

4123:1-3-16 Tunnels and shafts, caissons, cofferdams, and compressed air.

(A) Reserved.

(B) Definitions.

- (1) "Air lock" means a chamber designed for the passage of employees and materials from one air pressure to a greater or lesser air pressure.
- (2) "Bulkhead" means an airtight structure separating the working chamber from free air or from another chamber under a greater or lesser pressure than the working pressure.
- (3) "Caisson" means a wood, steel, concrete or reinforced concrete, air-and water-tight chamber in which it is possible for men to work under air pressure greater than atmospheric pressure to excavate the material below water level.
- (4) "Decanting" means a method used for decompressing under emergency circumstances. In this procedure, the employees are brought to atmospheric pressure with a very high gas tension in the tissues and then immediately recompressed in a second and separate chamber or lock.
- (5) "Emergency lock" means a lock designed to hold and permit the quick passage of an entire shift of employees.
- (6) "High air" means air pressure used to supply power to pneumatic tools and devices.
- (7) "Low air" means air supplied to pressurize working chambers and locks.
- (8) "Manlock" means an airlock for personnel.
- (9) "Materials lock" means an airlock for materials and equipment.
- (10) "Medical lock" means a special chamber in which employees are treated for decompression illness.
- (11) "Normal condition" means one during which exposure to compressed air is limited to a single continuous working period followed by a single decompression in any given twenty-four-hour period.
- (12) "Safety screen" means an air-and water-tight diaphragm placed across the upper part of a compressed air tunnel between the face and bulkhead in order to prevent flooding the crown of the tunnel.

- (13) "Shafting" means an air-and water-tight enclosure built in the roof of the caisson and extended upward until above the normal ground or water level.
- (14) "Working chamber" means the space or compartment under air pressure in which the work is being done.
- (15) "Working face" (work face) means the transverse face of the tunnel heading at the point of greatest advancement of the tunnel excavation.

(C) General.

- (1) Access to unattended underground openings shall be restricted by gates or doors. Unused chutes, manways, or other openings shall be tightly covered, bulkheads, or fenced off, and posted.
- (2) Where hazardous settlement of the earth has occurred the area shall be fenced and posted.
- (3) Each operation shall have a check-in and check-out system that will provide identification of every employee underground.
- (4) All pipe, fittings and wires extending in shafts, tunnels and caissons shall be securely fastened in place.

(D) Tunnels and shafts.

- (1) Emergency provisions.
 - (a) Evacuation plans and procedures shall be developed and made known to the employees.
 - (b) Emergency hoisting facilities shall be readily available at shafts more than fifty feet in depth, unless the regular hoisting facilities are independent of electrical power failures.
 - (c) Approved self-contained breathing apparatus shall be available near the advancing face adequate in number to equip each employee at the face. Such items shall be on the haulage equipment and in other areas where employees might be trapped by smoke or gas.
 - (d) A method of affording instant communications shall be provided between the work face and the tunnel portal, and such method shall be independent of the tunnel power supply.

- (e) Safety belts shall be worn on skips and platforms used in shafts unless guardrails or cages are provided.

(2) Ground support.

- (a) The exposed faces of tunnel excavations (except the portion being worked on at the particular time) and shafts made in material other than rock shall be supported and held in place by a securely fastened bracing system.
- (b) Damaged or dislodge tunnel supports, whether steel sets or timber, shall be repaired or replaced. New supports shall be installed whenever possible before removing the damaged supports.
- (c) All sets, including horseshoe-shaped or arched rib steel sets, shall be designed and installed so that the bottoms shall be securely anchored to prevent pressures from pushing them inward into the excavation. Lateral bracing shall be provided between sets to further stabilize the support.

(3) Ventilation.

- (a) When ventilation fails for longer than a safe temporary period employees shall be evacuated from the tunnel or shaft. Before employees are permitted to enter or reenter the tunnel or shaft the area shall be examined, after ventilation has been started, for gas and other hazards by an employee designated by the employer.
- (b) Under no circumstances shall a tunnel or shaft be entered to make any of the following prescribed tests.
 - (i) No employer shall permit entrance into any tunnel or shaft unless an entry procedure, incorporating one of the following, is used:
 - (a) Air sampling shall be performed by qualified, trained personnel prior to and periodically during occupancy to determine either that:
 - (i) The atmosphere within the tunnel or shaft contains an adequate quantity of oxygen (19.5 per cent) and harmful atmospheric contaminants have been diluted to safe concentrations; or
 - (ii) Adequate mechanically induced dilution ventilation is used prior to entry and continued in use during occupancy to ensure that no less than 19.5 per cent oxygen is maintained in the tunnel or shaft.
 - (b) A supplied-air respirator or self-contained breathing apparatus is provided and used.

(ii) When the tunnel or shaft has been exposed to, contained, or is likely to have combustible gases within its confines (such as sewage treatment plants), it shall not be entered if any reading is obtained on a combustible gas indicator (See "Appendix III to this rule).

(iii) If tests under paragraph (D)(3)(b)(i)(a) or (D)(3)(b)(ii) of this rule indicate that the atmosphere in the tunnel or shaft to be entered contains:

(a) Any concentration of flammable vapor or gas; and/or,

(b) A concentration of toxic contaminants above the threshold limit value; and/or

(c) Less than 19.5 per cent oxygen; then appropriate control measures shall be instituted. Control measures may consist of forced or natural ventilation, use of personal protective equipment, a combination of these, or other effective control techniques.

(c) Internal combustion engines other than approved mobile diesel powered equipment shall not be used underground.

(4) Illumination.

Lighting of no less than ten lumens shall be provided at the tunnel and shaft headings and no less than five lumens elsewhere in the tunnel or shaft where employees are required to work.

(5) Fire prevention and control.

(a) Signs warning against smoking and open flames shall be posted so that they can be readily seen in areas or places where fire or explosion hazards exist.

(b) The carrying of matches, lighters, or other flame-producing smoking materials is prohibited in all underground operations.

(c) Gasoline and liquefied petroleum gases shall not be taken, stored or used underground.

(d) Oil and grease stored underground shall be kept in tightly sealed containers in fire-resistant enclosures.

(e) Air that has passed through underground oil storage areas shall not be used to ventilate working areas.

- (f) Approved fire-resistant hydraulic fluids shall be used in hydraulically actuated underground machinery and equipment.
- (g) Fires shall not be built underground.
- (h) Noncombustible barriers shall be installed below welding or burning operations that are performed in or over a shaft.
- (i) Fire extinguishers or equivalent protection shall be provided at the head and tail pulleys of underground belt conveyors and at three-hundred-foot intervals along the belt line.
- (j) Sufficient employees trained in the use, care and limitations of oxygen breathing apparatus and the use of fire fighting equipment shall be on duty on each shift in tunnel operations.

(6) Personal protective equipment.

Protective clothing or equipment shall be worn as specified in rule 4123:1-3-03 - of the Administrative Code.

(7) Hearing protection.

Employees exposed to continuous noise levels of ninety or more decibels (dBA) slow response shall be provided with approved ear protection. (Variations in noise level involving maxima at intervals of one second or less, are to be considered continuous.)

(8) Drilling.

- (a) Employees shall not be required to be on a drill mast while the drill bit is in operation.
- (b) When a drill is being moved from one drilling area to another, drill steel, tools, and other equipment shall be secured, and the mast placed in a safe position.
- (c) Receptacles or racks shall be provided for drill steel stored on jumbos.
- (d) The employer shall be required to provide and employee shall use a warning system to warn all employees below jumbo decks before the drilling cycle is started.
- (e) Drills on columns shall be anchored firmly before drilling is started and shall be retightened when necessary thereafter.

- (f) The employer shall provide mechanical means for lifting drills, roof bolts, mine straps, and other unwieldy heavy material to the top decks of jumbos over ten feet in height.
- (g) Jumbo decks wide enough to accommodate two employees and more than ten feet in height shall be provided with stair or ladder access.
- (h) On jumbo decks over ten feet in height, standard guardrails, which may be removable shall be provided on all sides and back platforms.
- (i) Scaling bars shall be in good condition at all times, and blunted and severely worn bars shall not be used.
- (j) When jumbos are being moved, only the driver and those assisting the driver shall be permitted on the jumbo.
- (k) Before commencing the drill cycle, the face and lifters shall be examined for misfires (residual explosives) and, if found, they shall be removed before drilling commences at the face. Lifters shall not be drilled through blasted rock (muck) or water.
- (l) Air lines that are buried in the invert shall be identified by signs posted nearby, warning all personnel.

(9) Blasting.

- (a) All blasting and explosives-handling operations shall be conducted in compliance with rule 4123:1-3-15 of the Administrative Code.
- (b) When using explosives in tunnels, shafts and caissons, all metal pipes, rails, air locks, and steel tunnel lining shall be electricity bonded together and grounded at or near the portal or shaft, and such pipes and rails shall be cross-bonded together at no less than one-thousand-foot intervals throughout the length of the tunnel. In addition, each low air supply shall be grounded at its delivery end.

(10) Haulage.

- (a) Powered mobile equipment shall be provided with adequate brakes.
- (b) Powered mobile haulage equipment shall be provided with audible warning devices. Lights shall be provided at both ends.
- (c) Cab windows shall be of safety glass, or equivalent material in good condition.

- (d) Adequate backstops or brakes shall be installed on inclined conveyor drive units. A conveyor of such type which would cause injury when run in reverse shall not be reversed until employees in the area are alerted by a signal or by a designated person that the conveyor is about to start.
- (e) No employees shall be permitted to ride a power-driven chain, belt, or bucket conveyor, unless the conveyor is specifically designed for the transportation of employees.
- (f) The employer shall not permit employees to be transported in dippers, shovel buckets, forks, clamshells, or in the beds of the dump trucks, or on other haulage equipment not specifically designed or adapted for the transportation of employees.
- (g) Electrically powered mobile equipment shall not be left unattended unless the master switch is in the off position, all operations controls are in the neutral position, and the brakes are set, or other equivalent precautions are taken against rolling.
- (h) When dumping cars by hand, the car dumps shall be provided with tie-down chains or bumper blocks to prevent cars from overturning.
- (i) Rocker-bottom or bottom-dump cars shall be equipped with positive locking devices.
- (j) Equipment which is to be hauled shall be so loaded and protected as to prevent sliding or spillage.
- (k) Parked railcars shall be blocked securely.
- (l) Berms, bumper blocks, safety hooks, or similar means shall be provided to prevent over-travel and overturning at dumping locations.
- (m) Where necessary, bumper blocks, or the equivalent, shall be provided at all track dead ends.
- (n) Supplies, materials, and tools, other than small handtools, shall not be transported with employees in mantrip cars.

(11) Electrical equipment.

Oil-filled transformers shall not be used underground unless they are located in a fire-resistant enclosure and surrounded by a dike to contain contents of the transformers in event of a rupture.

(12) Hoisting.

- (a) Hoisting machines, either powered or hand operated, shall be worm-gearred or powered both ways. The design must be such that when the power is stopped, the load cannot move.
- (b) Controls for powered hoists shall be of the deadman type with a nonlocking switch or control.
- (c) A device to shut off the power shall be installed ahead of the operating control.
- (d) Hand-operated release mechanisms, which can permit the load to descend faster than the speed rating, may be performed if shaft conditions permit.
- (e) Hoist machines with cast metal parts shall not be used.
- (f) Every hoist shall be tested with twice the maximum load before being put into operation, and annually thereafter.
- (g) All anchorages of hoists shall be inspected at the beginning of each shift.
- (h) An enclosed covered metal cage shall be used to raise and lower employees in the shaft. The cage shall be designed with a safety factor of four and shall be load-tested prior to use. The exterior of the cage shall be free of projections or sharp corners. Only closed shackles shall be used in the cage rigging.
- (i) If the cage is equipped with a door, a locking device shall be installed to prevent the door from opening accidentally while the cage is being lowered or raised while hoisting or lowering employees.

(E) Caissons.

(1) Sinking of caissons.

(a) Bracing of caissons.

Caissons shall be substantially braced before loading with concrete or other weight.

(b) Concreting caissons.

When two or more caissons are sunk together, employees shall be removed from adjacent caissons during concreting operations.

(c) Air lock platforms.

All outside air locks shall be provided with a platform no less than forty-two inches wide, and such platform shall be provided with a standard guard railing and toeboard.

(d) Fifteen or more employees - two locks.

All caissons in compressed air environments in which there are fifteen or more employees, or are ten feet or more in diameter, shall have two locks, one of which shall be used as a manlock. It shall be the duty of one or more trained employees to be in charge of and operate said manlock and any associated man shafts.

(e) Door opening of locks.

The bottom of the lowest door opening of locks shall be no less than three feet above water level.

- (2) Where the working chamber is less than eleven feet in length, and the caisson is at any time suspended or hung while work is in progress so that the bottom of the excavation is more than nine feet below the deck of the working chamber, a shield shall be erected therein for the protection of the employees.
- (3) Shafting shall be subjected to a hydrostatic or air-pressure test, at which pressure such shafting shall be tight. Shafting shall be stamped on the outside shell about twelve inches from each flange to show the pressure to which it has been subjected.
- (4) Whenever shafting is used, it shall be provided, where space permits, with a safe, proper, and suitable staircase for its entire length, including landing platforms, no more than twenty feet apart. Where this is impracticable, suitable ladders shall be installed with landing platforms located about twenty feet apart to break the climb.
- (5) All caissons having diameter or side greater than ten feet shall be provided with a manlock and shafting for the exclusive use of employees.
- (6) In addition to the gauge in the locks, gauges shall also be maintained on the outer and inner side of each bulkhead. These gauges shall be accessible at all times and kept in accurate working order.
- (7) Where employees are exposed to compressed air working environments in caissons the requirements contained in paragraph (G) of this rule shall be complied with.

(F) Cofferdams.

- (1) If overtopping of the cofferdam by high waters is possible, means shall be provided for controlled flooding of the work area.
- (2) Warning signals for evacuations of employees in case of emergency shall be developed and instructions posted.
- (3) Cofferdam walkways, bridges, or ramps with no less than two means of rapid exit shall be provided and equipped with standard guardrails.
- (4) Cofferdams located close to navigable shipping channels shall be appropriately marked to protect them from vessels in transit.

(G) Compressed air.

- (1) General provision.

When work is in progress which requires employees to work in compressed air, there shall be present a representative of the employer, who is thoroughly trained and experienced in compressed air techniques.

- (2) Medical attendance, examination and regulations.

- (a) A licensed physician shall be designated for each job who is knowledgeable of compressed air work, who shall at all times be available for immediate service and who shall be responsible for all matters on the job pertaining to the health of employees, treatment on the job of illness and injuries, and medical and first aid equipment. The physician shall make all required physical examinations and shall make and sign all required reports of such examinations.
- (b) No employee shall be assigned to work in a compressed air environment until examined by the physician and reported to be physically qualified to engage in such work.
- (c) After being employed continuously in compressed air work for a period designated by the physician, but not to exceed one year, the employee shall be reexamined by the physician to determine if such employee is still physically qualified to engage in compressed air work.
- (d) An ambulance or transportation suitable for a litter case shall be provided at each project and at each portal of a project when the portals are more than five road miles apart.

- (e) A medical lock shall be established and maintained in immediate working order whenever air pressure in the working chamber is increased above the normal atmosphere.
- (f) Identification badges shall be furnished to all employees, indicating that the wearer is a compressed air worker. A permanent record shall be kept of all identification badges issued. The badge shall give the employee's name, address of the medical lock, the telephone number of the licensed physician for the compressed air project and contain instructions that in case of emergency of unknown or doubtful cause of illness, the wearer shall be rushed to the medical lock. The employer shall advise the employee to wear the badge at all times, off the job as well as on the job.

(3) Telephone and signal communication.

Effective and reliable means of communication, such as bells, whistles, or telephones, shall be maintained at all times between all the following locations:

- (a) The working chamber face;
- (b) The working chamber side of the manlock near the door;
- (c) The interior of the manlock;
- (d) The lock attendant's station;
- (e) The compressor plant;
- (f) The medical lock;
- (g) The emergency lock (if one is required); and
- (h) The special decompression chamber (if one is required).

(4) Signs and records.

- (a) The time of decompression shall be posted in each manlock as follows:

"Time of Decompression for this Lock"
pounds to.....pounds in.....minutes.
pounds to.....pounds in.....minutes.

--

(Signed by) _____

(Superintendent)

This form shall be posted in the manlock at all times.

- (b) Any code of signals used shall be conspicuously posted near workplace entrances and such other locations as may be necessary to bring them to the attention of all employees concerned.
- (c) For each eight-hour shift, a record of employees employed under air pressure shall be kept by another employee who shall remain outside the lock near the entrance. This record shall show the period each employee spends in the air chamber and the time taken for decompression. A copy shall be submitted to the appointed physician after each shift.

(5) Compression.

- (a) During the compression of employees, the pressure shall not be increased to more than three pounds per square inch gauge (p.s.i.g.) within the first minute. The pressure shall be held at three p.s.i.g. and again at seven p.s.i.g. sufficiently long to determine if any employees are experiencing discomfort.
- (b) After holding at seven p.s.i.g. the pressure shall be raised uniformly and at a rate not to exceed ten pounds per square inch (p.s.i.) per minute.
- (c) If any employee complains of discomfort, the pressure shall be held to determine if the symptoms are relieved. If, after five minutes the discomfort does not disappear, the lock attendant shall gradually reduce the pressure until the employee signals that the discomfort has ceased. If he does not indicate that the discomfort has disappeared, the lock attendant shall reduce the pressure to atmospheric and the employee shall be released from the lock.
- (d) No employee shall be subjected to pressure exceeding fifty pounds per square inch except in emergency.

(6) Decompression.

- (a) Decompression to normal condition shall be in accordance with the decompression tables in the appendix to this rule.
- (b) Except in emergencies no employee working in compressed air shall be permitted to pass from the place in which the work is being done to normal air pressure except after decompression in accordance with the decompression tables in the appendix to this rule.

(7) Compressor plant and air supply.

- (a) At all times there shall be a thoroughly experienced, competent, and reliable person, designated by the employer, on duty at the air control valves as a gauge tender who shall regulate the pressure in the working areas. During tunneling operations, one gauge tender may regulate the pressure in no more than two headings; provided, that the gauge and controls are all in one location. In caisson work, there shall be a gauge tender for each caisson.
- (b) The low air compressor plant shall be of sufficient capacity to not only permit the work to be done safely, but shall also provide a margin to meet emergencies and repairs.
- (c) Low air compressor units shall have no less than two independent and separate sources of power supply and each shall be capable of operating the entire low air plant and its accessory systems.
- (d) All high-and low-pressure air supply lines shall be equipped with check valves.
- (e) Low-pressure air shall be regulated automatically. In addition, manually operated valves shall be provided for emergency conditions.
- (f) The air intakes for all air compressors shall be located at a place where fumes, exhaust gases, and other air contaminants will be at a minimum.
- (g) Gauges indicating the pressure in the working chamber shall be installed in the compressor building, the lock attendant's station, and at the employer's field office.

(8) Ventilation and air quality.

- (a) Exhaust valves and exhaust pipes shall be provided and operated so that the working chamber shall be well ventilated, and there shall be no pockets of dead air.
- (b) The air in the workplace shall be analyzed by the employer no less than once each shift, and records of such tests shall be kept on file at the place where the work is in progress. The test results shall be within threshold unit values specified in "Appendix II," for hazardous gases, and within ten per cent of the lower explosive limit (see "Appendix III"), of flammable gases. If these limits are not met, immediate action to correct the situation shall be taken by the employer.

- (c) The temperature of all working chambers which are subjected to air pressure shall be maintained at a temperature not to exceed eighty-five degrees Fahrenheit.

(9) Electricity.

- (a) All lighting in compressed air chambers shall be by electricity exclusively, and two independent electric lighting systems with independent sources of supply shall be used. The emergency source shall be arranged to become automatically operative in the event of failure of the regularly used source.
- (b) The minimum intensity of light of any walkway, ladder, stairway, or working level shall be no less than ten foot-candles, and in all workplaces the lighting shall at all times be such as to enable employees to see clearly.
- (c) All electrical equipment, and wiring for light and power circuits, shall be suitable for use in damp, hazardous, high temperature, and compressed air environments.
- (d) External parts of lighting fixtures and all other electrical equipment, when within eight feet of the floor, shall be constructed of noncombustible, nonabsorptive, insulating materials, except that metal may be used if it is effectively grounded.
- (e) Portable lamps shall be equipped with noncombustible, nonabsorptive, insulating sockets, approved handles, basket guards, and approved cords.
- (f) The use of worn or defective portable and pendant conductors is prohibited.

(10) Fire prevention and protection.

- (a) Firefighting equipment shall be available at all times and shall be maintained in working condition.
- (b) While welding or flame-cutting is being done in compressed air, an employee with a fire hose or approved extinguisher shall stand by until such operation is completed.
- (c) Shafts and caissons containing flammable material of any kind, either above or below ground, shall be provided with a waterline and a fire hose connected thereto, so arranged that all points of the shaft or caisson are within reach of the hose stream.
- (d) Fire hose shall be no less than one and one-half inches in nominal diameter; the water pressure shall at all times be adequate for efficient operation of the type of nozzle used; and the water supply shall be such as to ensure an

uninterrupted flow. Fire hose, when not in use, shall be located or guarded to prevent damage thereto.

- (e) The power house, compressor house, and all buildings housing ventilating equipment, shall be provided with at least one hose connection in the waterline, with a fire hose connected thereto. A fire hose shall be maintained within reach of structures wood over or near shafts.
- (f) Tunnels shall be provided with a two-inch minimum diameter waterline extending into the working chamber and to within one hundred feet of the working face. Such line shall have hose outlets with one hundred feet of fire hose attached and maintained as follows: one at the working face; one immediately inside of the bulkhead of the working chamber; and one immediately outside such bulkhead. In addition, hose outlets shall be provided at two-hundred-foot intervals throughout the length of the tunnel, and one hundred feet of fire hose shall be attached to the outlet nearest to any location where flammable materials is being kept or stored or where any flame is being used.
- (g) In addition to fire hose protection required by this section, on every floor of every building not under compressed air, but used in connection with the compressed air work, there shall be provided at least one approved fire extinguisher of the proper type for the hazard involved. At least two approved fire extinguishers shall be provided in the working chamber as follows: one at the working face and one immediately outside the bulkhead (pressure side). Extinguishers in the working chamber shall use water as the primary extinguishing agent and shall not use any extinguishing agent which could be harmful to the employees in the working chamber. The fire extinguishers shall be protected from damage.
- (h) Highly combustible materials shall not be used or stored in the working chamber. Wood, paper, and similar combustible material shall not be used in the working chamber in quantities which could cause a fire hazard. The compressor building shall be constructed of noncombustible material.
- (i) Manlocks shall be equipped with a manual type fire extinguisher system that can be activated inside the manlock and also by the outside lock attendant. In addition, a fire hose and portable fire extinguisher shall be provided inside and outside the manlock. The portable fire extinguisher shall be the dry chemical type.
- (j) Equipment, fixtures, and furniture in manlocks and special decompression chambers shall be constructed of noncombustible material. Bedding, etc., shall be chemically treated so as to be fire resistant.

- (k) Head frames shall be constructed of structural steel or open frame-work fire-proofed timber. Head houses and other temporary surface buildings or structures within one hundred feet of the shaft, caisson, or tunnel opening shall be built of fire-resistant materials.
 - (l) No oil, gasoline, or other combustible material shall be stored within one hundred feet on any shaft, caisson, or tunnel opening, except that oils may be stored in suitable tanks in isolated fireproof buildings, provided such buildings are no less than fifty feet from any shaft, caisson, or tunnel opening, or any building directly connected thereto.
 - (m) Leaking flammable liquids shall be prevented from flowing into the areas specifically mentioned in the preceding paragraph.
 - (n) All explosives used in connection with compressed air work shall be selected, stored, transported, and used as specified in rule 4123:1-3-15 of the Administrative Code.
- (11) Bulkheads and safety screens.
- (a) Intermediate bulkheads with locks, or intermediate safety screens or both, are required where there is the danger of rapid flooding.
 - (b) In tunnels sixteen feet or more in diameter, hanging walkways shall be provided from the face to the manlock as high in the tunnel as practicable, with no less than six feet of head room. Walkways shall be constructed of noncombustible material. Standard railings shall be securely installed throughout the length of all walkways on open sides in accordance with rule 4123:1-3-04 of the Administrative Code. Where walkways are ramped under safety screens, the walkway surface shall be skidproofed by cleats or by equivalent means.
 - (c) Bulkheads used to contain compressed air shall be tested, where practicable, to prove their ability to resist the highest air pressure which may be used.

Effective: 1/1/11

Prior Effective Dates: 4/1/68, 11/1/79, 4/1/99