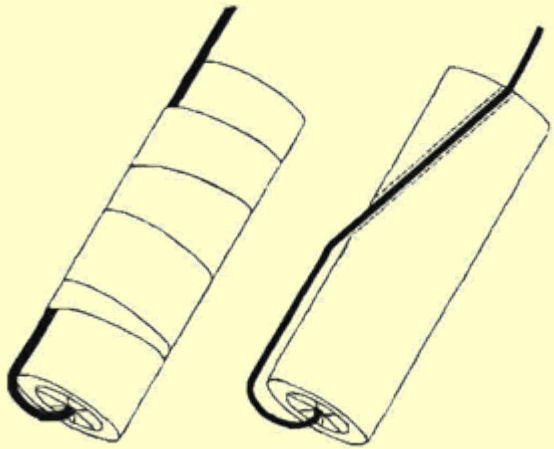
Blasthole Loading



This blaster-training module was put together, under contract, with Federal funds provided by the Office of Technology Transfer, Western Regional Office, Office of Surface Mining, U.S. Department of the Interior, located in Denver, Colorado.

The module is an example of the technical assistance the Federal government furnishes States to assist them in meeting the requirements of the Surface Mining Control and Reclamation Act of 1977, upon which their State surface coal-mine regulating programs are based. In particular, the module was requested and will be used by the Sheridan District Office, Wyoming Department of Environmental Quality, Land Quality Division.

A word of caution: please note that **this module is not intended to stand alone, nor is it a self-training type module**. Rather, **the information the module provides MUST BE SUPPLEMENTED** by information given by a certified blasting instructor.

DISCLAIMER

The technologies described in the module are for information purposes only. The mention herein, of the technologies, companies, or any brand names, does not constitute endorsement by the U.S. Department of the Interior's Office of Surface Mining.

Blasthole Loading

This module presents proper and safe blasthole loading practices.

Precautions Before Loading

Before any loading activities are started, a blast area must be clearly marked with flags, cones, or other readily identifiable markers. All unnecessary equipment must be removed from the area. All persons not essential to the powder-loading operation should leave. Observers should be under the control of a responsible person who will ensure that they do not create a hazard by wandering about the area. Any electrical power that might create a hazard should be disconnected. Where electric blasting or electric detonators are being employed, appropriate checks should be made with a blaster's multi-meter. Two-way radios must be turned off in areas where electric blasting or electric detonators are being employed.

Loading Overview

Blasthole loading involves placing all of the ingredients necessary for a blast—the main explosive charge, deck charges, initiation systems, primers, and stemming—into the borehole. Borehole loading requires various techniques depending on hole diameter, type of explosive, and the size of the blast. Possible considerations include:

- Checking the borehole (drill communication),
- Addressing problems (water, cave-ins, voids, etc.),
- Making the primer,
- Loading the primer,
- Addressing the need for multiple priming/decks,
- Loading explosives,
- Addressing the need for bulk equipment, and
- Stemming the blasthole.

Checking the Borehole

Before loading begins, the boreholes should be checked. ***Never load a borehole without confirming that it has been drilled to the proper depth.*** A weighted tape should be used to check the holes. If the hole is deeper than the designed depth, fill it with drill cuttings or other stemming until the bottom of the hole is at the proper depth. Loading an excessively deep borehole is a waste of explosives (which translates as unnecessary expense) and may increase vibrations. Boreholes that are shallower than the designed depth should either be cleaned out with a drill or compressed air or redrilled. The blasting foreman should make the decision to fire the shot with short holes.

While checking the borehole for proper depth, it is convenient to check for water in the borehole. With just a little experience, a blaster can closely estimate the level of water in a borehole by visually checking the weighted tape for wetness after the borehole depth check has been made. To get a more accurate check, the weighted end of the tape can be jiggled up and down at the water level, which can be identified by the splashing sound this process will generate.

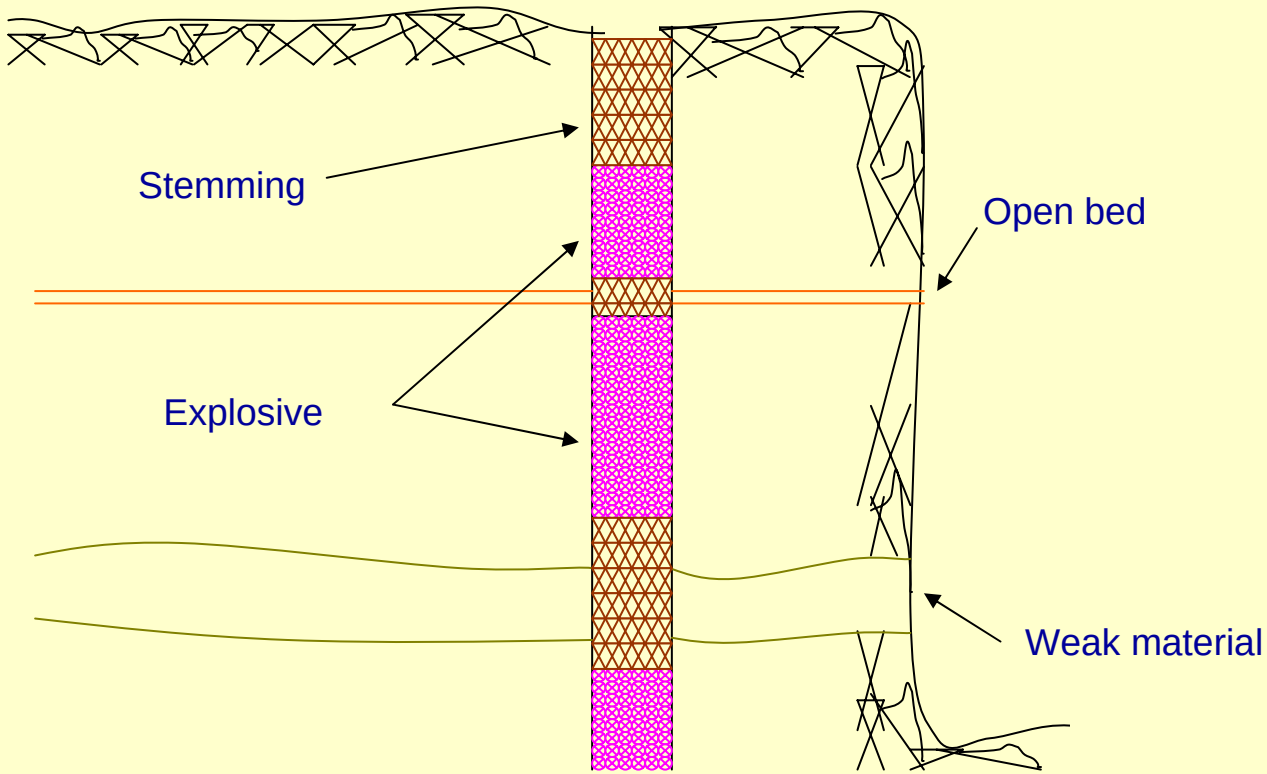
Communication with Drillers

As mentioned in the “Blasthole Drilling” module, communication between blast and drill crews is essential to achieving desired blast results. Check with the driller or the drill log to see if voids, mud seams, or other zones of weakness are present in the blast pattern. A borehole may pass through or bottom into an opening. In such a case, plugging the borehole may be necessary if the void cannot be filled with stemming material. Gas bags, stemming plugs, or other air-decking devices may be used to plug a borehole at various depths.

On occasion, a borehole may become obstructed. On a sunny day, a mirror may be used to check for obstructions. In other cases, a heavy weight (weighted tape) can be dropped repeatedly to free an obstruction. If a new hole must be drilled adjacent to a blocked hole, be sure to fill the blocked hole with stemming so that the new hole does not vent into the blocked one.

Weak Material and Incompetent Zones

Zones of weakness—for example, mud seams or faults—may cause serious problems, including unacceptable fragmentation, in blast patterns. Explosive energy always seeks the path of least resistance. The best way to counter a blast moving through weak material or incompetent zones is to use smaller diameter holes and a tighter pattern, both of which will result in better powder distribution.

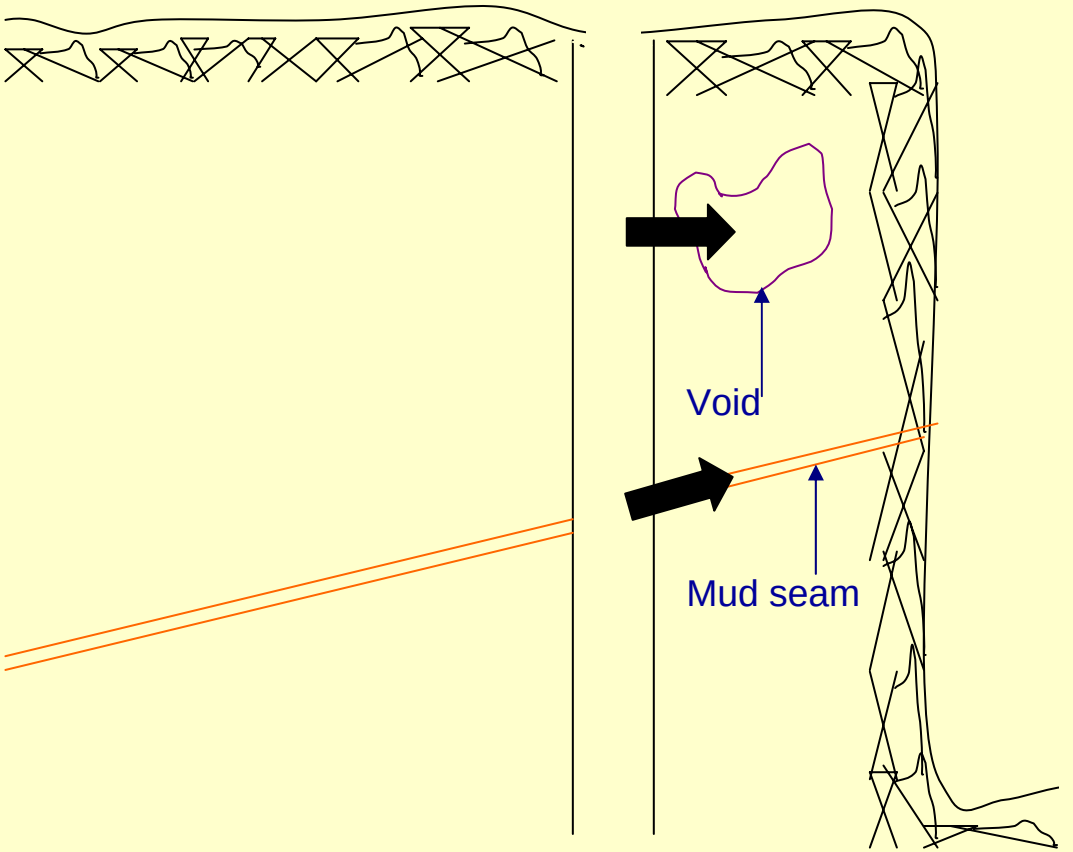


When charging the borehole, inert stemming material should be loaded through these weak zones in the rock.

Stem zones of weakness and open beds in boreholes.

Mud Seams and Voids

Where the condition of the borehole is in doubt, the rise of the powder column should be checked frequently while loading the hole. If the column fails to rise as expected, you have most likely encountered a void.



At this point, stop loading explosives and instead load a deck of inert stemming. Where this is impractical because of the size of the void, it may be necessary to block the hole above the void and continue loading the hole with explosive material. Make sure that you leave enough room at the top of the borehole to adequately stem the hole.

Loss of explosive energy through zones of weakness.

Wet Boreholes

Any time a blaster encounters water in a borehole, his or her job becomes more challenging. A decision must be made whether to load waterproof explosive products or instead to set in motion a dewatering plan. The cost of products designed for dewatered holes and products designed to be loaded into standing water must be evaluated and compared, along with the additional labor costs associated with dewatering. A water-resistant explosive—for example, an emulsion or a blend—may be quite useful for blasting in wet conditions. On the other hand, economics may favor dewatering the borehole and bulk-loading ANFO into it using a protective plastic borehole liner.

In either case, a word of caution: ***do not load ANFO product into wet boreholes, even if they have been dewatered***. The ANFO may become desensitized, in which case it will not shoot.

Wet Boreholes

Dewatering

To dewater, a pump is lowered to the bottom of the hole and the water is pumped out. A roll of hollow plastic tubing, called a “borehole liner,” is brought to the collar of the hole. A rock (weight) is placed in the liner, and a knot is tied in the bottom of it to keep the rock in place. Be sure to leave 4 to 6 feet of liner at the top of the hole, to account for slumping caused by the weight of the explosive. The hole can be primed and loaded inside the liner as normal. Where water is seeping into the borehole, it is important that the liner and ANFO be loaded quickly to prevent the hole from refilling with water.

Click on the image to the right to play a dewatering clip.

Wet Boreholes

Borehole Liners

In the event a decision is made not to use a waterproof explosive in a borehole that has required dewatering, flexible plastic borehole liners are available to protect the explosive used from any residual moisture in the hole. These liners are inserted into blastholes and ANFO then loaded inside them. The liners can be bought in pre-cut sealed lengths or in rolls. Rolls are most often used except in large casting operations, where single, heavy-duty liners are more economical.

Click on the image to the left to play a clip that shows a borehole liner in use.

Wet Boreholes

Bulk Emulsion Blends

Heavy ANFO is defined as a mixture of 20- to 25-percent non-sensitized emulsion and 75- to 80-percent ANFO. Heavy ANFO is used in dry holes to increase the energy output of an explosion over that of regular ANFO. A blend of 30-percent emulsion is used in wet, dewatered boreholes to maximize the water resistance of the explosive. This mixture can be "slept" in a borehole for several days without losing sensitivity.

Thirty-percent emulsion is bottom-primed like heavy ANFO, but the primer should be pulled up off the bottom of the borehole a little to avoid any water that may pool there. This product must be regularly monitored to maintain quality in the finished blend, as detonation sensitivity decreases as the density of the blend increases.

Cartridge, Bottom-Load Explosives

A cartridge product can be loaded into the wet portion of a borehole after the hole has been dewatered. A final cartridge is slit, loaded, and tamped to seal the bottom of the hole. ANFO can be loaded into the rest of the explosive column.

Water-Resistant ANFO

After a hole has been dewatered, "water-resistant ANFO" can be loaded into it from a bulk truck or in 50-pound bags. Water-resistant ANFO shoots a little harder than regular ANFO, because of its increased density, but additives in the mixture create a 1.2-g/cc waterproof seal on the outside of the explosive column.

Primers

A primer is a unit, package, or cartridge of explosives that contains either (1) a detonator or (2) a detonating cord to which is attached a detonator designed to initiate the detonating cord.

The effectiveness of a priming system is determined by many properties, including its detonation pressure, its energy, and its resistance to water. The size of the primer and the initiation system's compatibility with the main charge of explosives should also be considered.

Detonation Pressure

A good rule of thumb to follow when choosing a primer system is that the detonation pressure of the primer should always be greater than the detonation pressure of the explosive being primed. If this condition is not met, the main charge may not achieve steady-state velocity or fully develop its borehole pressure, or, worse yet, it may completely fail to initiate.

Energy

A booster must have sufficient energy both to initiate the detonation reaction in the main charge and to sustain it until the primed explosive produces enough energy to support the detonation reaction by itself.

Water-Resistance

The water-resistance of most boosters is sufficient enough to withstand exposure to water at various depths and for extended periods. Check with the manufacturer if you have questions about the water-resistance of your booster or priming system.

Making Primers

The process of making primers from boosters and detonators or detonating cord requires that proper care and technique be exercised when combining the sensitive initiator and the explosive cartridge. Primers should always be made up close to the blastsite and immediately before loading. The so-called “business end”—that is, the explosive tip—of the detonator should always be inserted in the booster so that it points in the direction of the main charge. This ensures maximum confinement and the most efficient use of the explosive’s energy.

Various types of boosters require different types of initiation systems, and the manufacturer or the technical data sheet should be consulted for the priming recommendations for each type of booster used.

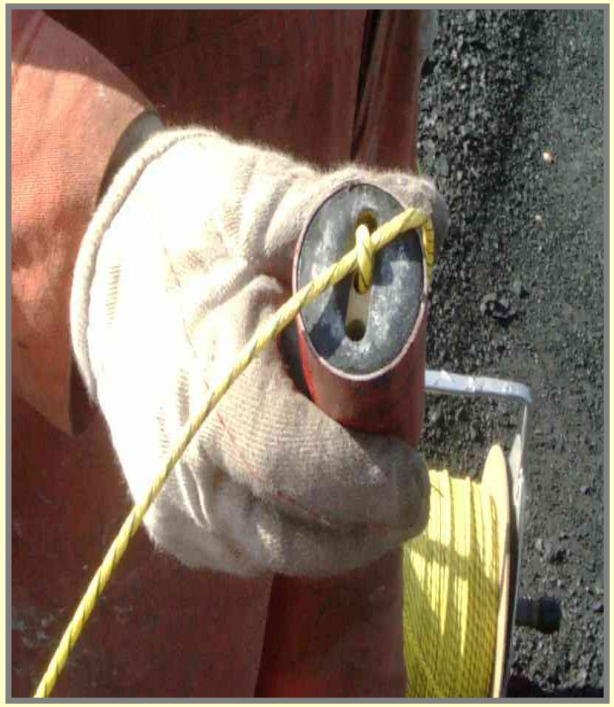
Click on the image above to play a clip showing how to load lined holes.

Making Primers

When priming small-diameter cartridges, the hole for the detonator is usually punched in the end of the cartridge. With electric detonators, the wires are usually half-hitched around the cartridge. The tubes or fuse from non-electric detonators are taped to the cartridge to ensure that the detonator is not pulled out during loading. Some safety fuse will not stand up under the sharp bend required for end-priming. Instead, punch a diagonal hole all the way through the cartridge and a second diagonal hole partially through. String the cap and fuse through the first hole, place them into the second hole, and pull to secure. Taping the fuse to the cartridge will ensure that the primer remains intact during loading.

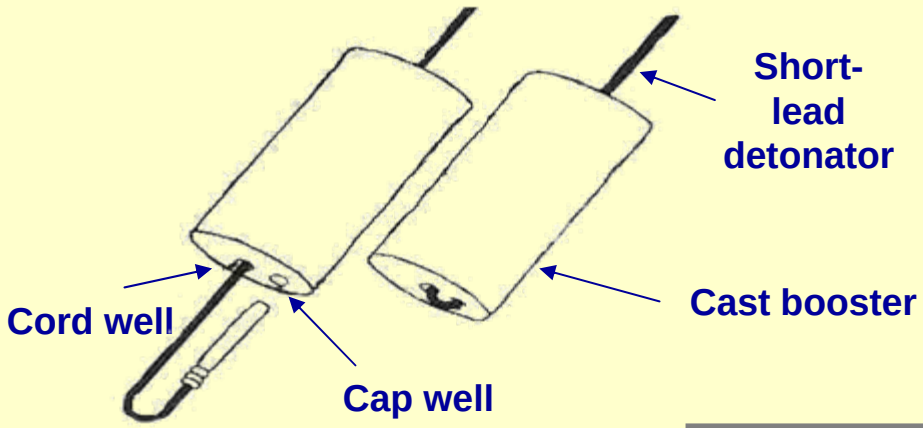
Detonating cord is secured to large-diameter cartridges by punching a diametrical hole through the cartridge, passing the cord through the cartridge, and tying the cord at the top of the cartridge with a secure knot.

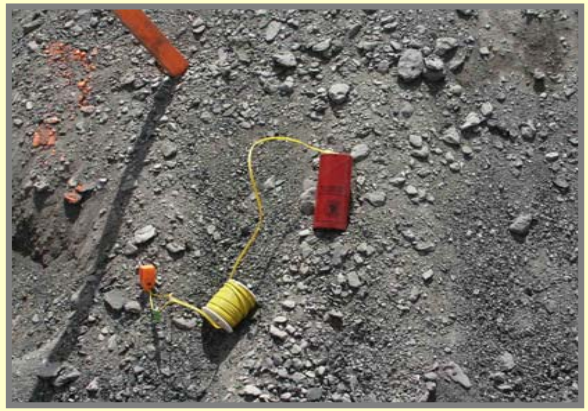
When attaching detonating cord directly to a small-diameter cartridge, the detonating cord is usually inserted into a deep axial hole in the end of the cartridge. The cord is then either taped to the cartridge, passed through a diagonal hole in the cartridge, or secured with a half-hitch to ensure that the cord will not pull out.



Making Primers

It is recommended that cast boosters, rather than large-diameter explosive cartridges, be used with non-electric initiators. With detonating cord, a cast primer with a single axial hole is used. The cord is passed through the cord tunnel and tightly knotted at the bottom of the primer. Because this knot will not pull back through the tunnel, it is not necessary to tie the cord around the primer. Primers can be added by passing the downline at the blasthole collar through each primer's tunnel and **sliding** the primer down the downline. Place the delay-cast primers on the cord using the tunnel connected to the perimeter of the primer, rather than passing through the center of the primer itself.





Photograph showing 1-pound cast primer with electronic detonator.

Photograph showing slider booster.

Review Questions and Discussion

1. If your column fails to rise to the desired level during loading, what may you have encountered?
    a. A void
    b. Nothing; keep loading
    c. Another blasthole

2. True or false: it is acceptable to load ANFO into wet boreholes as long as they have been dewatered?

3. What may be the consequence(s) of using a primer that is not powerful enough?
    a. The detonation will be too great in the hole
    b. The blasting agent may not reach its steady-state velocity soon enough to provide maximum energy
    c. The primer won't set off the detonator attached to it

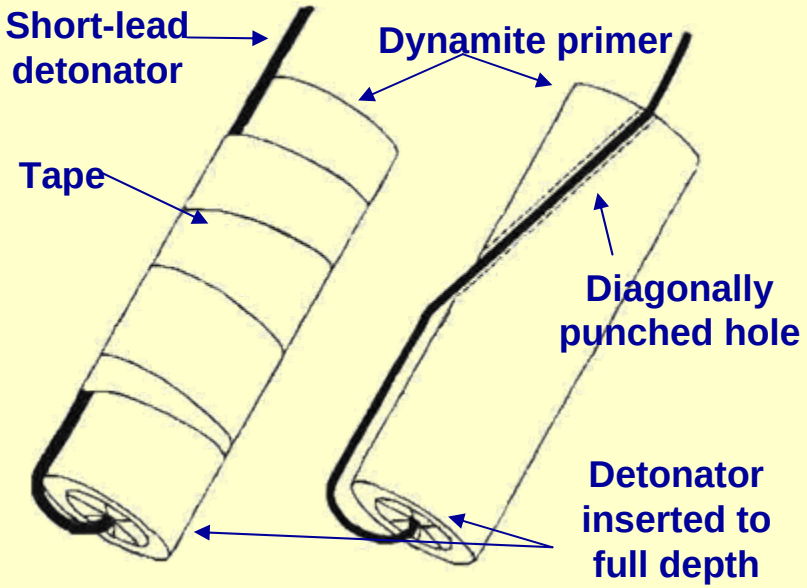
4. Where and how would you make a primer using a 1-pound cast booster and a detonating cord downline?
    a. At the magazine, using the manufacturer's recommended procedures
    b. At the borehole, using a secure Persian wrap knot
    c. At the borehole, using the manufacturer's recommended procedures

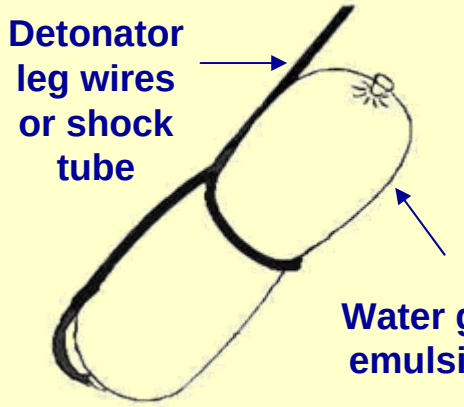
Answers

1. a. is correct.
2. False.
3. b. is correct.
4. c. is correct.

Typical Primer Configurations

Cast primers for use with detonators have a detonator well in addition to a tunnel. Insert the detonator through the tunnel and back up into the well, making sure that the detonator is seated in the bottom of the well. The detonator should remain securely in the primer; however, as an added precaution, it is a good idea to use electrician's tape to secure the detonator.





To prime large-diameter cartridges with electric blasting caps, punch a diagonal hole from the top center of the cartridge and out the side about 8 inches from the top. Then, double over the detonator wires, thread them through the hole, and wrap them around the cartridge. Place the detonator into a hole punched into the top of the cartridge, and pull the assembly tight. Tape the leg wires to the cartridge for extra security.

Making Primers

When making primers, remember to:

- Fasten the detonator or detonating cord so it cannot be pulled out of or off the primer cartridge or container;

- Place the detonator or detonating cord in the safest and most efficient position in the booster's cartridge (this is generally near the center of the booster and pointing towards the main charge);

- Not subject the shock tube or detonating cord of non-electric detonators, the wires of electric detonators, or detonating cord to damaging pull, strains, or abrasion;

- Select a booster with adequate detonation pressure (>100 KB), energy, and water-resistance to meet the demands of the blasting situation; and

- Employ a priming system that allows the entire assembly to be loaded safely, easily, and in the desired position in the charge.

Multiple Priming

Most blasting situations require only a single-point primer position per blasthole. A few of the situations where multiple priming is used are:

- Specifically, with decked charges;
- To break up boulder-prone caprock in the stemming area of a blast; or
- In decked charges, to reduce the charge weight per delay, thereby reducing vibrations.

In the first two situations, the decks may be on the same or different delays. However, in the third situation, the decks must be on different delays. In any case, each deck will require a separate primer.

Multiple Priming

Another reason for multiple priming that does not involve multiple decks is a **safety factor**, whereby multiple priming ensures total column detonation. This can take care of problems associated with long, thin charges or with slip planes that may be present in the borehole.

In these cases, two or more primers should be spaced throughout the powder column. These primers may be on the same delay, but, where single priming is preferred, they can be put on separate delays.

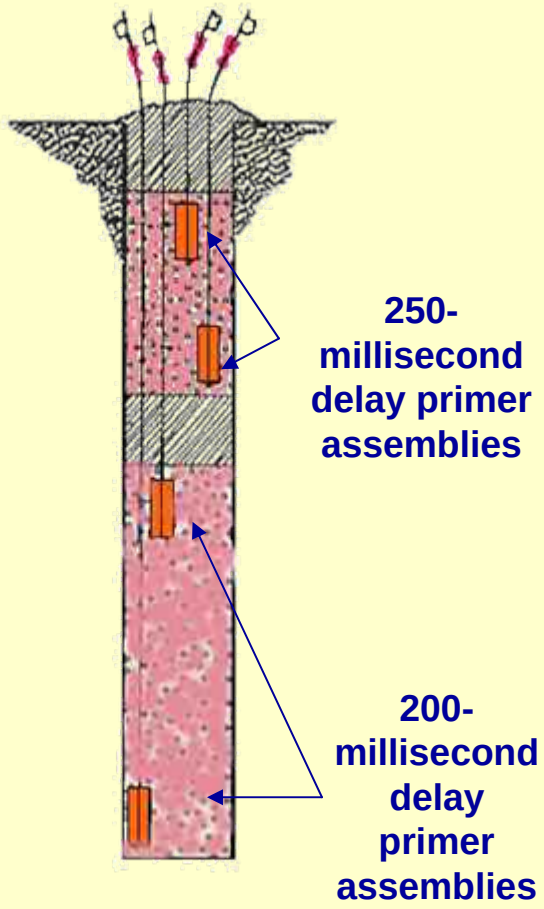
Primers

Primer Location

Proper location of the primer is important for both safety and efficiency reasons. Placing the primer in the bottom of the hole minimizes bootlegs and also protects against leaving undetonated explosives in the bottom of the hole if the cartridges become separated. The primer cartridge must not be cut, deformed, or tamped. If bulk products are being loaded, the primer may be raised slightly from the bottom of the hole.

To reduce ground vibrations in bench blasting with a designed subdrill, the primer should be placed at toe level and **NOT the bottom of the hole**.

In large-diameter blastholes, a recommended practice is to place the primer at the bottom of the blasthole to maximize the confinement of the charge. Bottom-initiated holes tend to produce less flyrock and airblast than do top-initiated holes, assuming all other dimensions are equal. If pulling the toe is not a significant problem, some blasters prefer placing the primer near the center of the explosive column. This gives the quickest total reaction of the explosive column and may yield improved fragmentation. A good rule of thumb when using a single primer in a large-diameter blasthole is to place the primer in the zone of most difficult breakage, normally the toe.



Loading Procedures

Before loading the primer, it is good practice to load a foot or so of powder so that the primer cartridge is protected from puncture and coupled in the bottom of the borehole. In almost all situations, it is recommended that the explosive charge be totally coupled or that it completely fill the borehole diameter. Bulk loading of explosives ensures good coupling. When cartridged products are used, coupling is improved by slitting the cartridges and tamping them firmly into place. ***NEVER tamp a primer cartridge.***

The primer (booster with the detonator inserted) should be lowered down the blasthole **BEFORE** loading additional boosters and the main charge of explosives. Bailing twine or some other form of lowering material should be used. ***NEVER lower large primers (>1 pound) using detonator leg wires or shock tubes, as damage to the initiation system may result***.

Care must be taken to ensure that the detonator does not come out of the primer cartridge during loading. ***NEVER drop or tamp the primer cartridge down the hole***. One or more cartridges or a few feet of ANFO should be placed above the primer cartridge before dropping or tamping begins.

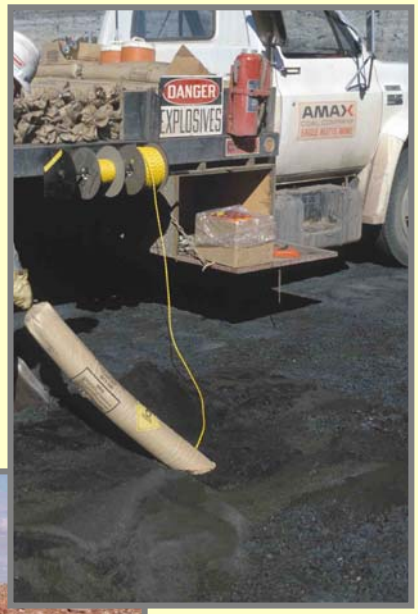
Loading Procedures

Blastholes may be loaded with bulk or packaged products. Bulk products are either poured, augered, or pumped into the hole or blown in through a loading hose. Packaged products are either dropped into the hole, pushed in with a tamping pole, or loaded with a pneumatic tube. It is a good idea to check the rise of the powder column frequently, using a weighted tape, as loading progresses. This will give warning of a cavity or oversized hole that is causing a serious overcharge or explosive to be loaded; it will also ensure that sufficient room is left at the top of the hole for the proper amount of stemming.

Click on the image above to play a clip showing the use of wet-hole boosters.

Packaged Products

Large-diameter dynamite cartridges are seldom used today, except occasionally as primers. ANFO and slurries are much more cost-effective. An operator who wants to use ANFO in wet boreholes will typically resort to water-resistant bags of partially pulverized heavy ANFO. Heavy ANFO will sink in water; accordingly, the bags should be carefully lowered into water-filled holes rather than dropped, because a broken bag will result in desensitized ANFO, an interruption in the powder column, and some undetonated explosive. With packaged products, coupling may be sacrificed.

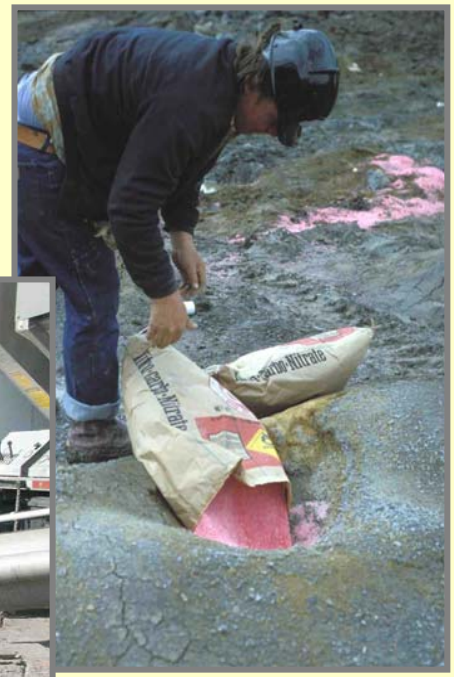


Bulk Dry and Blend Blasting Agents

Bulk-loading offers significant advantages over loading packaged products into large-diameter blast holes. Advantages include greater cost-effectiveness, faster loading, and better use of available space in the borehole.

Bulk ANFO or prills are stored in overhead storage bins, from which they are loaded into bulk trucks. ANFO may be trucked to a blast site in premixed form, or the oil may be metered into the prills as they are placed into the blast hole.

Auger-loading gives the fastest loading rates. A side-boom auger is satisfactory for loading one row of holes at a time. Where it is desirable to reach more holes from one set-up, an overhead-boom auger with a 350^{o} radius of swing can be used. Bulk-loading trucks have capacities of 2,000 to over 30,000 pounds of ANFO.



Bulk Emulsion

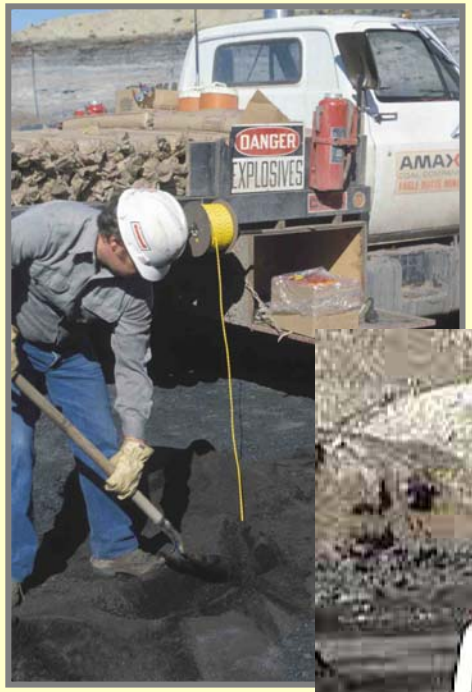
Bulk emulsion pumping is common in large-diameter, vertical-hole blasting. Some trucks will have capacities of up to 30,000 pounds and pumping rates of 200 to 400 pounds/minute. Emulsions may have micro-balloon sensitizers, or some blends may be gassed as they are loaded into the borehole.

Click on the image above to play a pumping clip

Bulk Emulsion

Quality should be controlled for each load to maintain the proper loading density for emulsion and blends. Any products that need to gas in-hole should be given adequate time before the hole is stemmed.

Stemming



It is recommended that all blastholes be stemmed to improve the efficiency of the explosive and to reduce airblast and flyrock. As a rule of thumb, the length of stemming should be from 14 to 18 times the borehole diameter. Sized, crushed stone or drill cuttings are most commonly used. Large rocks should never be used for stemming, as they may damage the initiation system or become projectiles if blown out of the borehole.

Click on the image immediately to the left to play a stemming clip.

Securing Downlines

It is important that the wires, tubes, or detonating cord leading from a primer are properly secured (using a stake) at the borehole collar in vertical or near-vertical holes.

Bulk Equipment

Bulk equipment is able to load different blends of ANFO and emulsion with the touch of a computer screen in the cab of modern vehicles.

Hydraulic controls are safe for bulk equipment, because there is no build-up of static electricity in electric controls.

Cab-mounted equipment uses a programmable computer that allows the operator to control the product feed and the boom from the cab. Back-up controls on the fender allow for boom and product control outside the bulk truck.

Side-boom trucks are typically used on large patterns and have controls both at the end of the boom and in the cab. Overhead mount trucks are used on smaller patterns and can load several holes without moving the truck.

Bulk Equipment

Table showing typical bulk-equipment configurations

Auger/mount type[1]	Mount location	Boom length (in feet)	Swing arc (in degrees of radius)	Discharge level (in feet)
Overhead auger, standard mount	rear	16 - 20	360	8 - 10
Overhead auger, reverse mount	front	16 - 20	360	8 - 10
Overhead auger, reverse mount	driver side	12 - 16	180	2 - 4

[1]The auger may have a flexible hose attached, which would affect its discharge level. Note, as well, that the bulk-equipment configurations described in this table are for overhead augers. There is evidence that side-mount augers are now in more prevalent use, and it is side-mount augers that are shown in both images below.

Click on the image above to play a load-parting clip

Click on the image above to play a clip showing the operation of a side boom.

Review Questions and Discussion

1. True or false: double-priming holes in a cast-blast pattern is a recommended safety practice?

2. True or false: recommended practice is to tamp a primer cartridge to achieve good coupling in the bottom of a borehole?

3. If you suspect an explosive is burning in a borehole, what should you do?
   a. Keep all personnel away from the blastsite
   b. Wait 30 minutes before entering the blast area to inspect the misfire
   c. Follow the manufacturer's recommendations for misfires
   d. All of the above

4. What is(are) recommended operating procedure(s) for areas in which charged (loaded and tied-in) holes are awaiting firing?
   a. All required warning signs should be in place to keep out unauthorized personnel
   b. Anyone proposing to enter the blast area should contact the blast supervisor prior to doing so
   c. Berms should be constructed to control equipment access to the blastsite
   d. All of the above

Review Questions and Discussion—continued

5. Losing a primer down a hole can easily be avoided by doing what?
    a. Tying downlines to the borehole stakes
    b. Avoiding placing primer(s)s too close to the hole prior to loading it
    c. Focusing on both working carefully and observing safe practices while loading the hole
    d. All of the above

6. What should the consideration(s) be when loading a packaged product into a blast hole?
    a. Care should be taken so that the coupling is not lost
    b. The product should be lowered, not dropped, into a wet blast hole
    c. The packaging for a water-gel or emulsion explosive should be slit prior to loading to achieve better coupling
    d. All of the above

7. What are some considerations with respect to selecting bulk equipment for a blasting operation?
    a. Explosive products being used
    b. Blast-pattern dimensions
    c. Explosive quantities needed
    d. All of the above

Answers

1. False. As a practical matter, double- or multiple-priming may be used with decked charges or to reduce the charge weight per delay. However, as a safety factor, double- or multiple-priming ensures total column detonation.

2. False. You should never drop or tamp the primer cartridge down the hole; instead, one or more cartridges or a few feet of ANFO should be placed above the primer cartridge before dropping or tamping begins.

3. a. and c. are correct.

4. d. is correct.

5. c. is correct.

6. c. is correct.

7. d. is correct.