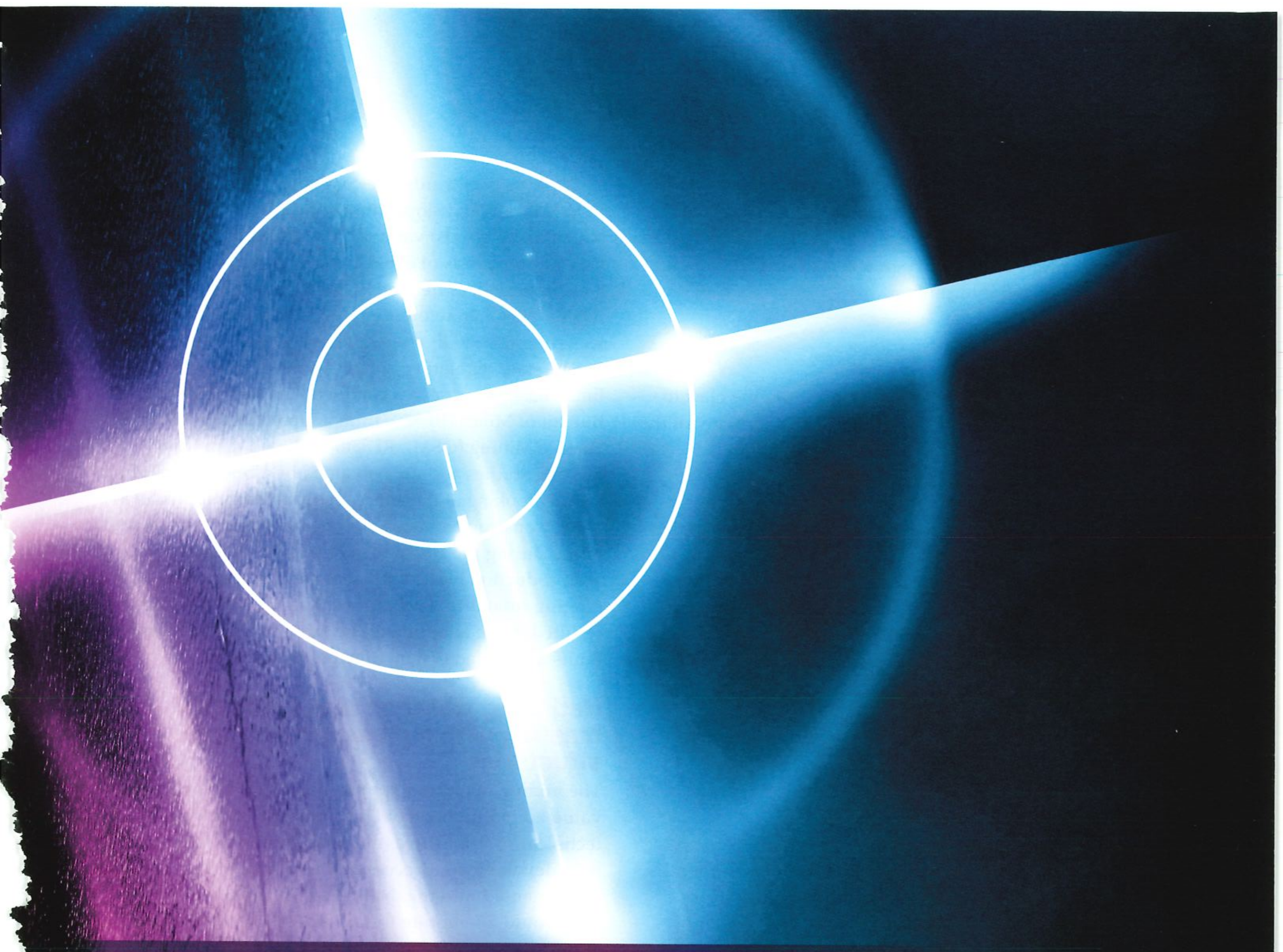

Cody Schaefer, Dyno Nobel Americas, describes how the company's software has been implemented at an opencast coal mine in the Midwest to reduce mining costs while ensuring compliance in close proximity drill and blast operations.

AT CLOSE RANGE

The continued use of one of Dyno Nobel's proprietary software programs, DYNO 42®, as well as its DigiShot® electronic initiation system, has resulted in substantial cost savings for an opencast coal customer in the Midwest (USA). DYNO 42 utilises signature hole data and a Dirac signal processing algorithm to provide timing analysis and DigiShot electronic initiation system is a user-friendly, reliable and accurate system primarily for use in large surface blasting applications. In the past, the customer utilised a modified ground transmission factor (K factor) to remain compliant when blasting near structures.

DYNO 42 has reduced vibration readings and allowed the customer to shoot more pounds per delay, reducing the costs associated with drilling and blasting. The goal of the study was to help the mining operation blast in areas of close proximity to structures, while reducing cost, maintaining blasting compliance and continuing to develop the relationship with the surrounding community. The study was conducted over a nine month period, during which time 30 shots were completed in the casting bench and analysed with DYNO 42, resulting in more than US$200 000 in cost savings.

Compliance blasting using modified K factors and scaled distance

When shooting near structures, mining operations typically use scaled distance factors, which is the ratio used to predict ground vibrations. In conjunction with the scaled distance, modified K factors are established to blast within legal limits set forth by the regulatory bodies. The maximum weight (lb) per delay is calculated using the scaled distance formula:

$$Ds = \frac{D}{\sqrt{W}}$$

This can be derived by the distance from the blast to the point of concern (ft), divided by the square root of the charge weight of explosives per delay (lb). In the equation, Ds represents the scaled distance, W is the maximum explosive charge weight in pounds or kilograms per delay period, and D is the distance to the structure (ft or m).

Using historical seismic data, this customer built a regression model, treating each seam separately. The opencast coal operation used data from the five shots closest to the compliance structure for each of the previous five cuts (for a total of 25 blasts), to develop the regression model utilised to calculate the modified K factor. The peak particle velocity (PPV) formula is:

$$PPV = (K) * (Ds)^{-Slope}.$$

The formula was then applied, where PPV is the peak particle velocity (in./sec. or mm/sec.), K is the ground transmission constant, the Ds is the scaled distance (ft/lb ^ 0.5 or m/kg ^ 0.5), and slope is the constant related to both the rock and site (usually -1.6).

DISTANCE TO STRUCTURE	PEAK PARTICLE VELOCITY	SCALED DISTANCE FACTOR
0 TO 300'	1.25 in/sec	50
301 to 5,000'	1.00 in/sec	55
5,001' and beyond	0.75 in/sec	65

Figure 1. State regulatory limits.

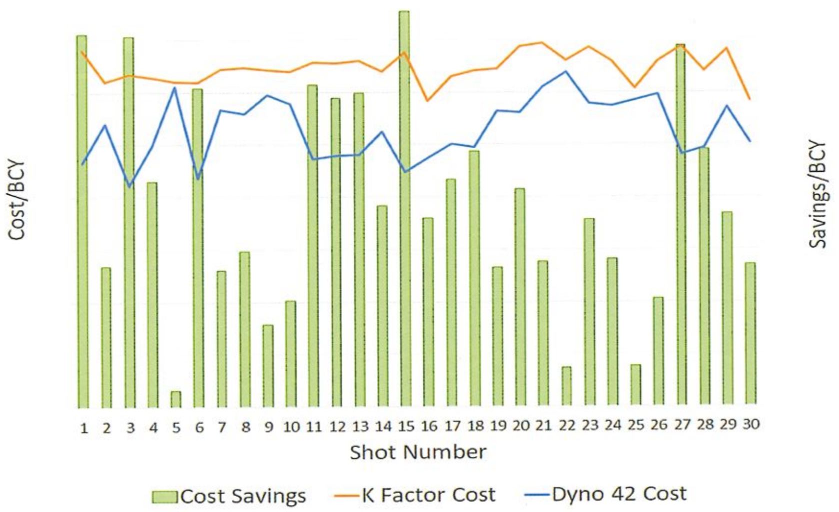

Figure 2. Cost comparison per bank cubic yard (BCY) for both the K Factor and DYNO 42 methods.

Working backwards, the customer inputted the desired PPV, K factor, and slope into the formula to yield the scaled distance (Ds) variable. The scaled distance table for maximum pounds of explosives per delay within an 8 msec. period, as defined by the Office of Surface Mining (OSM), was then referenced to verify that the blast design was compliant with the regulatory bodies.

The state regulatory body uses the ground vibration limits based on research conducted by the United States Bureau of Mines (RI 8507) and adopted by the Office of Surface Mining (OSM). RI 8507 included data from existing studies and data obtained by USBOM, including a study looking at the effects of ground vibrations on a newly constructed house built near a large opencast coal mine. During the study, the house was subjected to 587 production blasts with peak particle velocities ranging from 0.1 - 6.94 in./sec. The USBOM findings resulted in the adoption of the existing OSM vibration limits and scaled distance factors (Figure 1).

Reducing vibration and cost while blasting within close proximity to structures

The mining operation approached DynoConsult®, a value-added division of Dyno Nobel that develops technical solutions to assist customers' operations, for help developing a process that could be economically implemented into the drilling and blasting operation that would ameliorate the current situation dealing with close proximity structures. The goal of the study was to help the mining operation blast in areas of close proximity to structures, while reducing cost, maintaining blasting compliance, and continuing to develop the relationship with the surrounding community.

Maintaining a good relationship with the surrounding communities is vital to the mining operation for sustainable growth and fulfilling social responsibilities. As part of these initiatives, it is imperative for the mine to develop a method that reduces ground vibrations in a way that does not adversely affect the current mining operational methods, while still improving relationships with the surrounding community.

Introduction of disruptive interference processes

DynoConsult provided the tools and resources needed for the customer with a feasible vibration control method that matched both their needs and expectations. Assisting the customer with developing a process that utilised Dyno Nobel's proprietary software, DYNO 42, DynoConsult was able to develop a site-specific process.

The method called for the customer to shoot a signature hole near the blasting area that mimicked the hole profile to be used in the designed pattern, while remaining cognisant of treating each deck separately, as they would be detonated at different time intervals. The signature hole was then shot with 2500 msec. between delays, thus allowing for a clean trace on the seismograph.

After shooting the signature hole, the seismic data was collected from the desired unit and imported into DYNO 42 for analysis. Once in the software, the planned shot design and delay parameters were entered, and the analysis was completed in the software. The results of the analysis were then exported into a report, providing the blaster with a list of disruptive timing scenarios, along with the corresponding predicted PPVs for review and selection.

The customer used the DigiShot electronic initiation system to provide accuracy and versatility in timing sequences, allowing the blaster to confidently select the timing scenario best-suited to the application of seismic compliance at the monitored structure.

Reduce cost while ensuring regulatory compliance

The implementation of the new process involving the use of DYNO 42 showed a reduction in vibration, while contemporaneously shooting more pounds per delay. In a direct cost analysis comparing drilling cost, bulk explosive cost and accessories (Boosters and DigiShot electronic initiation system), costs from the previous method of regression analysis use for the modified K factor were compared to the new method of using DYNO 42 to produce timing for vibration control. DynoConsult was able to show cost savings in drilling and blasting of more than US$200 000 over 30 blasts completed in a nine month period. Through the continued use of the DigiShot electronic initiation system and the site-specific process built around the DYNO 42 software, the mine now has the proper tools in place to persevere in areas where close proximity structures have hindered operations in the past, either by regulatory compliance or financial constraints.

Conclusion

In today's world of connection, it is easy to communicate in real time, discuss new ideas, provide feedback, and influence others. As part of embracing the social media era, the mining operation is connecting with the surrounding community by monitoring the local social media sites, which helps to pinpoint areas of concern, so the issues can be addressed in real time, thus mitigating the chance of further repercussions.