Table 25-1
Soil classification— Continued

Soil Type	Criteria	Other Considerations
Type C	Cohesive soil with an unconfined compressive strength of 0.5 tsf (48 kPa) or less.	Type C soil can also be: • Granular soils including gravel, sand, and loamy sand; • Submerged soil or soil from which water is freely seeping • Submerged rock that is not stable; or • Part of sloped, layered system where layers dip into excavation on a slope of 4H:1V or steeper. • Can NOT be benched!

Table 25-2
Maximum Allowable Slopes By Soil Type

Soil Type	Maximum Allowable Slopes (H:V)
Stable Rock	Vertical (90°)
Type A Soil	¾:1 (53°) or ½:1 (63°) short term*
Type B Soil	1:1 (45°)
Type C Soil	1½: 1 (34°)

*A short term (<24 hours) maximum allowable slope of ½:1 (63°) is allowed in excavations in Type A soil that are 12 feet (3.7 m) or less in depth.

25-10. Checklists and Forms.

Not Applicable.

Chapter 26
Underground Construction, Shafts, and Caissons

26-1. References.

a. ASME B31, Code for Pressure Piping (https://www.asme.org) (26-1.a)

b. EM 1110-1-2907, Rock Reinforcement (https://www.publications.usace.army.mil/USACE-Publications/Engineer-Manuals/) (26-1.b)

c. EM 1110-1-2908 Rock Foundation (https://www.publications.usace.army.mil/USACE-Publications/Engineer-Manuals/) (26-1.c)

d. EM 1110-2-2901, Tunnels and Shafts in Rocks (https://www.publications.usace.army.mil/USACE-Publications/Engineer-Manuals/) (26-1.d)

e. EPA National Pollutant Discharge Elimination System (NPDES) (https://www.epa.gov/npdes) (26-1.e)

f. NFPA 122, Standard for Fire Prevention and Control in Metal/Nonmetal Mining and Metal Mineral Processing Facilities (https://www.nfpa.org/Codes-and-Standards) (26-1.f)

g. NFPA 55, Compressed Gases and Cryogenic Fluids Code (https://www.nfpa.org/Codes-and-Standards) (26-1.g)

h. NFPA 70, National Electrical Code (https://www.nfpa.org/Codes-and-Standards) (26-1.h)

i. NFPA 1006 Standard for Technical Rescue Personnel Professional Qualifications (https://www.nfpa.org/Codes-and-Standards) (26-1.i)

j. UFC 3-601-02, Fire Protection Systems Inspection, Testing, and Maintenance (https://www.wbdg.org/ffc/dod/unified-facilities-criteria-ufc) (26-1.j)

k. UFGS 14 21 13, Electric Traction Freight Elevators (https://wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs) (26-1.k)

l. UFGS 14 21 23, Electric Traction Passenger Elevators (https://wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs) (26-1.l)

m. UFGS 14 24 13, Hydraulic Freight Elevators (https://wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs) (26-1.m)

n. UFGS 14 24 23, Hydraulic Passenger Elevator (https://wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs) (26-1.n)

o. UFGS 22 15 14.00 40, General Service Compressed Air Systems, Low Pressure (https://wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs) (26-1.o)

p. UFGS 22 15 26.00 20, High and Medium Pressure Compressed Air Piping (https://wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs) (26-1.p)

q. UFGS 31 63 26, Drilled Caissons (https://wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs) (26-1.q)

r. UFGS 31 68 13, Soil and Rock Anchors (https://wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs) (26-1.r)

s. UFGS 41 24 26, Hydraulic Power Systems (https://wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs) (26-1.s)

t. 29 CFR 1910.22, General Requirements (https://www.govinfo.gov/content/pkg/CFR-2020-title29-vol5/pdf/CFR-2020-title29-vol5-sec1910-22.pdf) (26-1.t)

u. 29 CFR 1910.1020, Access to Employee Exposure and Medical Records (https://www.govinfo.gov/content/pkg/CFR-2020-title29-vol6/pdf/CFR-2020-title29-vol6-sec1910-1020.pdf) (26-1.u)

v. 29 CFR 1926.55, Gases, Vapors, Fumes, Dusts, and Mists (https://www.govinfo.gov/content/pkg/CFR-2020-title29-vol8/pdf/CFR-2020-title29-vol8-sec1926-55.pdf) (26-1.v)

w. 29 CFR 1926.1052, Stairways (https://www.govinfo.gov/content/pkg/CFR-2020-title29-vol8/pdf/CFR-2020-title29-vol8-sec1926-1052.pdf) (26-1.w)

x. 29 CFR 1926.1413, Wire Rope Inspections (https://www.govinfo.gov/content/pkg/CFR-2020-title29-vol8/pdf/CFR-2020-title29-vol8-sec1926-1413.pdf) (26-1.x)

y. 29 CFR 1926 Subpart D, Occupational Health and Environmental Controls (https://www.govinfo.gov/content/pkg/CFR-2020-title29-vol8/pdf/CFR-2020-title29-vol8-part1926-subpartD.pdf) (26-1.y)

z. 29 CFR 1926 Subpart F, Fire Protection and Prevention (https://www.govinfo.gov/content/pkg/CFR-2020-title29-vol8/pdf/CFR-2020-title29-vol8-part1926-subpartF.pdf) (26-1.z)

aa. 29 CFR 1926 Subpart K, Electrical (https://www.govinfo.gov/content/pkg/CFR-2020-title29-vol8/pdf/CFR-2020-title29-vol8-part1926-subpartK.pdf) (26-1.aa)

bb. 29 CFR 1926 Subpart M, Fall Protection (https://www.govinfo.gov/content/pkg/CFR-2020-title29-vol8/pdf/CFR-2020-title29-vol8-part1926-subpartM.pdf) (26-1.bb)

cc. 29 CFR 1926 Subpart S, Underground Construction, Caissons, Cofferdams and Compressed Air (https://www.govinfo.gov/content/pkg/CFR-2020-title29-vol8/pdf/CFR-2020-title29-vol8-part1926-subpartS.pdf) (26-1.cc)

dd. 29 CFR 1926 Subpart U, Blasting and the Use of Explosives (https://www.govinfo.gov/content/pkg/CFR-2020-title29-vol8/pdf/CFR-2020-title29-vol8-part1926-subpartU.pdf) (26-1.dd)

ee. 30 CFR Part 49, Mine Rescue Teams (https://www.govinfo.gov/content/pkg/CFR-2020-title30-vol1/pdf/CFR-2020-title30-vol1-part49.pdf) (26-1.ee)

ff. 30 CFR Part 57, Safety and Health Standards for Underground Metal and Nonmetal Mines (https://www.govinfo.gov/content/pkg/CFR-2020-title30-vol1/pdf/CFR-2020-title30-vol1-part57.pdf) (26-1.ff)

26-2. Definitions.

a. Authorized Entrant (underground construction). An individual who has completed the requisite training (see para 26-3.a), is wearing appropriate PPE, and has been given permission by the employer to perform duties underground. (26-2.a)

b. Caisson. A wood, steel, concrete, or reinforced concrete, air and watertight chamber in which it is possible to work under air pressure greater than atmospheric pressure to excavate material below water level. (26-2.b)

c. Competent Person (CP). See paragraphs 1-2 or 2-2, as applicable. (26-2.c)

d. Designated Person. An employee who has been trained or is qualified and assigned the responsibility to perform a specific task. (26-2.d)

e. Drilling Fluid. An engineered fluid that is pumped into a drilled hole and used to wash cuttings from the hole. Drilling mud is a type of drilling fluid made of a slurry of clay or polymers and water that is used to coat and support the sides of the drill hole and seal off permeable strata. (26-2.e)

f. Face. The advance end or wall of a tunnel, drift, or other excavation where work is progressing. (26-2.f)

g. Heading. A wall of unexcavated rock at the advance end of a tunnel. Also used to designate either a small tunnel or a small tunnel driven as a part of a larger tunnel. (26-2.g)

h. Hoist. A machinery unit that is used for lifting or lowering a freely suspended (unguided) load. (26-2.h)

i. Jumbo. A movable machine containing working platforms and drills, used for drilling rocks and loading blast holes, scaling the face, or performing other work related to excavation. (26-2.i)

j. Qualified Person (QP), Underground Construction. One, who by possession of a recognized degree, certificate, or professional standing, or extensive knowledge, training, and experience, has successfully demonstrated the ability to solve or resolve problems related to the subject matter, the work, or the project. A typical QP for this

paragraph is an RPE, Geotechnical Engineer, Mining Engineer or Engineering Geologist certified or licensed as required by the AHJ for the site location. The term "Qualified Person (QP)," as used in this chapter refers to "Qualified Person, Underground Construction." (26-2.j)

k. Scaling. The removal of loose, overhanging, protruding, or otherwise precariously positioned material from above or along the sides of an excavation. (26-2.k)

l. Shaft. A passage made from the surface of the ground to a point underground that cuts through the ground at an angle greater than 20° to the horizontal. (26-2.l)

m. Spring Line. The point where the curved portion of the roof meets the top of the wall. In a circular tunnel, the spring lines are at opposite ends of the horizontal center line. (26-2.m)

n. Tunnel. An excavation beneath the surface of the ground, the longer axis of which makes an angle not greater than 20° to the horizontal. (26-2.n)

o. Tunnel Boring Machine (TBM). A machine that excavates a tunnel by drilling out the heading to full size in one operation. May also be referred to as a 'mole'. The TBM is typically propelled forward by jacking off the excavation supports emplaced behind it or by gripping the side of the excavation. (26-2.o)

26-3. Personnel Required Qualification/Training.

a. Authorized Entrants. Authorized Entrants must receive safety instruction in the recognition and avoidance of hazards associated with underground construction according to 29 CFR 1926.800 (29 CFR 1926 Subpart S), including all relevant plans according to paragraph 26-7. (26-3.a)

b. Designated Persons. Designated Persons must: (26-3.b)

(1) Receive Authorized Entrant training and be thoroughly familiar with the check-in and check-out system used at the site.

(2) Know how to activate the Rescue Team and other emergency services in the event of any emergency.

(3) Have a thorough understanding of the lighting, ventilation, communication, and any other life safety related systems and be able to take appropriate action in the event of any failure.

c. Rescue Team. Rescue Team personnel must be familiar with the site, kept up to date on current operations that may impact their response plan, and be fully trained

according to NFPA-1006 or an equivalent standard acceptable to the USACE supervisor/KO or COR. (26-3.c)

26-4. Roles and Responsibilities.

a. Designated Persons. The Designated Person is responsible for keeping an accurate accounting of employee's underground and promptly summoning aid in case of an emergency. They must remain above ground near the entrance at all times and must not be so busy with any other functions that these duties are encumbered. List exact duties in the site-specific APP, AHA, or equivalent documentation. (26-4.a)

b. Qualified Person (QP). (26-4.b)

(1) A QP must conduct inspections of the work site to ensure that any geology-related conditions are anticipated, recognized, evaluated, and corrected before they may present a hazard to occupants or property. The scope and frequency of these inspections must be included in the site-specific APP, or equivalent plan, and amended as necessary to ensure adequacy whenever conditions or work processes change.

(2) A QP must design or review all ground support systems, shoring, roof support systems, excavation methods, and rock bolt support systems.

(3) A QP must inspect underground supports in the blast area after each blast according to paragraph 29-8.h.

(4) A QP must prepare a Contingency Response Plan (CRP) plan according to paragraph 26-7.c.

(5) A QP must inspect air monitoring devices according to paragraph 26-5.a.

c. Competent Person (CP). (26-4.c)

(1) A CP is responsible for ensuring air quality meets the requirements in chapter 6 of this manual. Perform personnel and area air sampling for all contaminants realistically expected to be potentially present where personnel are working. Perform sampling at sufficient frequencies to ensure that conditions and exposures are well characterized. Any changes required in safety controls revealed by this data must be promptly addressed and implemented. The CP must have the authority to coordinate with the Designated Person to stop work and evacuate the work site when dangerous levels exceeding any IDLH or LEL thresholds are encountered.

(2) Conduct inspections of the roof, face, and walls of tunnels according to paragraph 26-5.e.

(3) Inspect and test ventilation systems according to paragraph 26-5.a.

d. Equipment Operator. Inspect equipment according to paragraph 26-5.a. (26-4.d)

e. Electricians. Inspect trucks used for underground transportation of explosives according to paragraph 26-5.c. (26-4.e)

f. An IH or specially trained CP must perform a review of the jobsite and worker activities when the tasks involve ergonomics-related risk factors, such as awkward postures, exposure to physical hazards, such as excessive vibration or noise, thermal stress, or exposure to fluids, including water. Address and mitigate the hazards to the greatest practical extent. (26-4.f)

26-5. Inspection Requirements.

a. Equipment. (26-5.a)

(1) The operator must inspect equipment that is powered or is important for life safety before use and at the beginning of every shift. This includes guards, shut-off switches, lighting, and other safety equipment. Equipment must not be operated if guards, interlocks, safety switches, or other safety features are inoperable or have been modified.

(2) Rescue Equipment. Conduct and document monthly inspections and workability tests of rescue equipment.

(3) Drilling Equipment. Periodically inspect drilling equipment, drift, and direction to assess if the work area or ground conditions have become unstable.

(4) Inspect rigging according to chapter 15 and 29 CFR 1926.1413.

(5) A CP must inspect and test ventilation systems according to the Ventilation and Dust Control Plan (see para 26-7.e).

(6) A QP must inspect air monitoring devices according to the manufacturer's instructions.

b. Pneumatic Lines. Routinely inspect hydraulic and pneumatic lines according to the manufacturer's instructions or the most applicable reference listed in paragraph 26-5. Remove any damaged or defective lines from service. (26-5.b)

c. Electrical Hazards. Electricians must inspect trucks used for the underground transportation of explosives for electrical system hazards such as stray currents. Auxiliary lights on truck beds that are powered by the truck's electrical system are not permitted. Keep the most recent written record of such inspections inside the vehicle and available for review. (26-5.c)

d. Ground Conditions. A QP must inspect ground conditions along underground haulways and accessways before initial entry by Authorized Entrants. The inspection frequency is as specified in the site-specific APP or equivalent documentation and must be modified whenever changes that may affect stability are encountered, or when warranted by a change in the construction methods being used. (26-5.d)

e. Tunnels. A CP must inspect the roof, face, and walls of the work area at the start of each shift and as often as necessary to determine the stability of the tunnel and adequate protection from falling material. (26-5.e)

f. Blasting. A QP must inspect the underground supports in the blast area after each blast according to paragraph 29-8.h. (26-5.f)

26-6. Activity Hazard Analysis (AHA) Requirements.
Develop AHAs according to paragraphs 1-6 or 2-6, as applicable, to include the following:

a. The AHA for powered equipment must include all aspects required to safely operate the equipment in an underground environment. For equipment that will only be operated by specifically trained and authorized personnel, this requirement may be met if adequately covered in their PHA. Address inherent crushing, caught between, and engulfment hazards for large and heavy equipment operations. (26-6.a)

b. Include in site-specific AHAs potential water related occupational health considerations such as hypothermia, tissue damage from chronic immersion, the growth of potentially pathogenic bio-organisms, and BBP exposure due to sewage. (26-6.b)

26-7. Minimum Plan Requirements.

a. Specific plans required for any work covered in this paragraph must contain the following information in addition to the other requirements listed for the specific plan. (26-7.a)

(1) Detailed Description of Task.

(2) Anticipated Hazards.

(3) Personnel Required Training/Qualification.

(4) Personnel Roles and Responsibilities.

(5) Inspection Requirements.

b. Compressed Air Work Plan (CAWP). A CAWP is required when compressed gases are used on a project or when gas cylinders are used or stored at the project site for more than 24 hours. Include the following considerations in the CAWP: (26-7.b)

(1) Medical lock and operation requirements.

(2) Compressed air workers identification system.

(3) Communications system requirements.

(4) Signs and recordkeeping requirements.

(5) Special compression and decompression requirements.

(6) Personnel lock and decompression chamber requirements.

(7) Compressor systems and air supply requirements.

(8) Ventilation requirements.

(9) Electrical power requirements.

(10) Sanitation considerations.

(11) Fire prevention and fire protection considerations.

(12) Bulkheads and safety screens requirements.

c. Contingency Response Plan (CRP). A CRP is required when it is anticipated that the construction of underground tunnels, shafts, chambers, passageways, or other structures covered under this paragraph will impact existing structures or facilities. A QP must prepare the plan and must address, at a minimum, the following: (26-7.c)

(1) Project overview, background, and need for a CRP.

(2) Interactions or stability of soil and/or rock masses.

(3) Hydraulic and hydrogeological impacts.

(4) Vibration induced impacts.

(5) Monitoring systems.

(6) Alert criteria and alarm levels.

(7) Contingency response required when alert criteria and alarm levels are reached.

d. Emergency Rescue Plans and Equipment. Provide emergency equipment specified in the plan within 15 minutes travel time of each portal or shaft entry.

Emergency rescue plans and equipment must be carefully detailed and must include the following considerations: (26-7.d)

(1) Primary and backup means of activation.

(2) Primary and backup means of communication.

e. Ventilation and Dust Control Plan. Develop and implement a Ventilation and Dust Control Plan for every underground construction project. The plan must adequately detail how acceptable breathing air quality will be maintained while also addressing specific controls for any particulate and gaseous contaminates present and must be amended accordingly. At a minimum it must include the following: (26-7.e)

(1) Site-specific work practices that will be implemented.

(2) Equipment required, including material and performance specifications.

(3) Methods and frequency to confirm proper operation.

(4) Controls required to mitigate special hazards (for example, use of water when drilling, cutting, or grinding rock, concrete, or masonry, and measures to comply with the silica exposure requirements of 29 CFR 1926.55).

f. Fire Prevention and Protection Plan. Develop and implement a Fire Prevention and Protection Plan for every underground construction project according to chapter 9. All affected personnel must review the plan as often as is necessary for them to maintain a working knowledge of emergency responsibilities and procedures. The plan must address the following: (26-7.f)

(1) Inspection requirements according to UFC 3-601-02.

(2) Specific work practices and controls to be implemented for fire prevention.

(3) Response measures taken to control and extinguish any fire that may occur.

(4) Requirements for daily and weekly fire prevention and protection inspections.

(5) The frequency of drills and training required to ensure continuous efficacy.

26-8. General Requirements.

Paragraph 26-8 applies to the construction of underground tunnels, shafts, chambers, and passageways. Paragraph 26-8 also applies to cut-and-cover excavations which are both physically connected to ongoing underground construction operations within the scope of this paragraph and covered in such a manner as to create conditions characteristic of underground construction.

a. Access and Egress. The Designated Person is responsible for controlling the access to all underground openings to prevent unauthorized entry. Authorized Entrant access must be coordinated and controlled according to OSHA requirements. Establish worker documentation procedures and a check-in/check-out system according to 30 CFR 57.11058. (26-8.a)

b. Tunneling in Soil. (26-8.b)

(1) Where tunnels are excavated by conventional methods, the excavation must not be extended more than 24 inches (61 cm) ahead of ground supports. Where continuous mining machines are used for tunnel excavation, the excavation must not be extended more than 48 inches (122 cm) ahead of ground supports.

(2) Do not permit under any circumstances persons to work in unsupported sections of the tunnels.

(3) All voids behind ground supports must be filled, blocked, braced, or treated to prevent further cave-ins.

(4) Where liner plate is not used for tunnel support, 2 inches (5.1 cm) wire mesh or chain-link fabric must be installed over the crown section, extending down to the spring line on each side of the tunnel and secured in place.

c. Shafts. (26-8.c)

(1) Shaft Support.

(a) Support all wells or shafts over 5 feet (1.5 m) in depth with lagging, piling, or casing of sufficient strength to withstand shifting of the surrounding earth.

(b) Support the full depth of the shaft by casing or bracing, except where the shaft penetrates into solid rock having characteristics that will not change because of exposure as determined by a QP.

(2) Unsupported Auger-Type Excavations. Do not permit employees to enter an unsupported auger-type excavation in unstable material for any purpose. In such cases, necessary clean-out must be accomplished without entry.

(3) Safe Shaft Access. There must be two safe means of access in shafts at all times. This may include a ladder and hoist.

d. Protection from Falling Material. (26-8.d)

(1) A CP must inspect the roof, face, and walls of the work area at the start of each shift and as often as necessary to determine the stability of the tunnel and adequate protection from falling material.

(2) Rock masses separated from the main mass by discontinuities must be secured by rock bolting, other suitable means, or must be removed. A geotechnical engineer, structural engineer or other QP must design the means of securing the rock masses.

(3) Provide anchored chain-link fabric, or other method approved by the USACE supervisor or accepted by the KO or COR, on rock faces subject to spalling.

(4) Where tunnels are excavated through earth or shale, any excavation above or adjacent to portal areas must be sloped to the angle of repose or held in place by ground supports. When undercutting occurs on these slopes, whether due to erosion or other causes, the overhanging material must be promptly removed.

(5) Provide a protective shelter at each underground portal to protect persons and equipment from the hazards of falling rock or other material, when necessary. The protective shelter must be made of sufficiently durable and strong material and sized appropriately based on work site conditions and risk. This determination must be documented in a site-specific APP, or equivalent document.

(6) Promptly remove ice or snow buildup on rock faces or earth slopes that create a hazard.

e. Ground Support Systems. A QP must design or review all ground support systems, shoring, roof support systems, excavation methods, and rock bolt support systems. Provide suitable protection for employees exposed to the hazard of loose ground while installing ground support systems. (26-8.e)

f. Hoisting. Hoist ways may be used to hoist materials or personnel, but not both simultaneously. (26-8.f)

g. Material Handling Equipment. (26-8.g)

(1) Mount a revolving, flashing amber light on all vehicles and mobile equipment required to move in and out of underground construction areas. Mount the light so that it is visible in all directions and must be operational whenever the vehicle or mobile equipment is in operation.

(2) Equip haulage equipment with two headlights at both ends, a back-up light, and an automatic back-up alarm.

(3) Where narrow-gage railroads are used for haulage, the tracks must be secured to prevent shifting. No “humping” of mine dump cars will be permitted.

(4) Locomotives and mine dump cars must be equipped with automatic safety couplings, and cradle cars must be equipped with a positive locking device to prevent accidental dumping.

(5) Do not operate haulage equipment at a speed that will endanger any employee.

(6) Operators must ensure that a clear line of sight exists to the entire area where a load will be dumped, directly or via a spotter that has coordinated clearance requirements and communication methods with the operator before dumping loads. All other personnel must remain clear of this area until dumping is completed, and the operator signals that access can be resumed.

(7) Keep vehicles not directly involved in work away from portals and separated from construction activities.

(8) Conveyors used to transport muck from tunnels must be installed, guarded, and maintained according to chapter 14. Provide fire extinguishers or equivalent protection at the head and tail pulleys of underground belt conveyors and at 300 feet (91.4 m) intervals along the belt line.

h. Waterborne Safety and Flood Prevention. (26-8.h)

(1) Water discharged from any underground or construction site must be tested and treated to ensure that it meets EPA NPDES and local authority discharge requirements, as appropriate.

(2) When the potential exists, water must be tested to ensure that it contains no hazards that may expose workers above any OELs according to chapter 6 of this manual.

(3) Take measures to prevent flooding whenever openings are located adjacent to sources of water that may cause flooding in the underground work area.

(4) Personnel working in wet underground areas must wear rubber boots and rain gear, as necessary.

i. Compressed Air Work. Perform work in compressed air environments according to 29 CFR 1926.803 (29 CFR 1926 Subpart S), to include development of a CAWP according to paragraph 26-7.b. (26-8.i)

j. Drilling. Drilling operations in this paragraph are described for activities relating to underground construction and include drilling associated with exploratory borings, blasting, ventilation, and access shafts. For drilling associated with other operations, such as wells, geotechnical studies, and soil studies, see chapter 18. (26-8.j)

(1) Drilling Area Preparation.

(a) Clear the drilling location of utilities in advance of drilling operations. Utilities in the area must be identified and marked prior to performing intrusive operations.

Drilling from surface locations may require clearance of overhead utilities. The mast or boom must be clear of overhead obstructions in all operational positions.

(b) Prepare the drilling surface to receive drilling tools. Clear loose material, scale, and other obstructions in advance of stationing the drilling equipment according to 29 CFR 1910.22.

(c) Place drill rigs and jumbos on stable and level surfaces to the extent possible. Drilling equipment that must be placed on sloping or unstable surfaces requires anchorage, outriggers, blocking, or construction of drilling platforms.

(c-1) All anchorage and blocking must be sufficient to maintain boring direction and stability of the equipment and working compartments or platforms. All elevated work platforms must comply with this manual, 29 CFR 1926 Subpart M and 29 CFR 1926.1052.

(c-2) Periodically inspect drilling equipment, drift, and direction to assess if the work area or ground conditions have become unstable. The work platform, blocking, or anchorage must be adjusted as necessary to maintain work area stability.

(2) Drilling Equipment Movement.

(a) Secure heavy equipment, drill masts, rigging, outriggers, pipe, and compartments prior to movement.

(b) Movement of drill rigs, jumbos, and other heavy equipment must be performed with personnel located only in covered or otherwise protected operator compartments and not located on surfaces or in compartments that are not designed for occupancy during travel.

(c) Personnel must be clear of the anticipated travel path. Spotters may be required to properly position equipment. Spotters must be positioned out of the direct travel pathway to the extent practicable.

(3) Jumbos.

(a) Provide safe access to all working levels of drill jumbos.

(b) Design and secure jumbo decks and stair treads to be slip-resistant and to prevent accidental displacement.

(c) Only employees assisting the operator will be allowed to ride on jumbos unless the jumbo is designed for passengers. The design must include adequate seating arrangements that protect passengers from being struck, crushed, or caught between equipment and surfaces, and must permit safe access.

(d) Notify employees working under jumbo decks whenever drilling is about to begin.

(e) On jumbo decks over 6 feet (1.8 m) in height where there is no adjacent surface that provides fall protection, install removable guardrails or equivalent protection on all open sides, excluding access openings of platforms (see chapter 21).

(f) Stair access to jumbo decks over 10 feet (3 m) in height must be wide enough to accommodate two persons.

(g) Provide receptacles or racks for drill steel stored on jumbos.

(h) The employer must provide mechanical means for lifting drills, roof bolts, mine straps, and other material to the top decks of jumbos over 10 feet (3 m) in height.

(4) Borehole Advancement and Casing.

(a) Barricade or otherwise protect accessible areas within the swing radius of the equipment's rotating superstructure to prevent an employee from being struck or crushed by the equipment.

(b) Ensure that personnel are guarded or kept a safe distance from rotating drill pipe, bits, collars, rod, and casing during operation. Operate the equipment from the cabin or in working platforms to the extent possible. Take additional precautions to protect personnel located within swing radius of articulating booms, tooling, or rigging, or within an area located where cuttings or drilling fluids accumulate. Additional precautions include having a safe egress/escape route, maintaining direct visual, verbal, or radio communication between equipment operators and personnel working within the vicinity, and wearing high visibility clothing.

(c) Handle and lift drill rods, pipe, casing, and other down-hole tooling based on the size and weight of the tooling and in a manner that reduces struck-by and lifting hazards.

(c-1) Move heavy pipe, rods, or tooling using mechanical equipment if the size and shape of the equipment is not safe for manual handling.

(c-2) Rigging must be inspected and appropriately sized in according to 29 CFR 1926.1413.

(c-3) Couple and decouple drill string tooling, drill rod, drill pipe, and casing with the equipment secured and with minimum movement of the equipment. Ensure that personnel keep a safe distance between hydraulically actuated or mechanized clamps, tongs, jacks, pipe stabber, pipe spinner, and rotating parts. Maintain drill rod, pipe, casing, and tooling in secure racks or compartments when not in use.

(d) Manage drilling fluids and cuttings to maintain borehole stability, jumbo or drill rig stability, and to prevent pressure releases that may damage equipment or injure personnel.

(d-1) Do not allow drilling fluids and cuttings to clog equipment lighting, safety devices, or guards, or to create obstructions in personnel or equipment travel paths.

(d-2) Secure drill fluid hoses, pipe, and tooling from whipping hazards and place them where they can be inspected for wear and leaks.

(d-3) Do not manually clear clogged fluid pipes, hoses, casing, or drill pipe unless the equipment can be safely depressurized and when access by personnel does not require entry into the borehole.

(d-4) Locate, to the extent possible, accumulation areas for cuttings and drilling fluids away from drilling equipment and personnel. Maintain drill fluid circulation equipment and pumps free of damage and be readily available for inspection during operation. Containerize or stockpile cuttings in a manner that does not create work area obstructions, or trip, air quality or engulfment hazards.

(e) Perform casing or securing of a boring or drill area with equipment that is selected to withstand the loads expected for that area.

(e-1) Temporary borehole casing may be placed with percussive methods only when such methods are not expected to destabilize working areas.

(e-2) Place casing jacks in level and stable areas that will not de-stabilize the rock face, drill rig or jumbo footings, or personnel work areas. Personnel must not place hands on the jacks when in operation.

(e-3) Perform permanent installation of conductor or borehole casing with concrete or other sealing media that will prevent leakage or de-stabilization by drilling fluids, circulated air, muck, or cuttings.

(5) Drilling After a Blast. Before commencing the drill cycle after a blast, examine the face and any remaining blasting holes for misfires. Remove the misfire prior to continuing drilling operations.

k. Electrical and Lighting. See chapter 7 for lighting and chapter 11 for electrical. (26-8.k)

(1) Install lighting circuits on one side of the tunnel near the spring line and mount the cables on insulators at each point of suspension.

(2) Properly design and maintain all electrical and lighting systems. Use only nonmetallic and waterproof fixtures mounted in a manner that provides safe clearance for personnel and equipment.

(3) Protect personnel from potential lighting hazards such as thermal burns and optical discomfort. Remove unused lighting and systems from the work area when no longer needed.

(4) All personnel working underground must carry functional lighting devices on their person to help locate the backup area emergency lighting devices or to facilitate their safe egress.

l. Fire Prevention and Protection. (26-8.l)

(1) Fire Extinguishers.

(a) Provide and maintain fire extinguishers according to chapter 9, to include necessary training requirements.

(b) Provide and maintain fire extinguishers, or equivalent protection, at each portal and shaft entry, within 100 feet (30.5 m) of the face of each tunnel, and at locations containing combustible materials.

(2) Within tunnels, use only heating devices approved for such locations by an NRTL.

(3) Only combustible materials similar to diesel fuel or approved welding/cutting gases may be stored underground. Store no more than a one-day supply of these combustible materials. Never store flammable products such as Liquefied Petroleum Gas or gasoline underground. Never pipe flammable or combustible materials from the surface to underground locations.

(4) Hazardous Classifications. Obtain a hot work permit according to paragraph 9-8.g and maintain a fire watch, according to paragraph 9-8.g, when hot work is performed, or an area is designated as a gassy operation.

m. Ventilation. (26-8.m)

(1) Provide ventilation and exhaust systems for tunnel excavation with sufficient capacity to maintain an adequate supply of uncontaminated air at all points in the tunnel. Use only mechanical ventilation. Do not use natural ventilation.

(2) Supply at least 200 CFM (94 Liters per second) of fresh air for each employee underground. Supply additional air necessary to operate the equipment.

(3) Do not use air that has passed through underground oil or fuel-storage areas or any other hazardous atmosphere to ventilate work areas. Design the ventilation system to exhaust from these spaces via ducting that is properly rated for this service.

(4) The USACE supervisor/KO or COR must review the ventilation system and performance, flow rates, and volumes before acquiring or installing the system or any components. After installation a CP must inspect and test the system as stated in the Ventilation and Dust Control Plan (see para 26-7.e). Keep records onsite and readily available for review until project completion.

n. Air Monitoring and Air Quality Standards. (26-8.n)

(1) Air Monitoring Requirements.

(a) A QP must inspect, calibrate, maintain, and use air monitoring devices according to the manufacturer's instructions. Devices must have sufficient limits of detection and resolution and be routinely calibrated to competently detect and display contaminant levels less than or equal to 50% of the applicable OEL.

(b) Maintain a record of all air quality tests above ground at the work site and make them available to any USACE supervisor/KO or COR upon request. Record the location, date, time, substance(s) monitored, applicable limits, monitoring results, and name of person conducting the test. Also record the instrument specific data such as serial number, calibration date, bump test results, etc. If the calibration or bump test information is recorded in a different record such as in an automated system, ensure both records contain a unique identifier that will link them. Retain records of personnel exposure to toxic substances according to 29 CFR 1910.1020. Maintain all air quality test records at the jobsite until completion of the project and according to DoD, U.S. Army, and USACE policies. Records of personal monitor results, used in addition to other devices and intended only to alert personnel directly, do not need to be maintained, however, the calibration, bump test, and other pertinent information must be recorded.

(2) Air Quality Standards.

(a) Implement appropriate control strategies to ensure that the 8-hour TWA personal exposures will be maintained below the most restrictive OEL according to 29 CFR 1926.55, or as referenced in chapter 6 of this manual. Perform monitoring prior to routine entry by other Authorized Entrants and at frequencies dictated in other regulations or site-specific policies. Perform routine monitoring at least once each shift in stable environments and more often when conditions are realistically expected to change. Continuous monitoring is preferred. The site-specific policies and procedures must be updated to reflect current site conditions.

(b) The OELs for some contaminants required to be monitored by 29 CFR 1926.800 (29 CFR 1926 Subpart S) (that is, hydrogen sulfide and nitrogen