *loaded* forklift with the load on the *uphill* side. Back down.

2. Always drive an *unloaded* forklift with the forks on the *downhill* side. Drive down forward and back up.

3. Never turn a forklift sideways on a ramp.

Figure 2. Correct operation of forklift truck.

5. Training

5.1 Selecting and Training Personnel

Employers and supervisors are responsible for selecting and providing the proper training to operators, inspectors, and maintenance personnel. It is important that these individuals have the necessary training and are able and willing to perform their jobs properly.

Employers should establish a training program that includes:

- The nature of hazards in the work area.
- How to perform work safely.

Training programs for operators should include the following:

- Physical and mental condition, attitude, and aptitude.
- Rules of powered industrial truck operation and why these rules exist.
- Special emphasis on loading and unloading, center of gravity, stability, and mechanical limitations.
- Supervised practice on an operating course that simulates actual conditions, e. g., stacking, loading trucks and boxcars, and unloading.
- The types of trucks used in various hazardous locations and environments.
- A combination of oral, written, and operational performance test.
- Frequent refresher training.

5.2 In-House Training Development

Training programs should be tailored to employees' work situations. Employees benefit more from training that simulates their daily processes, rather than from watching "canned" programs that are not applicable to their specific operations. Training programs should be devised so that employees can demonstrate the knowledge and skills required for their job.

5.3 Driving Skills Evaluations

A key dimension of operator training is driver certification. Operators should be required to demonstrate their skills. Adequate completion of skills tests (recorded on rating sheets similar to those in Appendix B) demonstrates that the operator (1) knows and understands the unit's functional features, (2) is familiar with overall departmental safety rules and can identify specific safety factors at a dock and battery recharge station, and (3) demonstrates overall driving skills. Testing can be administered on the job during the employee's normal work day.

6. Hazards and Effects

Many hazards associated with the operation of powered industrial trucks are the result of common operator mistakes. For instance, collisions between trucks and stationary objects often occur while trucks are backing up—usually while turning and maneuvering. Unless care is exercised, operators can cause damage to overhead fixtures (e.g., sprinklers, piping, electrical conduits) while traveling and maneuvering under them.

Accidents often occur when an operator leaves a truck so that it obstructs a passageway and an unauthorized (untrained) worker tries to move it. Other common hazards include carrying unstable loads, tipping over trucks, dropping loads on operators or others, running into or over others, and pinning others between the truck and fixed objects.

Unauthorized passengers are often seriously injured from falling off trucks. Unless space is provided, do not allow passengers to ride on the trucks.

Dangerous misuse of trucks includes bumping skids, moving piles of material out of the way, moving heavy objects by means of makeshift connections, and pushing other trucks. All these activities can cause accidents or injuries; they also indicate poor operator training.

Factors that can influence stability (resistance to overturning) must be considered.

These include:

- Weight, weight distribution, wheel base, tire tread, truck speed, and mast deflection under load.
- Improper operation, faulty maintenance, and poor housekeeping.
- Ground and floor conditions, grade, speed, and judgment of the operator.

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Appendix A.1. Summary of Industrial Truck Use in Various Locations

Classes	Unclassified	Class I locations	Class II locations	Class III locations
Description of Classes	Locations not possessing environments described in other columns.	Locations in which flammable gases or vapors are, or may be, present in the air in quantities sufficient to produce explosive or ignitable mixtures.	Locations that are hazardous because of the present of combustible dust.	Locations in which easily ignitable fibers are present but not likely to be in suspension in quantities sufficient to produce ignitable mixtures.

Groups within classes	None	A	B	C	D	E	F	G	None
Examples of locations or environ-ments in classes and groups	Piers and wharves inside and outside general storage, general in-dustrial or commercial properties	Acetylene	Hydrogen	Ethyl ether	Gasoline Naphtha Alcohols Acetone Lacquer Solvent Benzene	Metal dust	Carbon black, coal dust, coke dust	Grain dust, flour dust, starch dust, organic dust	Baled waste, cocoa fiber, cotton, excelsior, hemp, istle, jute, kapok, oakum, sisal, Spanish moss, synthetic fibers, tow

Authorized Uses Of Trucks By Types In Groups Of Classes And Divisions

Groups within classes	None	A	B	C	D	A	B	C	D	E	F	G	E	F	G	None	None
Type of truck authorized																	
Diesel																	
Type D	D**																
Type DS									DS						DS		DS
Type DY									DY						DY	DY	DY
Electric																	
Type E	E**																E
Type ES									ES						ES		ES
Type EE									EE						EE	EE	EE
Type EX					EX				EX		EX	EX			EX	EX	EX
Gasoline																	
Type G	G**																
Type GS									GS						GS		GS
LP-Gas																	
Type LP	LP**																
Type LPS									LPS						LPS		LPS
*Paragraph Ref. in No. 505	210, 211		201(a)		203(a)		209(a)		204(a) 204(b)		202(a)	205(a)		209(a)	206(a) 206(b)	207(a)	208(a)

*See NFPA No. 505-1969, Powered Industrial Trucks.
**Trucks conforming to these types may also be used.

Appendix A.2 Truck Type Designations

- D—Units that have minimum accepted safeguards against inherent fire hazards.
- DS—Diesel-powered units with additional safeguards to the exhaust, fuel, and electrical systems. These units may be used in some locations where a D unit may not be considered suitable.
- DY—Diesel-powered units that have all the safeguards of the DS units and, in addition, do not have any electrical equipment including the ignition, and are equipped with temperature limitation features.
- E—Electrically powered units that have minimum acceptable safeguards against inherent fire hazards.
- ES—Electrically powered units that, in addition to all of the requirements for the E units, have additional safeguards to the electrical system to prevent emission of hazardous sparks and to limit surface temperatures. These units may be used in some locations where the use of an E unit may not be considered suitable.
- EE—Electrically powered units that have, in addition to all of the requirements for the E and ES units, the electric motors and all other electrical equipment completely enclosed. In certain locations the EE unit may be used where the use of an E and ES unit may not be considered suitable.
- EX—Electrically powered units that differ from the E, ES, or EE units in that the electrical fittings and equipment are designed, constructed and assembled so that the units may be used in certain atmospheres containing flammable vapors or dusts.
- G—Gasoline-powered units having minimum acceptable safeguards against inherent fire hazards.
- GS—Gasoline-powered units that have additional safeguards to the exhaust, fuel, and electrical systems. These units may be used in some locations where the use of a G unit may not be considered suitable.
- LP—This unit is similar to the G unit, except that liquefied petroleum gas is used for fuel instead of gasoline.
- LPS—Liquefied petroleum gas-powered units that have additional safeguards to the exhaust, fuel, and electrical systems. These units may be used in some locations where the use of an LP unit may not be considered suitable.

Appendix B. Driving Skills Evaluation

Chart 1 Forklift Truck Operators Safety Skills Rating

B.1 Physical examination of lift truck (touch and tell)

The objective of this rating sheet is to ensure that employees understand the mechanics of the lift truck as well as all of those items that involve standard checking prior to driving the lift truck.

The operator should be familiar with the features of the lift truck. This can be evaluated by having the operator demonstrate and describe the following:

1. Proper use of tilt.
2. Proper use of raise and lower.
3. Proper use of horn.
4. Check for oil leaks.
5. Check mast chains.
6. Check tilt and lift cylinders for wear and/or leakage.
7. Check brakes.
8. Check tires and wheels.
9. Check hour meter.
10. Check scissors reach.
11. Check warning light.
12. Check rear view mirror.
13. Check battery retainer.
14. Check discharge indicator.
15. Check back up alarm.
16. Check hose and hose reel.
17. Check overhead guard's light.
18. Know capacity of lift truck.

Chart 2 Forklift Truck Operators Safety Skills Rating

B.2 Knowledge of safeguards within the facility

The operator is asked to identify many safety items at the dock and battery recharging area, as well as overall safety.

Dock

Wheel chocking

Dock plate

Trailer lighting

Condition of trailer floor

Keep clear of dock loading area

Be aware of signs

Correct height of empty pallets

Commercial battery rules

Battery Charging Area

Protective equipment

Acid neutralizing

MSDS

No smoking

Plug/unplug procedures

Clean-up procedures

Eyewash station

Fire and Safety

Location of extinguishers

How to use extinguisher

Type of extinguisher to use

Eye protection during banding

Personal Safety

Use of eye protection

during banding operations

B.3 Operating Skills Evaluation

Determine the operating skills of employees by making a full evaluation while they are driving the lift truck.

1. Did the operator pull forward toward the designated section of racking without endangering anyone?
2. Did the operator place the forks under the pallet properly?
3. Did the operator raise or tilt the load properly?
4. Did any part of the container strike any section of racking while removing the pallet?
5. Did the operator lower the pallet before moving or backing out? (Don't drive and lower the pallets at the same time.)
6. Did the operator drive at a safe speed?
7. Did the operator slow down or stop at cross aisles?
8. Did the operator sound his/her horn at blind intersections?
9. Did the operator pull into the racking area properly to place the pallet back in the racking?
10. Did the operator strike any racking on the way up or going into the rack?
11. Did the operator back out and lower his/her forks before moving?
12. Did the operator **always** look behind before backing up?
13. Was the operator wearing protective equipment?
14. Did the operator drive around the block of wood or obstacle on the floor, or did he/she get out of the truck and remove it?
15. Did the operator set the load flat on the floor before getting out of the truck?
16. Did the operator put on a hardhat before getting out of the truck?
17. Did the operator perform any moves that were potentially dangerous?

Appendix C. Powered Industrial Trucks Safety Checklist

This safety checklist will help employees and supervisors follow minimal safety practices. This list is not meant to be comprehensive nor is it meant to form part of any official self-assessment practice. Where appropriate, local safety offices and supervisors are encouraged to add to these checklists. Relevant references are noted after each question.

These regulations apply only to installations or equipment used on temporary and permanent job sites.

General	OK	Action Needed
Do industrial trucks acquired after Feb. 15, 1972 meet the design requirements in "American National Standard for Powered Industrial Trucks, Part II, ANSI B56.1-1969?" 29 CFR 1910.178 (a) (2)	____	__________
Has the manufacturer provided written approval for modifications that affect the capacity and safety operations of the equipment? 29 CFR 1910.178 (a) (4)	____	__________
Do industrial trucks have labels designating approval for use in various hazardous and/or nonhazardous locations? 29 CFR 1910.178 (a) (3) and (7)	____	__________
Designations		
Are supervisors and procurers of equipment aware of the eleven designations of industrial trucks or tractors (D, DS, DY, E, ES, EE, EX, G, GS, LP, and LS)? 29 CFR 1910.178 (b)	____	__________
Designated Use of Requirements		
Are supervisors and operators knowledgeable about the use of industrial trucks in various locations? 29 CFR 1910.178 (c) (1)	____	__________
Fuel Handling and Storage Requirements		
Is the storage and handling of liquid fuels in accordance with NFPA Flammable and Combustible Liquids Code (NFPA No. 58-1969)? 29 CFR 1910.178 (f) (1)	____	__________
Is the storage and handling of liquefied petroleum gas fuel in accordance with NFPA Storage and Handling of Liquefied Petroleum Gases (NFPA No. 58-1969)? 29 CFR 1910.178 (f) (2)	____	__________
Changing and Charging Storage Batteries		
Are battery-charging installations located in areas designated for that purpose? 29 CFR 1910.178(g) (1)	____	__________
Are facilities provided for flushing and neutralizing spilled electrolyte? 29 CFR 1910.178 (g) (2)	____	__________

	OK	Action Needed
Are facilities provided for adequate ventilation for dispersal of fumes from gassing batteries? 29 CFR 1910.178 (g) (2)	____	________
Is proper handling equipment (conveyor and hoists) provided for handling batteries? 29 CFR 1910.178 (g) (4)	____	________
Is a carbon filter or siphon provided for handling electrolyte? 29 CFR 1910.178 (g) (6)	____	________
Is care taken to ensure that vent caps are functioning when charging batteries? **Note:** The battery (or compartment) cover(s) shall be open to dissipate heat. 29 CFR 1910.178 (g) (9)	____	________
Is smoking prohibited in the charging area? 29 CFR 1910.178 (g) (10)	____	________
Are precautions taken to prevent open flames, sparks, or electric arcs in battery-charging areas? 29 CFR 1910.178 (g) (11)	____	________
Are tools and other metallic objects kept away from the tops of uncovered batteries? 29 CFR 1910.178 (g) (12)	____	________

Dockboards (bridge plates)

Are portable and powered dockboards strong enough to carry the load imposed on them? 29 CFR 1910.30 (a) (i)	____	________
Are portable dockboards secured in position, either by being anchored or equipped with devices that will prevent slippage? 29 CFR 1910.30 (a) (2)	____	________
Are handholds or other effective means provided on portable dockboards to ensure safe handling? 29 CFR 1910.30 (a) (4)	____	________
Is positive protection provided to prevent railroad cars from being moved while dockboards or bridge plates are in position? 29 CFR 1910.30 (a) (5)	____	________

Trucks and Railroad Cars

Do trucks have positive protection to prevent them from moving during loading or unloading? 29 CFR 1910.178 (k) (1)	____	________
Are wheel stops or other recognized positive protection provided to prevent railroad cars from moving during loading or unloading? 29 CFR 1910.178 (k) (2)	____	________

	OK	Action Needed
Are fixed jacks available to support a semi-trailer and prevent upending during the loading or unloading when the trailer is not coupled to a tractor? 29 CFR 1910.178 (k)(3)	____	____________
Operator Training		
Are only trained and authorized operators permitted to operate a powered industrial truck? 29 CFR 1910.178 (l)	____	____________
Truck Operations		
Is it prohibited for a person to stand or pass under the elevated portion of any truck, whether loaded or empty? 29 CFR 1910.178 (m) (2)	____	____________
Are unauthorized personnel prohibited from riding on powered industrial trucks? 29 CFR 1910.178 (m) (3)	____	____________
Is it prohibited for arms or legs to be placed between the uprights of the mast or outside the running lines of a truck? 29 CFR 1910.178 (m) (4)	____	____________
Is it required for load-engaging means to be fully lowered, controls neutralized, power shut off, and brakes set when a powered industrial truck is left unattended? 29 CFR 1910.178 (m) (5) (i)	____	____________
Is it required to maintain a safe distance from the edge of ramps or platforms while on any elevated dock, platform, or freight car? 29 CFR 1910.178(m) (6)	____	____________
Is an overhead guard used as protection against falling objects? 29 CFR 1910.178 (m) (9)	____	____________
Is a load backrest extension used whenever necessary to minimize the possibility of the load or part of it from falling backward? 29 CFR 1910.178 (m) (10)	____	____________
Are only approved industrial trucks used in hazardous locations? 29 CFR 1910.178 (m) (11)	____	____________
Traveling		
Is it required that all traffic regulations be observed, including authorized plant speed limits? 29 CFR 1910.178 (n) (1)	____	____________
Is it required to yield the right of way to ambulances, fire trucks, or other vehicles in emergency situations? 29 CFR 1910.178 (n) (2)	____	____________
Is it required that drivers not pass other trucks traveling in the same direction at intersections, blind spots, or other dangerous locations? 29 CFR 1910.178 (n) (3)	____	____________

	OK	Action Needed
Is it required that drivers slow down and sound the horn at cross aisles and other locations where vision is obstructured? 29 CFR 1910.178 (n) (4)	____	____________
Is it required that railroad tracks shall be crossed diagonally, wherever possible? 29 CFR 1910.178 (n) (5)	____	____________
Is it required that when ascending or descending grades that exceed 10 percent loaded trucks be driven with the load upgrade? 29 CFR 1910.178(n) (7) (i)	____	____________
Is it required that on all grades the load and load-engaging means be tilted back, if applicable, and raised only as far as necessary to clear the road surface? 29 CFR 1910.178 (n) (7)(iii)	____	____________
Is it required that under all travel conditions the truck be operated at a speed that will permit it to stop in a safe manner? 29 CFR 1910.178 (n) (8)	____	____________
Is stunt driving and horseplay prohibited? 29 CFR 1910.178 (n) (9)	____	____________
Are dockboards or bridge plates properly secured before they are driven over? 29 CFR 1910.178 (n) (11)	____	____________
Is it required that elevators be approached slowly, and then entered squarely after the elevator car is properly leveled? 29 CFR 1910.178 (n) (12)	____	____________
Is it required that motorized hand trucks enter elevators or other confined areas with load end forward? 29 CFR 1910.178 (n) (13)	____	____________
Loading		
Are drivers instructed that only stable or safely arranged loads be handled? 29 CFR 1910.178 (o) (1)	____	____________
Are drivers instructed that only loads within the rated capacity of the truck shall be handled? 29 CFR 1910.178 (o) (2)	____	____________
Is a load-engaging means placed under the load as far as possible? 29 CFR 1910.178 (o) (5)	____	____________
Are drivers required to use extreme care when tilting the load forward or backward, particularly when high tiering? 29 CFR 1910.178 (o) (6)	____	____________
Operation of the Truck		
Are personnel instructed that fuel tanks not be filled while the engine is running? 29 CFR 1910.178 (p) (2)	____	____________

	OK	Action Needed
Is it required that spillage of oil or fuel be carefully washed away or completely evaporated and the fuel tank cap replaced before restarting the engine? 29 CFR 1910.178 (p) (3)	____	__________
Is it prohibited for a truck to be operated with a leak in the fuel system until the leak has been corrected? 29 CFR 1910.178 (p) (4)	____	__________
Is it prohibited for open flames to be used for checking electrolyte level in storage batteries or gasoline level in fuel tanks? 29 CFR 1910.178 (p) (5)	____	__________
Maintenance of Industrial Trucks		
Is it required that no repairs be made in Class I, II, and III locations? 29 CFR 1910.178 (q) (2)	____	__________
Is it required that repairs to the fuel and ignition systems of industrial trucks, which involve fire hazards, be conducted only in locations designated for such repairs? 29 CFR 1910.178 (q) (3)	____	__________
Is it required that trucks in need of repairs to the electrical system have the battery disconnected before such repairs are made? 29 CFR 1910.178 (q) (4)	____	__________
Is it required that industrial trucks not be altered without the manufacturer's approval? 29 CFR 1910.178 (q) (6)	____	__________
Is it required that industrial trucks be examined before being placed in service? 29 CFR 1910.178 (q) (7)	____	__________
Is it required that water mufflers be filled daily or as frequently as necessary to prevent depletion of the water supply below 75 percent of the filled capacity? 29 CFR 1910.178 (q) (8)	____	__________
Is it required that vehicles with mufflers and screens or other parts that may become clogged not be operated while such screens or parts are clogged? 29 CFR 1910.178 (q) (8)	____	__________
Is it required that any vehicle that emits hazardous sparks or flames from the exhaust system be immediately removed from service and not returned to service until the cause for the emission of such sparks and flames has been eliminated? 29 CFR 1910.178 (q) (8)	____	__________
Is it required that when the temperature of any part of any truck is found to exceed its normal operating temperature, thus creating a hazardous condition, the vehicle be removed from service and not be returned to service until the cause for such overheating has been eliminated? 29 CFR 1910.178 (q) (9)	____	__________

Chapter 7
Mobile Work Platforms

1. Introduction

1.1 Incidence of Injuries

During the past 10 years, workers at the Department of Energy (DOE) facilities have experienced over 2500 reportable injuries from slips and falls. Most injuries occurred outdoors and were related to weather conditions, such as snow, ice, or rain. The Bureau of Labor Statistics (BLS) studies indicate that falls account for more than 15 percent of all worker compensation cases.

1.2 Causes of Injuries

Unsafe Acts

- Disregarding instructions.
- Jumping from platform.
- Leaning too far out from platform.
- Dropping or throwing tools and equipment from elevated positions.
- Removing guardrail and toeboards.
- Standing on railways to perform work.
- Overloading.
- Extending boom beyond the design capability.
- Contacting energized circuit.
- Towing stands at too high a speed.
- Failure to enforce safe work practices.

Unsafe Condition

- Inadequate inspections.
- Inadequate maintenance.
- Lack of safe operating procedures.
- Lack of proper training.
- Lack of supervision.
- Failure to secure tools and equipment at elevated locations.
- Nonuniform spacing of steps and ladder rungs.
- Grease and/or oil on step tread, ladder rungs, and walking surfaces.
- Failure to ground mobile work platforms.
- Improperly designed and poorly built work platforms.

1.3 Purpose and Scope

This chapter applies to vehicle-mounted elevating and rotating platforms, manually propelled work platforms, and work platform accessories attached to cranes and other equipment used for fire fighting, construction, and facility maintenance. This equipment shown in Figures 1 through 5 is used for elevating one or more workers for the purpose of performing work. The chapter does not apply to scaffolding assembled in place and work platforms installed as real property.

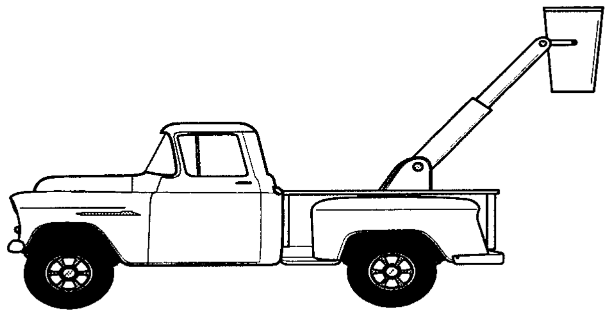

Figure 1. Vehicle-mounted elevating and rotating work platform.

1.4 Prevention Overview

Raised work platforms and scaffolds present a potential for severe injury from falls or falling objects. The hazards that result from work on platforms and scaffolds usually occur because of poorly built or designed equipment. Unsafe acts, by people building makeshift platforms, removing guardrails and toeboards, and failing to secure tools and equipment are some of the causes of mishaps. These hazards can be reduced by the proper design of platforms and scaffolds, by the training of people, and by the supervisor enforcing safe work practices. Working at high levels affects people in different ways. Some workers may become dizzy or experience feelings of instability or vertigo. These effects may be compounded by moving the platform on which the person is standing. Human factors such as illness, fatigue, and physical defects may cause or contribute to mishaps. Supervisors and workers should be alert to signs or symptoms from co-workers such as decreased performance, change in attitude, and/or physical changes that could result in mishaps.

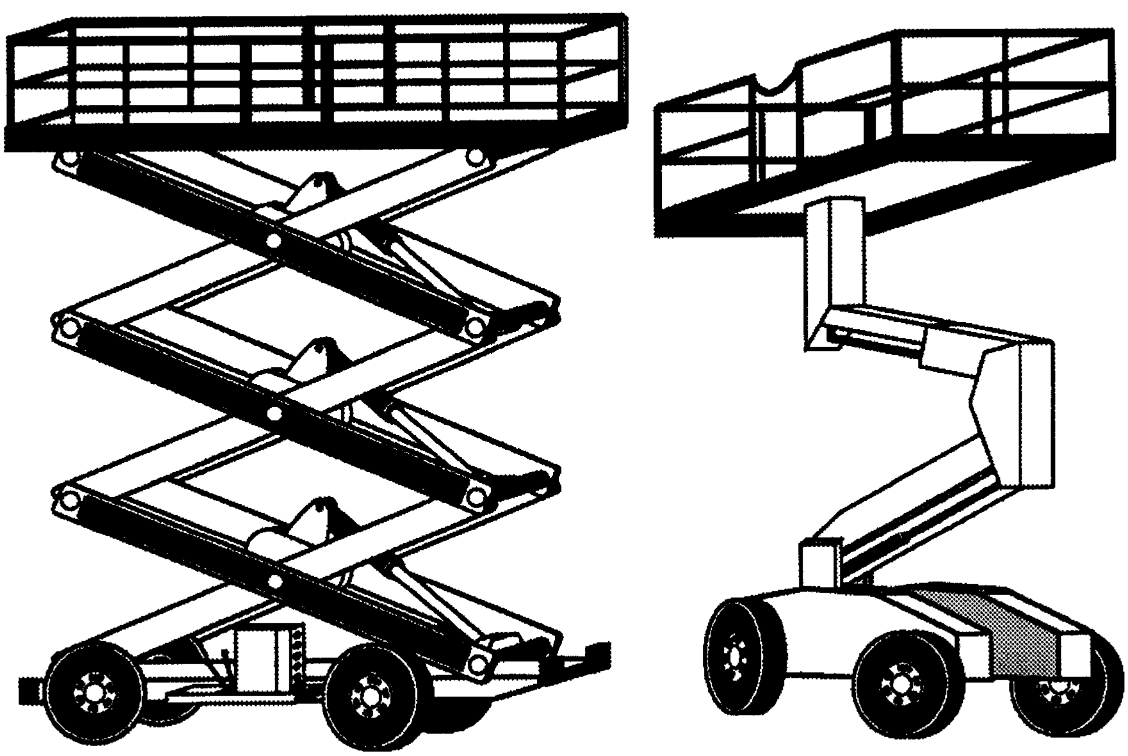

Figure 2. Self-propelled mobile work platforms.

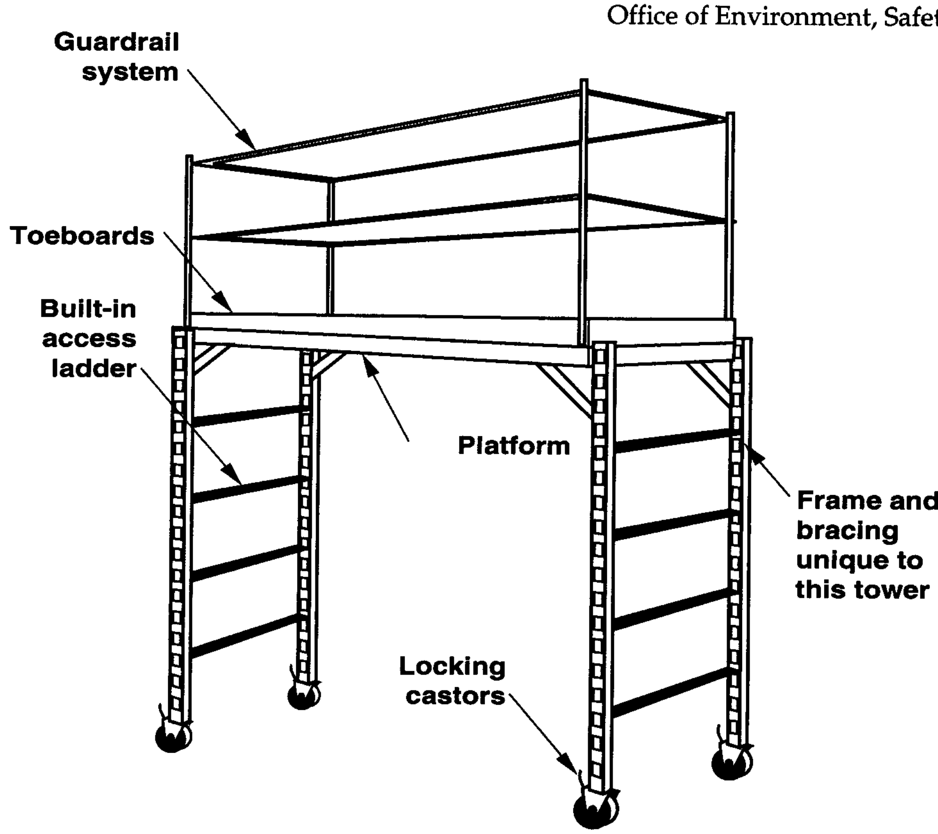

Figure 3. Manually propelled mobile scaffold.

1.5 Definitions

Aerial device. Any vehicle mounted device, telescoping or articulating, or both, which is used to elevate personnel to job sites aboveground. These devices include extendible boom platforms, vertical towers, and a combination of the above.

Aerial ladder. An aerial device consisting of a single or multiple-section extendible ladder.

Articulating boom platform. An aerial device with two or more hinged boom sections.

Extendible boom platform. An aerial device (except ladders) with a telescopic or extendible boom. Telescopic derricks with personnel platform attachments are considered to be extendible boom platforms when used with a personnel platform.

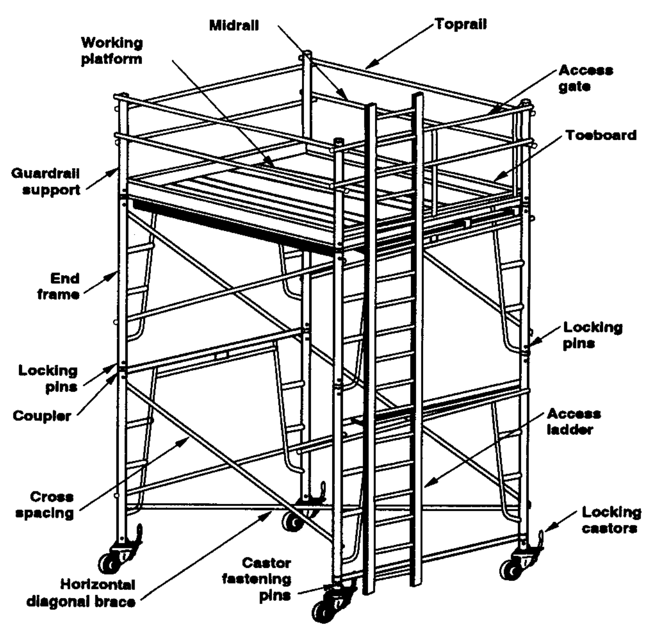

Figure 4. Fabricated tubular frame manually propelled mobile scaffold.

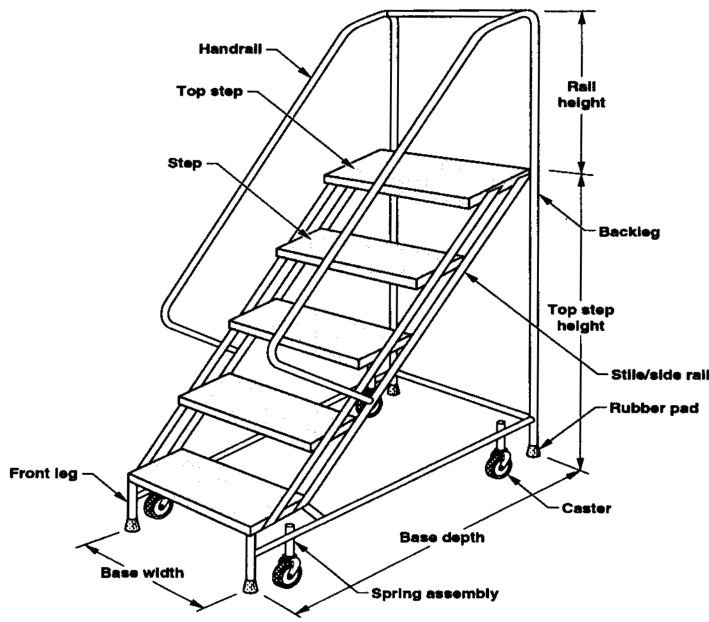

Figure 5. Mobile ladder stand nomenclature.

2. Standards and Codes

Group	Standard	Subject
OSHA	29 CFR 1910.29	Manually propelled mobile ladder stands and scaffolds (towers)
OSHA	29 CFR 1910.66	Powered platforms for building maintenance
OSHA	29 CFR 1910.67	Vehicle-mounted elevating and rotating work platforms
OSHA	29 CFR 1910.333	Selection and use of work practices
ANSI/SIA	A 92.2-1990	Vehicle-mounted elevating and rotating aerial devices
ANSI/SIA	A 92.3-1990	Manually propelled elevating aerial platforms
ANSI/SIA	A 92.5-1992	Boom-supported elevating work platforms
ANSI/SIA	A 92.6-1990	Self-propelled elevating work platforms
ANSI	A 92.2-1969	Vehicle-mounted elevating and rotating work platforms

OSHA = Occupational Safety and Health Administration.
ANSI = American National Standards Institute.
SIA = Scaffold Industry Association.

Table 2.1. Standards and codes for mobile work platforms.

3. Protective Devices

Proximity warning devices should be installed on all aerial devices where possible to warn of potential contact with overhead electrical wires. Wheel chocks, wheel locks, brakes, and outriggers prevent rolling and/or overturning on an incline. Floor locks secure platforms in position so that they don't move or fall under load. Handrails and guardrails protect workers from falling, while toeboards protect workers from tools falling on them. Upper controls allow the operator on an articulating and extended boom platform to control its movement while lower controls that override the upper controls allow a second person to control the movement of the lift in an emergency.

4. Work Practices

4.1 Clearances

4.1.1 Electrical

When operating aerial lifts near electric power lines, the following clearances must be maintained:

- For lines rated to 50 kilovolts, or less, the minimum clearance between the lines and any part of the aerial lift must be at least 10 feet (3 meters).
- For lines rated in excess of 50 kilovolts the minimum clearance between the lines and any part of the aerial lift must be at least 10 feet (3 meters) plus 0.4 inch (1 centimeter) for each kilovolt in excess of 50 kilovolts or twice the length of the line insulator, but never less than 10 feet (3 meters).

4.1.2 Exceptions to Electrical

- Where the work is performed from an aerial device insulated for the work, and the work is performed by trained communications personnel, outside plant workers, line clearance and tree-trimming employees, or exterior electric linemen.
- Where the electric power transmission or distribution lines have been deenergized and visibly grounded at the point of work or where insulating barriers not a part of or an attachment to the aerial lift have been erected to prevent physical contact with the lines.

4.1.3 RF Radiation

Whenever work is to be performed from elevated platforms in the vicinity of communication and radar equipment, prior clearance must be obtained from the installation's safety office.

4.2 Inspection and Test Procedures

4.2.1 Aerial Ladders

Aerial ladders must be inspected and tested annually or immediately following any activity when it is known or suspected that the ladder may have been loaded beyond the manufacturer's maximum load capacity. Ladders should also be inspected immediately following any repair of a structural or mechanical component of the ladder assembly. The procedures in Appendices A and B are the joint responsibility of the principal operator of the vehicle and a mechanic qualified to perform the annual vehicle safety inspection. A record of the inspection and test must be recorded on the vehicle historical record.

4.2.2 Articulating and Extendible Boom Platforms

These platforms must be inspected and tested annually. Special inspections and tests must be conducted immediately following any work where the platform may have been loaded beyond the manufacturer's rated capacity or immediately following any repair of a structural or mechanical component of the boom or platform assembly. The inspection and test procedures in Appendix C must be carried out jointly by the principal operator and a vehicle mechanic qualified to perform the annual safety inspection of the vehicle. A record of the inspection and test must be recorded on the vehicle historical record. When the personnel platform is an attachment to a telescoping derrick or crane with a rated capacity higher than that of the work platform, test procedures contained herein do not apply and testing must be accomplished in accordance with the standards on cranes.

4.2.3 Visual Inspections

The unit should be visually inspected and the lift controls tested prior to each shift or day's work to determine that the unit and controls are in safe working condition. The override feature explained in paragraph

4.3.4 should be tested at this time. A record of this test should be noted on the Operator's Inspection Guide and Trouble Report.

4.3 Operations

4.3.1 Operator's Manuals

A manufacturer of aerial devices is required by ANSI Standard 92.2 to publish a manual(s) and to provide for the distribution of the manual(s) to dealers and direct sale purchasers. The manual(s) must be procured by the DOE user of this equipment and must be readily available for use by workers and contain:

- Description, specification, and capacity of the aerial device.
- Instructions for installing or mounting the aerial devices.
- An expression of the operating pressure of any hydraulic or pneumatic system that is part of the aerial device.
- Instructions regarding operation and maintenance.
- Replacement part information.

4.3.2 Nameplates

The manufacturer is also required to attach to each aerial device a plate(s) located in a readily accessible area, clearly visible, stating:

- Make, model, and manufacturer's serial number.
- Rated capacity.
- Platform height.
- Maximum recommended operating pressures of hydraulic or pneumatic system(s) or both.
- Cautions or restrictions.
- Operating instructions.

Where alternative configurations are possible, the plate must show by chart, schematic, or scale, the capacities of all combinations in their operating positions and cautions or restrictions or both for operation of all alternate or combinations of alternate configurations. These plates must not be removed from the device, painted over, or otherwise made unavailable for reference by the operator.

4.3.3 Traveling

Before a mobile unit is moved for travel, the aerial device must be secured in the specified lower traveling position (to prevent rotation) by the use of cradles or locking devices in accordance with the manufacturer's instructions.

4.3.4 Upper/Lower Controls

Articulating and extendible boom platforms must have both upper and lower controls. Upper controls must be in or beside the platform within easy reach of the operator. Lower controls must provide for overriding the upper controls. Controls must be plainly marked as to their function. Lower level controls must not be operated unless permission has been obtained from the employee in the lift, except in case of emergency. Whenever a worker is in or on an elevated work platform, at least one person qualified to operate the equipment must be stationed near the lower-level control panel.

4.3.5 Load Limits

Boom and basket load limits specified by the manufacturer must not be exceeded. An aerial lift truck must not be moved when the boom is elevated in a working position with men in the basket, except for equipment that is specifically designed for this type of operation. In all cases, the manufacturer's operating instructions must be followed.

4.3.6 Brakes and Chocks

The brakes must be set and outriggers positioned on pads or a solid surface. Wheel chocks must be installed before using an aerial lift on an incline.

4.3.7 Electrical Conductors

Aerial devices including insulated aerial devices, must not be brought into contact with an electrical conductor. Workers should not rely on the dielectric capabilities of aerial devices.

4.4 Maintenance and Repair

4.4.1 Maintenance

Manufacturer's recommended maintenance procedures must be strictly followed. If deficiencies that affect the safe operation of the equipment are discovered during the daily operator inspection or during use, the equipment must immediately be removed from service until repairs can he made.

4.4.2 Repair

All repairs must be done by qualified personnel. Workers must always stand firmly on the floor of the basket, must not sit or climb on the edge of the basket, or use planks ladders or other devices for a work position. Climbers must not be worn while performing work from an aerial lift.

4.5 Manually Propelled Work Platforms and Scaffolds

4.5.1 Safety Rules

- Scaffolds must be provided with a climbing ladder or stairway for access and egress and either be affixed or built into the scaffold. It must be located so that its use will not have a tendency to tip the scaffold. A landing platform must be provided at intervals not to exceed 30 feet (9.1 meters).

- Personnel must not ride on mobile units while they are being moved. If equipment is left on the work level, it must rest securely on the platform protected by the rail or toeboard.

- Scaffold casters must have a positive wheel and/or swivel lock to prevent movement. Ladder stands must have at least two of the four casters lockable and be the swivel type.

- A minimum of two brakes, wheel locks, or permanently installed jacks, must be operable on all mobile work platforms.

- The erection of a scaffold exceeding 50 feet (15.2 meters) in height above the base must be done in accordance with manufacturer's instructions under the supervision of a qualified professional engineer. Plant engineering is the authorizing agency for scaffold erection.

- The minimum base width of mobile work platforms must not be less than 20 inches. (50.8 centimeters)

- Steps must be uniformly spaced, with a rise of not less than 9 inches (22.9 centimeters) or more than 10 inches (25.4 centimeters) and a depth of not less than 7 inches (17.8 centimeters). The slope of the steps section must be a minimum of 55 degrees and a maximum of 60 degrees measured from the horizontal.

- Mobile work platforms having more than four steps or 60 inches (1.5 meters) vertical height to the top step must be equipped with handrails.

4.5.2 Work Level Height Requirements

- The maximum work level height must not be more than four times the minimum or least base dimension (width) of any mobile ladder stand or scaffold. Where the basic mobile unit does not meet this requirement, suitable outrigger frames must be used to obtain this least base dimension or the unit must be tied with guy wires or braced to keep the unit from tipping.

- The minimum platform width for any work level must not be less than 20 inches (50.8 centimeters) for mobile scaffolds (towers). Ladder stands must have a minimum step width of 16 inches (40.6 centimeters).

- The steps of ladder stands must be built fabricated with slip resistant treads.

- Scaffold work platforms at work levels of 10 feet (3 meters) or higher above the ground or floor must have a standard 4-inch (10.2-centimeter) nominal toeboard.

- Scaffold work platforms at work levels of 10 feet (3 meters) or higher above the ground or floor must have a guardrail of 2- by 4-inch (5.1- by 10.2-centimeter) nominal lumber or the equivalent installed no less than 36 inches (91.4 centimeters), or more than 42 inches (106.7 centimeters) high, with a midrail when required of 1- by 4-inch (2.5- by 10.2-centimeter) nominal lumber or equivalent.

5. Training and Personal Protective Equipment

5.1 Training

Workers should be trained to keep stairs, ladder rungs, and platforms free of debris and slippery items such as grease, oil, and ice. They should also be trained to use handrails and not to overload platforms. Workers need to be reminded not to remove guardrails and toeboards. They also need to report any hazardous conditions including defective guardrails, steps, ladder rungs, and hazardous surfaces (such as ice). They need training in proper towing, positioning, and securing of mobile work platforms. This includes "hands-on" training prior to actual participation in "on-the-job" training tasks. Completion of training and qualification of specific elevating and rotating work platforms should be documented.

5.2 Safety Belts and Lanyards

A body belt and lanyard (not to exceed 6 feet [1.8 meters] in length) must be worn by each bucket/basket occupant. The lanyard must be attached to the boom. Belting off to an adjacent pole, structure, or equipment while working from an aerial lift is not permitted.

6. Hazards

The most common hazards to workers are from electricity, falls, and objects falling from elevated positions. The hazard of electric shock is increased when work platforms provide access to energized power lines or to areas near power lines. The potential for falling from elevated heights is increased when mobile platforms are moved unexpectedly either by deliberate action or because equipment runs into them.

7. Bibliography

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Appendix A. Inspection and Test Procedures for Vehicle-Mounted Work Platforms

Aerial Ladder

Before any test is conducted, make a thorough inspection as outlined below and prepare test equipment for use. The preliminary check must include:

- **Inspecting the ladd**er carefully to make sure that the truss posts are vertical, the longitudinal trusses are straight, and there are no dents.
- Checking the ladder beams for bends, depression, or other evidence of rough usage.
- Checking the ladder for evidence of loose rungs, loose rivets, or cracks at welds.

The tests must be conducted in still air to avoid dynamic loading of the ladder.

A close watch must be maintained during the test to see that the ladder rails remain square and that there is no evidence of twist in the ladder. If the ladder shows twist at any time, the test must be discontinued immediately and the ladder taken out of service until the cause of the twist is determined and repairs are made.

The test load is 400 pounds (182 kilograms).

The following test procedures apply to metal aerial ladders which can be fully extended in a horizontal position over the rear of the vehicle.

1. The vehicle should be on a level surface or road. All outriggers must be down and have a firm footing on the ground. The aerial turntable must be level.
2. With the ladder supported by the apparatus bedding arches, extend the aerial ladder sections fully to the rear.
3. Place a 50-pound (22.7-kilogram) weight on a board spanning the second and third rungs from the top end of the top section.
4. Measure the distance from the underside of the rear rung to the ground.
5. Remove the board and the 50-pound (22.7-kilogram) weight and retract the sections fully. Attach a testing bracket and cable to the top rung of the top section.
6. Elevate the ladder to 60 degrees. Rotate the turntable if necessary until the ladder is over either the front or rear of the aerial apparatus vehicle, and then extend the ladder until each section is two rungs short of full extension.
7. Secure the testing equipment to the cable. Make sure that there is a 60-inch (1.5-meter) clearance from the ground.

8. Add weight carefully until total load (weight of bracket, cable, etc.) is equal to the test weight of 400 pounds (182 kilograms). Do not drop weights or "shock load" the ladder. Keep the maximum test weight on the ladder for five minutes.

9. Remove test weight from ladder.

10. With the ladder supported by the apparatus bedding arches, extend the aerial ladder sections fully and add the 50-pound (22.7-kilogram) weight and repeat the second and third steps above.

11. If the measurement taken in step 10 is within 2 inches (5.1 centimeters) of the measurement taken in step 4, the ladder is in satisfactory condition for continued use.

Appendix B. Inspection and Test Procedures for Metal Aerial Ladders (which can be fully extended in a horizontal position over the rear of the vehicle)

The inspection and tests described are to supplement, not to replace or modify any instructions recommended by the manufacturers in their maintenance manuals. Since each manufacturer's unit is somewhat different, specific attention must be given to the manufacturer's instructions concerning periodic maintenance and inspection checks of the elevating platform systems.

Visual inspection of the equipment is intended to detect any visible defects, damage, or improperly secured parts. Any problems detected during this examination must be corrected prior to proceeding to subsequent tests. The following items must be inspected:

Ladder Test Conditions

A visual inspection of the ladder must be accomplished in accordance with the following section of this appendix.

The tests must be conducted in still air to avoid dynamic loading of the ladder.

A close watch must be maintained during the test to see that the ladder rails remain square, and there is no evidence of twist in the ladder.

> **Note:** If the ladder show twist at anytime, the test must discontinued immediately and the ladder must be taken out of service until the cause of the twist is determined and repairs are made.

The test load is 400 pounds (182 kilograms).

The vehicle must be on a level surface or road.

All outriggers must be down and have a firm footing on the ground.

The aerial turntable must be level.

Preliminary Visual Inspection of the Ladder.

Are the truss posts vertical?

Are the longitudinal trusses straight?

Is the ladder dent free?

Are the ladder beams free of bends, depressions, or evidence of rough usage?

Does the ladder have tight rungs?

Does the ladder have tight rivets?

Is the ladder free of cracks at welds?

> **Note:** Any problems detected during the visual inspection of the ladder must be corrected prior to proceeding to the next section of this appendix.

Ladder Test Procedure

1. With the ladder supported by the apparatus bedding arches, extend the aerial ladder sections fully to the rear.
2. Place a 50-pound (22.7-kilogram) weight on a board spanning the second and third rungs from the top end of the top section.

3. Measure the distance from the underside of the rear rung to the ground.

4. Remove the board and the 50-pound (22.7-kilogram) weight and retract the sections fully. Attach a testing bracket and cable to the top rung of the top section.

5. Elevate the ladder to 60 degrees. Rotate the turntable if necessary until the ladder is over either the front or rear of the aerial apparatus vehicle, and then extend the ladder until each section is two rungs short of full extension.

6. Secure the testing equipment to the cable. Make sure that there is a 60-inch (1.5-meter) clearance from the ground.

7. Add weight carefully until total load (weight of bracket, cable, etc.) is equal to the test weight of 400 pounds (182 kilograms). Do not drop weights or "shock load" the ladder. Keep the maximum test weight on the ladder for five minutes.

8. Remove test weight from ladder.

9. With the ladder supported by the apparatus bedding arches, extend the aerial ladder sections fully and add the 50-pound (22.7-kilogram) weight and repeat steps 1 and 2 above.

10. If the measurement taken in step 9 is within 2 inches (5.1 centimeters) of the measurement taken in step 3, the ladder is in satisfactory condition for continued use.

Appendix C. Inspection And Test Procedures For Articulating and Extendible Boom Platforms

The inspection and tests described are to supplement, not to replace or modify any instructions recommended by the manufacturers in their maintenance manuals. Since each manufacturer's unit is somewhat different, specific attention must be given to the manufacturer's instructions concerning periodic maintenance and inspection checks of the elevating platform systems.

Visual inspection of the equipment is intended to detect any visible defects, damage, or improperly secured parts. Any problems detected during this examination must be corrected prior to proceeding to subsequent tests. The following items must be inspected:

Frame and Mainframe	**OK**	**Action Needed**
Check pins holding outrigger cylinder and outrigger legs for proper installation and fastener security.	______	____________
Inspect all welds for cracks or fractures.	______	____________
Check bolts holding rotation gear for proper tightness.	______	____________
Check tie-down bolts for tightness.	______	____________
Check all hydraulic components and cylinders for external oil leakage.	______	____________
Check rotary hydraulic manifold for proper attachment and fastening.	______	____________
Turntable		
Check fasteners retaining turntable to rotation mechanism for proper tightness.	______	____________
Inspect turntable structure for weld cracks or fractures.	______	____________
Check pin securing cylinder to boom and turntable for proper installation and fastener security.	______	____________
Check hydraulic hoses, tubing, and connections for chafing, kinks, or oil leaks.	______	____________
Check center post manifold for oil leaks.	______	____________
Check hydraulic cylinder and holding valves for any sign of damage or oil leaks.	______	____________
Check wiring and electrical swivels.	______	____________
Booms		
Check all boom pivot pins and upper cylinder pins for proper installation and fastener security.	______	____________

	OK	Action Needed
Inspect entire booms for visible defects such as weld cracks, dents, or misalignment, particularly in areas of cylinder attachment.	______	____________
Check all hydraulic hoses, tubing, and connections for chafing, kinks, or oil leaks.	______	____________
For articulated boom elevating platforms, it is desirable, after checking the upper boom, to raise the upper boom from the lower boom to provide access for checking the upper cylinder and area between the two booms. In the case of telescopic elevating platforms, extend the boom to its maximum extension.	______	____________
Cylinders		
Check pins securing cylinders.	______	____________
Check cylinder end glands.	______	____________
Check cylinder piston rods for damage.	______	____________
Platform basket		
Check all control linkage for proper installation, adjustment, and free movement.	______	____________
Check platform basket structure for visible defects such as weld cracks, dents, or bends, particularly in the area of attachment to the boom.	______	____________
Check hydraulic tubing and hoses for any chafing, kinks, or oil leaks.	______	____________
Platform basket leveling system		
Check all leveling components for visible defects kinks or oil leaks such as weld cracks, bent areas, frayed cables, and loose cable terminals.	______	____________
Check all pins for proper installation and security.	______	____________
After satisfactorily completing the visual examination, an operational test must be performed to determine that the hydraulic system, safety systems, and all structural mechanisms are performing in a normal manner. For this test, the aerial device must be placed on a hard level surface in an open area. Check that full movement of the booms through their complete operating range is allowed.	______	____________

	OK	Action Needed
Hydraulic system		
Check hydraulic pressure to see that it is within limits recommended by the manufacturer.	______	____________
Outriggers		
After engaging the hydraulic drive pump (either power takeoff or auxiliary engine operated), the outriggers should be extended to proper engagement with the ground as recommended by the manufacturers. Note any unusual operation of the outriggers during lowering. Check the interlock system.	______	____________
Operation from lower controls		
The elevating platform must be operated in all positions using the lower or ground controls. This should include movement of platform basket from ground to maximum elevation, as well as revolving platform basket 360 degrees to the left and to the right while the unit is at its maximum horizontal reach.	______	____________
Operation from platform controls		
With only one operator in the platform basket, booms must again be moved through all positions operating from the platform control station. Any operation accomplished with a ma in the platform basket requires a second man to stand by at the lower control station.	______	____________
Check all operation safety devices to determine proper operation.	______	____________
Check platform basket deactivation valve from ground or lower controls to determine proper operation.	______	____________
Observe proper leveling of the platform basket as the booms are moved.	______	____________
With hydraulic pump stopped, check pilot operated holding valves on cylinders to determine their proper operation in holding the booms in position without power.	______	____________
With the unit located on a hard level surface and sufficient room for unrestricted boom movement, a stability and structural test must be performed to determine its ability to perform properly while carrying rated capacity loads in the platform basket. Manufacturers test new equipment platform basket loads in excess of rated capacity. Stability and structural testing by the user should be conducted only to rated capacity. If it is desired to test beyond rated load, it is recommended that such testing be conducted by or in the presence of a representative of the manufacturer.	______	____________
Properly stabilize the unit according to the manufacturer's recommendation. Stability, placement, loading and speed must be given careful consideration.	______	____________
Place the platform basket near the ground and load to rated capacity. Weight of equipment added to the platform basket after delivery must be subtracted from the load rating.	______	____________

	OK	Action Needed
Operate the unit from the lower controls through all allowable phases of operation.	______	____________
• Check the outriggers for evidence of any instability.	______	____________
• Check all boom movements for any abnormal noise, vibration, or deflection.	______	____________
• Check platform for proper leveling.	______	____________
• Check weld joints at outrigger structure, outriggers, frame, mainframe, frame reinforcements, turntable, cylinder anchors, boom joints, leveling system, platform basket, and pilot pin bosses.	______	____________

Dielectric test of insulated aerial devices

To ensure that aerial lift boom and work platform insulation provides personnel protection from electrical shock, it is necessary to conduct periodic dielectric tests on insulated portions of this type of equipment. The person responsible for this test is the principal operator of the equipment. Tests must be conducted at least semi-annually with additional tests performed depending on the unit's activity, severity of service, and environmental conditions. Dielectric tests must also be conducted prior to returning an aerial lift to service when:

	OK	Action Needed
• Repairs are made to boom or aerial basket.	______	____________
• Aerial basket has been removed and reinstalled.	______	____________
• Repairs or replacement have been accomplished on cables or insulated cable connecting links.	______	____________
• Replacement has been accomplished on boom associated hydraulic or air lines.	______	____________
• Hydraulic oil has been changed.	______	____________
DOE-owned insulated aerial platform units are factory certified when new for use below 69 KVAC. The minimum DC test voltage for maintenance testing of 69 kilovolts and below booms or aerial platforms is 100 KVDC. All personnel operating high voltage test equipment must be constantly aware of the inherent dangers of high voltage. Adequate precautions must be taken to prevent the operator and observers from coming into contact with high voltage during a test.	______	____________
• Steel winch cables of line maintenance derrick trucks must be removed from the head sheave and fiberglass pull-out extension before conducting field test.	______	____________
• Insulation test failures are usually attributable to wet or dirty conditions and can be corrected either by letting the equipment dry out or cleaning it in accordance with the manufacturer's recommendations. It is the operator's responsibility to maintain the equipment in a clean, dry condition to insure that the insulation qualities are maintained. Suitable cover could be useful as an aid to keeping this equipment clean and dry.	______	____________

Appendix D. Safety Checklist for Mobile Work Platforms

This safety checklist will help employees and supervisors to follow minimal safety practices. This list is not meant to be comprehensive or to form part of any official self-assessment practice. Where appropriate, local safety offices and supervisors are encouraged to add to these checklists. Relevant references are noted after each question.

Clearances	OK	Action Needed
Do operators of aerial lifts operating near electrical powerlines maintain the following clearances? 29 CFR 1910.333(c)(i)(1) & (2)	____	________
• **For lines rated at 50 kilovolts,** the minimum clearance between the lines and any part of the aerial lift may be at least 10 feet (3 meters).	____	________
• **For lines rated in excess of 50 kilovolts,** the minimum clearance between the lines and any part of the aerial lift may be at least 10 feet (3 meters) plus 0.4 inch (1 centimeter) for each kilovolt in excess of 50 kilovolts or twice the length of the line insulator, but never less than 10 feet (3 meters).	____	________
Inspection and Test Procedures		
Are aerial ladders inspected and tested annually? AFOSH 127-47	____	________
Are aerial ladders inspected immediately when known or suspected that the ladder may have been loaded beyond the manufacturer's rated capacity? AFOSH 127-47	____	________
Are aerial ladders inspected immediately following any repair of a structural or mechanical component of the ladder assembly? AFOSH 127-47	____	________
Are articulating and extendible boom platforms inspectedand tested annually? AFOSH 127-47	____	________
Are articulating and extendible boom platforms inspected and tested when it is known or suspected that the work platform may have been loaded beyond the manufacturer's rated capacity? AFOSH 127-47	____	________
Are articulating and extendible boom platforms inspected and tested immediately following any repair of a structural or mechanical component of the boom or work platform assembly? AFOSH 127-47	____	________
Are tests and inspections recorded on the vehicle historical record? AFOSH 127-47	____	________
Is Appendix A used as a guide by the principal operator and a qualified vehicle mechanic while performing tests or annual inspections of aerial ladders? AFOSH 127-47	____	________

	OK	Action Needed
Is Appendix B used as a guide by the principal operator and a qualified vehicle mechanic while performing tests or annua inspections of articulated boom platforms? AFOSH 127-47	______	____________

Operations

	OK	Action Needed
Is the manufacturer's operator's manual for the aerial device available for use by operators, and does it contain the following information? AFOSH 127-47	______	____________
• Description, specification, and capacity of the aerial device.	______	____________
• Instructions for installing or mounting the aerial device.	______	____________
• Operating pressure of any hydraulic or pneumatic system which is part of the aerial device.	______	____________
• Instructions regarding operation and maintenance.	______	____________
• Replacement part information.	______	____________
Have operators of vehicle-mounted elevating and rotating work platforms been thoroughly trained and qualified in the use of this equipment? 29 CFR 1910.66(g)(7)(i) 29 CFR 1910.67(a)(ii)	______	____________
Has the training and qualification of operators been documented? AFOSH 127-47	______	____________
Is the aerial device of a mobile unit secured in the specified lower traveling position, utilizing a cradle or locking device, prior to movement of the unit? 29 CFR 1910.67(c)(2)(xii)	______	____________
Are units visually inspected and the lift controls tested prior to each shift or day's work to determine if the unit and controls are in safe working order? 29 CFR 1910.67(c)(2)	______	____________
Is the override feature tested during each daily or shift change inspection? AFOSH 127-47	______	____________
Are daily/shift inspections recorded? AFOSH 127-47	______	____________
Is a person qualified on the equipment available at the lower control panel any time a worker is on the platform or bucket? AFOSH 127-47	______	____________
Are equipment controls plainly marked as to their function? AFOSH 127-47	______	____________
Are boom and basket load limits specified by the manufacturer <u>not</u> exceeded? AFOSH 127-47	______	____________

	OK	Action Needed
Is it prohibited for an aerial lift truck to be moved with boom in elevated position and men in the basket? 29 CFR 1910.67(c)(2)(viii)	______	____________
Are brakes set and outriggers positioned on pads or a solid surface prior to use? 29 CFR 1910.67(a)(2)(vii)	______	____________
Is a body belt and lanyard attached to the boom or basket, worn by each bucket/platform occupant? 29 CFR 1910.67(c)(2)(v)	______	____________
Is it prohibited to belt off to an adjacent pole, structure, or equipment while working from an aerial lift? 29 CFR 1910.67(c)(2)(ii)	______	____________
Do workers always stand firmly on the floor and not sit or climb on the edge of the basket, or use planks, ladders, or other devices for a work position? 29 CFR 1910.67(c)(2)(iv)	______	____________
Is it prohibited to wear climbers while performing work from an aerial lift? 29 CFR 1910.67(c)(2)(x)	______	____________
Is it prohibited for aerial devices, including insulated aerial devices, to be brought into contact with an electrical conductor? AFOSH 127-47	______	____________
Are all repairs accomplished by qualified personnel? AFOSH 127-47	______	____________
Working Loads		
Are mobile ladders or scaffolds designed to safely hold the specified loads? 29 CFR 1910.29(a)(2)	______	____________
Is the design of the working load of ladders calculated on the basis of one or more 200-pound (91-kilogram) person with 50 pounds (22.7 kilograms) of equipment each? 29 CFR 1910.29(a)(2)(ii)(c)	______	____________
Work Levels		
Is the maximum work level height not more than four times the minimum or at least the base dimension (width) of any mobile ladder stand or scaffold? 29 CFR 1910.29(a)(3)(i)	______	____________
Is the minimum width of any work level less than 20 inches (50.8 centimeters) for mobile scaffolds? 29 CFR 1910.29(a)(3)(ii)	______	____________
Are all supporting structures for working levels rigidly braced? 29 CFR 1910.29(a)(3)(iii)	______	____________
Are steps of ladder stands fabricated with slip resistant treads? 29 CFR 1910.29(a)(3)(iv)	______	____________

	OK	Action Needed
Are work level platforms of scaffolds made of wood, aluminum or plywood planking, steel, or expanded metal? 29 CFR 1910.29(a)(3)(v)	____	________
Are work scaffold platforms at work level 10 feet (3 meters) or higher above the ground or floor, equipped with a standard toeboard and guardrail? 29 CFR 1910.29(a)(3)(vi) & (vii)	____	________
Are scaffolds provided with a climbing ladder or stairway for access and egress? 29 CFR 1910.29(a)(3)(viii)	____	________
Wheels or Casters		
Are wheels or casters of proper design? 29 CFR 1910.29(a)(4)(i)	____	________
Are scaffold casters provided with a positive wheel and/or swivel lock to prevent movement? 29 CFR 1910.29(a)(4)(ii)	____	________
Is a minimum of two brakes, wheel locks or permanently installed jacks on all mobile work platforms? 29 CFR 1910.29(a)(4)(ii)	____	________
Mobile Tubular Welded Frame Scaffolds		
Are scaffolds properly braced by cross braces and/or diagonal braces for securing vertical members together laterally? 29 CFR 1910.29(b)(2)	____	________
Is spacing of panels or frames consistent with the loads imposed? 29 CFR 1910.29(b)(3)	____	________
Are panels locked together vertically by pins or other equivalent means where uplifts occur? 29 CFR 1910.29(b)(4)	____	________
Mobile Ladder Stands		
Is the maximum work level height not more than four times the minimum or at least base dimension (width)? 29 CFR 1910.29(f)(2)	____	________
Are steps uniformly spaced with a rise of not less than 9 inches (22.9 centimeters), nor more than 10 inches (25.4 centimeters), and a depth of not less than 7 inches (17.8 centimeters)? 29 CFR 1910.29(f)(3)	____	________
Handrails		
Are units having more than five steps or 60-inch (1.5-meter) vertical height to the top equipped with handrails? 29 CFR 1910.29(f)(4)	____	________

	OK	Action Needed
Are handrails a minimum of 29 inches (73.7 centimeters) high the same height all along the steps? 29 CFR 1910.29(f)(5)	______	____________

Mobile Work Platforms and Ladder Stands

	OK	Action Needed
Are ladder stands and platforms kept free of grease, oil, or other substances which could cause slips and falls? AFOSH 127-9	______	____________
Do guardrails and toeboards meet the criteria of this section? Appendix D to 29 CFR 1910.66(b)(v)(b)(9) & (10)	______	____________
Are guardrails installed before work is performed where location and configuration permit? AFOSH 127-9	______	____________
Are locking pins installed when mobile platforms are raised? AFOSH 127-9	______	____________
Are mobile work platforms marked with reflectorized tape? AFOSH 127-9	______	____________
Are mobile work platforms that are stored outside secured to prevent collision with vehicles or other equipment? AFOSH 127-9	______	____________
Are mobile work stands inspected by the user daily? AFOSH 127-9	______	____________

Movement of Mobile Work Platforms

	OK	Action Needed
Are personnel prohibited from riding on work platforms while they are being towed? AFOSH 127-9	______	____________
Are platforms equipped with hitches? AFOSH 127-9	______	____________
Are the following rules applied when work platforms are being towed by vehicles? AFOSH 127-9	______	____________
a. Is a maximum of two platforms towed on a single hitch?	______	____________
b. Are larger stands towed singly and on a center-mounted hitch?	______	____________
c. Is the maximum speed limit of 5 miles (8 kilometers) per hour observed when towing small stands in tandem or larger stands over smooth paved surfaces?	______	____________
d. Are platforms used in operations such as fuel cell repair or refueling vehicle maintenance where static electricity is hazardous to the work operation ground and equipped with static discharge plates?	______	____________

AFOSH = Air Force Occupational Safety and Health Manual

29 CFR = Code of Federal Regulations Title 29

Chapter 8

Walking and Working Surfaces Including Stairs, Platforms, and Fixed Ladders

1. Introduction

1.1 Incidences of Slips and Falls

In the past ten years, workers at Department of Energy (DOE) facilities have reported over 2,500 injuries from slips and falls. Most of these occurred outdoors and were related to weather (e.g., snow, ice, rain). Approximately 400 of the slips or falls reported on the Safety Performance Measurement System (SPMS) occurred indoors as a result of water or oil on floors and other surfaces. Of these, over two-thirds resulted in injuries severe enough to require lost or restricted work days. More than 5,600 lost workdays resulted from the incidents.

Service workers, such as clerks and food service personnel, have a higher risk of accidents because they frequently use stairs while serving customers. Most of these incidents occur while going down the stairs. Stairs are also an important cause of slips and falls at DOE facilities. Typical stair terminology is given in Figure 1.

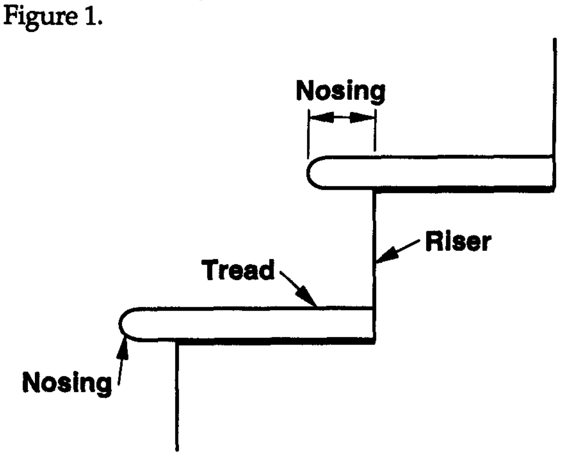

Figure 1. Stair terminology.

1.2 Causes of Slips and Falls

The typical causes of slips and falls are:

- Presence of oil or water on floors and surfaces.
- Inferior lighting conditions.
- Improperly constructed stairs or platforms.
- Worn, broken, or uneven steps.
- Unguarded floor and wall openings.
- Poor floor conditions, such as cracks or holes, protruding nails, and improper floor finishes.

In 1984, a Bureau of Labor Statistics (BLS) survey, *Injuries Resulting from Falls on Stairs*, stated that loss of traction caused the largest number of accidents. Water and other liquids on indoor stairs were usually the cause. Snow and ice were the major hazards on outdoor stairs. The survey also indicated that nearly two-thirds of the workers were not using handrails. Over one-fifth of the stairs on which accidents occurred were not equipped with railings. These falls resulted in serious injuries, and some required a long recuperative period.

1.3 Prevention Overview

Prevention consists of proper maintenance and good housekeeping, such as cleanup of liquid spills and appropriate guards for floor and wall openings.

1.4 Scope

This chapter covers walking/working surfaces including floor holes, stairs, ladders, and platforms. It does not cover portable ladders, scaffolding, or fall protection that are discussed in other chapters.

2. Standards and Codes

Group	Standard	Subject
OSHA	**29 CFR 1910 subpart D**	**Walking–working surfaces**
OSHA	**29 CFR 1910.22**	**Walk and work surfaces**
OSHA	**29 CFR 1910.23**	**Floor and wall openings**
OSHA	**29 CFR 1910.24**	**Fixed industrial stairs**
OSHA	**29 CFR 1910.27**	**Fixed ladders**
ANSI	**A10.18**	**Construction and demolition operation temperature**
ASAE	**S412.1**	**Ladders cages, walkways and stairs**
ASSE	**A1264.1**	**Floor and wall openings and stair and railing systems**
ANSI	**A58.1**	**Design loads**
ANSI	**Z535.2**	**Environmental and facility safety signs**
ANSI	**Z4.1**	**Sanitation**
ANSI	**A14.3**	**Safety requirements for fixed ladders**
ANSI/IES	**RP-7**	**Industrial lighting**
ANSI	**Z53.3**	**Safety symbols**
AFOSH	**127-1**	**Walking surfaces**
AFOSH	**127-6**	**Fixed stairs**

OSHA = Occupational Safety and Health Administration.
ANSI = American National Standards Institute.
ASAE = American Society of Agricultural Engineers.
ASSE = American Society of Safety Engineers.
IES = Illuminating Engineers Society.
AFOSH = Air Force Occupational Safety and Health.

Table 2.1. Standards and codes for walking and working surfaces.

3. Protective Devices

3.1 Climbing Devices for Fixed Ladders

Fixed-ladder safety devices consist of rail or cable that is attached to the ladder. A sleeve or collar travels on the rail or cable and is attached to the climber's safety belt by hooks and short lengths of chain. At normal climbing speed, the sleeve or collar slides up and down without hindrance. If the climber falls, a locking trigger or friction brake is activated. A stop is usually installed at the top of the rail or cable to prevent the sleeve or collar from sliding off.

3.2 Railings

3.2.1 Standard Railings

Railings protect personnel from inadvertently falling over the edge of a platform or through an opening in the floor or wall, as well as from contact with dangerous equipment. Railings can be made of wood, fiberglass, or metal. Platforms greater than 4 feet (1.2 meters) above ground level, should have standard railings 42 inches (1.1 meters) high with an intermediate railing and a 4-inch (10-centimeter) toeboard. Table 3.1 lists the minimum requirements for these railings.

All railing construction should meet the following conditions:

- A smooth-surfaced top rail about 42 inches (107 centimeters) above the floor level
- A strength to withstand at least 200 pounds (91 kilograms) of top-rail pressure with a minimum deflection.
- Protection between the top rail and floor equivalent to at least a standard intermediate rail.
- Elimination of overhanging rail ends, unless the overhang does not constitute a hazard.

Fiberglass railings are particularly suited to corrosive environments, such as chemical companies, metallurgical plating operations, and maritime operations. They are electrically nonconductive and fire retardant (see Appendix A).

3.2.2 Stair Railing

A stair railing is constructed like a standard railing, but the vertical height must not be more than 34 inches (86 centimeters) or less than 30 inches (76 centimeters) from the upper surface of the top rail to the surface of the tread in line with the riser face at the forward edge of tread.

3.2.3 Handrail

A handrail consists of a lengthwise member mounted directly on a wall or partition with brackets attached to the lower side of the handrail. The handrail should be rounded or of another design that furnishes an adequate handhold for anyone grasping it. The length of brackets should provide at least a 3 inch (7.6 centimeters) clearance between the handrail and the wall or any projection thereon. See Appendix A for additional specifications.

	Wood	Pipe	Steel
Post	2 x 4 in.	1 x 1/2-in. diam	2 x 2 x 3/8 in.
	5 x 10 cm	3.8 cm	5 x 5 x 1 cm
Spacing	6 ft	8 ft	8 ft
	1.85 m	2.4 m	2.5 m
Top Rail	2 x 4 in.	1 x 1/2-in. diam	2 x 2 x 3/8 in.
	5 x 10 cm	3.8 cm	5 x 5 x 1 cm
Intermediate	1 x 6 in.	1 x 1/2-in. diam	2 x 2 x 3/8 in.
	2.5 x 15 cm	3.8 cm	5 x 5 x 1 cm
Toeboard	4 in. high	4 in. high	4 in. high
	10 cm	10 cm	10 cm

Table 3.1 Minimum requirements for railings.

3.3 Fencing/Barriers

Physical fences can include metal, wood, or plastic fencing. Plastic safety fence, a minimal security fence made of polyethylene, is lightweight and portable. The fence has smooth edges and high visibility. It is nontoxic, nonconductive, and will not corrode.

3.4 Hole Covers

Hole covers should be made of a strong impervious material (strong enough to support most loads), such as metal or reinforced plastic. To allow access, they may need to be hinged. See Appendix A for additional specifications.

3.5 Built-In Safety Features in Stairs

Fixed stairs should be built at horizontal angles between 30 and 50 degrees. The minimum tread width of fixed stairs is 22 inches (56 centimeters); the minimum tread depth is 8 inches (19 centimeters); and the riser height can vary from 6.3 to 9.5 inches (16 to 24 centimeters). Certain safety features may be incorporated, such as:

- Slip-resistant tread.
- Nonslip noses.
- Uniform riser height and tread width.
- Open-grating type treads (outside stairs).
- Landings.

3.6 Flooring

Flooring decisions should take into account the following factors:

- Noise.
- Dustiness.
- Maintenance.
- Drainage.
- Load.
- Durability.
- Resilience.
- Appearance.
- Electrical conductivity.
- Slip resistance.
- Heat conductivity.
- Chemical composition.

Inserts of various materials can reduce slipperiness in specific areas. For example, steel gratings filled with concrete can be installed at the door sills of elevators. (See Appendix B for guidance on floor materials and surfaces.) Abrasive-coated tape or fabric strips can reduce slipperiness in high-hazard locations.

3.7 Mats

3.7.1 Fatigue-Reducing Mats

Fatigue-reducing mats lessen muscular fatigue and often reduce noise. They are made of cocoa fiber (vinyl backed), vinyl, wood (chemically treated), visco-elastic material, or rubber with resilient surfaces.

3.7.2 Slip-Resistant Mats

Slip-resistant mats protect against hazardous footing caused by water, oil, grease, ice, or mud and can be made of neoprene, vinyl, rubber, cocoa fiber, and wood.

3.7.3 Absorbent Mats

Absorbent mats have been specially treated to absorb more than seven times their weight in oil and chemicals. They are especially useful in heavy traffic areas and around leaking machinery.

3.7.4 Conductive (Antistatic) Mats

Conductive mats are designed to dissipate static electricity from persons working with or near electrical equipment. They are used in rooms with high oxygen content, sensitive electronic components, explosives, or volatile liquids.

3.7.5 Insulating High-Voltage Mats

Nonconductive rubber mats can be used in front of switchboards and other hazardous locations. Various thicknesses withstand from 3,000 to 15,000 volts.

3.7.6 Other Mats

Other mats include disposable decontamination mats, metal link floor mats, and thermally insulated mats.

4. Work Practices

4.1 Housekeeping

4.1.1 Inside Buildings

All floor surfaces, including stairs, should be kept dry, clean, and orderly. If needed, use floor drains, false floors, and mats to keep floors dry. If spills occur, they should be mopped up immediately. Where spills or drips are likely (such as where liquids are poured from one container to another), drip pans should be used.

4.1.2 Outside Areas

Grounds should be kept free of debris. Walkways (preferably smooth concrete) should be clear of snow and ice, and of obstacles that block the right of way or present slipping and tripping hazards. Abrasive materials may be used on walk surfaces when it is impractical or impossible to remove snow and ice. Use night lighting, where needed.

4.2 Flooring

Only nonskid finishing compounds should be used to protect floors. Use of the wrong cleaning materials and methods of cleaning can make floors slippery. Any problems with the flooring surface should be repaired immediately or immediately marked and repaired as soon as possible.

4.3 Aisles and Passages

Machines should be arranged so that operators do not have to stand in aisles to work. Aisles should be at least 30 inches (76.2 centimeters) wide to permit free movement of workers and equipment. In open-bay shops, permanent aisles should be marked with lines on the floor. New lines should be yellow and at least 2.5 inches (6.4 centimeters) wide. Where material-handling equipment is used, allow enough clearance to permit safe vehicle turns. A safe clearance should be at least 2 feet (.61 meters) wider than the widest vehicle used. Lighting in aisles should be at least a minimum of 5-foot candles of illumination at floor level.

4.4 Floor Loading

Floor load capacities should not be exceeded. Floor loading capacities should be posted in all above-grade buildings or storage areas.

4.5 Guarding

4.5.1 Floor Openings and Holes, Open-Sided Platforms, and Runways

Ladder ways, floor openings, runways, and platforms should be protected with a standard railing and toeboard on all open sides (except at entrances), with the passage through the railing built either with a swinging gate or offset so that personnel cannot walk straight into the opening. Hatch and chute floor openings should be guarded by one of the following: a hinged floor opening cover, a permanent standard railing and toeboard, or a removable railing with toeboard on not more than two sides of the opening. Standard covers should be provided to protect manholes. Temporary floor openings should be attended by someone or have temporary standard railings installed. Floor holes into which people might walk should be guarded by a hinged floor hole cover. While the cover is not in place, the floor hole must be constantly attended by someone or be guarded by a removable standard railing and toeboard. Clearly mark all floor openings and holes.

4.5.2 Stair Railings and Guards

In general, every flight of stairs that has four or more risers must be equipped with a standard handrail. Spiral stairs must have a handrail offset to stop people from walking on the parts of the treads that are less than 6 inches (15 centimeters) wide (see Figure 2).

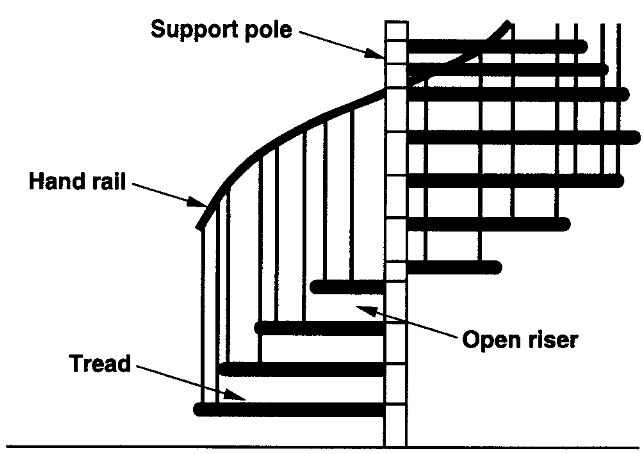

Figure 2. Spiral stairs.

5. Training

Employees should be trained in spill clean up, good housekeeping, proper guarding, use of handrails, and floor loading, as well as reporting defective guardrails, steps, and other hazardous surfaces (such as ice and damaged carpets).

6. Hazards

Personnel injuries result from slipping, tripping, or falling caused by poor housekeeping, insufficient lighting, poor maintenance, slippery or uneven surfaces, inattention to tasks, running, failure to use safety equipment, and fatigue.

Lack of guardrails may result in personnel falling over the edge of platforms, stairs, and pits. In addition, personnel can be struck by objects falling from overhead openings, platforms, and walkways.

7. Bibliography

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Appendix A. Construction/Material Specifications

1. A standard railing must consist of top rail, intermediate rail, and posts. It must have a vertical height of 42 inches (105 centimeters) nominal from upper surface of top rail to floor, platform, runway, or ramp level. The top rail must be smooth surfaced throughout the length of the railing. The intermediate rail must be approximately halfway between the top rail and the floor, platform, runway, or ramp. The ends of the rails must not overhang the terminal posts except where the overhang would not constitute a hazard.

1.1 For wood railings, the posts must be of at least nominal 2- by 4-inch (5- by 10-centimeter) stock spaced not to exceed 6 feet; the top and intermediate rails must be of at least nominal 2- by 4-inch (5- by 10-centimeter) stock. If the top rail is made of two right-angle pieces of 1- by 4-inch (2.5- by 10-centimeter) stock, posts may be spaced on 8-foot (2.4-meter) centers, with 2- by 4-inch (5- by 10-centimeter) intermediate rail.

1.2 For pipe railings, posts, and top and intermediate railings must be of at least 1.5-inch (4-centimeter) nominal (outside) diameter with posts spaced not more than 8 feet (2.4 meters) on centers.

1.3 For structural steel railings, posts and top and intermediate rails must be of 2- by 2- by 0.375-inch (5- by 5- by 1-centimeter) angles or other metal shapes of equivalent bending strength with posts spaced not more than 8 feet (2.4 meters) on centers.

1.4 The anchoring of posts and framing of members for railings of all types must be constructed so that the completed railings can withstand a load of at least 200 pounds (91 kilograms) applied in any direction at any point on the top rail.

1.5 Other types, sizes, and arrangements of railing are acceptable if they meet the following conditions: (1) Be a smooth-surfaced top rail at a height above floor and a platform, runway or ramp level of 42 inches (105 centimeters) nominal; (2) When frequent removal is required, use flexible material such as wire, rope, or chain for top and intermediate rails; (3) Cover the wire rope with a suitable material such as plastic to eliminate rough surfaces; (4) Have a strength to withstand at least 200 pounds (91 kilograms) of top rail pressure, with no more than a 3-inch (8-centimeter) deflection with posts set at a maximum of 8 feet (2.4 meters) apart; (5) Have protection between the top rail and floor, platform, runway, ramp, or stair treads equivalent at least to that afforded standard intermediate rail; (6) Eliminate overhanging rail ends unless the overhang would not constitute a hazard, such as bluster, scroll work, or paneled railings.

2. A stair railing must be of constructed like a standard railing but the vertical height must not be more than 34 inches (85 centimeters) or less than 30 inches (75 centimeters) from upper surface of top rail to the surface of tread in line with the face of the riser at the forward edge of tread.

3. A standard toe board must be 4 inches (10 centimeters) nominal in vertical height from its top edge to the level of the floor, platform, runway, or ramp. It must be securely fastened in place with not more than a 0.25-inch (0.55-centimeter) clearance above floor level. It may be made of any substantial material either solid or with openings not over 1 inch (2.5 centimeters). Where material is piled to such height that a standard toe board does not provide protection, paneling from the floor to the intermediate rail, or to the top rail must be provided.

4. A handrail must have a lengthwise member mounted directly on a wall or partition with brackets attached to the lower side of the handrail and have a smooth surface along the top and both sides. The handrail must be of a rounded or other design that must furnish an adequate handhold for anyone grasping it to avoid falling. The ends of the handrail should be turned in to the supporting wall.

4.1 The height of handrails must not be more than 34 inches (85 centimeters) or less than 30 inches (75 centimeters) from upper surface of handrail to surface of tread in line with face of riser or to surface of ramp.

4.2 Hardwood handrails must be at least 2 inches (5 centimeters) in diameter. Metal pipe rails must be at least 0.5 inches (1.25 centimeters) in diameter. The length of brackets must provide a clearance between the handrail and wall or any projection thereon of at least 3 inches (8 centimeters). The spacing of brackets must not exceed 8 feet (2.4 meters).

4.3 The mounting of handrails must be such that the completed structure can withstand a load of at least 200 pounds (91 kilograms) applied in any direction at any point on the rail.

4.4 Provide handrails with at least a 3-inch (7.6-centimeter) clearance between the handrail and any other object.

5. Floor opening covers may be any material that meets the following strength requirements:

- Trench or conduit covers and their supports, when located in roadways, must be designed to carry an axle load of at least 20,000 pounds (9,091 kilograms).

- Manhole covers and their supports, when located in roadways, must comply with local standard highway requirements if any; otherwise, they must be designed to carry an axle load of at least 20,000 pounds (9,091 kilograms).

5.1 The construction of floor openings or manhole covers in buildings must be sufficiently strong to withstand a load of at least 300 pounds (136 kilograms) applied perpendicularly to any area of the cover. Covers projecting not more than 1 inch (2.5 centimeters) above the floor may be used providing all edges are beveled to an angle of 30 degrees to the floor. Hinges, handles, bolts, or other parts must be flush with the floor or cover surface.

6. Construct and mount skylight screens so that they can withstand a load of at least 200 pounds (91 kilograms) applied perpendicularly at any one area on the screen. They shall also be constructed and mounted so that under ordinary loads or impacts, they will not deflect downward sufficiently to break the glass below them. The construction must be of grillwork with openings not more than 4 inches (10 centimeters) long or of slat work with openings not more than 2 inches (5 centimeters) wide with length unrestricted.

7. Wall-opening barriers must be constructed and mounted so that, when they are in place at the opening, the barrier can withstand a load of at least 200 pounds (91 kilograms) applied in any direction (except upward) at any point on the top rail or corresponding member.

8. Wall-opening grab handles must not be less than 12 inches (30 centimeters) long and must be mounted to provide 3 inches (8 centimeters) of clearance from the side framing of the wall opening. The size, material, and anchoring of the grab handle shall be such that the completed structure can withstand a load of at least 200 pounds (91 kilograms) applied at any point of the handle.

9. Wall-opening screens must be constructed and mounted so that they can withstand a load of at least 200 pounds (91 kilograms) applied horizontally at any point on the near side of the screen. They may be of solid construction, of grillwork with openings not more than 8 inches (20 centimeters) long, or of slat work with openings not more than 4 inches (10 centimeters) wide with length unrestricted.

Appendix B. Floor Materials and Surfaces

Type of floor	Characteristics	Use of abrasives	Dust control or cleaners recommended	Dressing recommended	Sealers recommended	Avoid
Asphalt Title	Composed of blended asphalt and/or thermoplastic binders, asbestos fibers and/or other inert filler materials, and pigments.	Various types of abrasive materials may be used to reduce slipperiness.	Neutral detergent impregnated mop sweeper. Sweeping powder	Emulsion	None	Solvents, Oils
Linoleum	Cork dust, wood flour, held together by cinders consisting of linseed oil or resins and gum.	Colloidal silica can be incorporated in wax and synthetic resin floor coatings.	All types except strong alkalis and abrasive sweeping powders.	Solvent non-slip emulsion	Any	Water/ Alkali Acids
Rubber	Vulcanized, natural, synthetic, or combination rubber compound cured to a sufficient density to prevent creeping under heavy foot traffic.	Slip-resistant except when wet.	Neutral detergent impregnated mop sweeper. Sweeping compound	Nonslip emulsion	None	Solvents, Oils
Vinyl	Composed of inert, non-flammable, non-toxic resins compounded with other filler and stabilizing ingredients.	Adhesive fabric with ingrained abrasives can be used. They are patterned in strips, tiles, and clots.	Neutral detergent impregnated mop sweeping compound.	Nonslip emulsion	None	Solvents, Oils
Terraza	Consists of marble of granite chips mixed with a cement matrix.	Silicon carbide or aluminum oxide can be included in mix when floor is laid.	Neutral detergent impregnated mop sweeper.	Nonslip emulsion	Water-based resin emulsion	Alkali Acids
Concrete	Made of cement mixed with sand, gravel and water and then poured.	Reinforced plastic coating can be painted on.	Any	Nonskid solvent polish, nonslip emulsion over a sealed surface.	Any	Acids

Floor Materials and Surfaces, continued.

Type of floor	Characteristics	Use of abrasives	Dust control or cleaners recommended	Dressing recommended	Sealers recommended	Avoid
Mastic	Like asphalt tile in composition but is heated on the job and trawled onto the floor to form a seamless flooring. Such floors are often used to give a new durable, resilient surface.	(Same as asphalt tile)	All types except white spirit.	Nonslip emulsion.	Water-Based.	Solvents
Wood	May be either soft or hard, in a variety of thicknesses and designs.	Metallic particles and artificial abrasives in varnish or paint gives good nonslip qualities.	All types except alkaline and abrasive.	Nonskid solvent polish. Nonslip emulsion over sealed surface.	All except water-based.	Alkali, Water
Cork	Made of molded and compressed ground cork bark with natural resins of the cork to bind the mass together when heat cured under hydraulic presure.	(Same as asphalt tiles)	Neutral detergent impregnated mop sweeper.	Nonskid solvent polish. Nonslip emulsion over sealed surfaces.	All except water-bases.	Alkali, Water, Acids

* Floors and stairways should be designed to have slip-resistant surfaces; adhesive carborundum strips may used on stirs treads or ramps and at critical concrete areas. Etching with mild muriatic acid solution will lessen slip problems.

** Colloidal silica is an opalescent, aqueous solution confining 30 percent amorphous silica dioxide and a small amount of alkali as a stabilizing agent.

Appendix C. Walking and Working Surfaces Including Stairs, Platforms, and Fixed Ladders Safety Checklist

This safety checklist will help employees and supervisors follow minimal safety practices. This list is not meant to be comprehensive, nor is it meant to form part of any official self-assessment practice. Where appropriate, local safety offices and supervisors are encouraged to add to these checklists. Relevant references are noted after each question.

Floors and Aisles	OK	Action Needed
Are the floors of all shop areas, service rooms, utility areas, and storerooms kept clean and orderly? 29 CFR 1910.22 (a) (1) & (2)		
Are drain platforms, mats, or other dry standing places used when floors are continually wet? 29 CFR 1910.22 (a) (2)		
Are only nonskid finishing compounds used to protect floors? AFOSH 127-1, para 4 a (4)		
Are machines located so that the movement of one operator will not interfere with the work of another? 29 CFR 1910.22 (b) (1)		
Are aisles at least 30 inches (75 centimeters) wide and machines arranged so that operators do not stand in aisles? 29 CFR 1910.22 (b) (1)		
Do aisles, loading docks, and through doorways have enough clearance to allow safe turns where material handling equipment is used? 29 CFR 1910.22 (b) (1)		
Are permanent aisles marked with lines on the floor in open bay shop areas? Note: New lines should be yellow and be at least 2-1/2 inches wide. 29 CFR 1910.22 (b) (2)		
Are floors, aisles, and passageways free from obstructions? 29 CFR 1910.22 (b) (1)		
Is lighting sufficient to make walking surfaces and obstructions visible? AFOSH 127-1, para 3 c		
Are floor-loading capabilities posted in all required areas? 29 CFR 1910.22 (d) (1)		
Are floor load capabilities exceeded? 29 CFR 1910.22 (d) (2)		

Outdoor Walkways	OK	Action Needed
Are abrasive materials used on walking surfaces when it is impractical or impossible to remove snow and ice? AFOSH 127-1, para 4 f (1)		

	OK	Action Needed
Are grounds kept free of debris? AFOSH 127-1, para 4 f (2)	____	__________
Is loose gravel or crushed rock less than 0.5 inch (1.25 centimeters) in diameter used for permanent walkway surfaces? AFOSH 127-1, para 4 f (1)	____	__________

Floor and Wall Openings/Holes

	OK	Action Needed
Is each stairway, ladder way, or platform floor opening guarded by a standard railing and toe board and/or a hinged floor opening cover? 29 CFR 1910.23 (a) (1) & (2)	____	__________
Are all pit or trap openings guarded by a hinged cover or, if the cover is not in place, is the opening protected by standard removable railings? 29 CFR 1910.23 (a) (5)	____	__________

Is each hatchway, chute, or similar floor opening guarded by either:

- A hinged floor opening cover?
- A standard railing and toe boards?
- A removable railing and toe boards on two sides with standard railings and toe boards on other open sides?
- Personnel barriers to prevent persons from falling into chutes or hatches?

29 CFR 1910.23 (a) (3)

	OK	Action Needed
Are temporary floor openings attended by someone or guarded by temporary standard railings? 29 CFR 1910.23 (a) (7)	____	__________
Are floor holes guarded with a floor-hole cover that is hinged in place? 29 CFR 1910.23 (a) (6)	____	__________
If the floor-hole cover is not in place, is the opening attended by someone, or guarded by a removable standard railing and toe boards? 29 CFR 1910.23 (a) (7)	____	__________
Are floor holes around or near fixed machinery guarded by a cover to preclude personnel, tools or material from falling into the hole? (Perforations in guard materials must not be greater than 1 inch in width.) 29 CFR 1910.23 (a) (9)	____	__________
Are platforms used where doors or gates open directly on stairs? 29 CFR 1910.23 (a) (10)	____	__________

	OK	Action Needed
Are wall openings where personnel or materials could fall more than 4 feet guarded by one of the following methods: • Railing, picket fence, half door or equivalent guard? • Hinged doors to cover all chute openings? • Standard slats, railing, grill work and toe boards? **Note:** This is in addition to the normal protective doors. 29 CFR 1910.23 (b) (1)		
Is every open-sided floor platform that is 4 feet (1.2 meters) or more above adjacent floor or ground level guarded by standard railings on all open sides except the access point to fixed stairs, ladders, or ramps? 29 CFR 1910.23 (b) (3)		
Are railings equipped with toe boards installed on open sides of floors or platforms where people might pass beneath? 29 CFR 1910.23 (b) (5)		
Are all walkways constructed with a minimum 18-inch- (45-centimeter-) wide walking surface and adequately guarded with standard railing and toe boards? 29 CFR 1910.23 (c) (2)		

Fixed Stairs

	OK	Action Needed
Are fixed stairs installed where people must routinely move from one structure level to another? 29 CFR 1910.24 (b)		
Are stairs available to people who need access to operating platforms or equipment to perform their jobs? 29 CFR 1910.24 (b)		
Do fixed stairs have a minimum width of 22 inches (55 centimeters)? 29 CFR 1910.24 (d)		
Is the angle of fixed stairs within the preferred range of 30 and 50 degrees? 29 CFR 1910.24 (e)		
Are standard railing or hand rails installed on every flight of stairs having four or more risers? 29 CFR 1910.23(d)		
Is there a minimum of one hand rail installed on all enclosed stairways that have treads less than 44 inches (110 centimeters) wide? 29 CFR 1910.23 (d) (1) (i)		
Is there a stair rail provided on the open side of all stairways less than 44 inches (110 centimeters) wide? 29 CFR 1910.23 (d) (1) (ii)		

	OK	Action Needed
Are stair rails provided on both sides of open stairways that are less than 44 inches (110 centimeters) wide? 29 CFR 1910.23 (d) (1) (iii)	____	____________
Is there a handrail on each enclosed side and a railing on each open side of all stairways that are more than 44 inches (110 centimeters) but less than 88 inches (220 centimeters) wide? 29 CFR 1910.23 (d) (1) (iv)	____	____________
Is there a stair handrail on each enclosed side, one stair rail on each open side and one hand rail in the center of all stairways more than 88 inches (220 centimeters) wide? 29 CFR 1910.23 (d) (1) (v)	____	____________
Are spiral staircase hand rails offset to prevent walking on tread surfaces less than 6 inches (15 centimeters) wide? 29 CFR 1910.23 (d) (2)	____	____________
Are fixed stairs installed where people need access to high levels daily or during each work shift to gauge, inspect, or to perform maintenance where workers are exposed to acids, caustics, or other harmful substances? 29 CFR 1910.24 (b)	____	____________
Does each tread and the top of landings where risers are used have a nose that extends 0.5 inches (1.25 centimeters) beyond the face of the lower riser? AFOSH 127-3, para 4 f	____	____________
Does the tread nose have an even leading edge that has been rounded or beveled to prevent people from catching their heels on the treads? 29 CFR 1910.24 (f)	____	____________
Are stair treads slip-resistant and do their noses have a nonslip finish? 29 CFR 1910.24 (f)	____	____________
Are long fights of stairs broken by landings or platforms? AFOSH 127-3, para 4 g	____	____________
Do platforms have the same width as the stairs and a minimum of 30 inches (75 centimeters) of length, measured from the direction of travel? 29 CFR 1910.24 (g)	____	____________
Are standard railings used on the open sides of all exposed stairs and platforms? 29 CFR 1910.24 (h)	____	____________
Are handrails used on at least one side of closed stairs, preferably on the right side going down? 29 CFR 1910.24 (h)	____	____________
Do stairs having treads of less than 9 inches (20 centimeters) in width have open risers? AFOSH 127-3, para 4 i	____	____________

	OK	Action Needed
Are stairs lighted with a minimum of 5-foot candles of light so that all treads and landings are visible? 29 CFR 1910.37 (q) (6)	____	____________

Fixed Ladders

	OK	Action Needed
Do all fixed ladders meet the requirements of rungs having a minimum diameter of 0.75 inch (1.9 centimeters) for metal ladders, 1 inch (2.5 centimeters) for corrosive atmospheres, and 1.125 inch (3 centimeters) for wood ladders? 29 CFR 1910.27 (b) (1) (i).	____	____________
Is the distance between rungs, cleats, and steps not more than 12 inches (30 centimeters)? 29 CFR 1910.27 (b) (1) (ii).	____	____________
Are rungs, cleats, and steps spaced uniformly throughout the length of the ladder? 29 CFR 1910.27 (b) (1) (ii)	____	____________
Is the minimum width of rungs or cleats 16 inches (40 centimeters)? 29 CFR 1910.27 (b) (1) (iii)	____	____________
Are rungs, cleats, and steps free of splinters, sharp edges, or projections that may be a hazard? 29 CFR 1910.27 (b) (1) (iv)	____	____________
Are the rungs of the ladder so designed that the foot cannot slide off the end? 29 CFR 1910.27 (b) (1) (v)	____	____________
Are fastenings an integral part of fixed ladder design? 29 CFR 1910.27 (b) (3)	____	____________
Are metal ladders and appurtenances painted or otherwise treated to resist corrosion and rusting where the location demands? 29 CFR 1910.27 (b) (7)	____	____________
Is the preferred pitch of fixed ladders in the range of 75 to 90 degrees from the horizontal? 29 CFR 1910.27 (a) (2)	____	____________
Is a clear width of at least 15 inches (37 centimeters) provided each way from the centerline of the ladder in the climbing space except when cages or wells are necessary? 29 CFR 1910.27 (c) (2)	____	____________
Do cages extend down the ladder to a point not less than 7 feet (2.1 meters) nor more than 8 feet (2.4 meters) above the base of the ladder? 29 CFR 1910.27 (d) (1) (iv)	____	____________
Is the distance from the centerline of rungs, cleats, or steps to the nearest permanent object in back of the ladder 7 inches (17.5 centimeters) or more, except when unavoidable obstructions are encountered? 29 CFR 1910.27 (c) (4)	____	____________

	OK	Action Needed
Are cages and wells provided on ladders of more than 30 feet (9.2 meters) except where ladder safety devices are used? 29 CFR 1910.27 (d) (1) (ii)	____	________
Is the distance from the centerline of grab bars to the nearest permanent object in back of the grab bars more than 4 inches (10 centimeters)? 29 CFR 1910.27 (c) (5)	____	________
Do the grab bars protrude beyond the climbing side of ladder rungs? 29 CFR 1910.27(c)(5)	____	________
Is the step across distance from a ladder to equipment or structure not less than 2.5 inches (6.3 centimeters) nor more than 12 inches (30 centimeters)? 29 CFR 1910.27 (c) (6)	____	________
Do counterweighted hatch covers open a minimum of 60 degrees from the horizontal? 29 CFR 1910.27 (c) (6)	____	________
Are there protruding hazards within 24 inches (60 centimeters) of the centerline of rungs or cleats? 29 CFR 1910.27 (c) (7)	____	________
Are any potential hazards within 30 inches (75 centimeters) of the centerline of rungs or cleats fitted with deflector plates? 29 CFR 1910.27 (c) (7)	____	________
Do protective cages extend a minimum of 42 inches (105 centimeters) above the top of a landing, unless other acceptable protection is provided? 29 CFR 1910.27 (d) (1) (iii)	____	________
Are protective cages at least 27 inches (67 centimeters) in width? 29 CFR 1910.27 (d) (1) (v)		
Are landing platforms provided for each 30 feet (9.2 meters) of height or fraction thereof when ladders are used to ascend to heights exceeding 20 feet (6.1 meters) (except chimneys)? NOTE: Where no cage, well, or ladder safety device is provided, landing platforms shall be provided for each 20 feet (6.1 meters) or fraction thereof. 29 CFR 1910.27 (d) (2)	____	________
Is a landing platform provided where a person has to step a distance greater than 12 inches (40 centimeters) from the centerline of the ladder rung? 29 CFR 1910.27 (d) (2) (i)	____	________
Are platforms not less than 24 inches (60 centimeters) in width and 30 inches (75 centimeters) in length? 29 CFR 1910.27 (d) (2) (ii)	____	________
Is one rung of any section of the ladder located at the same level as the landing? 29 CFR 1910.27 (d) (2) (iii)	____	________

	OK	Action Needed
Do the side rails of through or side-step ladder extensions extend 3.5 feet (1.07 meters) above parapets and landings? 29 CFR 1910.27 (d) (3)	____	__________
Are grab-bar diameters the equivalent of the round rung diameters? 29 CFR 1910.27 (d) (4)	____	__________
Do all ladder safety devices used on ladders over 20 feet (6.1 meters) in unbroken length meet design requirements of ladders they serve? 29 CFR 1910.27 (d) (5)	____	__________
Is a stop provided at the top of the rail or cable safety device to prevent the sleeve or collar from disengaging? AFOSH Std, 127-6, para 4 e (4)	____	__________
Do ladder safety devices extend above the landing platforms so persons can remove or attach themselves before stepping onto the ladder? AFOSH Std, 127-6, para 4 e (3)	____	__________
Are all ladders inspected regularly, with the interval between inspections being determined by use and exposure? 29 CFR 1910.27 (f)	____	__________
Are stairways in good condition with standard railings provided for every flight having four or more risers? 29 CFR 1910.23 (d)(1)	____	__________

AFOSH = Air Force Occupational Safety and Health Manual

29 CFR = Code of Federal Regulations Title 29

Chapter 9
Portable Ladders

1. Introduction

1.1 Incidences of Occupational-Related Deaths

Excluding motor vehicle accidents, falls are the number one cause of occupational-related deaths. The Occupational Safety and Health Administration (OSHA) estimates that 18,757 injuries and 24 fatalities per year are caused by falls from ladders. The Bureau of Labor Statistics (BLS) studies indicate that falls account for more than 15 percent of all worker compensation cases. The Department of Energy Computerized Accident and Incident Recording System (CAIRS) reported 855 ladder mishaps in 1991–92, of which 391 were severe enough to result in lost workdays.

1.2 Causes of Occupational-Related Deaths

Hospital data from northern Sweden indicated that of 114 ladder accidents, in one year, the most common was a fall from an extension or straight ladder (73 percent) or a stepladder (20 percent).

Ladder mishaps result from several unsafe acts and conditions:

- Ladders placed on unstable surfaces.
- Personnel reaching too far out to the sides.
- Personnel standing too high to maintain balance.
- Defective or broken ladders (e.g., broken rails, rungs, missing hardware).
- Ladders that were not secured or braced.
- Personnel hand carrying loads while ascending or descending.
- Selecting the wrong ladder for the job.
- Improper positioning of the ladder.
- Strong winds or rain.

A recent BLS survey of 1400 workers, *Ladder Accidents Resulting in Injuries*, found that:

- Eighty percent fell or slipped and almost half fell at least 8 feet.
- Fifty-seven percent were holding object(s) with one or both hands.
- Sixty-six percent were not trained in how to inspect ladders.
- Seventy-three percent were not provided written instructions on the safe use of ladders.
- Thirty percent had wet, greasy or oily shoes.

The survey of the ladders determined that:

- Fifty-six percent (52 percent were metal) fell or broke.
- Fifty-three percent of non-self-supporting ladders were not secured or braced at the bottom, and 61 percent were not secured or braced at the top.

  Thirty-nine percent were not extended 3 feet above the level for getting off.

1.3 Prevention Overview

The survey showed that most ladder accidents could be prevented by inspecting ladders before use (avoiding defective ladders) and following safe work practices.

1.4 Scope and Purpose

This chapter covers portable ladders, it does not cover the ladder dimensions, tests, and design specifications found in the Code of Federal Regulations (CFR) Title 29 or the American National Standards Institute (ANSI) standard. It is not meant as a substitute for knowledge of OSHA regulations as found in the CFR. No scaffolds or fire ladders are discussed.

2. Standards and Codes

Organization	Standard	Subject
OSHA	29 CFR 1910.25–.27	Portable ladders
OSHA	29 CFR 1926.1053–.1060	Portable ladders—construction
ANSI	A14.1	Portable wood ladders
ANSI	A14.2	Portable metal ladders
ANSI	A14.5	Portable reinforced Plastic ladders
ANSI	A14.4	Job-made ladders
AFOSH	127-3 (July 77)	Ladders

OSHA = Occupational Safety and Health Administration.
ANSI = American National Standards Institute.
AFOSH = Department of the Air Force.

Table 2.1. Standards and codes for portable ladders.

3. Protective Devices

Ladder safety devices for portable ladders include nonslip feet and rungs as well as locking devices. Stabilizers, although not safety devices, can help keep the ladder steady.

4. Work Practices

4.1 Selection

4.1.1 Types

Portable ladders can be carried or pushed from place to place. Portable ladders can be made from metal (mostly steel or aluminum), wood, fiberglass, or reinforced plastic.

4.1.2 Selection for the Job

If a safer means of access (e.g., scaffolds, work platforms, or fixed ladders with safety devices) is possible, portable ladders should not be used. In many locations, ladder selection may be constrained by local, state, or OSHA codes or specific departmental policy.

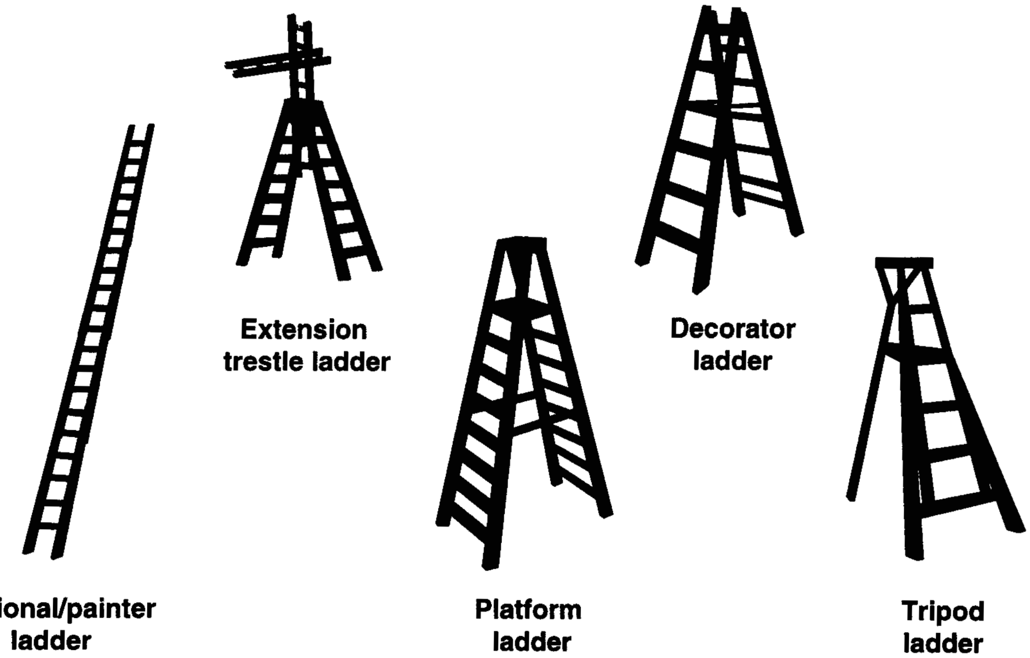

Figure 1. Ladder types.

Portable ladder types can be subdivided for different jobs (see Figure 1). These ladders include single or straight ladders, stepladders, extension ladders, sectional ladders, trestle ladders, and extension trestle ladders. Not all ladders are suitable for all jobs. A ladder that happens to be available may not only be wrong but also dangerously unsafe. For instance, when working near electricity, ONLY wood or nonconductive fiberglass ladders should be used.

Employees should be trained to select the proper portable ladder for each job, considering:

- The height the ladder must reach.
- The kind of activity it will be used for.
- The weight capacity (or working load) needed.

4.1.3 Height of the Ladder

Each ladder must be long enough so that the user does not stand on the top two steps of a stepladder or the top four rungs of a straight ladder. When an extension ladder is used to access a roof, the ladder should extend 3 feet above the support point at the eave, gutter, or roof line (see Figure 2). Short ladders should never be spliced together to form a longer ladder. Ladders should not be placed on boxes, barrels, or other unstable bases to gain additional height.

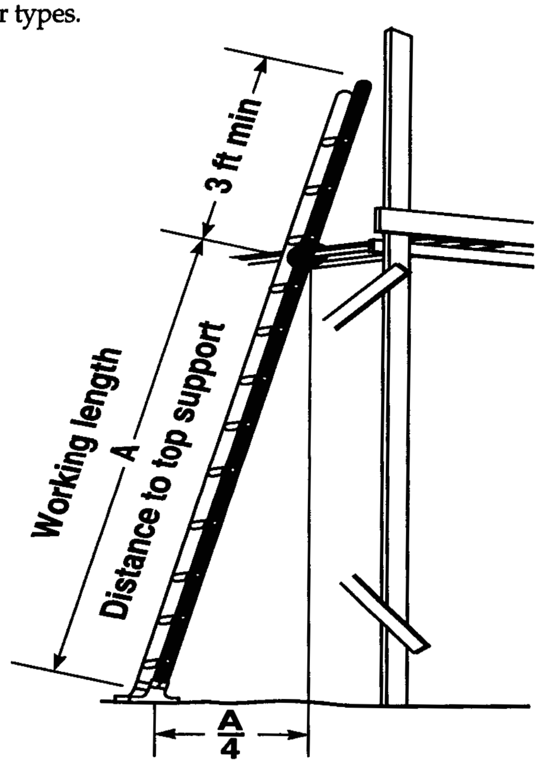

Figure 2. Ladder placement.

4.1.4 Kind of Activity

In many cases, the activity will determine the correct ladder. For example, indoor painting usually requires a conventional stepladder while outdoor painting requires extension ladders. A heavier job may require an "upgraded" ladder, such as a platform ladder.

4.1.5 Weight Capacity of the Ladder

Ladders are constructed to safely hold a specific amount of weight. These weight limits consist of users, their clothing, tools, and materials. Extra allowance should be made for stress exerted by the worker while performing the job. The heavy-duty ladder is best suited for industrial use because it holds up against frequent and rigorous demands. The four weight-capacity classifications for ladders are presented in Table 4.1.

Grade	Duty (lb)	Rating (kg)	Use
Household	**III**	**200 (91)**	**Household**
Commercial	**II**	**225 (102)**	**Tradesman**
Industrial	**I**	**250 (114)**	**Industrial**
Heavy-duty industrial	**IA**	**300 (136)**	**Heavy industrial**

Table 4.1. Weight capacity classifications.*

*Every ladder's duty rating is displayed by a label on the ladder.

4.2 Inspection

Employees should be trained to inspect ladders before using them. Additionally, the organization that owns the ladder should perform at least an annual inspection. They should look for loose, broken, or missing rungs, steps, cleats or side rails; missing safety feet, frayed ropes, and other defective parts. Additionally, all rungs should be free from oil, grease, or other slippery substances. Rungs or steps on metal ladders should be skid resistant (through corrugating, knurling, dimpling or coating). Movable parts should operate freely. Metal bearings should be well oiled. See the self-assessment section for a list of ladder requirements. Damaged ladders should not be used and, after labeling, should be either repaired or destroyed. The labels should read "Condemned—Do Not Use."

4.3 Precautions

The following precautions are highly recommended:

> Avoid using a ladder if you are excessively tired, on medication, have recently consumed alcohol, or are otherwise temporarily impaired.

Placement

- Place the ladder angle so that the *base* is *1 foot (0.305 meter) out for each 4 feet* (1.2 meter) of ladder working length (support point to the base).
- Place the top of the ladder so that *both rails* are fully *supported*. Allow extra room in case of ladder shifting.
- Place the ladder on a substantial and *level base,* staking or securing the lower end of the ladder, whenever possible. The top support point for portable ladders must be rigid and have adequate strength to support the applied load.
- Place the ladder away from unlocked or unguarded doors that may open toward the ladder.
- Extend the ladder side rails *at least 3 feet (0.91 meters) above the support point.*
- Always raise extension ladders so that the *upper section overlaps* and rests on the bottom section. The upper section must always overlap on the climbing side of the extension ladder. Make sure that there is at least a 3 foot *(0.91 meters)* overlap for extension ladders of 36 feet (11 meters) or more.
- *Do not place a metal or metal-reinforced* ladder close to *electric* wiring.
- Do not use ladders in a horizontal position.
- Take care when ladders are used on oily, metal, concrete, or slippery surfaces.
- Extend the ladder only while standing on the ground at the ladder base.
- Do not place ladders on boxes, barrels, or other unstable bases to obtain additional height.
- Do not use ladders to gain access to a roof unless the top of the ladder extends at least 3 feet (0.91 meters) above the support point (at roof line).

Climbing

- Face the ladder and use *both hands* to grip the side rails while ascending or descending.

- Only one person at a time should stand on portable ladders.
- Carry tools on a tool belt. Haul materials up on a line, rather than carrying them.
- Do *not exceed the maximum safe height limit* (fourth rung from the top on extension ladders; second step from the top on stepladders).
- Wipe off greasy or muddy shoes, as much as possible, before using the ladder.
- Do *not overload* a ladder.

Other

- Be sure that a *stepladder is fully open* and locked before you use it.
- Do not leave placed ladders unattended. They may be a hazard for others.
- Keep ladders clean and free from grease.
- Use extra caution while climbing in windy weather.
- *Never use a defective ladder.*
- Do not drop or throw ladders.
- Do not use make-shift ladders.
- Do not splice short ladders together to make long ladders.
- Use portable ladders with reinforced rails, only with the metal reinforcements on the underside.
- Make sure portable ladders have nonslip feet.

4.4 Handling

Handle ladders with care. Do not drop or misuse them.

4.5 Repairs

Field or makeshift repairs on existing ladders or the fabrication of ladders is discouraged. Do not attempt to straighten or use a bent ladder made of metal or reinforced plastic. All ladder repairs should be made by qualified personnel.

4.6 Coating

If necessary, coat metal, wood, and plastic ladders with a suitable protective material. However, do not paint wood ladders with opaque coating (e.g., paint) because possible defects may be covered up. Use transparent coatings or wood preservatives instead. Metal ladders may need extra protection in cases of excess moisture, salt spray, acidic, or alkaline conditions.

4.7 Storage

Store ladders in a manner that provides easy access for inspection and permits safe withdrawal for use. Ladders should not be stored where they present a tripping hazard, nor where they can fall on personnel. When stored horizontally, ladders should be supported at several points to avoid sagging. The ladders should be kept away from sources of heat and moisture and in a well-ventilated area. Aluminum ladders should not be stored in certain atmospheres (e.g., acidic) due to severe corrosion problems. The ultraviolet rays of the sun can cause deterioration in fiber-glass ladders. Wax fiber-glass ladders with paste wax for extended storage.

4.8 Transportation

Assistance may be needed in transporting heavy or long ladders. When transported on vehicles, ladders should be adequately supported (preferably on hardwood or rubber-covered pipe) to avoid sagging and should be fastened securely.

5. Training

With proper training in the inspection, selection, maintenance, and use of ladders, employees can reduce their chances of injury when working with ladders. The employer should establish a training program for each worker who must use a ladder. A typical program would include:

- Nature of fall hazards in the work area.
- Proper use, placement, and care in handling of all ladders.
- Correct procedures for erecting, maintaining, and disassembling any fall protection system.

- Maximum intended load-carrying capacities of ladders.
- Recognition of temporary physical inability (e.g., dizzy or fainting spells) to climb or use ladder.

6. Hazards

Most ladder mishaps result in falls, sometimes fatal, caused by of various hazards summarized in Table 6.1.

Electrical shock can occur if the user is working with electrical equipment while standing on a conductive metal ladder. Portable metal ladders should always carry warning labels.

Hazard	Helpful Hint
Personnel slipping	**Remove grease, oil, and mud from shoes. Avoid overreaching. Do not climb past SAFE height. Watch step.**
Ladder movement	**Secure base and top of ladder. Use nonskid feet. Set the ladder at the proper 4:1 angle. Avoid slippery surfaces.**
Ladder breakup	**Inspect all ladders before using.**
Electrical shock	**Use nonmetal ladders around electricity**
Environmental conditions	**Use extra caution in climbing on windy days. Avoid climbing during storms.**
Pinching	**Use gloves where required. Use caution in closing ladder.**

Table 6.1. Hazards causing falls from ladders.

7. Bibliography

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Appendix A. Portable Ladders Safety Checklist

This safety checklist will help employees and supervisors follow minimal safety practices. This list is not meant to be comprehensive, nor is it meant to form part of any official self-assessment practice. Where appropriate, local safety offices and supervisors are encouraged to add to these checklists. All ladders should meet the standard requirements of OSHA 29 CFR 1910 and 1926. Compliance with the design standards is verified by checking tags or stamps on each ladder. Relevant references are noted after each question.

	OK	Action Needed
Do all ladders meet the requirements of 29 CFR 1910.25/26 and/or ANSI A14.5-1974? (Compliance with cited standards can be verified by checking tags or stamps on each ladder.) 29 CFR 1910.25	____	____________
Are all portable ladders equipped with nonslip bases? AFOSH Std 127-3, para 4 b	____	____________
Are all ladders that are used for electrical work constructed of non conductive materials? AFOSH Std 127-3, para 4 c	____	____________
Are ladders maintained in good usable condition? 29 CFR 1910.26 (c) (2) (iv)	____	____________
Are ladders properly stored when not in use? AFOSH Std 127-3, par a 4 d (2)	____	____________
Are defective ladders removed from service until repaired or if necessary destroyed? 29 CFR 1910.25 (d) (2) (viii)	____	____________
Is only one person allowed on a ladder at a time? (Exception: More than one person is allowed on a ladder when jacks with scaffold planking are used in conjunction with ladders capable of supporting 225 pounds [102 kilograms] or more.) 29 CFR 1910.26 (c) (3) (ii)	____	____________
Is it prohibited to place ladders on boxes, barrels, or surfaces with unstable bases? 29 CFR 1910.25 (d) (2) (v)	____	____________
Are employees instructed on the proper way to ascend/descend ladders? 29 CFR 1910.26 (c) (3) (v)	____	____________
Are employees instructed not to stand above the fourth rung/step from the top of a straight ladder? AFOSH Std 127-3, para 4 d (22)	____	____________
Have ladders been checked for loose steps or rungs, serviceable nonslip bases, and noticeable defects, such as cracks, broken braces, and split rungs? 29 CFR 1910.25 (b) (1) (i)	____	____________
Are the ropes on extension ladders in good condition? 29 CFR 1910.25 (d) (1) (iii)	____	____________

Question	OK	Action Needed
Are all portable metal ladders stenciled with the warning "DANGER DO NOT USE AROUND ELECTRICAL EQUIPMENT" in 2-inch (5 centimeters) red letters or smaller if necessary to fit on the rails? AFOSH Std 127-3, para 4 c	____	____________
Are all ladders kept clean and free of oil or grease to limit conductivity of electric current? AFOSH Std 127-3, para 4 c	____	____________
Are ladders strapped or tied to support racks on vehicles to prevent damage from road shock? AFOSH Std 127-3, para 4 d (3)	____	____________
Is regular lubrication of metal bearings, locks, or pulleys on ladders performed? 29 CFR 1910.25 (d) (1) (ii)	____	____________
Are safety feet and other auxiliary equipment on portable ladders in good condition? 29 CFR 1910.25 (d) (1) (iv)	____	____________
Have users inspected ladders that have been subject to unusual circumstances, such as excessive heat or fires? AFOSH Std, para 4 d (9) (b)	____	____________
Have nonskid coatings been applied to metal ladder rungs or steps that are not corrugated, knurled, or dimpled in design? 29 CFR 1910.26 (a) (1) (v)	____	____________
Are the bottoms of non-self-supporting (straight) ladders placed so that the distance from the base of the vertical support is one-fourth the working length of the ladder? 29 CFR 1910.25 (d) (2) (i)	____	____________
Are straight ladders placed so they extend 3 feet (7.5 centimeters) (minimum) above the roof line or other work surface? 29 CFR 1910.25 (d) (2) (xv)	____	____________
Are procedures established to ensure that ladders are not placed in front of doors that open toward the ladders unless the doors are locked, blocked, or otherwise guarded? 29 CFR 1910.25 (d) (2) (iv)	____	____________
Are sections of extension ladders totaling less than 36 feet (11 meters) overlapping by at least 3 feet (9.1 meters)? AFOSH Std 127-3, para d (12)	____	____________
Are workers instructed not to stand above the second step from the top of any self-supporting step ladder? (The top plate or table is not a step, except on those ladders designed with a work platform at the top, such as ware house ladders.) AFOSH Std 127-3, para e (22).	____	____________
Have ladders been checked for loose nails, screws, bolts, or other projecting metal parts? 29 CFR 1910.25 (d) (1) (i)	____	____________

AFOSH = Air Force Occupational Health and Safety Manual

29 CFR = Code of Federal Regulations Title 29

Chapter 10
Woodworking Machinery

1. Introduction

1.1 Incidence of Injuries

According to the Tiger Team's May 1991 analysis of industrial violations, machine guarding problems, including woodworking equipment, were the second leading cause of deficiencies, trailing only electrical discrepancies.

The woodworking trade in general industry, as well as within The Department of Energy (DOE), rates as one of the most hazardous occupations. Rotating devices, cutting or shearing blades, in-running nip points, and meshing gears are examples of machinery that is hazardous in carpentry shops. Crushed hands, severed fingers, and blindness are examples of woodworking accidents.

1.2 Causes of Injuries

Unsafe Acts

- Jamming or kicking back of material and wood chips.
- Poor housekeeping.
- Improper material handling.
- Inhalation of wood dust.

Unsafe Conditions

- Flying objects (wood chips and broken saw blades, etc).
- Unsatisfactory maintenance of machinery.
- Inadequate guarding.

1.3 Prevention Overview

The majority of accidents involving woodworking machines could have been prevented by:

- Good work practices.
- Proper guarding.
- Sufficient operator training.
- Good housekeeping.

1.4 Scope and Purpose

This technical reference provides general guidance for working with woodworking machinery. Specific machines require specific practices, for example operator instructions from the manufacturer.

1.5 Basic Terms

Chuck. A revolving clamp-like device used for gripping and driving stock or tools.

Dog. A device for gripping or holding material or machine components in place.

Feather Board. An angular board with multiple parallel saw cuts that is used as a side and top hold-down to prevent kickbacks and keep hands away from moving blades and cutters.

Guard. A barrier that prevents entry of the operator's hands or fingers into the point of operation.

Kickback. The tendency of blades and cutters to force material being milled or cut to suddenly move up and back towards the operator.

Point of Operation. The area(s) of a machine where cutting, shearing, forming, assembling, etc., takes place.

Push Stick (Block). A strip of wood or block with a notch cut into one end that is used to push short or narrow lengths of material through saws (see Figure 1).

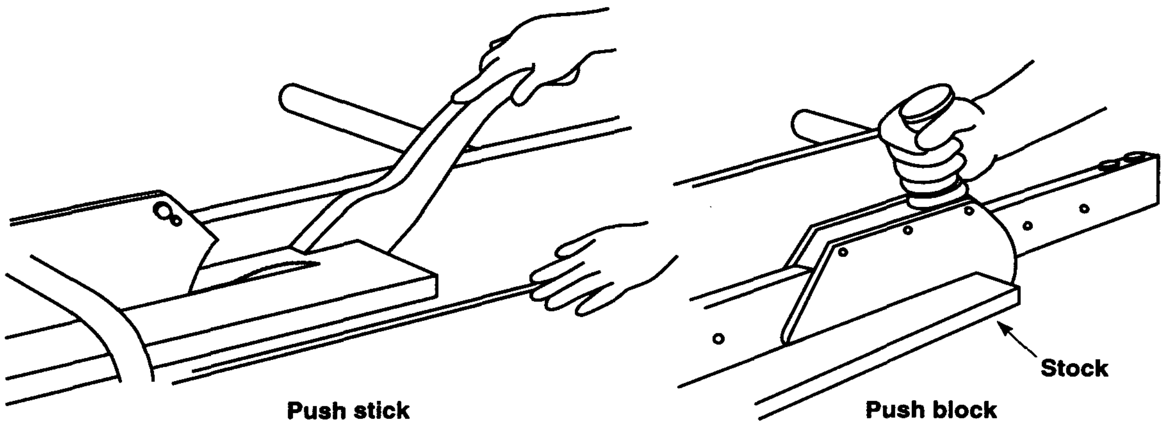

Figure 1. Push stick (block).

2. Standards and Codes

Group	Standard	Subject
OSHA	29 CFR 1910.211	Machinery and machine guarding
OSHA	29 CFR 1910.212	General requirements for all machines
OSHA	29 CFR 1910.213	Woodworking machinery requirements
OSHA	29 CFR 1910.219	Mechanical power transmission apparatus
ANSI	01.1-1975	Safety requirements for woodworking machinery
ANSI/ASME	B11.19	Performance criteria for the design, construction, care, and operation of safeguarding when referenced by other B11 machine-tool safeguards
AFOSH	STD 127-12	Machinery

OSHA = Occupational Safety and Health Administration.
AFOSH = Air Force Occupational Safety and Health.
ANSI = American National Standards Institute.

Table 2.1. Standards and codes for woodworking machinery.

3. Protective Devices

3.1 Personal Protective Equipment

Protective eye and face equipment is required where there is reasonable probability of injury while performing woodworking tasks. It is the responsibility of the employer to make suitable protection available. More information can be obtained about eye and face protection in ANSI Std Z87.1-1968. Persons whose vision requires the use of corrective lenses and who are also required to wear eye protection must have one of the following:

- Spectacles whose protective lenses provide optical correction.
- Goggles that can be worn over corrective spectacles without disturbing the adjustment of the spectacles.
- Goggles that incorporate corrective lenses mounted behind the protective lenses.

Respirators must be provided by the employer when such equipment is necessary to protect the health of employees. An industrial hygienist, through the respiratory protection program, will determine shop and employee requirements. Hearing protection must also be provided when exposure to noise exceeds the federal standard or any ANSI standard pertaining to woodworking requirements. The industrial hygienist also determines those requirements.

3.2 Electrical Safeguards

All machinery must be installed according to the National Electrical Code (NEC). If machines have exposed noncurrent-carrying metal components, they have the potential to become energized and should be grounded. Control switches should be available to workers at their operating positions so they do not need to reach over moving parts of machinery. Also, machine controls must not be wedged for continuous operation.

Machines that are not adequately safeguarded to protect the worker during an undervoltage situation or a power failure must have an undervoltage protective device installed. This device prevents the machine from starting up after a power interruption, which may, in some cases, expose the worker to the hazards of moving parts.

Before performing maintenance or major adjustments to moving parts that require panels and guards be removed, all machine energy sources or energy isolating devices must be locked and/or tagged out. (Refer to the lockout/tagout chapter for more information.)

3.3 Machine Guarding

3.3.1 Circular, Crosscut, and Rip Saws

Guarding beneath the table level should be provided to enclose the saw blade from unintentional contact and prevent contact with moving parts of the drive mechanism. Saws must be equipped with a hood that covers the blade and automatically adjusts itself to the thickness of the material upon which it rides. The hood covers the part of the saw blade exposed above the material and is adaptable to cover tilted blades. When ripping, table saws must be provided with a spreader to prevent the wood's internal stresses from clamping down on the saw blade and an antikickback device to prevent the stock from possible kickback.

3.3.2 Radial Saws

Radial saws must be equipped with a hood that encloses the saw blade and the arbor ends. The lower section of the hood must be hinged so it rises and falls and adjusts itself automatically to the thickness of the material as the saw passes through it. An antikickback device or hold-down wheels must also be installed on saws used for ripping. The device must be adaptable to any thickness of stock.

3.3.3 Band Saws

Both upper and lower wheels must be completely enclosed on both sides. The enclosures should be capable of being removed easily to permit saw blade maintenance. The working part of a saw blade, between the guide rolls and the upper wheel enclosure, must be guarded to prevent accidental contact with the saw blade. The guard must be self-adjusting and attached to the gauge so that, in any position of the gauge, the guard completely covers the portion of the saw blade between the guide rolls and the upper wheel enclosure.

3.3.4 Jointers

Each hand-fed planer and jointer with a horizontal or vertical head should be equipped with a cylindrical cutting head, the knife projection of which must not exceed 0.125 inch (0.31 centimeters) beyond the cylindrical body of the head. Also, jointers with front-table-mounted fences must be equipped with an adjustable device to prevent thin stock from slipping laterally under the portion of the fence at the rear of the table. An automatic guard must be provided that covers the section of the cutter head near the operator (on the working side of the fence) and contacts the wood to prevent any opening from remaining between the guard and wood during the operation. The guard should also cover the section of the cutter head on the nonworking side of the fence, especially when the fence is moved toward the automatic guard. The guard over the section of the cutting head on the rear side of the fence should consist of a sliding metal shield that automatically adjusts to the exposed length of the cutter head.

3.3.5 Power Feed Planers

Guards must be provided for feed rolls, cutting heads, and hold-down rolls at the discharge end. Feed rolls should be guarded by a metal strip in front of the rolls under which the material may pass. This prevents an operator's fingers from being drawn into the rolls while feeding the machine. Where the top roll is corrugated, the strip should extend over the top of the roll. Cutting heads and discharge rolls must be guarded by a solid metal enclosure of substantial construction. The hood of an exhaust system may form part or all of the enclosure. When other than corrugated top feed rolls are used, an antikickback device should be installed.

3.3.6 Shapers

Shapers must be equipped with a braking device that brings the cutting head to a stop within 10 seconds after power is shut off. Cutting heads must be enclosed by a guard. The guard must not be less than the greatest diameter of the cutter. Whenever possible, hold downs and jigs should be used to limit exposure of hands to cutters. It is good practice when a blade is removed from a spindle for sharpening, or for some other purpose, that all other blades be removed at the same time.

3.3.7 Lathes

Rotating, cutter-head type lathes must be provided with a hinged metal shield or hood that completely covers the knives and material when the machine is in operation. Exhaust system hoods may be included as part of the guard if they comply with standard guard designs. Automatic lathes should be equipped with a brake that brings the rotating material to a quick, but not instantaneous, stop after the power is shut off.

3.3.8 Sanding Machines

Feed rolls of self-feed sanding machines should be protected with a semicylindrical guard to prevent hands from coming in contact with the in-running rolls at any point. The guard and its mounting should be designed to remain in adjustment for any thickness of stock. Drum/disk sanding machines should have an exhaust hood, or other guard, so arranged as to enclose the revolving drum/disk, except for the working portion of the drum/disk above the table. Belt sanding machines should be provided with guards at each nip point. These guards must effectively prevent hands or fingers from coming in contact with the nip points. The unused run of the sanding belt must be guarded against accidental contact.

3.3.9 Boring and Mortising Machines

The top of the driving mechanism must be enclosed.

3.3.10 Tenoning Machines

Feed chains and sprockets of double end tenoning machines must be completely enclosed, except for that portion of chain used for conveying the stock. Sprockets and chains must be guarded at the sides by plates projecting beyond the periphery of sprockets and the ends of lugs at the rear ends of frames over which feed conveyors run. Each tenoning machine that has cutting heads and saws must be covered by metal guards when used. These guards should cover at least the unused part of the periphery of the cutting head. Where an exhaust system is used, the guard may form part or all of the exhaust hood.

4. Work Practices

4.1 General

Supervisors must ensure that only authorized employees operate and maintain shop equipment. Personnel who are operating, helping, or observing machine operations must comply with the personal protective equipment requirements for the area and particular machine. Employees must not wear loose fitting clothing, rings, bracelets, or other apparel that can become entangled in moving machinery, power transmission apparatus, or moving parts. Also, hair nets or caps should be worn to keep long hair under control and safely away from moving machinery and parts.

Machines must not be operated unless all guards are in place and in working order. For instance, there must be a self-adjusting guard on the working side of the fence on a jointer (see Figure 2). However, guards may have to be removed for certain cuts. In those instances, additional precautions must be taken that afford the same protection. For example, narrow cuts on table saws should be performed with feather boards and push sticks. Also, machines must be used only for work within the rated capacity specified by the machine manufacturer. If an employee needs to clear jammed work or clean around the machine, it should be completely stopped and the main power turned off. In some cases, the equipment will also have to be locked or tagged out of service.

Cleanliness around woodworking machinery must be maintained at all times. During cleaning, chips or other particles can be removed by brushes or compressed air. If compressed air is used, the nozzle pressure at the discharge end of the air line should not exceed 30 psi. Compressed air may not be used to blow chips or other debris from a worker's body or clothing.

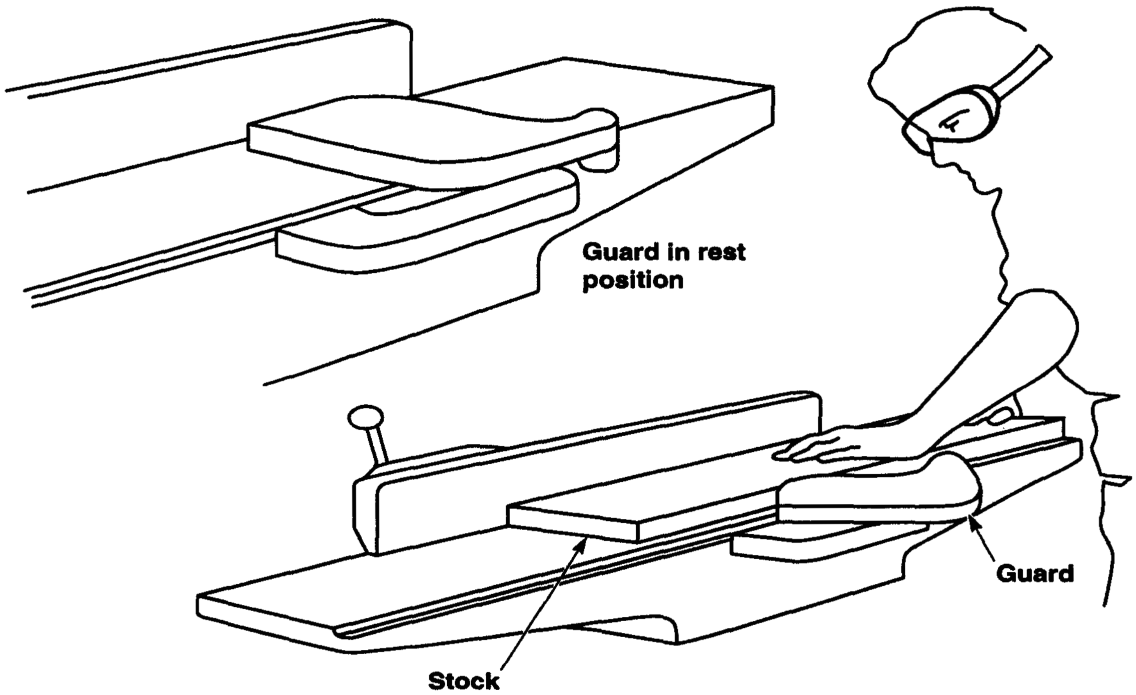

Figure 2. Self-adjusting guard on a jointer.

A machine should never be left unattended with the control switch in the "on" position. Also, no blades, cutter heads, or collars should be placed or mounted on a machine arbor unless it has been accurately sized and shaped to fit the arbor. If blades are dull, badly set, improperly filed, or improperly tensioned, they should be immediately removed from service. Sharpening or tensioning saw blades or cutters must be done only by employees demonstrating the proper skill for this kind of work.

4.2 Inspections

Inspections should be performed periodically by a supervisor or other qualified person familiar with the machinery. As a minimum, inspections must determine that:

- The operator and machine are equipped with the safety accessories suitable for the hazards of the job.
- The safety equipment is in working condition and in place.
- The machine operator is properly trained.

Documentation reflecting inspection results must, as a minimum, contain the machine number, inspection date, discrepancies noted, and corrective actions.

4.3 Machine Operators

Operators and others who are exposed to moving parts can get clothing, hair, or body parts caught in the machinery. The chance of these mishaps occurring is greater as fatigue increases or as attention decreases. Pressure to get the job done may result in either overlooking sound work practices or attempting to bypass guards. This is particularly true when the operation requires the removal of guards to make adjustments.

4.4 Acquisition

All newly acquired machines should meet the design and construction requirements identified in the OSHA standards (see Section 2). Supervisors needing access to OSHA standards or help in making a guarding determination for a machine not specifically covered by OSHA, should contact their safety staff.

4.5 Installation

Machines designed for fixed locations or that might tip over should be securely fastened to the floor or other suitable foundation to eliminate all movement or "walking." Small units should be secured to benches, tables, or stands of adequate strength and design. Weight limitation of floors or foundation should be considered prior to machinery installation.

Machines should be arranged in a manner that permits an even flow of materials and eliminates backtracking and crisscrossing. Adequate space should be provided to allow handling material with the least possible interference from or to workmen or other machines. Machines should be located so it will not be necessary for an operator to stand in or near an aisle. Additionally, the layout of machines should allow for easy maintenance and repair. (For detailed information on shop layout, passageways, and machine clear zones, refer to OSHA standard 1910.21, Walking–Working Surfaces.)

It is recommended that the height of the table or point of operation above the floor for various machines be as shown in Table 4.1.

Industrial hygienists will determine the requirements for exhaust systems. Normally, machines that develop fine dust and fumes that are hazardous to workers should be equipped with effective hoods and connected to an exhaust system.

4.6 Floors and Aisles

Floors and aisles should be kept in good repair and free from discrepancies such as protruding nails, splinters, holes, unevenness, and other tripping hazards. Floors in working areas should also be provided with an effective means to prevent workers from slipping. Aisles and walkways should be straight as possible, with corners rounded or diagonal. Lines marking the floor around workspaces and aisles may be painted on the floor, or some similar method employed to highlight them.

Machine	Height (in.)(m)
Circular saws (hand fed)	36 (.92)
Circular saws (power fed)	32 (.82)
Band saws	46 (1.18)
Shapers	36 (.92)
Jointers	33 (.85)
Lathes	41 (1.05)
Sanders	36 (.92)
Radial arm saws	39 (1.0)

Table 4.1. Recommended above-floor height for table or point of operation

5. Training

Employees must be trained on all machinery or equipment they are required to use. Usually, shop personnel are trained by their supervisor or a designated trainer. Within DOE, only trained personnel or those undergoing supervised on-the-job training will be allowed to operate shop machinery or equipment. All operators should be trained in the proper operation, safety procedures, hazard recognition, and emergency shutdown procedures for each machine or piece of equipment they use.

The operator training programs should be tailored to an employee's work area. Employees learn more and draw a greater benefit from training that duplicates their daily work rather than a "canned program." As a minimum, the training program should include:

- The nature of hazards for each piece of equipment.
- Safety procedures for special set-ups for each tool.
- How to perform work in a safe manner.

Additionally, the training should be devised so employees can demonstrate their knowledge and skills required to perform their tasks. The supervisor must determine that the employee knows and understands the features of the equipment, all applicable safety rules, and is skilled in operating the equipment (see Appendix A).

6. Hazards

Many injuries that occur in woodworking occupations result from employees failing to follow prescribed safe operational practices. These failures arise from worker attitudes, inadequate training, and supervisory failure to enforce safe job procedures. The use of machine guards, environmental controls, good training, and maintenance programs, coupled with supervisory enforcement of protective equipment use and safe job practices can eliminate most mishap-producing factors.

Among the most frequently occurring woodworking accidents are two involving saws: (1) blade cuts or abrasions, (2) kickbacks.

Circular saw operators are often injured when their hands slip from the stock while pushing it into the saw or when they hold their hands too close to the blade while cutting. Kickbacks occur during ripping when a part or all of the work piece is violently thrown back at the operator. Operators should keep their face and body to one side of the saw blade, out of line with a possible kickback.

Overhead swing saws and straight-line pull cutoff saws cause hand injuries because of several operational characteristics. Hands are sometimes cut while the saw blade is coasting or idling and the operator attempts to remove a section of board, or while measuring a board and the saw is still running. Also, the operator may pull the saw against his or her hand or may suffer body cuts from a saw that swings beyond its safe limits. Overhead swing saws, like straight-line pull cutoff saws, require many adjustments to permit their full use. Sometimes these adjustments can create additional hazards for the user.

The principal sources of injury connected with radial saw operations are those common to other power-driven saw operations. They include cutting injuries to the arms and hands caused by the saw blade, by flying wood chips, and by handling materials. When crosscutting, radial saws cut downward and pull the wood away from the operator and against the fence.

Although injuries from band saws are less frequent and less severe than those from circular saws, they are not uncommon. The usual cause of band saw injuries is the user's hands coming into contact with the saw blade. When hand feeding, the operator's hands must come close to the blade. Therefore, it is particularly important that the saw table be well lighted and free from glare. Band saw point of operations cannot be completely covered. However, an adjustable guard, U-shaped and designed to prevent operator contact with the front and sides of the saw blade above the upper blade guides, should be set as close as possible to the work piece.

Jig saws are not normally considered hazardous, but occasionally cause injuries to the fingers and hands. Safe operating procedures require the blade be properly attached and secure, the threshold rest (slotted foot) to be on the stock, the guard to be in an effective position, and the operator to keep his or her hands a safe distance away from the blade.

The principal danger in the use of the wood shaper is that hands and fingers might strike the revolving knives. Therefore, a ring guard is suggested. Severe accidents can also result when broken knifes are thrown by the machine. When a shaper knife breaks or is thrown from the collar, the other knife is usually thrown too, so that four or five pieces of heavy, sharp steel are thrown about the shop with sufficient speed to kill a person. The danger from broken or thrown knifes can be eliminated by using solid cutters that fit over the shaper spindle. Also, there are various types of safety collars that can be used to prevent shaper knifes from flying. However, collars should not be considered substitutes for perfectly balanced and fitted knifes of adequate length.

Hand-feed jointers or surface planers are, second to circular saws, considered the most dangerous woodworking machines. Most of the injuries are caused by hands and fingers contacting the knifes. Many of these accidents occur when narrow lengths of stock are being jointed. The National Safety Council recommends that hold-down push blocks be used whenever the operator joints wood that is narrower than 3 inches (7.5 centimeters). Also, it is mandatory that the unused end of the cutting head be enclosed at all times. A sheet metal telescoping guard is acceptable for this purpose.

Drum, disk, or belt sanding machines should be enclosed by an exhausting dust hood that encloses all portions of the machine except the portion designed for the work feed. Personnel who operate sanders should wear goggles and dust respirators during sanding operations and cleanup. On a belt sanding machine, a guard should be placed at each in-running nip point on both power transmission and feed roll parts. The unused run of the abrasive belt on the operator's side of the machine should be guarded to prevent contact.

7. Bibliography

National Safety Council (NSC). 1992. Accident Prevention Manual for Industrial Operations: *Engineering and Technology*, "Machine Guarding," 10th Edition. NSC: Itasca, Il.

Occupational Safety and Health Administration (OSHA). 1981. OSHA Manual 3067, Department of Labor. *Concepts & Techniques of Machine Safeguarding*. U.S. Government Printing Office: Washington, DC.

Appendix A. Summary of Safety Rules for Various Woodworking Tools

Every operator should be trained in the safety rules covered in this chapter. As a summary, specific safety conditions that demand close attention are listed below. Be sure that the operator checks the manufacturer's manual, understands the requirements, and follows the recommended procedures.

Table Saw

- Feed with body to side of stock.
- Ensure correct blade height.
- Use splitter and antikickback fingers for ripping.
- Use with stock firm against fence.
- Remove rip fence for crosscuts.
- Use blade guards.

Circular Saw

- Use blade guards.
- Do not let the blade bind.
- Use correct type blade.
- Make sure blade is tight on arbor.
- Use firm support for work.
- Ensure no obstructions.
- Begin cut with motor at manufacturer's recommended speed.

Radial Arm Saw

- Ensure the ripsawing direction of the cut, feed, and antikick fingers.
- Use blade guards.
- Pull for cross cuts.
- Ensure end plates are on track.
- Clamp handles tight.
- Ensure materials are tight to the fence.
- Return cutter to rear of track.

Band Saw

- Feed with body to side of stock.
- Set guard height for 0.125-inch (0.31-centimeters) clearance.
- Use correct tension and proper type of blade.
- Release cuts before long curves.
- Use flat stock.
- Stop machine to remove scrap or pull out incomplete cut.

Jointer/Planer

- Check depth of cut.
- Use minimum length of stock.
- Ensure cutters are sharp.
- Ensure hands do not pass over cutters.
- Use push stick for small stock.
- Check all guards.

Wood Shaper

- Clamp work piece.
- Use correct guard.
- Feed into knifes—don't back off.
- No feeding between fence and cutters.
- Ensure fence opening is only enough to clear cutters.
- Use stock as guard by shaping the underside of stock.
- Ensure spindle nut is tight.
- Make sure the stock being shaped is 10 inches (25 centimeters) or longer.

Sander

- Keep hands from abrasive surface.
- Check belt or disk condition.
- Sand on downward side of disk.

Lathe

- Use stock without defects and make sure glued joints are dry.
- Hold tool rest close to stock.
- Hold tools firmly in both hands.
- Remove tool rest when sanding or polishing.

Appendix B. Woodworking Machinery Safety Checklist

This safety checklist will help employees and supervisors follow minimal safety practices. This list is not meant to be comprehensive or to form part of any official self-assessment practice. Where appropriate, local safety offices and supervisors are encouraged to add to these checklists. Relevant references are noted after each question.

Circular, Crosscut, Rip Saws	OK	Action Needed
Is the table saw equipped with a hood that covers the blade and automatically adjusts itself to the thickness of the material upon which it rides? 29 CFR 1910.213(c)(1)	____	__________
Does the hood cover the part of the saw blade exposed above the material? 29 CFR 1910.213(c)(3)(e)	____	__________
Is the hood adaptable to cover tilted blades? 29 CFR 1910.213(a)(6)	____	__________
Is a spreader provided at the table saw to prevent the wood's internal stresses from clamping down on the saw blade? 29 CFR 1910.213(c)(2)	____	__________
Are table throat openings kept as small as possible to prevent material from dropping below the level of the table? 29 CFR 1910.212(a)(1)	____	__________
Are several size throat pieces available to accommodate rabbeting, grooving, and dadoing operations? AFOSH Std 127-12, para 2-2 a (1)	____	__________
Are antikickback dogs/fingers or safety hold-down wheels installed when material is being ripped? 29 CFR 1910.213 (c)(3)	____	__________
Are antikickback dogs/fingers kept sharp to maintain their holding power? AFOSH Std 127-12, para 2-2 a (4)	____	__________
Is a helper positioned at the output end of the saw whenever it appears it might be necessary to reach over a revolving saw blade? AFOSH Std 127-12, para 2-2 a (5)	____	__________
Are saw blades allowed to come to a stop on their own rather than by thrusting a piece of wood against the cutting edge or side of the blade? AFOSH Std 127-12, para 2-2 a (6)	____	__________
Do saw tables extend far enough on either side of a machine to give full support to a length of board that may be cut AFOSH Std 127-12, para 2-2 a (7)	____	__________
Is the blade or cutting head inspected for proper cutting condition (i.e.., teeth sharp and properly set, no cracks, free of foreign residue) before a job is started? 29 CFR 1910.213 (s)(1)(i)	____	__________

	OK	Action Needed
Is the correct blade matched to the work being done? AFOSH Std 127-12, para 2-2 a (9)	_____	__________
Do operators take care that they do not crowd (force material faster that it can be cut) the saw? AFOSH Std 127-12, para 2-2 a (10)	_____	__________
Are adjustments to the rip fence made after the saw has been turned off and the blade rotation has stopped? AFOSH Std 127-12, para 2-2 a (11)	_____	__________
Is a permanent line marked on the table in front of and in line with the saw blade to enable the operator to set the rip fence without lifting the saw guard? AFOSH Std 127-12, para 2-2 a (11)	_____	__________
Are push sticks used when there isn't enough room for the operators hands between the rip fence and saw blades? AFOSH Std 127-12, para 2-2 a (12)	_____	__________
Is the hood left in place when narrow material is ripped? AFOSH Std 127-12, para 2-2 a (13)	_____	__________
Are saw blades set only high enough to cut through the material being worked? AFOSH Std 127-12, para 2-2 a (14)	_____	__________
Are feather boards used as side guides and top hold-down on operations (rabbeting, grooving, and dadoing) when a blade hood cannot be used? AFOSH Std 127-12, para 2-2 a (1)	_____	__________

Radial Arm Saw

	OK	Action Needed
Are radial saws equipped with a hood which encloses a saw blade and the arbor ends? 29 CFR 1910.213 (h)(1)	_____	__________
Is the lower section of the hood adjustable so it rises and falls automatically to the thickness of the material as the saw passes through it? 29 CFR 1910.213 (h)(1)	_____	__________
Is an antikickback device or are hold-down wheels installed on saws used for ripping? 29 CFR 1910.213 (h)(2)	_____	__________
Does the device adapt to any thickness of stock to be cut? 29 CFR 1910.213 (h)(2)	_____	__________
Are manually operated radial saws installed so the front end of the table is slightly higher than the rear so the cutting head does not move forward when the motor is turned on? 29 CFR 1910.213 (h)(4)	_____	__________

	OK	Action Needed
Do operators take the unit out of service if at any time the saw rolls or moves as result of vibrations? AFOSH Std 127-12, para 2-2 b (7)	____	____________
Does the saw have a positive limit-stop to prevent the saw from traveling beyond the front edge of the table? 29 CFR 1910.213 (h)(3)	____	____________
Is material measured by placing the material to be cut against a stop gauge (whenever repeat cuts are necessary)? AFOSH Std 127-12, para 2-2 b (10)	____	____________
If it is necessary to measure with a ruler, the material must be kept well away from the saw until measuring is completed? AFOSH Std 127-12, para 2-2 b (10)	____	____________
Is the saw head rotated 90 degrees right or left and clamped in position when ripping with a radial saw is necessary? AFOSH Std 127-12, para 2-2 b (11)	____	____________
Is the material fed against the revolving blade from the side where the blade rotates upward towards the operator? AFOSH Std 127-12, para 2-2 b (11)	____	____________
Do the teeth of the saw extend slightly through the material being cut? AFOSH Std 127-12, para 2-2 b (11)	____	____________
Is the direction of the saw rotation conspicuously marked on the hood? 29 CFR 1910.213 (h)(5)	____	____________
Is a permanent decal or sign not less than 1 inch (2.5 centimeters) by 0.75 inch (1.9 centimeters), reading "CAUTION; NEVER RIP FROM THIS END" (or the nearest commercially available equivalent) affixed to the rear of the guard at approximately the level of the arbor? 29 CFR 1910.213 (h)(5)	____	____________
Is the saw allowed to return to its stopped position before the stock is removed from the table? AFOSH Std 127-12, para 2-2 b (12)	____	____________
Is the locking device on the saw head securely fastened when angle or miter cuts are being made? AFOSH Std 127-12, para 2-2 b (12)	____	____________
Does the operator ensure that the blade being used is the proper one for the work being performed? AFOSH Std 127-12, para 2-2 b (15)	____	____________
When picking short pieces off a table close to a saw blade, does the operator ease the saw back to the idling position and make sure that all bouncing has stopped before putting his/her hand(s) down on the table? AFOSH Std 127-12, para 2-2 b (16)	____	____________

	OK	Action Needed
Is cylindrical stock securely clamped before being cut on a radial saw? AFOSH Std 127-12, para 2-2 b (16)	____	____________
Band Saws		
Are both upper and lower wheels completely enclosed on both sides of the band saw? 29 CFR 1910.213 (i)(1)	____	____________
Are these enclosures capable of being easily removed to permit saw blade maintenance? AFOSH Std 127-12, para 2-2 c (1)	____	____________
Is the guard self-adjusting and attached to the gauge so that (in any position of the gauge) the guard will completely cover the portion of the saw blade between the guide rolls and the upper wheel enclosure? 29 CFR 1910.213 (i)(1)	____	____________
Is the saw equipped with an automatic tension control? 29 CFR 1910.213(i)(2)	____	____________
Does the feed roll on a self-fed band saw have a guard to prevent the operator's hands from coming into contact with the in-running rolls at any point? 29 CFR 1910.213(i)(3)	____	____________
Is the saw always operated within the safe limit recommended by the manufacturer? AFOSH Std 127-12, para 2-2 c (5)	____	____________
If material binds or pinches on the blade, is the machine turned off and blade motion allowed to stop before the operator attempts to back the work away from the blade? AFOSH Std 127-12, para 2-2 c (6)	____	____________
Jointers		
Is each hand-fed planer and jointer (with a horizontal or vertical head) equipped with a cylindrical cutting head? 29 CFR 1910.213 (j)(1)	____	____________
Does the knife on these machines project no more than 0.125 inches (0.31 centimeters) beyond the cylindrical body of the head? 29 CFR 1910.213 (j)(1)	____	____________
Is the opening in the table kept as small as possible? 29 CFR 1910.213 (j)(2)	____	____________
Is the clearance between the edge of the rear table and the cutting head circle or knife no more than 0.125 inches (0.31 centimeters)? 29 CFR 1910.213 (j)(2)	____	____________

	OK	Action Needed
Is the table throat opening no more than 2.5 inches (6.2 centimeters) when tables are reset or aligned with each other for a zero cut? 29 CFR 1910.213 (j)(2)	____	________
Are jointers with front-table mounted fences equipped with an adjustable device to prevent thin stock from slipping laterally under the portion of the fence at the rear of the table? AFOSH Std 127-12, para 2-2 d (3)	____	________
Is an automatic guard provided to cover the section of the cutter head near the operator (on the working side of the fence) and to contact the wood to prevent any opening from remaining between the guard and wood during the operation? AFOSH Std 127-12, para 2-2 d (4)	____	________
Does the guard cover the section of the cutter head on the nonworking side of the fence? AFOSH Std 127-12, para 2-2 d (4)	____	________
When power feeders are used, is the feeding mechanism guarded by a metal shield or hood? AFOSH Std 127-12, para 2-2 d (5)	____	________
Do operators use hold down push blocks, jigs, or fixtures? AFOSH Std 127-12, para 2-2 d (6)	____	________

Power Feed Planers

	OK	Action Needed
Are guards provided for feed rolls, cutting heads, and hold-down rolls at the discharge end of power feed planers? AFOSH Std 127-12, para 2-2 e (1)	____	________
Are feed rolls guarded by a metal strip in front of the rolls under which material may pass, but will prevent an operator's fingers from being drawn into the machine? 29 CFR 1910.213 (n)(3)	____	________
Are cutting heads and discharge rolls guarded by a solid metal enclosure of substantial construction? 29 CFR 1910.213 (n)(1)	____	________
When other than corrugated top feeders are used, is an antikickback device installed? 29 CFR 1910.213 (n)(4)	____	________
If the top roll is corrugated, does the strip extend over the top of the roll? AFOSH Std 127-12, para 2-2 e (1)	____	________
Does the operator examine each planer before using it to ensure that knifes are not set to take too heavy a cut for one pass? AFOSH Std 127-12, para 2-2 e (3)	____	________

	OK	Action Needed
Do helpers position themselves where they won't be pinned between the material and an immovable object? AFOSH Std 127-12, para 2-2 e (4)	____	________
Do operators take precautions to keep their fingertips from being pinched between the table top and the material if the material is tipped quickly up and down by the in-feed rolls? AFOSH Std 127-12, para 2-2 e (5)	____	________
Shapers		
Are shapers equipped with a braking device that will ring the cutting head to a stop within 10 seconds after power is shut off? AFOSH Std 127-12, para 2-2 f (1)	____	________
Is a double spindle machine equipped with separate braking devices? AFOSH Std 127-12, para 2-2 f (1)	____	________
Does the fence have as small an opening for knives as possible? AFOSH Std 127-12, para 2-2 f (2)	____	________
Does the fence extend at least 18 inches (45 centimeters) on either side of the spindle? AFOSH Std 127-12, para 2-2 f (2)	____	________
Are cutting heads enclosed by a guard? AFOSH Std 127-12, para 2-2 f (3)	____	________
Are hold downs and jigs used to limit exposure of hands to cutters, when ever possible? AFOSH Std 127-12, para 2-2 f (4)	____	________
When a blade is removed from a spindle, are all other blades removed at the same time? AFOSH Std 127-12, para 2-2 f (5)	____	________
Lathes		
Is a hinged metal shield or hood (that completely covers the knives and material when the machine is in operation) provided on rotating, cutter-type lathes? 29 CFR 1910.213 (o)(2)	____	________
Are automatic lathes placed with the back side against a wall or barrier that will stop knives if they are thrown rearwards? AFOSH Std 127-12, para 2-2 g (3)	____	________
Are tool rests set parallel, as close as possible to the work, and high enough so the tools butt into the wood slightly above the horizontal center of the piece being turned? AFOSH Std 127-12, para 2-2 g (4)	____	________

	OK	Action Needed
Is a control stop provided on faceplate-type lathes? AFOSH Std 127-12, para 2-2 g(5)	____	________
Do operators stand to the side when working with hand-turning tools? AFOSH Std 127-12, para 2-2 g (7)	____	________
Is sandpaper held in the fingers and pressed lightly against a small area at the top of the rotating material? AFOSH Std 127-12, para 2-2 g (8)	____	________
Sanding Machines		
Is a guard installed on the feed rolls of self-feed sanding machines? 29 CFR 1910.213 (p)(1)	____	________
Are guards installed at each nip point on a belt sanding machine? 29 CFR 1910.213 (p)(4)	____	________
Boring and Mortising Machines		
Is the unused run of the sanding belt guarded? 29 CFR 1910.213 (p)(4)	____	________
Are set screws on safety-bit chucks non-projecting? AFOSH Std 127-12, para 2-2 i (1)	____	________
Is a guard, enclosing all portions of the bit and chuck above the material being worked, installed on boring bits? AFOSH Std 127-12, para 2-2 i (2)	____	________
Is the top of the driving mechanism enclosed? AFOSH Std 127-12, para 2-2 i (3)	____	________
Are universal joints on spindles of boring machines completely enclosed? AFOSH Std 127-12, para 2-2 i (5)	____	________
Are hold-down devices installed on table-type boring or mortising machines? AFOSH Std 127-12, para 2-2 i (6)	____	________
Tenoning Machines		
Are feed chains and sprockets of double end tenoning machines completely enclosed, except for the portion of cabin used for conveying the stock? AFOSH Std 127-12, para 2-2 j (1)	____	________
Are sprockets and chains guarded at the sides by plates projecting beyond the periphery of sprockets and the ends of lugs at the rear ends of frames over which feed conveyors run? AFOSH Std 127-12, para 2-2 j (2)	____	________

AFOSH = Air Force Occupational Safety and Health Manual
29 CFR = Code of Federal Regulations Title 29