

TRAINING MANUAL
CERTIFICATION OF SHOTFIRER

PREFACE

During recent years the number of accidents in the use of explosives have increased throughout the West Kentucky District of the Commonwealth. There has been progress made in this direction toward safety largely due to a concerted effort of the Mining and Enforcement Agencies, coal mining companies and labor organizations, the mutual cooperation of all the individuals engaged in the production of coal. However, we feel that if all persons handling explosives should be well trained and instructed so they can do their job, well and more efficiently. Most accidents with explosives occur in the careless handling and use of these elements.

Initiating Devices – These consist of two categories, electric devices, and non-electric devices. This manual will deal with the former. One (1) initiate charges of explosives, two (2) transmit from one point to another or from one charge of explosives to another, when fired with an electric current.

Basically, all electric blasting caps consist of a metal shell into which are loaded several powder charges and an electrical ignition element attached to a pair of insulated wires called leg wires. The powder charge consists of a base load of high explosive, a primer load, and an ignition load in which the electrical ignition element is imbedded. The electrical ignition element is a short length of high resistance wire which is welded across the end of the leg wires forming a bridge, hence the name “Bridge Wire.” A rubber plug which surrounds the leg wires just above the bridge wire is securely crimped in the end of the shell. This forms a highly water-resistant closure and firmly positions the bridge wire in the center of the ignition mix. When sufficient energy passes through the electrical system, the bridge wire becomes hot enough to ignite the ignition mix which in turn causes the primer charge to detonate, which initiates the high explosive base charge. A fourth component, the delay charge, is interposed between the ignition mix and the primer charge. The delay charge requires a definite period of time to burn, and this gives a predetermined delay interval between the application of the electric current and the detonation of the cap.

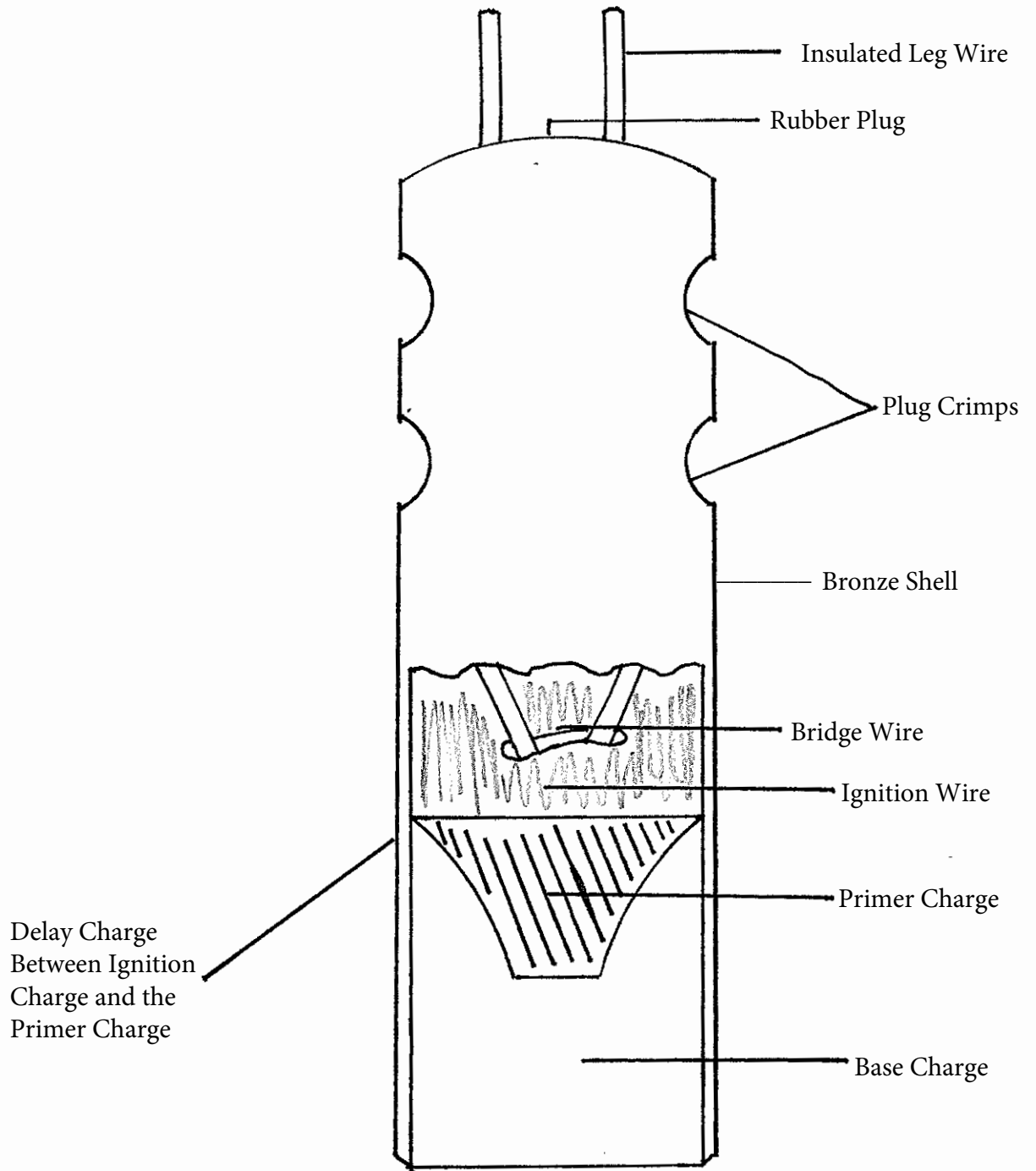


Figure (1)

Iron wire instantaneous # 6 E. B. blasting cap – For use in underground coal mines. This cap as well as all underground blasting caps are made with a bronze shell and iron leg wires. One wire has light blue insulation and the other has light orange insulation for good visibility against the coal.

There are four (4) coal mine delay E. B. Caps other than the instant cap described in figure (1) that are approved for use in underground coal mines. They are a special series of millisecond delay caps designed for use in coal mines. They are available only with bronze shells and iron leg wires. Four standard delay intervals are provided: 25, 100, 175, and 250 milliseconds. These are numbered consecutively 1 through 4. The sequence number is shown on the paper band which surrounds the figure-8-fold, and, in addition, the leg wire insulation is color coded to the sequence number: on Period 1 caps, both leg wires are white, on Period 2, they are pink; Period 3, blue; and Period 4, orange. Leg wires are available in standard lengths from 6 to 20 feet.

Note: Instant caps cannot be fired with the Period 1 caps as there is not a 75-millisecond delay between shots.

Instant Caps	Delay 0	Color Code Light Blue & Light Orange
Period #1	25 Milliseconds	Both White
Period #2	100 Milliseconds	Both Pink
Period #3	175 Milliseconds	Both Blue
Period #4	250 Milliseconds	Both Orange

The leg wires of all blasting caps are insulated with plastic, which provides an outstanding combination of insulating efficiency, abrasion resistance and flexibility. This wire covering is brightly colored to provide maximum visibility even under poor

lighting conditions. It is important that electric blasting caps be protected from extraneous electricity, which might cause accidental initiation.

An important safety measure in this respect is a short-circuiting device (shunt) provided on the free ends of the leg wires so that an unwanted current cannot flow through the bridge circuit. The shunt consists of aluminum foil with a coating of cellophane on one side, wrapped on the bare leg wires with the cellophane coat next to the wire. It extends from a position well up on the leg wire insulation to at least 1/8 inch beyond the ends of the wire. This shielded shunt forms a short circuit of the leg wires through the entire length of their bared ends and, in addition, insulates the wires against contact with electric currents. For maximum protection, the shunt should not be removed from an E. B. cap until connecting the wires into a blasting circuit. The shunt is easily removed by simply pulling the wires apart. The leg wires are folded in a figure-8-fold secured with a paper band. The band is easy to tear off and the wires then unfold without tangling or kinking. On the paper band will denote the series of the cap.

HAZARDS OF ENTRANEIOUS ELECTRICITY: Two categories (1) nature and (2) man made. Nature – lightning, static and galvanic action. Man-made – radio frequency, currents, static generators, and stray ground currents. The maximum current that can be tolerated is 0.05 ampere, or one-fifth of the minimum firing current for commercial blasting caps (0.25 ampere). Never test a blasting cap other than an approved blasting galvanometer.

FACE PREPARATION: Face preparation is the most important key to good coal mining efficiency. Bottom-cutting is especially suitable where the bottom of the seam consists of fire clay or other types of materials that are soft. The bug dust is dragged back under and packed into the kerf (cut) and must be moved either mechanically or by hand shoveling. When the kerf is not completely clean, more explosives are required to adequately displace the coal. With the need of added expansion room when using long cutting bars double undercutting (braiding) is commonly used and especially in extreme pitching seams. The importance of accurate cutting cannot be over emphasized. All cuts should be square, and every effort should be made to avoid "gripping" the ribs.

DRILLING: Proper drilling with accurate alignment of the holes is essential to good blasting. When holes are properly located and the depth and alignment are accurately controlled, fewer holes and less explosives will be required to displace the coal for efficient loading. Before drilling, the depth and direction of the cut should be established with a tamping stick in order to determine the correct depth and alignment for each hole. The holes should never be drilled beyond the depth of the cut. They should never be drilled deeper than the cut nor gripped into the ribs. The placement of holes will vary with the individual seam. However, the holes should be drilled (1) the maximum distance from the ribs at which the explosive charge will shear the ribs, usually 6 to 18 inches, (2) no deeper than necessary to shear the cut (a depth of six inches less than the cut will usually pull full depth), (3) parallel to the line of sights (i.e., the direction in which the room or entry is being advanced). At

least 18 inches of burden is required by law and usually considerably more can be allowed for each hole. Holes should be spaced to ensure that one does not rob the other and that the explosive charges will be adequately confined for maximum efficiency and safety.

STEMMING: One of the requirements is that explosive charges be stemmed or confined in the hole with incombustible material. Damp clay, sand, limestone dust ("rock-dust") or water-filled plastic bags. Regardless of the type of stemming used, it is imperative that charges be completely confined to eliminate any open flame from the shot and to utilize the maximum amount of energy produced.

ORDER OF FIRING: The use of coal mine delays will result in better fragmentation by allowing sufficient time for the coal from each hole to be displaced before the next hole fires. By allowing the burden on each hole to move before the next hole fires, a better shearing action is achieved. The details in the matter of firing electrically, should be studied by anyone contemplating multiple shooting. Electric blasting caps should be connected in series and energized through a well-insulated shot firing cable of at least 16-gauge copper wire.

SAFETY PRECAUTIONS: There may be more items of safety than listed below, but, these will be helpful unto you in the safe performance of your job.

Upon entering your working place, examine the roof and check for explosive gas. Be sure to watch out for overhangs.

Check for hole spacing, depth of holes and the depth of cut.

Make up only one shot at a time.

Use the correct amount of stemming.

When the holes are charged, remove explosives and caps to a safe location outby the face, at a right angle, separate 15 feet apart and in a safe location.

When ready to fire, wire in series and unreel the shot firing cable from the face to the firing station Do not tie one place to another with an exposed blasting cap.

Be sure that all persons are in the clear before blasting

Be sure to holler fire "three times" before touching off shot.

Never fire more than 20 holes at one time except when all the men are out of the mine.

Never shoot an unconfined shot (adobe).

Never use a high explosive detonating cord in an underground mine.

Upon shooting a place, allow the smoke to clear out and then examine the place, roof, ribs, and explosive gas.

PERMISSIBLE EXPLOSIVES: The most important requirements of permissible usage are: (1) that the explosive is in all respects similar to the sample submitted by the manufacturer for test; (2) that it is fired with an electric blasting cap of not less than

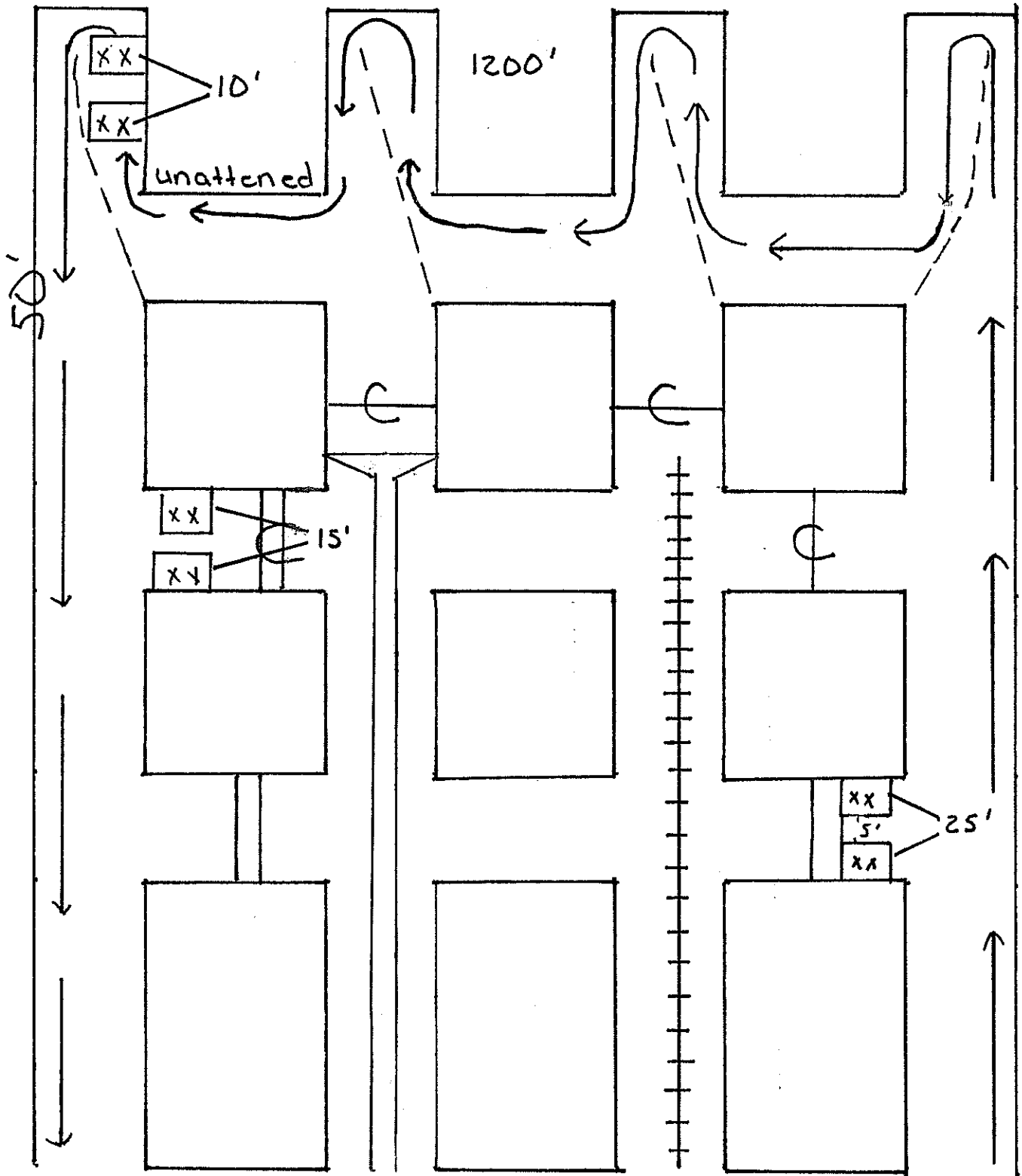
No. 6 strength; (3) that it is stored in surface magazines under proper conditions, and that it is not stored more than 48 hours underground; (4) that the explosive is properly confined in a borehole tamped with noncombustible stemming; (5) that the charge is not fired in the process of a dangerous percentage of gas; (6) that the quantity used for a shot does not exceed one and one-half pounds when fired in accordance with these requirements; and (7) that the quantity use for shot does not exceed three pounds when fired in accordance with certain additional requirements as, for example, that the borehole be six feet or greater in length. The cartridge count usually is found to be about 120 per 50-pound case, stick size being 1 ¼ X 8 inches. Water resistance good to very good, 9,000 velocity foot per second, fume class A



“MONOBEL” AA

Note: The bands marking stick denote use for underground.

1%
5% - 15% gelatin
10%



This content is from the eCFR and is authoritative but unofficial.

Title 30 – Mineral Resources

Chapter I – Mine Safety and Health Administration, Department of Labor

Subchapter O – Coal Mine Safety and Health

Part 77 – Mandatory Safety Standards, Surface Coal Mines and Surface Work Areas of Underground Coal Mines

Authority: 30 U.S.C. 811.

Source: 36 FR 9364, May 22, 1971, unless otherwise noted.

Subpart N Explosives and Blasting

§ 77.1300 Explosives and blasting.

§ 77.1301 Explosives; magazines.

§ 77.1302 Vehicles used to transport explosives.

§ 77.1303 Explosives, handling and use.

§ 77.1304 Blasting agents; special provisions.

Subpart N—Explosives and Blasting

§ 77.1300 Explosives and blasting.

- (a) No explosives, blasting agent, detonator, or any other related blasting device or material shall be stored, transported, carried, handled, charged, fired, destroyed, or otherwise used, employed or disposed of by any person at a coal mine except in accordance with the provisions of §§ 77.1301 through 77.1304, inclusive.
- (b) The term “explosives” as used in this Subpart N includes blasting agents. The standards in this Subpart N in which the term “explosives” appears are applicable to blasting agents (as well as to other explosives) unless blasting agents are expressly excluded.

§ 77.1301 Explosives; magazines.

- (a) Detonators and explosives other than blasting agents shall be stored in magazines.
- (b) Detonators shall not be stored in the same magazine with explosives.
- (c) Magazines other than box type shall be:
 - (1) Located in accordance with the current American Table of Distances for storage of explosives.
 - (2) Detached structures located away from powerlines, fuel storage areas, and other possible sources of fire.
 - (3) Constructed substantially of noncombustible material or covered with fire-resistant material.
 - (4) Reasonably bullet resistant.
 - (5) Electrically bonded and grounded if constructed of metal.
 - (6) Made of nonsparking materials on the inside, including floors.

- (7) Provided with adequate and effectively screened ventilation openings near the floor and ceiling.
 - (8) Kept locked securely when unattended.
 - (9) Posted with suitable danger signs so located that a bullet passing through the face of a sign will not strike the magazine.
 - (10) Used exclusively for storage of explosives or detonators and kept free of all extraneous materials.
 - (11) Kept clean and dry in the interior, and in good repair.
 - (12) Unheated, unless heated in a manner that does not create a fire or explosion hazard.
- (d) Box-type magazines used to store explosives or detonators in work areas shall be constructed with only nonsparking material inside and equipped with covers or doors and shall be located out of the line of blasts.
 - (e) Secondary and box-type magazines shall be suitably labeled.
 - (f) Detonator-storage magazines shall be separated by at least 25 feet from explosive-storage magazines.
 - (g) Cases or boxes containing explosives shall not be stored in magazines on their ends or sides nor stacked more than 6 feet high.
 - (h) Ammonium nitrate-fuel oil blasting agents shall be physically separated from other explosives, safety fuse, or detonating cord stored in the same magazine and in such a manner that oil does not contaminate the other explosives, safety fuse or detonating cord.

§ 77.1302 Vehicles used to transport explosives.

- (a) Vehicles used to transport explosives, other than blasting agents, shall have substantially constructed bodies, no sparking metal exposed in the cargo space, and shall be equipped with suitable sides and tail gates; explosives shall not be piled higher than the side or end.
- (b) Vehicles containing explosives or detonators shall be maintained in good condition and shall be operated at a safe speed and in accordance with all safe operating practices.
- (c) Vehicles containing explosives or detonators shall be posted with proper warning signs.
- (d) Other materials or supplies shall not be placed on or in the cargo space of a conveyance containing explosives, detonating cord or detonators, except for safety fuse and except for properly secured nonsparking equipment used expressly in the handling of such explosives, detonating cord or detonators.
- (e) Explosives and detonators shall be transported in separate vehicles unless separated by 4 inches of hardwood or the equivalent.
- (f) Explosives or detonators shall be transported promptly without undue delays in transit.
- (g) Explosives or detonators shall be transported at times and over routes that expose a minimum number of persons.
- (h) Only the necessary attendants shall ride on or in vehicles containing explosives or detonators.
- (i) Vehicles shall be attended, whenever practical and possible, while loaded with explosives or detonators.
- (j) When vehicles containing explosives or detonators are parked, the brakes shall be set, the motive power shut off, and the vehicles shall be blocked securely against rolling.

- (k) Vehicles containing explosives or detonators shall not be taken to a repair garage or shop for any purpose.

§ 77.1303 Explosives, handling and use.

- (a) Persons who use or handle explosives or detonators shall be experienced men who understand the hazards involved; trainees shall do such work only under the supervision of and in the immediate presence of experienced men.
- (b) Blasting operations shall be under the direct control of authorized persons.
- (c) Substantial nonconductive closed containers shall be used to carry explosives, other than blasting agents to the blasting site.
- (d) Damaged or deteriorated explosives or detonators shall be destroyed in a safe manner.
- (e) Where electric blasting is to be performed, electric circuits to equipment in the immediate area to be blasted shall be deenergized before explosives or detonators are brought into the area; the power shall not be turned on again until after the shots are fired.
- (f) Explosives shall be kept separated from detonators until charging is started.
- (g) Areas in which charged holes are awaiting firing shall be guarded, or barricaded and posted, or flagged against unauthorized entry.
- (h) Ample warning shall be given before blasts are fired. All persons shall be cleared and removed from the blasting area unless suitable blasting shelters are provided to protect men endangered by concussion or flyrock from blasting.
- (i) Lead wires and blasting lines shall not be strung across power conductors, pipelines, railroad tracks, or within 20 feet of bare powerlines. They shall be protected from sources of static or other electrical contact.
- (j) For the protection of underground workers, special precautions shall be taken when blasting in close proximity to underground operations, and no blasting shall be done that would be hazardous to persons working underground.
- (k) Holes shall not be drilled where there is danger of intersecting a charged or misfired hole.
- (l) Only wooden or other nonsparking implements shall be used to punch holes in an explosive cartridge.
- (m) Tamping poles shall be blunt and squared at one end and made of wood, nonsparking material, or of special plastic acceptable to the Mine Safety and Health Administration.
- (n) Delay connectors for firing detonating cord shall be treated and handled with the same safety precautions as blasting caps and electric detonators.
- (o) Capped primers shall be made up at the time of charging and as close to the blasting site as conditions allow.
- (p) A capped primer shall be prepared so that the detonator is contained securely and is completely embedded within the explosive cartridge.
- (q) No tamping shall be done directly on a capped primer.
- (r) Detonating cord shall not be used if it has been kinked, bent, or otherwise handled in such a manner that the train of detonation may be interrupted.

- (s) Fuse shall not be used if it has been kinked, bent sharply, or handled roughly in such a manner that the train of deflagration may be interrupted.
- (t) Blasting caps shall be crimped to fuses only with implements designed for that specific purpose.
- (u) When firing from 1 to 15 blast-holes with safety fuse ignited individually using hand-held lighters, the fuses shall be of such lengths to provide the minimum burning time specified in the following table for a particular size round:

Number of holes in a round	Minimum burning time, minutes
1	2
2 to 5	2 ² / ₃
6 to 10	3 ¹ / ₃
11 to 15	5

In no case shall any 40-second-per-foot safety fuse less than 36 inches long or any 30-second-per-foot safety fuse less than 48 inches long be used.

- (v) The burning rate of the safety fuse in use at any time shall be measured, posted in conspicuous locations, and brought to the attention of all men concerned with blasting.
- (w) Electric detonators of different brands shall not be used in the same round.
- (x) Adequate priming shall be employed to guard against misfires, increased toxic fumes, and poor performance.
- (y) Except when being tested with a blasting galvanometer:
 - (1) Electric detonators shall be kept shunted until they are being connected to the blasting line or wired into a blasting round.
 - (2) Wired rounds shall be kept shunted until they are being connected to the blasting line.
 - (3) Blasting lines shall be kept shunted until immediately before blasting.
- (z) Completely wired rounds shall be tested with a blasting galvanometer before connections are made to the blasting line.
- (aa) Permanent blasting lines shall be properly supported, insulated, and kept in good repair.
- (bb) At least a 5-foot airgap shall be provided between the blasting circuit and the power circuit.
- (cc) When instantaneous blasting is performed, the double-trunkline or loop system shall be used in detonating-cord blasting.
- (dd) When instantaneous blasting is performed, trunklines, in multiple-row blasts, shall make one or more complete loops, with crossties between loops at intervals of not over 200 feet.
- (ee) All detonating cord knots shall be tight and all connections shall be kept at right angles to the trunklines.
- (ff) Power sources shall be suitable for the number of electrical detonators to be fired and for the type of circuits used.
- (gg) Electric circuits from the blasting switches to the blast area shall not be grounded.

- (hh) Safety switches and blasting switches shall be labeled, encased in boxes, and arranged so that the covers of the boxes cannot be closed with the switches in the through-circuit or firing position.
- (ii) Blasting switches shall be locked in the open position, except when closed to fire the blast. Lead wires shall not be connected to the blasting switch until the shot is ready to be fired.
- (jj) The key or other control to an electrical firing device shall be entrusted only to the person designated to fire the round or rounds.
- (kk) If branch circuits are used when blasts are fired from power circuits, safety switches located at safe distances from the blast areas shall be provided in addition to the main blasting switch.
- (ll) Misfires shall be reported to the proper supervisor and shall be disposed of safely before any other work is performed in that blasting area.
- (mm) When safety fuse has been used, men shall not return to misfired holes for at least 30 minutes.
- (nn) When electric blasting caps have been used, men shall not return to misfired holes for at least 15 minutes.
- (oo) If explosives are suspected of burning in a hole, all persons in the endangered area shall move to a safe location and no one should return to the hole until the danger has passed, but in no case within 1 hour.
- (pp) Blasted areas shall be examined for undetonated explosives after each blast and undetonated explosives found shall be disposed of safely.
- (qq) Blasted areas shall not be reentered by any person after firing until such time as concentrations of smoke, dust, or fumes have been reduced to safe limits.
- (rr) In secondary blasting, if more than one shot is to be fired at one time, blasting shall be done electrically or with detonating cord.
- (ss) Unused explosives and detonators shall be moved to a safe location as soon as charging operations are completed.
- (tt) When electric detonators are used, charging shall be stopped immediately when the presence of static electricity or stray currents is detected; the condition shall be remedied before charging is resumed.
- (uu) When electric detonators are used, charging shall be suspended and men withdrawn to a safe location upon the approach of an electrical storm.

§ 77.1304 Blasting agents; special provisions.

- (a) Sensitized ammonium nitrate blasting agents, and the components thereof prior to mixing, shall be mixed and stored in accordance with the recommendations in Bureau of Mines Information Circular 8179, "Safety Recommendations for Sensitized Ammonium Nitrate Blasting Agents," or subsequent revisions.
- (b) Where pneumatic loading is employed, before any type of blasting operation using blasting agents is put into effect, an evaluation of the potential hazard of static electricity shall be made. Adequate steps, including the grounding and bonding of the conductive parts of pneumatic loading equipment, shall be taken to eliminate the hazard of static electricity before blasting agent use is commenced.
- (c) Pneumatic loading equipment shall not be grounded to waterlines, airlines, rails, or the permanent electrical grounding systems.

- (d) Hoses used in connection with pneumatic loading machines shall be of the semiconductive type, having a total resistance low enough to permit the dissipation of static electricity and high enough to limit the flow of stray electric currents to a safe level. Wire-counteracted hose shall not be used because of the potential hazard from stray electric currents.