TESTING THE DETONATOR ACCURACY USING VELOCITY OF DETONATION AND AIRBLAST METERS

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ABSTRACT

Detonator accuracy is extremely important to produce better fragmentation and for controlling vibrations. To control such problems, tests were performed to check the accuracy of electric detonators manufactured by a leading manufacturing company in the United States. These tests were conducted at the University of Missouri–Rolla (UMR) as part of a Graduate research program. Testing was conducted simultaneously with the Velocity of Detonation and the two Airblast meters. There was a reasonably good consistency of results shown by the Velocity of Detonation and the two airblast meters. The testing confirmed the accuracy and reliability of a relatively simple and inexpensive procedure for testing the accuracy of detonators.

INTRODUCTION

During the period starting from early 1600 up to 1940 accurate means of blasthole timings were not in vogue, both cap and fuse, and later electric detonators, that had long period delays, were used in the initiation system. Delayed blastholes showed better fragmentation than simultaneously blasting.

In the late 1940's the millisecond delay, electric blasting caps were manufactured. It became apparent that they were much better than long period delay blasting caps for controlling vibrations and producing better fragmentation.

By the mid 1950's, many explosives manufacturers started producing millisecond delay blasting caps. Until now, with some improvements, these caps (both electric and non–electric), are most widely used methods of sequencing holes.

It became clear that inspite of using the millisecond delay blasting caps the level of vibration and the degree of fragmentation was not as good as it was desired. The operator considered and the manufacturer insisted that this departure in results was entirely due to changed conditions, variation in geology, and change in explosive. Nobody thought that a major portion of the variation in results was caused by the inaccuracy of detonators. Detonators of the same delay period would not fire at the same time. For instance, a blasting cap rated as 400 ms may fire between 370 & 430 ms. Because of this discrepancy in timings, the firing time from hole to hole would overlap and thus lead to out of sequence firing. This caused a change in the confinement conditions on a blasthole at the time it fired, thus leading to significant changes in breakage ground vibration and airblast.

Airblast monitors based on microprocessors have largely changed the landscape for cap manufacturer and users. Now users of delay caps can quickly, cheaply, and accurately test caps. Claims of precision and accuracy can easily be verified. The customers must test caps and then determine if the design tolerance is sufficient for the application.

Some variation in firing time will always exist with pyrotechnic delays, however the new

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generation of "high precision blasting caps" has minimized some of this variability. The electronic detonator will give the user better control on blasting results, if used properly.

In the manufacture of detonators, tolerances are held on the manufacturing process. Within the tolerance similar detonators will not be identically the same (timings or otherwise). Slightly differences in detonators results from the manufacturing process and cause times to vary slightly from one detonator to another or from batch to batch. If we test a batch of detonators for their timings, we can determine the mean firing time for that particular batch and from this the standard deviation and the tolerances can also be found. In the blasting parlance, these tolerances in firing time is called "cap scatter". Detonators are given a rated firing time, but it is highly improbable for detonators to fire at exactly the same time. "Cap scatter", if overlooked in the design of a blast, would complicate the problem. The problem is further compounded by the use of short delay times between charges. Short period surface delays often provide less time than the tolerance in firing time of the detonators. This usually leads to crowding of firing times or out of sequence shooting. This causes back rows to fire before the front rows, thus leading to high vibrations, blow outs and airblast.

DESIGN AND METHOD

A series of seven electric caps (3 MASTER DET, and 4 ROCK MASTER) manufactured by a leading manufacturing company were chosen for testing their delay accuracy. The MASTER DET were having the delay numbers 0, 1 and 2 (instantaneous, 25 ms, and 50 ms respectively), where as the ROCK MASTER had the delay numbers 9, 10, 11 & 12 (200 ms, 250 ms, 300 ms & 350 ms respectively). The choice of these caps were largely based on the availability.

A ten–foot circle was marked out at the UMR Quarry, and the caps were placed at a distance of about 2 feet apart on the circumference of the circle. In order to prevent the shrapnel cut–offs, the caps were placed in the steel pipes about 8 inches long. These electric detonators were connected in a series and hooked up to the firing line.

Two self–triggering airblast meters were taken. One of them placed at the center of the circle. This was done to make sure that all the caps are equidistant from the airblast meter, the second airblast meter was placed about 20 feet away from the caps. This could have caused some discrepancy in the distance from the caps to the second airblast meter, but this would not be much as caps were not widely spread apart. The reason for choosing two airblast meters was to make reasonably sure that if one of them misses the reading it is recorded by the other.

The trigger level was chosen at 106 dB to make sure that the background noise from wind gusts etc. does not cause a false trigger.

To verify the accuracy of the blast meters method, simultaneous test was conducted by using the VODEX–100 meter. The data is tabulated in table 1. The same ribbon cable used in the VOD measurement experiment was stripped and connected to the meter.

The data recorded in the field was transferred to a PC. An image of the waveform (Figures 1 & 2) is displayed on the screen. A reference time is set at the spike of the instantaneous cap. As the cursor is moved along the waveform, the elapsed time is displayed on the screen. The times were tabulated and are given in tables II & III.

RESULTS AND DISCUSSIONS

There is a reasonably good harmony in the results shown by the VODEX–100 and the two blast meters. This proves that the results obtained by the experiments are reliable. The testing confirmed the accuracy of an inexpensive and reliable cap testing procedure.

The cap scatter on the MASTER DET # 1 (18.4%), as shown in Figure 4, is quite a bit and is more than what the manufacturer claims (less than 10%). However, the scatter on MASTER DET # 2 (7%) was within the range of the manufacturer's claim. Examining the date code, as appeared on the box, it was revealed that the MASTER DET, were manufactured in Nov. 1988. This aging of the caps have certainly increased the scatter on the caps. The cap scatter on the ROCK MASTER detonators ranged between 10 & 20%. This is quite in agreement to the manufacturer's claim.

Similar tests can be performed on non–electric caps. These can be tied by the 25 grain detcord. However in this case a higher over pressure generated by the cord requires a higher threshold of recording. A higher over pressure in this case may saturate the microphone and can possibly pin back diaphragm by the initial surge of air pressure. This can be eliminated by covering the detcord.

CONCLUSIONS

1. There is a reasonably good matching of results shown by the VODEX–100 and the airblast meters, which proves that the results obtained by the experiments are reliable.
2. The cap scatter on the MD # 1 was 18.4% which is quite a bit and is more than what the manufacturer claim (Less tan 10%).
3. The scatter on MD # 2 (7%) was within the range of the manufacturer's claim.
4. The cap scatter on RM series of detonators was quite in agreement to the manufacturer's claim.
5. The aging of the caps, as revealed by examining the date code, certainly may have increased the scatter on the caps.
6. It appears that aging tend to make the timings long on the detonation. This conclusion needs further investigation.

REFERENCES

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Table 1: Data for the Accuracy of Detonators with VODEX–100

Det Type & Delay No.	Time (μs)	Time (ms)	Channel No.	Recorded Delay	Cap Scatter (%)
MD # 1 (25 ms)	29645	29.9	1+2	29.6	18.4
MD # 2 (50 ms)	23909	53.5	2+3	53.5	7.0
RM # 9 (200 ms)	166082	219.6	3+4	219.6	9.8
RM # 10 (250 ms)	64159	283.8	4+5	283.8	13.5
RM # 11 (300 ms)	75802	359.6	5+6	359.6	19.9
RM # 12 (350 ms)	39955	399.5	6+7	399.5	14.2

Table 2: Data for the Accuracy of Detonators with Airblast Meter (Sr. No. 16) 10 ft. Away

Det Type & Delay No.	Spike Time (ms)	Recorded Delay (ms)	Scatter (%)
MD # 0 (Instant)	250	—	—
MD # 1 (25 ms)	279.8	29.8	19.2
MD # 2 (50 ms)	303.8	53.8	7.6
RM # 9 (200 ms)	468.8	218.8	9.4
RM # 10 (250 ms)	533.2	283.2	13.2
RM # 11 (300 ms)	608.9	358.9	19.6
RM # 12 (350 ms)	648.9	398.0	14.00

Table 3: Data for the Accuracy of Detonators with Airblast Meter (Sr. No. 17) 20 feet away

Det Type & Delay No.	Spike Time (ms)	Recorded Delay (ms)	Scatter (%)
MD # 0 (Instant)	250.0	—	—
MD # 1 (25 ms)	279.0	29.0	16.0
MD # 2 (50 ms)	303.7	53.7	7.4
RM # 9 (200 ms)	469.2	219.2	9.6
RM # 10 (250 ms)	533.7	283.7	13.5
RM # 11 (300 ms)	608.8	358.9	19.6
RM # 12 (350 ms)	648.9	398.9	14.0