Chapter 7
LOADING BOREHOLES

PRIMING CHARGE

Priming a charge is simply positioning a suitable primer within a charge or column of explosives. The object is to provide the primary-initiating explosion needed to detonate the main charge efficiently.

When the primer is the first cartridge or one of the first cartridges to be loaded into the borehole, it is called bottom priming. In this cartridge, the explosive end of the blasting cap must be pointed toward the collar of the borehole. Regardless of where the primer is placed in a column of explosives, the explosive end of the cap should ideally be pointed toward the main column of explosives.

Bottom priming is generally considered a safer practice than placing the primer at the collar. The most important reason for this is less chance of misfires caused by such things as the cap being separated from the primer, the primer being separated from the main charge, or the explosives becoming separated from each other during loading. Bottom priming initiates the explosive train where the rock is usually the hardest, in order to "carry the toe." There is also less chance of the primer being dislodged, cut off, or blown from the hole when multiple-hole delay blasting is being used.

If the blaster is firing single shots, he or she may position the primer cartridge toward the top of the collar. This is known as top priming. The advantages of top priming are to keep the primer from becoming immersed in water at the bottom of wet holes, and to keep the primer high (more accessible) in the hole if it misfires and needs to be reprimed. Another advantage is that there is no fuse, detonating cord, or leg wires running the full length of the hole which must be protected when loading and tamping.

When priming blasting agents with holes up to 2 1/2 inches in diameter, a full cartridge of high velocity explosives like 60 percent ammonia gelatin, gels, slurries, or cast primers with a blasting cap, is a sufficient charge.

For larger holes, the priming requires much more care, especially if the hole is wet or decked charges are used. A small quantity of a high-velocity primer is better than a large amount of a lower velocity primer. The detonating velocity of the primer must be greater than or equal to the detonating velocity of the agent for efficient detonation.

The best location for priming a charge is at either end of the charge. The placement of primers anywhere else within the powder column shall *never* be done if there is not also a bottom primer.

With large diameter holes, the shape of the primers, as well as the strength, is important. The diameter of such primers should approach the diameter of the borehole so that the major portion of the available energy is released to propagate a strong detonation wave along the column.

The use of detonator cord as a sole detonant is not recommended, since it could cause deflagration rather than detonation of the charge.

The objective of the primer is to achieve a stable detonation. Neither over-priming or under-priming the agent is desirable. The diameter of the primer must be larger than the critical diameter of the explosive.

Every explosive has a certain critical diameter below which detonation will not propagate beyond the primer point. Confined, ANFO's critical diameter is approximately 1 1/4 inches. That is, a borehole or column of ANFO less than two inches in diameter will detonate in the immediate area of the primer, but cannot reliably carry the detonation process much beyond that point.

The problem of determining how many primers to use and where to locate primers in an explosive column is a difficult one. Too many unnecessary primers add to the cost of blasting, while too few primers rob the blast's efficiency. Basically, the primers must be located so that the detonation travels through the entire powder column before any of the gas and pressure is vented.

In a shallow hole with a short explosive column, only one primer would be needed. However, as the hole depth increases, the time required for the entire powder column to detonate increases correspondingly. The requirement for additional primers is determined by the amount of burden and stemming which confines the gases and pressures. The following equation gives the maximum hole depth when the borehole is bottom primed:

$$H = \frac{2.5 \times Ve \times B + T}{Vr}$$

Where:
H = hole depth
Ve = velocity of the explosive
Vr = velocity of the rock
B = burden
T = stemming

As an example, assume the burden for a shot is 11 feet, the stemming is 9 feet, the velocity of the explosive is 11,000 feet per second, and the velocity of the rock is 20,000 feet per second. What should be the maximum hole depth for this type of shot?

$$H = \frac{2.5 \times Ve \times B}{Vr} + T$$

$$H = \frac{2.5 \times 11{,}000 \times 11}{20{,}000} + 9$$

$$H = 27.5 + 9$$

$$H = 36.5 \text{ feet}$$

This equation indicates that if the borehole depth is greater than 36.5 feet, we need an additional primer in the column. As long as the borehole is less than 36.5 feet, one primer located at the bottom of the column will suffice.

When the boreholes are subdrilled, the equation becomes more complicated:

$$H = \frac{2.5 \times Ve \times (B^2 + J^2)^{½} + T}{Vr}$$

Where: J = subdrilled distance

Example: Burden = 13 feet
Stemming = 10 feet
Subdrilling = 4 feet
Velocity of ANFO = 12,000 ft/sec
Velocity of limestone = 16,400 ft/sec

What is the maximum hole depth that should be used with a single primer?

$$\frac{H = 2.5 \times 12{,}000 \times (13^2 + 4^2)^{½} + 10}{16{,}400}$$

$$\frac{H = 2.5 \times 12{,}000 \times (185)^{½} + 10}{16{,}400}$$

$$H = \frac{408{,}044 + 10}{16{,}400}$$

$$H = 24.8 + 10$$

$$H = 34.8 \text{ feet or } 35 \text{ feet}$$

LOADING, TAMPING, AND STEMMING

LOADING is the process of placing an explosive charge, complete with primer, into a drilled, punched, or dug hole.

Before loading, first test the hole with a pole or measuring tape to confirm that it is the desired depth and to ensure that there are no obstructions or rough spots which might interfere with loading. Check with the driller to see if there are any mud or sand seams in the rock and on the general conditions of the rock. The driller serves as the blaster's eyes and the two must work together. When loading, remember that the wrapper, or shell, on a primer cartridge should never be slit, or tamped.

TAMPING is the compacting of the charge in the borehole to ensure that there are no breaks in the continuity of the column and to increase the density of the charges, as well as fill all available borehole space. A non-sparking pole should be used for tamping.

Cartridge explosives are covered with paper and it is usually a common practice to slit the wrappers lengthwise before placing them in the hole. The purpose of this is to make the cartridge easier to collapse and compact when you later "tamp" the charge.

Primer charges should be lowered or pushed carefully into place. One cartridge may be used between the primer and the loading pole to act as a cushion.

Sometimes cartridges may be tamped sufficiently by merely pressing down firmly with the pole. More often, two or three light blows of the pole are needed to crush the cartridge. Never tamp vigorously or continue to tamp after the explosives have filled-out to the walls of the hole. Only tamp one or two cartridges at a time.

Throughout the loading and tamping operation, great care must be taken to guard against damaging or sharply kinking fuse, lead tubes of non electric blasting caps, or leg wires of electric blasting caps leading to the primer charge.

STEMMING is packing an inert material, such as gravel, sand, or drill cuttings, on top of the charge to the top of the borehole.

When loading a borehole, the blaster must always leave space for adequate stemming. Explosives should never extend to the collar of the borehole.

Stemming does more than confine the explosive. It also protects the loaded explosives from accidental ignition or detonation. In the stemming operation, a small quantity of stemming should be carefully and gently pressed over the charge. The remainder of the stemming should be progressively added and firmly tamped into the hole. Ideally, stemming should be packed so that it is at least as solid as the surrounding earth.

The height or depth of the stemming depends on various factors ranging from the power of explosives, burden, spacing, and material being blasted to material being used as the stemming. The blaster wants to confine the explosive, but still achieve the desired fragmentation. The stemming must occur in an amount sufficient to confine the gases released by the explosives long enough for the gases to do their work, before the rock movement begins and the stemming is blown out. In solid rock, the stemming should be equal to the burden.

However, when blasting rock that is not solid, rock that has seams, cracks, and crevices, and laminated layers, the amount of stemming should be decreased according to this formula:

$$\text{Stemming} = .7 \times \text{Burden}$$

DELAY PRIMERS

Non electric down-the-hole delay priming allows distribution of large amounts of explosives in many small decks or charges in the overburden. This results in a level of shock and vibration below the legal level, even though the same amount of explosives is used. The charges are simply detonated at different time intervals.

Normally, to set off a sequence of blasts at different levels within a single hole, several blasting caps are placed down the hole, with explosives packed at the desired levels separated by stemming material. The complexity of many wires extending out of the hole creates the possibility of attaching wrong wires to the firing system.

With the delay primer, however, decks may be initiated starting at the top, the bottom, or the middle of the burden, simply by choosing the right timing inserts.

The delay primer consists of two parts—the main explosive charge and a delay insert that are joined at the time the hole is loaded. The main explosive charge is cast into a molded plastic container that has a detonating cord tunnel on the side and a sensor well and a cap well at the one closed end. The other end is open.

It takes only a few seconds to make up a delay interval. First, the proper delay insert is selected. The cap end is pushed down onto the cap well, which is embedded in the primer. Then, the sensor end is pushed into the well, which points or touches the detonating cord tunnel.

When the detonating cord is passed through the tunnel, the primer is ready for loading. The first primer made up is held by a knot in the detonating cord. Later, decks in the same hole are created simply by sliding the primer down the cord into the hole.

When the downline is initiated at the surface by a blasting cap or detonating cord, the propagation wave travels through the cord at over 23,000 feet per second. When the wave passes through one of the cord tunnels, it activates the sensor of the delay insert. This starts the delay column burning at a prescribed rate toward the blasting cap in the primer. When the cap is initiated, it explodes, initiating the primer.

Currently, there are two manufacturers of this type of primer.
Atlas Powder Company manufactures the Deckmaster with time intervals from 0 to 500 milliseconds. The product can be initiated with a 25 grain detonating cord.

Austin Powder Company manufactures the Austin Delay Primer (ADP) with time intervals from 25 to 600 milliseconds. This product can be initiated with a 40 grain or more detonating cord.