Too Much **and** Too Fast....

by Wes Bender

Those of you who may have attended any of the blasting seminars and training sessions where I've had the pleasure of making a presentation have heard me say that, in my investigation of blasting problems, most have been the result of either (1) shooting the material too hard or (2) shooting it too fast. (Using the wrong explosive for the application is a distant third.) There are basic guidelines that most blasters use to determine the range of powder factors for a particular type of rock. It's understandable that the loading may have to change as the rock varies. It's equally important to use an initiation timing scheme that is neither too fast, nor too slow. Too fast and you have excessive heave and possible flyrock. Too slow and you can start to experience cutoffs in the initiation system and/or cutoffs in the powder columns.

It isn't very often that you encounter both of these causes at the same problem site, but here is a case history where that happened. As usual, the names and places aren't disclosed. The lessons learned are more important than affixing blame. The open pit gold mining operation in southeastern California near Las Vegas was operating two pits simultaneously. The ore in each pit occurred in narrow meandering bands. The actual drilling and blasting was being conducted for the owner by a contract mining company. The contract mining company was only interested in achieving adequate fragmentation so that they could dig the material and haul it either to the leach pads or the waste dump. On the other hand, the mine owner did not want the ore bands to be intermixed too badly with the surrounding waste material when it was shot. Too much dilution meant that the muck from the blast would have to be dumped as waste because it wasn't economical to leach it. Exacerbating the problem a bit was that one pit contained relatively hard material, while the other pit could be shot rather easily.

I was asked to visit the site, analyze their blasts and recommend corrective measures. I obtained blast diagrams and videotaped several blasts. They were using 6-1/2" diameter holes, 23 feet deep on a 16 ft x 16 ft square pattern. The first thing that was apparent was that the pattern was a bit large considering the narrowness of the ore bands, which averaged 10 feet. The pattern could have been made to work, just not as easily as a tighter pattern with smaller holes. They loaded a 50/50 mixture of ANFO and emulsion to a column height of 13 feet and stemmed the top 10 feet. The initiation timing, using 500 millisecond (ms) delay detonators in the holes and Noiseless Trunkline Delays (NTDs), was 17 ms between holes in a row and 42 ms between rows. The videotaped blasts were rather violent and the good ore was badly mixed with the waste. The pin flags that were used to delineate the ore bands were either missing or badly scattered. Portions of the swell in the center of the shot was 10 to 12 feet above original ground (for holes only 23 feet deep). In addition, numerous holes 'rifled', with the resulting loss of useful energy.

A diagram of the timing scheme they were using is depicted as Figure 1 on the next page.

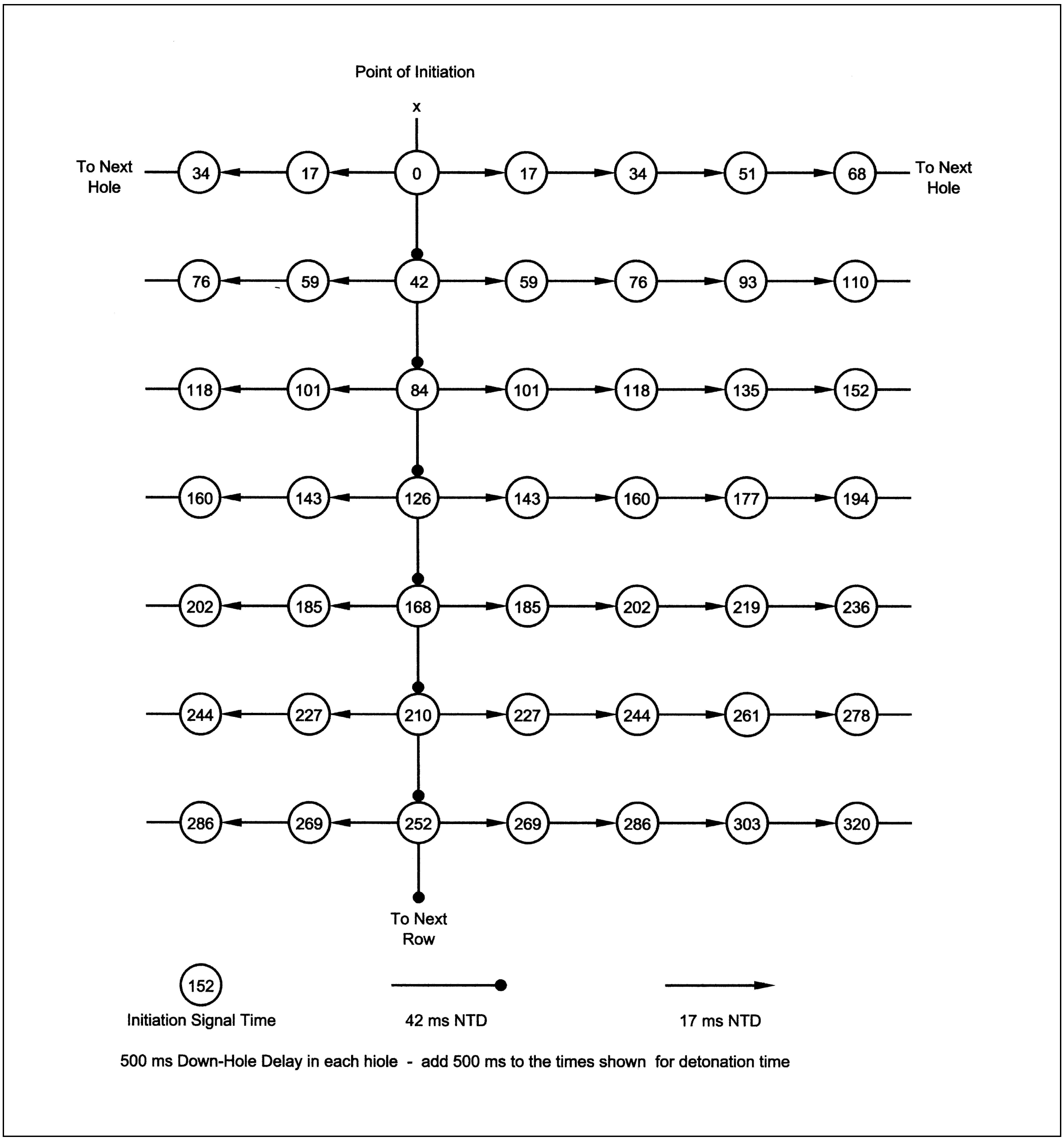

Figure 1 - Timing scheme as originally used.

Note that for a typical blast approximately12 rows deep, the entire blast would be detonated in less than a half a second. For a shot that is nearly 200 feet long, this is far too fast. It's completely understandable that the results were not only violent, but that there was no way that decent separation could be maintained between the gold-bearing ore and the waste material.

Photos taken from my videotape of the blast are on the next page.

Figure 2 - Original scheme. All detonators have fired and early rows are erupting.

Figure 3 - Violent results of the original timing scheme and loading.

I calculated the powder factor for some blasts as being as high as 1.24 lbs. per cubic yard while others were between 1.05 to 1.10 lbs. per cubic yard, considerably higher than should have been required. In addition, the timing of 17 ms by 42 ms was far too fast for a 16 ft by 16 ft pattern, especially when the goal should have been to minimize ore movement, mixing and heave.

When I questioned the blasters as to why they were using a timing scheme that was that fast, they indicated that a representative of the explosive manufacturer (not the detonator manufacturer) had advised them that, for safety purposes, they should strive to have all, or as many as possible, of the in-hole detonators 'lit' before the first hole detonated. I pointed out that, while this might be possible on small blasts with short burdens and spacing, it resulted in timing that was much too fast for their large blasts. Their timing between holes in a row was just over 1 ms per foot of burden. This was at the extreme lower end and conventional wisdom holds that it should be somewhere near 2 ms to 3 ms per foot which, for a 16 ft burden would be 32 to 48 ms between holes. While the 42 ms delay time between rows related well to the 17 ms between-hole times, it was also too fast for such a pattern. Both times would need to be increased.

I suggested that, provided the blasts were adequately diagrammed with timing information and the actual detonation times compared to the detonator 'ignition' times, a buffer zone of four holes between any detonating hole and one that has not seen the ignition signal would be sufficient to prevent cutoffs. This could be accomplished by obtaining different delays or, with the product on hand, by merely using the 42 ms NTDs for the delay from hole to hole across the rows and the 17 ms NTDs (with a different connection point) between the rows. I carefully diagrammed the proposed timing for them and showed them how to draw up their shots and verify the buffer zone as being adequate. It should be pointed out that, for those who do this sort of blast design on a regular basis, this may seem to be extraordinarily basic, but it was totally new to the blasters working for the contract mining company.

The easiest way to reduce the powder factor would have been to reduce the hole diameter. With the same pattern, but reducing the hole to 6" and leaving the powder column at 13 feet would reduce the powder factor from 1.05 to 0.88 lbs. per cubic yard. Lowering the top of the powder column to 11 feet would have further reduced the powder factor to 0.76 lbs. per cubic yard. On the chance that some oversize material would result from the lowered column, I suggested that smaller satellite holes might have to be incorporated in the middle of the square pattern. Of course, a total redesign of the blasting scheme, with smaller holes, burden and spacing would have been the best solution, but the contract between the owner and the contract mining company precluded the owner mandating that.

My suggested timing scheme using the 17 ms and 42 ms NTDs on hand is included as Figure 4 on the next page.

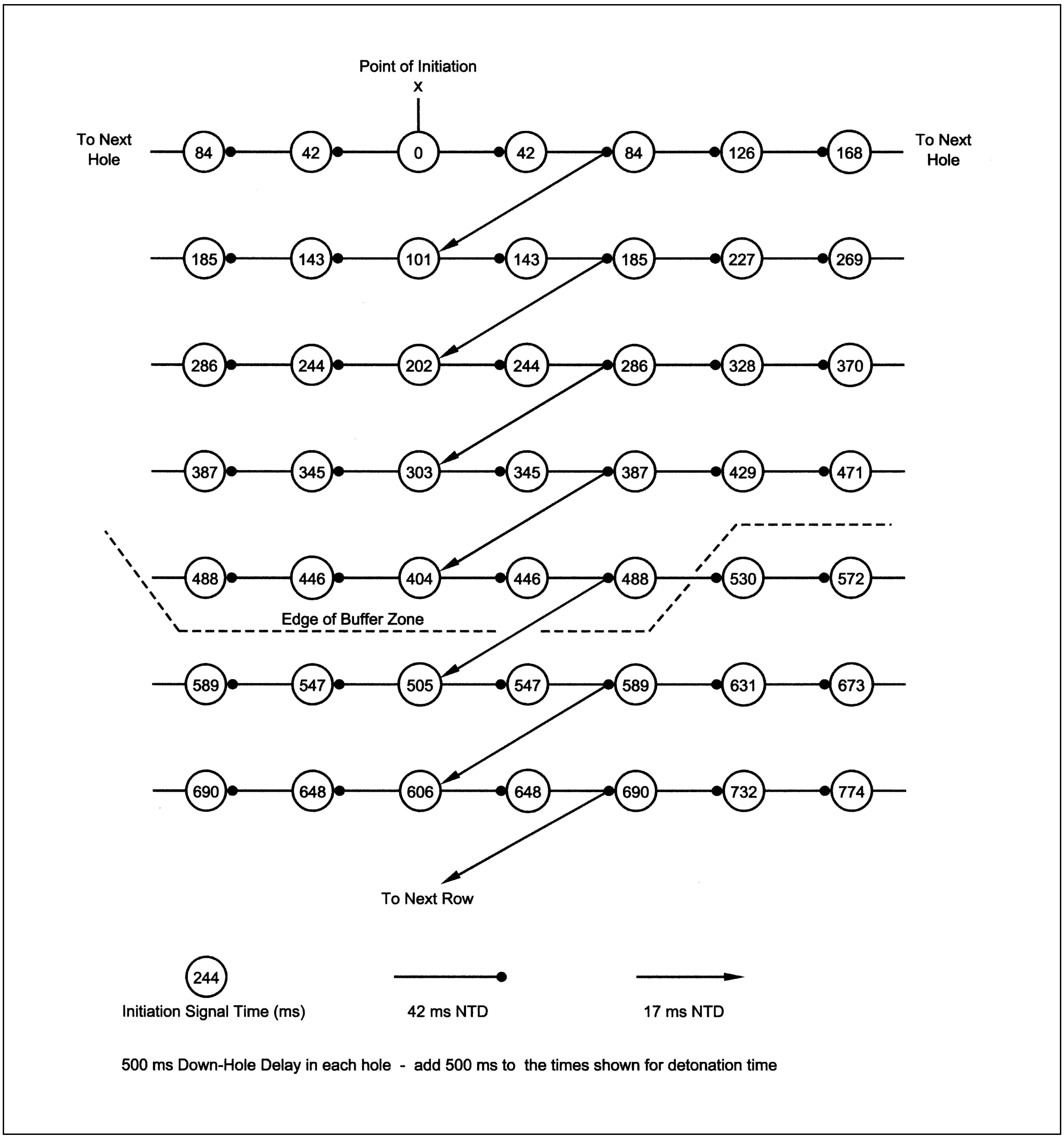

Figure 4 - Improved timing scheme.

Note that there is an adequate buffer zone between a hole detonating and those yet to see the initiation signal. The dotted line marks the extent of the initiating signal when the first hole detonates.

The slower initiation that results would have a 12 row blast be initiated in approximately 1-1/4 seconds. This timing would allow rows to shift slightly before the succeeding row shot and result in much less mixing of waste and ore. A typical blast using this timing is shown in Figure 5.

Figure 5 - Typical blast using slower time of detonation.

They used my proposed pattern and timing for a period of time, apparently with good results. For whatever reason though, at some point the contract mining company went back to their previous blast designs. I was contacted again by the owner six months later to come and investigate a failed blast in one of the pits. (Said investigation is an interesting story in itself, but is best left to another time.) I found that blasts in the pit with the harder rock were now being shot with powder factors as high as 1.6 to 2.2 lbs. per cubic yard. Undoubtedly, the companies supplying the explosives were overjoyed with the mine's consumption. Their delight was short lived however, when the mine closed. The primary reason: <u>They were unable to maintain sufficient ore/waste separation to make it a profitable operation</u>. The contract between the owner and the contract mining company didn't provide sufficient control over the latter's procedures and processes.

The contract mining company cost itself a project, caused the closing of a potentially viable mine, eliminating a decent explosives consumer, mostly by following a powder company representative's poor blast design advice.