

## Section 24

# Blasting Operations

This section discusses blasting operations, with specific focus on the following areas:

- General Requirements
- Radio and Electromagnetic Radiation
- Transporting Explosives
- Transporting Explosives Underground
- Storing Explosives
- Handling Explosives
- Loading Explosives and Blasting Agents
- Wiring operations
- Firing explosives
- Inspection following a blast
- Misfires
- Using safety fuses
- Using detonator cord
- Underwater blasting

### 24.1 General Requirements for Blasting Operations

In addition to the requirements of this section, the transportation, handling, storage, and use of explosives are subject to provisions of ANSI A10.7 - Safety Requirements for Transportation, Storage, Handling, and Use of Commercial Explosives and Blasting Agents; 29 CFR 1910.109 - Explosives and Blasting Agents; 29 CFR 1926, Subpart U - Blasting and the Use of Explosives (1926.900 to 1926.914); and 27 CFR Part 55 - Commerce in Explosives.

**24.1.1 Competent Supervision.** A blasting supervisor must be designated to direct and supervise all blasting operations. This includes the transportation, handling, storage, and use of explosives and blasting agents. The supervisor must provide written records of past experience to the employer as evidence of competency.

#### 24.1.2 Qualifications.

**a. Personnel.** Employees who transport, store, handle, or use explosives or blasting agents must be at least 21 years of age. They must be able to give and understand written and verbal instructions.

**b. Blasters.** Blasters must be qualified through training, knowledge, and experience in transporting, storing, handling, and using explosives, and have a working knowledge of State and local laws and regulations which pertain to explosives. Blasters must hold a Federal, State, or local license or certificate, have proof of formal training attended within the last 5 years, or three recommendations from past employers or explosives manufacturers testifying to the blaster's knowledge and ability to perform in a safe manner the type of blasting that will be required.

**24.1.3 Blasting Plan.** Submit a comprehensive blasting plan before the start of blasting operations and have it approved. The blasting plan may be submitted as part of the overall site safety plan, as required by the "Contractor Requirements" section of these standards (for contract operations) or as a supplementary plan to a Job Hazard Analysis. Explosives must not be transported onto the jobsite before the plan has been approved. The plan must identify proposed methods and procedures for conforming with referenced standards and regulations, and it must include the following information:

- Method and equipment for transporting explosives and detonators
- Type and location of storage facilities
- Type and quantity of explosives and detonators
- Primer assembly procedure and location
- Employee training programs
- Provisions for protecting people, structures, and private and public property
- Provisions for developing and distributing a daily blasting plan covering hole diameter, spacing, loading, and delay patterns
- Provisions for disposal of explosives, blasting agents, and associated materials

**24.1.4 Security and Inventory.** Secure and protect explosives from theft. Maintain an accurate running inventory of all explosives stored at the jobsite. Such records must be available. Promptly report any loss or theft to the appropriate authorities.

**24.1.5 Notifications.** Notify the owners and operators of the facility and take all necessary precautions for the safe control of the blasting operations before beginning blasting operations in the immediate vicinity of buildings, public roads, overhead powerlines, utility services, or similar facilities. At least 24 hours before blasting in the vicinity of gas, electric, water, communications, or other utilities is to begin, the blasting supervisor must notify appropriate utility representatives.

**24.1.6 Smoking Restrictions.** Prohibit smoking, firearms, matches, open flame lamps, fire, heat-producing devices, and sparks in or near explosive storage sites or in areas where explosives are handled, transported, or used.

**24.1.7 Thunderstorms.** Discontinue the handling or use of explosives during the approach and progress of a thunderstorm. All employees must leave the danger areas and seek a place of safety when these conditions are present. Install an approved lightning warning device capable of detecting atmospheric conditions that could produce lightning on the jobsite. Warning devices must be acceptable to the COR or office head before installation.

**24.1.8 Damage Control.** Take precautions to minimize ground vibration, airblast, and flyrock. Include a damage control section in the site blasting plan that addresses these issues. Use blasting mats where flyrock damage is possible. Use modern blasting seismographs and methods to measure ground vibrations and air blast levels at designated structures or locations. Unless otherwise specified, control the blasting so that ground vibrations and airblast levels do not exceed the following:

Ground Vibration Limits <sup>1</sup>		
Type of Structure <sup>2</sup>	Peak Particle Velocity (inches per second)	
	At Low Frequency <sup>3</sup> (<40 Hertz)	At High Frequency (>40 Hertz)
Modern homes, drywall interiors	0.75	2.0
Older homes, plaster on wood lath construction for interior walls	0.5	2.0

Reference: Siskind, D.E., M.S. Stagg, J.W. Kopp, and C.H. Dowding, "Structure Response and Damage Produced by Ground Vibration from Surface Mine Blasting." U.S. Department of the Interior, Bureau of Mines, Report of Investigations RI 8507, 1980.

<sup>1</sup>The graph in Appendix B of the above reference may be used in lieu of the limits listed in this table.

<sup>2</sup>For precarious structures not listed in the table, use the limits for older homes; for all other structures not listed in the table, use the limits listed for modern homes.

<sup>3</sup>All spectral peaks within 50 percent amplitude of the predominant frequency must be analyzed.

Airblast Limits	
Instrumentation	Air Blast (decibels)
0.1 hertz high-pass system	134
2 hertz high-pass system	133
5 or 6 hertz high-pass system	129
C-slow (for events not exceeding 2 seconds' duration)	105

Reference: Siskind, D.E., V.J. Stachura, M.S. Stagg, and J.W. Kopp, "Structure Response and Damage Produced by Airblast from Surface Mining," U.S. Department of the Interior, Bureau of Mines, Report of Investigations RI 8485, 1980.

**24.1.9 Warning Signs.** Post warning signs at access points to blasting areas.

**24.1.10 Destruction of Explosives.** Deteriorated or damaged explosives, blasting agents, blasting supplies are prohibited. Destroy and remove these and all excess explosives from the site in accordance with the specific written instructions of the manufacturer.

**24.1.11 Empty Explosive Containers.** Destroy empty boxes and combustible packing materials which have contained explosives in accordance with the manufacturer's disposal procedures. If disposal is through burning, all personnel must remain at least 100 feet from the burning site once the material has been ignited and until no visible flames or smoke have been detected for 1 hour.

**24.1.12 Fire.** If a fire begins that involves explosives, or where the danger of the fire contacting explosives is imminent, do not fight the fire. All personnel must seek safe shelter; guard the fire area to prevent intruders.

## **24.2 Radio and Electromagnetic Radiation**

Take adequate precautions to prevent accidental discharge of electric blasting caps from current induced by radar, radio transmitters, powerlines, and similar sources of electromagnetic radiation.

**24.2.1 Mobile Radio Transmitters.** Mobile radio transmitters or cellular telephones within 100 feet of electric blasting caps or delays not in their original containers are prohibited unless de-energized and effectively locked.

Post warning signs at least 36 by 42 inches in size, stating **BLASTING ZONE—TURN OFF 2-WAY RADIOS AND CELLULAR TELEPHONES**, on all public roads within 1,000 feet of blasting operations, using electronic detonators.

**24.2.2 Non-electric Firing Systems.** If it is not possible to observe the safe clearance distances from radio frequency (RF) transmitter stations, as set forth in Institute of Makers of Explosives (IME) publication 20, "Safety Guide for the Prevention of Radio Frequency Radiation Hazards in the Use Of Electric Blasting Caps," use nonelectric firing systems to blast. Electrical detonators must not be stored or used within the IME-specified distances of a transmitter station.

## **24.3 Requirements for Transporting Explosives**

Transporting explosives by air, water, or on public highways must comply with the provisions of US Department of Transportation Regulations contained in 46 CFR 146-149 - Water Carriers; 49 CFR 171-177 Subchapter C - Hazardous Materials Transportation; and 49 CFR 390-397, "Motor Carriers."

**24.3.1 Vehicles.** Vehicles used to transport explosives must conform to the following requirements:

- a. They must be in good repair, with all electrical wiring completely protected and securely fastened to prevent short circuits.
- b. They must have tight floors. Cover any exposed spark-producing metal with wood or other nonsparking material to prevent contact with containers of explosives.
- c. Do not load them beyond rated capacity, and secure the explosives to prevent shifting or dislodgment.
- d. Transport explosive materials in open-bodied motor vehicles only if they have been loaded into a portable magazine that is securely fastened to the truck bed. Never transport explosive materials in open-bodied motor vehicles that depend on a fire-resistant tarpaulin cover for protection.
- e. Mark vehicles transporting explosives with reflectorized signs on both sides and the front and rear with "EXPLOSIVES" in red letters. Make letters at least 4 inches high on a white background or placarded in accordance with 49 CFR Part 172, Subpart F - "Placarding."
- f. Equip them with two or more fire extinguishers with a rating of at least 2-A:40-B:C.
- g. Inspect them daily before use to ensure that the vehicle is in proper condition for safe transportation. The inspection must determine that fire extinguishers are charged and ready; electric wiring is protected and fastened to prevent short circuiting; chassis, motor, pan, and underbody are reasonably clean and free of oil and grease; fuel tanks and lines are secure and have no leaks; tires are in serviceable condition with proper inflation; and lights, brakes, horns, wipers, etc., are functioning properly.

**24.3.2 Vehicle Operators.** Motor vehicle operators transporting explosives must be at least 21 years old and be properly licensed drivers. Drivers must be physically fit, careful, capable, and reliable. Drivers must not be unlawful users of, or addicted to, alcohol, narcotics, or dangerous drugs. Drivers must be familiar with applicable local, State, and Federal laws and regulations governing the transportation of explosive materials. Transportation on Federal highways or other public roads requires a commercial driver's license.

**24.3.3 Caps and Detonators.** Do not transport blasting caps and detonators with other explosives unless the blasting caps or detonators are in a closed metal storage container that has at least a 2-inch wood lining. Such containers must be at least 2 feet away from other explosives.

**24.3.4 Flammable Materials.** Do not transport spark-producing tools, carbides, oil, matches, firearms, acids, storage batteries, oxidizing or corrosive compounds, or flammable materials with explosives.

**24.3.5 Parking.** Attend vehicles containing explosives at all times. Do not park loaded vehicles, even if attended, near any bridge, tunnel, or other structure that may be occupied or locations where people may congregate or assemble.

**24.3.6 Fueling.** Do not refuel vehicles while they are carrying explosives.

**24.3.7 Smoking Restrictions.** Employees who transport, handle, or use explosives must not smoke or carry on their persons or in the vehicle matches, lighters, firearms, ammunition, or flame-producing devices of any description.

**24.3.8 Riders.** Permit only the authorized driver and helper to ride on trucks transporting explosives or detonators.

## **24.4 Requirements for Transporting Explosives Underground**

In addition to the requirements set forth in the previous subsection, "Requirements for Transporting Explosives," the provisions of this subsection apply to underground transportation of explosives.

**24.4.1 Hoists.** Notify the hoist operator before transporting explosives or blasting agents in a shaft conveyance. Do not permit any person to ride a hoist or shaft conveyance transporting explosives or blasting agents. Do not transport detonators while transporting explosives.

**24.4.2 Powder Cars and Trucks.** Convey explosives and blasting agents only in specifically built or equipped insulated powder cars or truck-mounted containers approved by the State entity having jurisdiction. Mark powder cars with reflectorized signs on both ends and sides with "EXPLOSIVES" in letters at least 4 inches high against a sharply contrasting background at all times that there are explosives in the car. Cover or remove the signs when no explosives are present. Do not transport explosives or blasting agents on a locomotive; at least two car lengths must separate the locomotive from the powder car. Pull (do not push) powder cars.

### **24.4.3 Common Transport of Detonators and Explosive Materials.**

Physically separate compartments for transporting both detonators and explosive materials in the same conveyance or car by at least 24 inches or by a solid partition at least 6 inches thick. Do not transport detonators and other explosive materials together in any shaft-conveyance.

**24.4.4 Transportation of Personnel and Explosives.** No personnel, other than the transport operator, helper, and the individuals handling the explosives may ride transports carrying explosives.

**24.4.5 Truck Transportation.** Trucks transporting explosives underground must meet other applicable provisions of these standards and have their electrical systems checked weekly to detect possible electrical hazards. A written record of

such inspections must be maintained. Auxiliary lights on truck beds powered by the truck's electrical system are prohibited. Do not store explosives in trucks.

**24.4.6 Transporting Explosives to the Face or the Loading Area.** Take only the quantity of explosives or blasting agents estimated necessary for the blast to the face or loading area. Take explosives or blasting agents to the loading area only after the drilling has been completed and the holes are ready to be loaded. Remove surplus explosives and blasting agents from the area before wiring up the blast.

**24.4.7 Makeups.** Make up primers and delays at the face or loading area, unless a primer-makeup plan is submitted and approved.

## **24.5 Explosives Storage**

**24.5.1 Requirement.** Store explosives and related materials in approved magazines and in accordance with the applicable provisions of the Bureau of Alcohol, Tobacco, and Firearms as set forth in 27 CFR 55, "Commerce in Explosives." Magazines must be bulletproof, rodent-resistant, weather-resistant, ventilated, and constructed to the standards of the Bureau of Alcohol, Tobacco, and Firearms, or the Institute of Makers of Explosives.

**24.5.2 Magazine Location.** Locate explosives magazines in accordance with the State and local laws. The COR or office head must approve the proposed sites before location or construction. Consider contractor and Government offices, shops, etc., to be inhabited buildings when determining magazine locations, quantities, and safe distances.

**24.5.3 Notifications.** Notify local authorities, such as law enforcement agencies and fire departments, of the type, planned quantity, and storage location on the site before bringing explosives onto a site for storage.

**24.5.4 Detonators.** Do not store blasting caps, electric blasting caps, detonating primers, and primed cartridges in the same magazine as other explosives or blasting agents. Locate detonator magazines at least 100 feet from magazines containing other explosives or blasting agents, if unbarricaded, and at least 50 feet away, if barricaded.

**24.5.5 Combustible Materials.** Do not permit smoking or open flame within 100 feet of storage magazines. Remove vegetation and combustible material within 25 feet of all magazines.

**24.5.6 Security.** Securely lock magazines at all times except to inspect or move explosives. Maintain an inventory of all storage and withdrawal of explosives. Inspect magazines storing explosives at least every 7 days to ensure that there has been no unauthorized entry or removal of explosives.

**24.5.7 Posting.** Post areas around magazines with "EXPLOSIVES" signs. Place the signs so that a bullet passing through the sign will not strike a magazine.

**24.5.8 Storage.** Store explosives in their original containers. Store containers of explosives with the top side up as designated on the container. Use the oldest stock of explosives first.

**24.5.9 Maintenance.** Promptly remove debris and combustible material from magazines. When magazine floors become stained with explosives, clean them in accordance with the explosive manufacturer's instructions.

**24.5.10 Transfer In and Out.** Provide for the safe transfer of explosives in and out of magazines, including providing ramps or walkways, as necessary.

**24.5.11 Storage Underground.** Do not permanently store explosives underground. Temporary storage must comply with the following requirements:

**a. Powder Cars.** Restrict temporary storage to limited supplies stored in specially designed powder cars located at least 1,000 feet from the face or blasting area. Do not permit transformers, storage of flammable materials, welding, open flame, smoking, and other ignition sources within 100 feet of the powder car.

**b. Posting and Lighting.** Designate the storage area or siding by a red light visible in all directions, and post both ends of the powder car with a luminous sign, stating "EXPLOSIVES - NO SMOKING, FLAME, OR WELDING WITHIN 100 FEET."

**c. Protection.** Locate or barricade the powder car to protect it from damage. Design siding or car-passes, when used for temporary storage, to protect the powder car from accidental entry by other cars and to prevent accidental entry of the powder car to the main line. The protective devices installed are subject to approval of both the employer and the State entity having jurisdiction.

## **24.6 Requirements for Handling Explosives**

**24.6.1 Handling Explosives.** Handle explosives carefully. Do not drop, throw, or slide them. Carry detonators, primers, and other explosives in separate containers when transporting them manually. When they are not in their original containers, place them in a suitable nonmetallic container for manual transportation.

**24.6.2 Removal from Containers.** Remove explosives from their original containers only as needed for immediate use. Use only nonsparking tools or devices to open such containers. Dispose of empty containers and packing in accordance with the manufacturer's recommendations, or promptly burn them in an approved location.

## 24.7 Loading Explosives and Blasting Agents

**24.7.1 Planning.** Plan and schedule excavation so that drilling and loading operations will not conflict. Do not permit loading within 50 feet of drilling operations. Do not permit any activity, other than that which is required for loading holes, within 50 feet of loaded holes or holes that have the explosives in place, ready to load. A qualified blaster must supervise loading operations.

**24.7.2 Drilling.** Do not drill in an area already blasted until examining remaining "bootlegs" (holes that do not detonate full depth) for unexploded charges, as well as the total area, to make sure no unexploded charges remain. Do not insert drills, picks, or bars into bootlegs, even if examination fails to disclose explosives.

**24.7.3 Loading Areas.** Make boreholes ready for loading, and remove equipment and tools not used for loading from the area before delivering the explosives to the site. Isolate the loading areas with appropriate signs or temporary barricades to prohibit access by unauthorized people. While the boreholes are being loaded with explosives, exclude all personnel, other than those involved in the loading of boreholes, from the blast site.

**24.7.4 Boreholes.** Make boreholes large enough to permit loading of cartridges and explosives without forcing. Prime, load, tamp, and fire as promptly as possible with a minimum of exposure to personnel.

**24.7.5 Tamping.** Tamp only with wooden or plastic tamping poles without exposed metal parts. Nonsparking metal connectors on jointed poles are permissible. Seat cartridges by even, steady pressure, and do not tamp primers.

**24.7.6 Priming.** Follow the manufacturer's recommendations in priming cartridges. Make primers up only at the loading area and in quantities limited to the number required for a single round of blasting.

**24.7.7 Stemming.** Stem all blastholes in open work with noncombustible material to the collar or to a point that will confine the charge.

**24.7.8 Extraneous Electricity.** Prohibit electric conductors, electric equipment, and all sources of ignition in or adjacent to the loading area. Remove lights 50 feet from the face before starting to load in tunnels and shafts. If stray currents are suspected, thoroughly check out the area with suitable instruments. If stray currents cannot be eliminated, use nonelectrical detonators, delays, and caps.

**24.7.9 Shunts.** Do not remove the manufacturer's shunt from the cap leg wires until you complete loading and connect the cap into the blasting circuit.

**24.7.10 Sprung Holes.** Do not chamber (spring) boreholes.

**24.7.11 Blasting Mats.** Where blasting may expose personnel or property to injury or damage from flying material, cover the charges with blasting mats. Carefully protect the blasting circuits, and do not permit the circuits to contact steel mats.

**24.7.12 Loading and Shooting.** Do not leave loaded holes unattended or unprotected. If possible, fire all holes loaded on a shift during that same shift. If it is necessary to delay firing because of an emergency, isolate the area and post watchpersons to prevent entry to the area. Conduct aboveground blasting operations between sunup and sundown.

**24.7.13 Pneumatic Loading Systems.** Conduct the hazards from static electricity and stray currents associated with pneumatically loading boreholes with blasting agents, take the following precautions:

- a. Use only approved pneumatic loaders.
- b. Effectively ground and bond the entire system, including placers, valves, and loading hose. Ground at the face in tunnels and shafts. Do not use piping and rails to ground the system.
- c. Following installation of the ground, check the ground with an approved meter to ensure that the resistance is within safe limits.
- d. Use loading hoses of an approved, nonsparking, semiconductive material designed to maintain static electricity within safe limits.

**24.7.14 Underground Use of Blasting Agents.** Before using blasting agents underground, a powder technician representing the explosive manufacturer or supplier must inspect the proposed method of loading and the loading equipment. Submit written evidence of such inspection and approval of the systems.

## **24.8 Wiring Operations**

**24.8.1 Firing Devices.** Use an electric blasting machine to fire blasts using electronic detonators. Do not fire blasts by connection to any other electrical system. Fire blasts using nonelectric detonators with a blasting machine or starting device prescribed by the detonator manufacturer. Do not use cap and fuse firing underground or in the excavation of shafts. Do not use electric blasting caps within 500 feet of energized high-voltage lines or facilities.

**24.8.2 Wiring Procedure.** Do not remove the manufacturer's shunt from the cap leg wires until the cap has been connected to the leadlines or to another cap in preparation for the assembly of two or more caps into a single series. When firing two or more series of caps as a series-parallel system, make sure that the caps in each series are the same in number (quantity, not delay periods), and test each series separately with an approved blasting galvanometer to: (1) ensure that the

series is complete, and (2) ensure that each series has the same resistance and that the resistance is close to the calculated resistance for the series. If the first reading indicates an incomplete circuit, locate the fault and correct it. If the second reading indicates a higher or lower resistance than calculated, correct the situation before final hookup and firing.

**24.8.3 Electric Caps and Delays.** All caps and delays in a shot must be made by the same manufacturer, and the number in a circuit must not exceed the capacity of the blasting machine or power source.

**24.8.4 Galvanometer Testing.** Make the following tests with an approved blasting galvanometer during all wiring operations:

- (1) Test the circuit, including all caps, before connecting it to the firing line.
- (2) Check the firing line before connecting it to the blasting machine or power source.

**24.8.5 Firing Lines.** Firing lines must be of sufficient current-carrying capacity but not smaller than No. 14 gauge solid copper wire or equivalent. Do not connect the firing line to the blasting machine or power source until you have completed and tested the wiring and cleared the blast area. Do not ground a power circuit used for firing electric blasting caps.

**24.8.6 Connecting and Lead Wires.** Connecting and lead wires must be insulated single solid wires of sufficient current-carrying capacity.

**24.8.7 Power Circuit.** When using a power circuit for firing, lock the firing switch in the "OFF" (open) position at all times, except when firing. Design the power circuit so that the firing lines to the cap circuit are automatically short-circuited when the switch is in the "OFF" position. Entrust the keys to the firing switch only to the blaster. In underground operations, the firing circuit must have a "lightning" gap of at least 5 feet, located between the firing switch and the source of power. Bridge the gap with a flexible jumper cord just before firing the blast.

## 24.9 Firing

**24.9.1 Preparation.** Before connecting the firing line to the power source, notify all personnel in the danger area of the blast and remove them to a safe area. Make satisfactory arrangements for evacuating the danger area and ensuring that no one enters the area before the blast.

**24.9.2 Responsibility.** The blaster must be in charge of the blasting machine or firing switch, and must connect the firing line to the firing device. The blaster must make all connections from the cap circuit back to the firing device, and the firing line must remain shorted until connected to the firing device immediately before firing.

**24.9.3 Blasting Signal.** Sound the following blasting signal on a clearly audible whistle, horn, or siren before each surface or underground blast:

- Blasting warning: A 1-minute series of long blasts 5 minutes before the blast signal
- Blast signal: A series of short blasts 1-minute before the shot
- All clear: A prolonged blast following inspection of the blast area

**24.9.4 Posting Blasting Signals.** Post blasting signals at all access points, and before each shot, post competent flagpersons at all access points to the danger area.

**24.9.5 Disconnecting.** Immediately following the blast, disconnect the firing line from the firing power source or blasting machine and shunt it. Lock firing switches open.

## **24.10 Inspections Following a Blast**

**24.10.1 All Blasts.** Before the all-clear signal, the blaster must thoroughly inspect to determine if all charges have fired. The blaster must carefully check wires and search for unexploded charges.

**24.10.2 Underground.** In addition to the previously listed requirements, check and test the heading for adequate ventilation and safe concentrations of dusts, toxic vapors, and gases. Also, before permitting personnel in the heading, scale the face and make it safe.

**24.10.3 All-Clear Signal.** Sound the all-clear signal only after satisfactorily completing the inspection.

## **24.11 Requirements Regarding Misfires**

If you suspect or find a misfire, keep all personnel, except the blaster and employees necessary to handle the misfire, out of the danger area. Prohibit all work in the danger area except that necessary to remove the misfire hazard. If a misfire occurs while using cap and fuse, all personnel must remain at a safe distance from the charge for at least 1 hour. If other electric or nonelectric initiating methods are used, the blasting supervisor may reduce the waiting period to 30 minutes.

**24.11.1 Refiring.** Refiring is the desired method of clearing misfires. The following actions are mandatory:

- a. For electrically fired blasts in which broken wires or faulty connections caused the misfire, make repairs, reconnect the firing line, and attempt to fire the charge.
- b. For misfires originally initiated by detonating cord or nonelectrical detonators, the blaster must inspect lines coming out of the holes, and if

they appear to be intact, the blaster can reconnect them and attempt to detonate the misfired holes.

c. In blastholes where leg wires are discontinuous or leads or detonating cord cut off, there may still be explosives in the hole that can be reprimed and fired. Remove any stemming in the hole. Float stemming out with water. Place a new primer in the hole and attempt to fire the charge.

**24.11.2 Removal of Explosives.** This procedure must be the last resort. Perform it only when refiring has failed or when refiring would present a hazard. Remove explosives by washing them out with water, or, if the misfire is underwater, blow them out with air.

**24.11.3 Work Restrictions.** Do not permit drilling, digging, or picking until: (1) you have detonated all missed holes or removed the explosive, and (2) the blaster has approved the resumption of work.

## **24.12 Requirements for Using Safety Fuses**

Use safety fuses only where sources of extraneous electricity make the use of electric caps dangerous. Do not use damaged fuse or fuse with sharp kinks.

**24.12.1 Capping.** Before capping a safety fuse, cut a short length from the end to ensure a fresh-cut end in each blasting cap.

**24.12.3 Crimper.** Use cap crimpers of approved design for attaching blasting caps to safety fuse.

**24.12.4 Length of Fuse.** The minimum length of safety fuse must be as required by State law, but it must not be less than 30 inches. Provide the blaster sufficient time to permit the blaster to reach a place of safety.

**24.12.5 Multiple Cap and Fuse Use.** At least two blasters must be present when multiple cap fuse blasting is done by hand lighting methods. Each blaster must light no more than 12 fuses when using hand-lighting devices.

**24.12.6 Mudcapping.** Do not use cap and fuse to fire mudcap charges unless you separate the charges sufficiently to prevent one charge from dislodging other shots in the blast.

## **24.13 Use of Detonating Cord**

**24.13.1 Care in Use.** Use only detonating cord consistent with the type and physical condition of the borehole, stemming, and the type of explosive. Consider and handle detonating cord in the same manner as other explosives.

**24.13.2 Installation.** Cut the line of detonating cord extending out of a borehole or from a charge from the supply spool before loading the remainder of the hole or placing additional charges. All runs must be free of loops, sharp kinks, or angles that take the cord back toward the oncoming line of detonation.

**24.13.3 Connections.** Detonating cord connections must be competent and positive and in accordance with approved and recommended methods. Make knot-type or other cord-to-cord connections only with detonating cord in which the explosive core is dry. Inspect connections before firing.

**24.13.4 Use of Delays.** When using detonating cord millisecond-delay connectors or short-interval-delay electric blasting caps with detonating cord, follow the manufacturer's recommendations.

**24.13.5 Connecting Blasting Caps.** When connecting blasting caps to detonating cord, tape or otherwise attach the cap securely along the side or the end of the cord, with the end of the cap containing the explosive pointed in the direction in which the detonation is to proceed.

**24.13.6 Detonators.** Do not bring detonators for firing the trunkline to the loading area, and do not attach the detonating cord until everything else is in readiness for the blast.

## **24.14 Underwater Blasting**

**24.14.1 Supervision.** A competent blaster must conduct all blasting operations. Do not fire any blast without that person's approval.

**24.14.2 Loading Tubes.** Do not use loading tubes and casings of dissimilar metals for electric or other stray-current-affected detonators or explosives. When tubes are necessary, load these electrically affected devices through nonsparking loading tubes.

**24.14.3 Detonators.** For underwater blasting operations, use only water-resistant blasting caps and detonating cord or other detonators and/or firing systems and methods approved by the manufacturer.

**24.14.4 Marking Charges.** When placing more than one charge underwater, attach a float device to an element of each charge so that it will be released by the firing. Handle misfires using precautions and procedures in this section.

**24.14.5 Blast Warning.** In addition to the standard audible blast warning, display blasting flags.

**24.14.6 Boats in Area.** Do not fire blasts while any vessel underway is within 1,500 feet of the blasting area. Notify those onboard vessels moored or anchored within 1,500 feet before the blast is fired.

**24.14.7 Swimming and Diving.** Do not fire blasts when swimmers or divers are in the vicinity and exposed to injury from the blast.