Cap Testing at the Minntac Mine

by
Jack Eloranta
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Abstract

To improve control of blasting, tests were performed to assess non-electric cap accuracy. Simultaneous testing using a Velocity of Detonation Recorder (VODR), Red Lake Lo- Cam and an Instantel DS-677 blast monitor was done. Favorable comparisons were found in the three records. This testing confirmed the accuracy of an inexpensive and expedient cap testing procedure.

Introduction

The Minntac Mine is located 70 miles north of Duluth on the central Mesabi Range in northeast Minnesota. Minntac began operations in 1967 as a wholly owned facility of the USS division of the USX Corporation. Mining operations consist of two areas, the East pit and the West pit that together cover an area of 7.5 miles long by 1.5 miles wide. The ore body is mined by using 12 to 14 cubic yard electric shovels for loading. All the crude ore is hauled to the crusher by rail, using 1500 horsepower locomotives and 50 cubic yard side dump cars. Surface stripping is hauled to out of mine stockpiles using 170-ton electric drive trucks The Minntac mine blasts 60 million tons of rock annually. Using 16-inch blastholes, blasts can exceed 2 million tons each. A combination of hard rock (over 60,000 psi compressive strength), neighbors on three sides and high production requirements leaves little room for error in blast design. Such problems are exacerbated during the long winters of Northern Minnesota when temperature inversions and prevailing northwest winds sometimes proscribe blasting for periods of over a month.

BLAST TIMING

Blast timing is achieved using a non-electric system. Twentyfive-grain cord ties five-hole echelons together. A pair of redundant, shock tube downlines lead to 350 ms. downhole delay caps. Fifty-millisecond surface delays are used to separate the echelons. Cap timing is a critical problem especially in the areas where the bedding planes are poorly attached. Block sliding will occur when blasts are shot in the updip direction. The shallow (6%) dip forms long triangular blocks as viewed in cross section which daylight in the direction of the footwall The holes become cutoff if shifting occurs. The combination of 50 ms. surface delays with 350 ms. Downhole delays gives a seven hole margin of safety against cutoffs. At spacing of 32 feet the surface initiation leads movement by 224 feet. Timing is limited on the fast side by supersonic airblast problems. Supersonic airblast occurs when the sound from successive holes arrives simultaneously at a location causing a multiplication of the sound level. The blast must progress slower than the speed of sound. The speed of sound is faster in warm weather. When ambient temperatures are at zero degrees Fahrenheit, any echelons firing under 29 ms. will result in a supersonic wave front. Testing of 35 ms. delays showed that 24% of the caps fell in that category. Examination of the date codes showed that some caps were over a year old. Suppliers of caps have recognized an aging process that causes caps initially to speed up with age. As a result, 35 ms. delays have been replaced with 50 ms. delays. The increased time also allows more time for burden movement between echelons.

CAP TEST PROCEDURE

A fifty-foot radius circle is staked out in a remote and secure location. [SEE FIG.1] A self-triggering airblast meter is placed at the center of the circle. Blasters lay out a circle of delay caps connected in series. The trigger level must be chosen with care as background noise from wind gusts or door slams can cause false triggers at or below 110 db. [SEE FIG.2] A threshold of 115 db may not trigger the recorder if the caps are buried and shock tube is used. However, uncovered caps can result in shrapnel cutoffs. The triggering problem is reduced when testing MS connectors where detonating cord is used to simulate actual blast layouts. The higher overpressure generated by cord allows a higher threshold for recording. A second problem is introduced with cord, however. Early testing showed that the first caps in each test were unusually fast. [SEE FIG.3] This pattern became so predictable that closer scrutiny was required. Covering the cord eliminated the problem. Apparently the high overpressure may have saturated the microphone and the diaphragm may have been pinned back by the initial surge of airpressure.

ANALYSIS

New airblast/ground vibration meters have optional analysis programs available. Programs are priced under $1000 and run on most small computers. They are menu driven and largely are self explanatory. In a matter of hours a blaster can become proficient with the programs. The data are transferred to a PC. An image of the waveform is displayed on the screen. Time zero is set at the spike of the electric cap used to start the string of delays. As one moves the cursor along the waveform, the elapsed time is displayed on the screen. The times are tabulated and can be entered into a software spreadsheet. At this point statistical calculations and graphs can be generated. In this fashion, a test of 50 caps has been completed in less than two hours.

CROSS-CHECK WITH HIGH-SPEED FILM AND VODR

Simultaneous tests were done to verify the accuracy of the airblast meter method. The following graph summarizes the times obtained through the use of a Red Lake Lo-Cam and VODR measurements. The airblast meter appears to correlate well with the VODR. The camera was run at 500 frames per second. [SEE FIG. 4

RESULTS

Tests have been done on over 500 delay caps ranging from 9 ms to 350 ms. The accuracy and precision have been variable. Clearly, there is room for improvement. The following graph summarizes our test results. [SEE FIG. 5] This testing was limited to MS and 'NTD type' caps but electric cap users should be able to test caps in a similar means. A loop with period 0 through 20 caps could be fired in a similar manner. The data could be processed the same way.

Micro processor based airblast monitors have irreversibly changed the landscape for cap manufacturers and users. Now users of delay caps can quickly, cheaply and accurately test caps.

Claims of precision and accuracy can easily be verified. Minntac has been routinely testing caps to determine if the design tolerance is sufficient for their application. To encourage the manufacture of caps with accurate design tolerances, suppliers of delay caps at the Minntac Mine have been notified that cap testing is now a way of life. Whatever the quality, a rational acceptance of cap timing limitations must be the basis of blast design. The claim that greater accuracy would cost too much must be challenged. Since manufacturers know little about particular applications and since we users know little about cap manufacturing problems; the cost/benefit relationship of higher quality is unknown Manufacturers should not underestimate the blasters in the field. Cap users don't want to pay for unnecessary accuracy. Manufacturers can't afford to test endlessly and reject too much product. But, who can strike a balance? Not anyone operating in a vacuum. Only through an open exchange of information in a working partnership will the most economical compromise be found for each application.

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