

Section 23

Tunnel and Shaft Construction

This section sets forth requirements for tunnel and shaft construction. It covers the following specific areas:

- General Requirements
- Emergency Provisions
- Ventilation
- Air Quality
- Dust Control
- Internal Combustion Engines
- Noise Control
- Fire Prevention and Control
- Excavation Operations
- Ground Support
- Transportation and Haulage
- Shafts
- Tunneling in Soil
- Compressed Air Work

23.1 General Requirements for Tunnel and Shaft Construction

In addition to complying with the safety requirements set forth in this section and other parts of these standards, comply with applicable provisions of the contract when excavating and constructing tunnels and shafts. Begin underground-related work only after an acceptable safety program or a detailed supplementary submittal specific to underground operations has covered all aspects of the operation.

23.1.1 Employee Identification. Entrances to all underground facilities must have a check-in and checkout system that provides the contractor with an accurate record of each person underground. The system must be able to identify each individual and general location. General locations include heading, train crew, track crew, maintenance area, storage area, survey stations, etc. Additionally, when underground, all employees must carry or wear a positive means of identification, such as a metal disk or tag.

23.1.2 Illumination. Underground lighting and illumination intensities must adhere to the current ANSI/IES RP-7, "Recommended Practice for Industrial Lighting" and UL 924, "Emergency Lighting and Power Equipment." Use nonmetallic light fixtures and support lighting conductors on insulators located on the side of the tunnel or shaft opposite the firing line. Use acceptable portable lighting equipment within 50 feet of any underground heading during explosives handling.

23.1.3 Electrical Equipment. A professional engineer (PE), knowledgeable in underground wiring practices, must design and certify the underground electrical distribution system to meet good practice and applicable standards. Install and maintain all electrical equipment, including the section on "Electrical Safety," to meet applicable requirements. Permit only dry-type transformers underground and ensure they are protected from possible damage. Separate or insulate power lines from air and waterlines, metal ducts, telephone lines, and blasting lines.

23.1.4 Bonding and Grounding. Ground and bond air and water piping, metal vent pipe, rails, and similar conductive devices at the portal or shaft head and at no more than 1,000-foot intervals.

23.1.5 Communications. Install a telephone system or an equivalent powered communication system between the tunnel heading and the portal, the shaft bottom and shaft head, and the first-aid station. Keep the powered communication systems independent of the tunnel or shaft power supply, and install the powered communication systems so that failure or disruption of any one station will not disrupt the operation of any other station. Test communication systems at the beginning of each shift and more frequently, when necessary, to ensure reliability. An employee must not work alone unless that employee is either within voice communication distance of another employee or has an appropriate powered communication system to obtain instructions and emergency assistance.

23.1.6 Blasting. Blasting and explosive-handling operations must conform to the requirements in the "Blasting" section.

23.1.7 Personal Protective Equipment. Employees entering underground workings must wear, as a minimum, hardhats, appropriate eye protection, and foot protection. Employees entering wet areas must wear rubber footwear; underground type rain gear; and eye, face, and head protection as described in the section on "Personal Protective Equipment." When applicable, provide employees with other personal protective equipment, and ensure they wear them.

23.2 Emergency Provisions

23.2.1 Evacuation Plan. Develop and post emergency evacuation plans, including provisions for rescue equipment, at the portal or shaft head. Instruct employees in the emergency procedures.

23.2.2 Self-Rescuers. Provide employees and others with self-rescuers, approved by National Institute of Occupational Safety and Health (NIOSH) and/or Mine Safety and Health Administration (MSHA), or make them available at headings, shaft bottoms, and all other underground work areas. Provide at least one readily available self-rescuer for each employee and

visitor. Ensure that employees and others have satisfactorily completed certified training before going underground. Visitors instructed in operating the self-rescuer and accompanied by a trained employee are exempt from this training requirement. Maintain self-rescuers in accordance with the manufacturer's requirements.

23.2.3 Emergency Hoists. Provide an emergency personnel hoist for shafts more than 50 feet deep. Design the hoist so that, as a minimum, the load hoist drum is powered in both directions and a brake automatically applies upon power release or failure. Provide the emergency hoist in addition to the primary hoist.

23.2.4 Rescue Crews. As part of the emergency plan required in the section on "Emergency Planning," develop an emergency plan covering the possible emergencies requiring the use of a rescue crew. The plan must include the equipment, training, and organization of the rescue crews.

- a. Provide at least two rescue crews of at least five men each for tunnel and shaft operations employing 25 or more employees at one time underground. One crew must be on the jobsite or within ½ hour travel time away from the portal. The other crew must be within 2 hours travel time.
- b. Organize and train at least one crew of at least five employees as a rescue crew, or, for smaller jobs, arrange in advance with a locally available rescue service. Locate the rescue crew or rescue service on the jobsite or within ½ hour travel time from the portal.
- c. Thoroughly instruct new crew members upon assignment to the rescue crew and conduct refresher training for the full crew at least every 6 months.
- d. Instruct and train rescue team members to perform rescue operations; use and care for oxygen breathing apparatus; and use firefighting equipment. Provide oxygen-breathing apparatus unless, in the development of the emergency plan, analysis specifically indicates that the use of self-contained breathing apparatus is sufficient. Keep breathing apparatus in good repair and ready for use at all times. Maintain a sufficient supply of spare breathing apparatus, replacement parts, and regenerating material or air cylinders.

23.2.5 Emergency Lighting. Provide each employee and visitor entering underground workings with an MSHA-approved portable hand or cap lamp and make sure the employee or visitor carries it. Providing hand or cap lamps does not take the place of meeting lighting requirements.

23.2.6 Designated Person. At least one designated person must be on duty above ground when personnel are underground. The designated person must be familiar with operating features of the lighting and ventilation system and the procedures for obtaining emergency service. The designee must remain within contact range of the communication system annunciator.

23.3 Requirements for Ventilation

Mechanically ventilate all areas of tunnels, shafts, and other underground workings with clean, breathable, nonrecirculated, outside air. Place the ventilation system in operation before employees enter any underground workings and keep the system in operation until all personnel have left the area serviced by the system.

23.3.1 Ventilation System Design Requirements. Submit the system(s) design criteria, specifications, and appropriate drawings before acquiring or installing the system. Incorporate the following specific design features in all ventilation systems:

- a. Mechanically induce all airflows. Do not provide required air quantities by natural ventilation methods.
- b. Construct primary ducts and fans of noncombustible metallic materials. You may use short, noncritical sections of expandable-type ducting in secondary systems.
- c. Use class 1, division 1 electric motors, fans, drives, and auxiliary equipment, including wiring, starters, and controls. Design, install, and maintain the system in explosion-proof condition and make sure it is capable of operating in an explosive atmosphere.
- d. Ensure the noise levels of ventilation fans does not exceed 90 decibels when measured at the closest point of employee exposure.
- e. Ensure system airflows, secondary systems excepted, are reversible from a surface location. Incorporate a control system in the reversing feature so it is not necessary to rewire fans or electrical circuits to accomplish the reversing sequence.
- f. Design the primary ventilation systems to operate in the exhausting mode.
- g. Maintain primary duct system inlets within 3 duct diameters of the tunnel face or shaft bottom when operating in exhaust and within 10 duct diameters of the tunnel face or shaft bottom when operating on blow. In conventional drill and blast tunnels, you may need to install a supplemental ventilation system to maintain minimum ventilation rate to

the tunnel face or shaft bottom during all portions of the excavation cycle. "Blow Joes" or similar-type recirculating devices do not meet this requirement.

h. Heat or cool the ventilation air as necessary to ensure air temperatures at work sites are between 40 °F and 100 °F.

i. Design ventilation system capacities (cubic feet per minute) to be the greater of:

1. The total rate (cubic feet per minute) required for all MSHA-approved diesel engines operating underground.
2. The total rate (cubic feet per minute) required for all non MSHA-approved equipment. Non MSHA-approved diesel equipment must meet appropriate requirements in this section.
3. The total rate (cubic feet per minute) required to control airborne contaminants or toxic and flammable gas or vapor within prescribed limits or values specified or referenced in this section and in the "Occupational Health" section.
4. The rate (cubic feet per minute) required to maintain a minimum air velocity of 100 feet per minute (feet per minute) over the gross bore area of all sections of the underground workings.

23.3.2 Air Volume Measurements. Develop and implement a procedure to maintain design airflows in all sections of underground workings. The procedure, as a minimum, must require the following:

- a. Determining airflows immediately after any system installation or modification that could significantly affect airflows (e.g., adding new fans, repairing fans, or changing duct arrangements).
- b. Continuously monitoring airflows in primary ventilation systems with direct readout instruments containing low-air volume alarms.
- c. Determining airflows in congested tunnel areas (e.g., headings and near rapid excavation machines) by pitot tube traversing of the duct system supplying or exhausting air from the area. (Refer to American Conference of Governmental Industrial Hygienists publication, "Industrial Ventilation," for acceptable equipment and methods for air volume determinations.)
- d. Maintaining all data obtained by measurement, including the date, place, time, instrumentation, calculations, results, and the names of test personnel, on the surface and make it available for review.

23.4 Requirements for Air Quality

Underground air quality must meet the following specifications:

- (a) Oxygen concentrations must be between 19.5 percent and 22.0 percent.
- (b) Carbon monoxide concentrations must not exceed 25 parts per million (0.0025 percent).
- (c) Carbon dioxide concentration must not exceed 5,000 parts per million (0.5 percent).
- (d) Nitrogen dioxide concentration must not exceed 3 parts per million (0.0003 percent).
- (e) Hydrogen sulfide must not exceed 10 parts per million (0.001 percent).
 - 1. Conduct tests for hydrogen sulfide in the affected areas every 4 hours whenever hydrogen sulfide levels exceed 5 parts per million (0.0005 percent).
 - 2. Use a continuous sampling hydrogen sulfide indicator with alarm to monitor the affected work area if hydrogen sulfide levels exceed 10 parts per million (0.001 percent).
 - 3. Take steps to increase ventilation to reduce the concentration if the concentration of hydrogen sulfide exceeds 10 parts per million (0.001 percent) time-weighted average for an 8-hour period.
- (f) Do not allow methane gas to exceed 20 percent of the lower explosive limit:
 - 1. Whenever 5 percent or more of the lower explosive limit for methane or other flammable gases is detected, take steps to increase the ventilation rate or other steps to lower the methane concentration.
 - 2. Whenever 10 percent of the lower explosive limit for methane or other flammable gases is detected, evacuate all employees except those necessary to eliminate the hazard, and disconnect electrical power except for explosion-proof pumps and ventilation equipment.
- (g) Do not allow other flammable gases or vapors to exceed 10 percent of the lower explosive limit.
- (h) Do not allow other airborne contaminants, including dust, to exceed the limits prescribed in the section on "Occupational Health."

23.4.1 Quantitative Sampling of Underground Environments. A competent person must conduct the quantitative sampling of underground

environments. A competent person is one who through education, experience, and training can, using acceptable scientific instruments and methods, determine the quality of air in underground environments. Conduct quantitative sampling as follows:

- a. While excavating the tunnel at least once each 4 hours and before reentry into the face area after each blast, test the environment in the face area: first for oxygen concentration and then for flammable gas or vapors, carbon monoxide, hydrogen sulfide, and nitrogen dioxide.
- b. At least once during each work shift change, test all working environments for oxygen concentration, flammable gas or vapors, carbon monoxide, nitrogen dioxide, hydrogen sulfide, and other applicable gases or vapors.
- c. Sample all working environments near dust-producing operations for applicable airborne particulates within 10 days after underground operations begin, and at 90-day intervals thereafter, or within 10 days following major changes in tunnel excavation methods or major modifications to ventilation systems. Within 10 days following the sampling date, furnish a full report of the sampling method and analysis and an evaluation of the environmental conditions to the affected employees.
- d. Log and file environmental sampling data, including procedures, equipment, personnel, dates, and results at a surface location and make it available for review.

23.4.2 Specialized Instrumentation. In addition to quantitative sampling requirements, install specialized direct reading instruments to determine the concentration of flammable gases and vapors as follows:

- a. Equip all rapid excavation machines with a multisensor continuous flammable gas and vapor detector designed to shut down excavation operations when gas or vapor concentrations reach 10 percent of the lower explosive limit. Locate one sensor at the dust shield near the conveyor belt opening. Locate another sensor at the operator's station and a third sensor in the primary duct of the exhaust mode ventilation system.
- b. In conventional (drill and blast) operations, install an automatic multisensor continuous gas detector near the tunnel heading or shaft bottom. Equip the unit with visual and audio alarm components capable of alerting employees working at the heading or bottom that flammable gas or vapor concentrations have exceeded 10 percent of the lower explosive limit. Locate one sensor in the primary duct of an exhausting ventilation system and at least one more sensor in the general tunnel area within 30 feet of the face. Locate all sensors installed in the tunnel proper as near the crown as practical.

- c. Machine excavation operations, other than those described in paragraph a. above, require a similar detection system, a system with one sensor effectively placed to detect flammable gas and vapor concentrations near the cutter head.

23.4.3 Suspensions of Operations. Suspend all underground operations and remove all employees from underground workings whenever flammable gas or toxic gas or vapor concentrations exceed the acceptable levels set forth in this section on "Air Quality." Prohibit reentry, except for rescue operations, until authorized in writing by the contracting officer or representative, or office head. Do not provide written authorization until the following occurs:

- a. The employer has engaged the services of a PE experienced in gaseous tunneling or mining operations.
- b. The PE has, after onsite investigation and testing, developed a written detailed procedure for safely reentering the underground workings and resuming operations.
- c. The procedure complies with all requirements of these standards and the regulations of Federal and State entities having jurisdiction.

23.5 Requirements for Dust Control

Carry out all drilling and excavation operations in a manner that meets the requirements of this subsection and control airborne dust concentrations within limits prescribed in the section on "Occupational Health." Quantitative testing is required for underground environments and operations to ensure effectiveness of dust control methods.

23.5.1 Drilling. Equip rotary and percussion drills with water or chemical dust-control systems or other control systems.

23.5.2 Machine Excavation. Equip tunnel boring machines or other excavating machines with an effective dust-control system(s) before installation. Make sure the system can control the dust concentrations within the specified safe hygienic limits. Routinely maintain and test the system to ensure its effectiveness.

23.5.3 Muck Piles. Keep muck piles wet to reduce dust concentrations.

23.6 Requirements for Combustion Engines

Do not use internal combustion engines, other than approved diesel-powered equipment, underground. Provide written approvals or certifications before taking the equipment underground. Do not consider equipment approved until it meets one of the following provisions:

(a) The diesel-powered equipment has been approved or certified under the provisions of MSHA regulations 30 CFR Part 32 or Part 36 (formerly schedules 24 and 31). When applicable, obtain a permit from the State entity having jurisdiction.

(b) The employer certifies the diesel-powered equipment is equivalent to MSHA-approved equipment and meets the following requirements:

1. The engine's fuel injection system allows adjustments to the mechanism controlling maximum fuel injection only by breaking a seal or by altering the design.
2. At maximum fuel air adjustment under normal operating conditions and within the rated output range of the engine, make sure the undiluted exhaust gas does not contain more than 2,500 parts per million carbon monoxide and no more than 2,000 parts per million oxides of nitrogen.
3. Dilute the exhaust gas with air before discharging it into the surrounding tunnel atmosphere. Ensure that the discharged mixture of exhaust gas and air doesn't contain more than 100 parts per million carbon monoxide, 25 parts per million oxides of nitrogen, 10 parts per million aldehydes, and 2 milligrams per cubic meter of exhaust gas particulate emissions.
4. Cool engine exhaust to less than 160 °F before releasing it into the surrounding tunnel atmosphere.

23.6.1 Ventilation Requirements. Ensure that ventilation (cubic feet per minute) incident to the use of diesel-powered equipment underground meets the requirements of this section, including the following:

- a. The cumulative MSHA-approved ventilation rate for all diesel-powered equipment must be used for underground ventilation.
- b. For non-MSHA-approved equipment, a ventilation rate (cubic feet per minute) adequate to dilute all gaseous exhaust contaminants to below the prescribed limits or values specified or referenced in the "Occupational Health" section and to reduce the particulate emissions to below 1 milligram per cubic meter. In no case must the required ventilation rate be less than 150 cubic feet per minute multiplied by the manufacturer's rated horsepower of all engines when operating at maximum fuel/air ratio.

23.6.2 Maintenance and Testing. Inspect and maintain diesel equipment in accordance with the manufacturer's instructions. Design, operate, and maintain diesel equipment in conformance with MSHA 30 CFR Parts 36, 75.1909, and 1914. Maintain records of inspections and maintenance.

23.7 Requirements for Noise Control

Assess and control noise associated with underground operations, using the section on "Occupational Health."

23.8 Requirements for Fire Prevention and Control

In addition to the requirements set forth in the section, "Fire Prevention and Protection," the following requirements apply to all underground operations.

23.8.1 Heating. Do not use liquified petroleum gas (LPG) and natural gas heaters underground.

23.8.2 Gasoline, Diesel, and LPG. Do not permit gasoline or liquefied petroleum gases underground. Do not permit more than 1 day's supply of diesel oil underground. Do not pipe diesel fuel or combustible liquids from the surface to below ground.

23.8.3 Welding and Cutting. Comply with the section, "Hand Tools, Power Tools, Pressure Vessels, Compressors, and Welding," as well as this paragraph when welding and cutting underground. You may use acetylene and methyl acetylene propadiene stabilized gas underground for welding, cutting, and hot work. Do not permit underground more than the amount of fuel gas and oxygen necessary for work under progress for that shift. Before and continuously during welding or cutting, a competent person must determine that the atmosphere does not exceed the flammable gas, vapor, or oxygen limits.

23.8.4 Lubricants. Keep oil, grease, and diesel fuel stored underground in tightly sealed containers in fire-resistant areas at least 300 feet (91.44 meters) from explosive magazines and 100 feet (30.48 meters) from shaft stations, inclined passageways, and major electrical installations. Install in the storage area only electrical lighting systems that are approved for class I, division 2 locations.

23.8.5 Hydraulic Fluids. Use only fire-resistant hydraulic fluids approved by a recognized authority, such as Underwriters Laboratories, Inc., or Factory Mutual, in hydraulically actuated machinery and equipment, unless the equipment is protected by a fire protection system.

23.8.6 Belt Conveyors. Provide fire extinguishers of at least 2-A:40-B:C units at the head and tail pulleys and at 300-foot intervals along the belt line. Install a device on the conveyor drive system that automatically disconnects power to the drive unit if the conveyor stalls.

23.8.7 Portal Structures. Erect fire-resistive structures within 100 feet of a tunnel portal or shaft entrance. Place flammable material storage areas at least

200 feet away from the portal or shaft entrance. Do not permit combustible or flammable material within 100 feet of the portal or shaft entrance, main fan installation, or in a location where, in case of a spill or leak, the material will flow into the portal area.

23.8.8 Fire-Suppression Systems for Diesel-Powered Equipment. Equip all diesel-powered equipment operated underground with all of the following:

- a. A minimum of one 2-A:40-B:C dry chemical fire extinguisher that is accessible from ground level.
- b. Factory Mutual or other nationally recognized independent testing laboratory must specifically approve a dry chemical, pre-engineered, fixed-nozzle-type fire-suppression system for the respective service and the potential hazard. The design, installation, operation, and maintenance of the system must be in accordance with the testing laboratory's recommendation. The system, where applicable, must conform to National Fire Protection Association Standard No. 17, "Dry Chemical Extinguishing System," and the requirements of the authority having jurisdiction. Manual system actuators must be accessible from ground level and within reach of the operator when seated in the operating position.

23.9 Requirements for Excavation Operations

Before the start of excavation operations, train employees in the safety requirements for the method of excavation to be used: include the equipment to be used, the ground support systems, and the material handling systems in the training program.

23.9.1 Drilling Operations.

- a. **Examination and Scaling.** Before starting the drill cycle, examine the face and lifters for misfires. If found, remove them before drilling. Don't drill lifters through loose rock or water. Inspect the heading, including the face, for loose rock, and scale it before mucking and drilling. Protect employees engaged in these activities from dislodgements by location, ground support, or other equivalent means.
- b. **Equipment Inspection.** Inspect drilling equipment each shift and correct defects affecting safety before using the equipment.
- c. **Drill Jumbos.** On jumbo decks, more than 6 feet high, install removable guardrails with pipe uprights and chain handrails or equivalent protection on the open sides and back. Also provide safe access to the deck and cover the decks with solid, nonslip decking. When moving jumbos, do not permit riders on the deck unless they are assisting the operator.

1. Chock jumbos to prevent movement while employees are working on them.
2. Maintain walking working surfaces of jumbos to prevent slipping, tripping, and falling.

d. Moving Drills. Secure drill steel, tools, mast, and other equipment in a safe position when moving a drill to another area. Provide receptacles or racks for drill steel stored on drill jumbos.

e. Drill Masts. Do not permit employees on the drill mast when the drill bit is in operation.

f. Column Drills. Firmly anchor drills supported on columns before operation and retighten the drill frequently during operation.

g. Startup Warning. Before the drill cycle begins, warn the employees working below the jumbo deck.

h. Lifting Material and Equipment. Provide a mechanical means to raise heavy materials and equipment to the top decks of jumbos more than 4 feet high.

i. Airhose. Secure all airhose with an inside diameter greater than 0.5-inch at each connection and at the drill with clips and wire rope, chain lashings, or an equivalent safety device.

23.9.2 Mechanical Excavation.

a. Mechanical Hazards. Sound an audible warning before excavating or conveying machinery. Equip excavating machines with dead-man controls. Provide adequate guarding where workers are exposed to moving parts or to hydraulic lines operating at temperatures greater than 160 °F.

b. Lockout. In addition to requirements found in the section, "Hazardous Energy Control Program," provide a means to lock out all power sources from the mechanical excavating equipment. Where employees may need to work between the face and the cutter head tunnel-boring machines, provide the employees with a positive mechanical block to prevent movement of the cutter head and a provision to lock out the power.

c. Examination. Thoroughly examine the heading before starting excavation equipment.

23.10 Requirements for Ground Support

23.10.1 Tunnel Portals. Keep rock faces above and adjacent to portal areas thoroughly scaled, and remove all loose or overhanging rock. Provide chain link fabric on rock faces that are subject to spalling or raveling. Provide a fire-resistive protective canopy at all tunnel portals. The protective canopy must project at least 15 feet from the portal face and must withstand falling earth or rock.

23.10.2 Inspection and Scaling. At least once a shift, a competent person must inspect tunnels and shafts where employees are working. Scale and support them as required. Provide scaling bars and maintain them in good condition. A competent person must inspect the entire tunnel, including roof and walls at least weekly. Maintain weekly inspection records on the surface.

23.10.3 Loose Ground. Remove or support loose rock and earth. Employees scaling or installing supports must work from supported areas or protect them with spiling, crown bars, shielding, or other equivalent protective systems.

23.10.4 Rock Bolting. A PE must design rock bolt support systems. Make torque meters and torque wrenches available where rock bolts are in use. Make sure a competent person establishes torque testing and retightening intervals, on the basis of rock conditions and existing vibration sources.

23.10.5 Damaged Tunnel Supports. Immediately repair or replace damaged or dislodged tunnel supports of any description. Whenever possible, install new supports before removing the damaged supports.

23.10.6 Anchorage. Design and install all sets, including horseshoe-shaped or arched rib steel sets, with the bottoms sufficiently anchored to prevent movement. Install lateral bracing between sets to stabilize the support.

23.10.7 Wood Supporting Structures. Do not use timber supports or wood lagging.

23.11 Requirements for Transportation and Haulage

The employer must develop a complete set of operating rules for all types of haulage equipment. Provide a copy of these rules and discuss them with all employees before they go underground. Do not implement operational changes affecting the rules until you change the rules.

23.11.1 Inspection. Maintain all haulage equipment in safe operating condition. A qualified person must inspect it at the beginning of each shift. Correct equipment defects affecting safe operation before using the equipment.

23.11.2 Rail Haulage Systems

a. Locomotives. In addition to ensuring that locomotives meet the requirements of this section, equip them with: (1) a braking system, capable of stopping and holding a loaded train on any section of track; (2) headlights, a backup light, an audible warning device, a continuous revolving flashing amber light that is visible in all directions; (3) seats for the operator and all passengers; (4) adequate platforms and handholds for the train crew; (5) rerailers and jacks; (6) dead-man controls; and (7) falling object protection in accordance with the latest revision of 29 CFR 1926, Subpart S, "Tunnels and Shafts, Caissons, Cofferdams, and Compressed Air."

b. Man-Haul Units. (1) Totally enclose man-haul units, except for doors, small windows, and ventilation openings; (2) equip man-haul units with seats for all passengers, adequate access devices, and safety chains in addition to safety coupling devices; (3) use man-haul units only to transport personnel, their personal equipment, and small secured tools. Man-haul trips must consist of an engine and man-haul car(s) only. Pull man-haul cars when occupied. Personnel who are incidentally transported between shift changes may sit on locomotive seats or in specially equipped, empty muck cars that have adequate headroom. Engines must pull muck cars carrying personnel, and muck cars must be equipped with safety chains.

c. Haulage Cars. Equip mine dump cars with automatic safety couplings. Equip cradle or bottom dump cars with a positive-locking device to prevent accidental dumping. Provide and use tiedown chains or bumper blocks to prevent overturning of cars dumped by hand.

d. Tracks. Install and maintain rails in a manner that prevents shifting or excessive settlement. Anchor rails to prevent unsafe separation, and gauge them during laying operations and regularly while in use. Provide berms, bumpers, blocks, safety hooks, or equivalent means to prevent overtravel or overturning at dumping areas.

e. Operations. Load and secure materials to be hauled to prevent sliding or dislodgement. Carry only small hand tools, lunch pails, or similar light items on top of locomotives, provided that the top of the locomotive is designed or modified to retain them while traveling. Chock, block, or set the brakes on parked equipment to prevent inadvertent movement.

23.11.3 Nonrail-Type Haulage Systems. Nonrail-type haulage systems must comply with the following applicable requirements:

a. Rubber-tired or crawler equipment and operations must comply with applicable requirements of this section and the section, "Mobile and Stationary Mechanized Equipment."

- b. Conveyor systems equipment and operation must conform with applicable requirements of this section and the section, "Hoisting Equipment, Piledrivers, and Conveyors."

23.12 Requirements for Shafts

In addition to other applicable provisions of this section, the following requirements apply to the excavation of vertical and inclined shafts. Support shafts more than 5 feet deep if employees must enter. A competent person must determine the method of support.

23.12.1 Access. Provide all shafts with a protected manway designed to permit safe entrance to and exit from the shaft bottom. Hoisting systems designed, installed, operated, and maintained as set forth in this section may transport personnel.

23.12.2 Guards. Protect the shaft opening with totally enclosed perimeter guarding that is as high as a standard guardrail. Slope the ground adjacent to the top of the shaft collar away from the shaft to prevent liquids from entering and construct an effective barrier to prevent mobile equipment from accidentally entering the shaft.

23.12.3 Hoisting Systems. Do not use cranes, derricks, or similar equipment as the primary hoisting system to raise or lower personnel. Only use cranes, derricks, or similar equipment meeting the requirements of this section for an emergency hoisting system. Do not use cranes to raise or lower muck or concrete buckets or similar devices to remove excavated material or to place concrete, except in shafts less than 75 feet (22.86 meters) deep. You may use cranes to raise and lower construction materials or equipment that cannot be safely handled by the hoisting system. Cranes must conform with applicable provisions of the "Hoisting Equipment, Piledrivers, and Conveyors" section and all of the following requirements:

- Equip primary and secondary hoisting lines with planetary or worm gears, torque convertors, automatic braking systems, or other equivalent systems that prevent the loadlines from being placed in a free wheeling or neutral position controlled only by a manual brake or dogs (hooked or U-shaped device used for gripping or holding heavy devices).
- Equip hoisting lines with: (1) an anti-two-blocking device or a two-block damage prevention feature; and (2) a limit switch to prevent overtravel at the bottom of the shaft. Keep at least two full wraps of wire rope on the drum at all times.
- A competent person must inspect the crane at the beginning of each shift and each time it is set up at the work site. Give the crane a full cycle operational test lift before initial use at the shaft site and each time it is reset at the site.

a. General Requirements of the Primary Hoisting System. Install a stationary hoisting system meeting the requirements of this subsection and applicable provisions of the "Hoisting Equipment, Piledrivers, and Conveyors" section, and ANSI A10.22, "Safety Requirements for Rope-Guided and Non-Guided Workmens' Hoists," at all shaft sinking operations 75 feet (22.86 meters) or more deep. A PE must design all stationary hoisting systems. Follow the more stringent standard if there are conflicts between these and referenced standards.

b. Specific Requirements of the Primary Hoisting System. The stationary hoisting system must meet applicable ANSI standards, the requirements of the State having jurisdiction, and the following specific requirements:

1. Personnel Hoisting. You may use the primary hoisting system to hoist personnel in attached cages or mankips that meet the requirements of referenced ANSI standards or in buckets suspended beneath crossheads operating on rail or rope guides, provided: (1) the sides of the bucket are steel and at least 4 feet high, and at least 1/16 inch thick; (2) you use emergency chains, slings, or double clevis pins between the lower end of the hoisting rope and the bucket to prevent the bucket from falling in the event of ring bolt or clevis pin failure; (3) you provide a bonnet that covers the top to protect it from falling rock or other objects; (4) the bonnet is the equivalent of two steel plates 3/16 inch thick, sloping toward each side and arranged to permit safe egress from the bucket; (5) the speed of the personnel platform does not exceed 200 feet per minute; and (6) governor controls set for 200 feet per minute are installed in the control system and used during personnel hoisting.

2. Hoist Motors. Design the hoist motor so that the load powers up and down through the gears. There must be no friction gearing or clutch mechanism by which the motor or other power source can be disconnected from the hoist drum. When the control is brought to the "stop" position, or should the motor stop, the load must stop and remain in the stopped position.

3. Hoist Controls. Design the hoist control to return to the "stop" position when the operator removes his/her hand from the control lever. Whenever the control lever is in the stop position, the brakes must automatically apply and the power must cut off. All hoist controls and the emergency power cutoff must be within reach from a single operating position.

4. Guides. Equip shafts more than 75 feet (22.86 meters) deep with guide rails or guide cables to prevent the cage or bucket from swaying.

When sinking shafts more than 75 feet (22.86 meters) deep, keep the guide rails or cables as close as possible to the bottom of the shaft. Maintain rail guides within one rail length of the bottom. Provide a safe means of access from the bottom landing to the bottom of the shaft. When sinking shafts less than 75 feet (22.86 meters) deep, guide cages, skips, and buckets that may swing, bump, or snag against shaft sides or other structural protrusions by fenders, rails, ropes, or a combination of those means. Guide cages, skips, and buckets in all completed shafts by ropes or rails for the full length of their travel.

5. Broken-Rope Safety. Equip cages, skips, or buckets operating on guides or guide cables in shafts more than 75 feet (22.86 meters) deep with a broken-rope safety device, or equivalent, that will stop and hold a weight that is 150 percent of rated capacity in the event of a hoisting cable failure.

6. Limit Stops. Equip hoists with approved-type limit switches that will automatically stop the cage or bucket at the limits of travel.

7. Communications. Provide hoist operators with a closed-circuit communications system to each landing station. Locate a speaker-microphone so that the operator can communicate with individual landing stations during the hoist.

8. Performance Inspections and Tests. Following installation and before use, at 6-month intervals thereafter, and after modification or repair of the critical components, inspect each hoist and load test it under the direction of the PE or a qualified person certified by the PE to conduct such inspections and tests. Maintain a comprehensive report detailing the required inspections and test procedures and results. The PE, or his or her designee, must sign and maintain the report. Include a broken rope drop test to verify that safety clamps function properly and that the guide ropes/rails, their supports, and the bucket/cage are able to withstand the imposed load.

(**Note:** ANSI A10.5, "Safety Requirements for Material Hoists," under "Standards for Material Handling, Storage, and Disposal," details one method for conducting such tests.)

Further, performance test the hoist with a test load of 125 percent through all limits of travel to ensure satisfactory operation of limit switches, speed indicators, braking systems, and controls.

9. Periodic Inspection and Tests. A competent person must visually check all hoisting machinery equipment, anchorages, and hoisting rope at the beginning of each shift and during hoist use, as necessary. A competent person must check each safety device at least weekly during

hoist use to ensure suitable operation and safe condition. Periodic inspections and tests must conform to the PE's recommendations.

c. Overhead Protection. Do not hoist or lower material or tools while personnel are working at the bottom of a shaft unless a barrier of adequate strength is installed to protect the personnel from falling objects or material. Do not lower any load, cage, skip, or bucket directly to the bottom of a shaft when personnel are working there. All such equipment must stop at least 15 feet above the bottom of the shaft and remain there until the signal person at the bottom of the shaft gives the signal to lower.

23.12.4 Suspended or Movable Work Platforms. Design, inspect, and test suspended or movable work platforms in accordance with applicable provisions of this section and the section, "Hoisting Equipment, Piledrivers, and Conveyors." The term "platform" in this subsection is synonymous with the terms skip or cage, in referenced subparagraphs, subsections, or standards.

23.12.5 Small-Diameter Shafts. Provide small-diameter shafts, such as manholes, wells, or test pits that employees must enter, with a steel casing, concrete pipe, timber cribbing, or other support adequate to retain surrounding earth.

23.12.6 Inspection. Following a blast, check the walls, ladders, supports, blocking, and wedges to determine if they have loosened. If they are loose or unsafe, make repairs before continuing work in the shaft.

23.13 Requirements for Tunneling in Soil

23.13.1 Support. When excavating by conventional methods, do not extend the excavation more than 2 feet in advance of the tunnel supports. When using continuous mining machines, keep the support within 4 feet of the face or shield. Do not permit employees under unsupported or unshielded sections of the tunnel.

23.13.2 Voids. Fill, block, or brace voids behind ring beams, liner plates, or other supports to prevent caving.

23.13.3 Design of Support. A PE must design support systems for tunnels excavated in soil.

23.14 Requirements for Compressed-Air Work

The employer must comply with the requirements set forth in 29 CFR 1926.803, "Compressed Air," when operations involve work in a compressed-air environment.