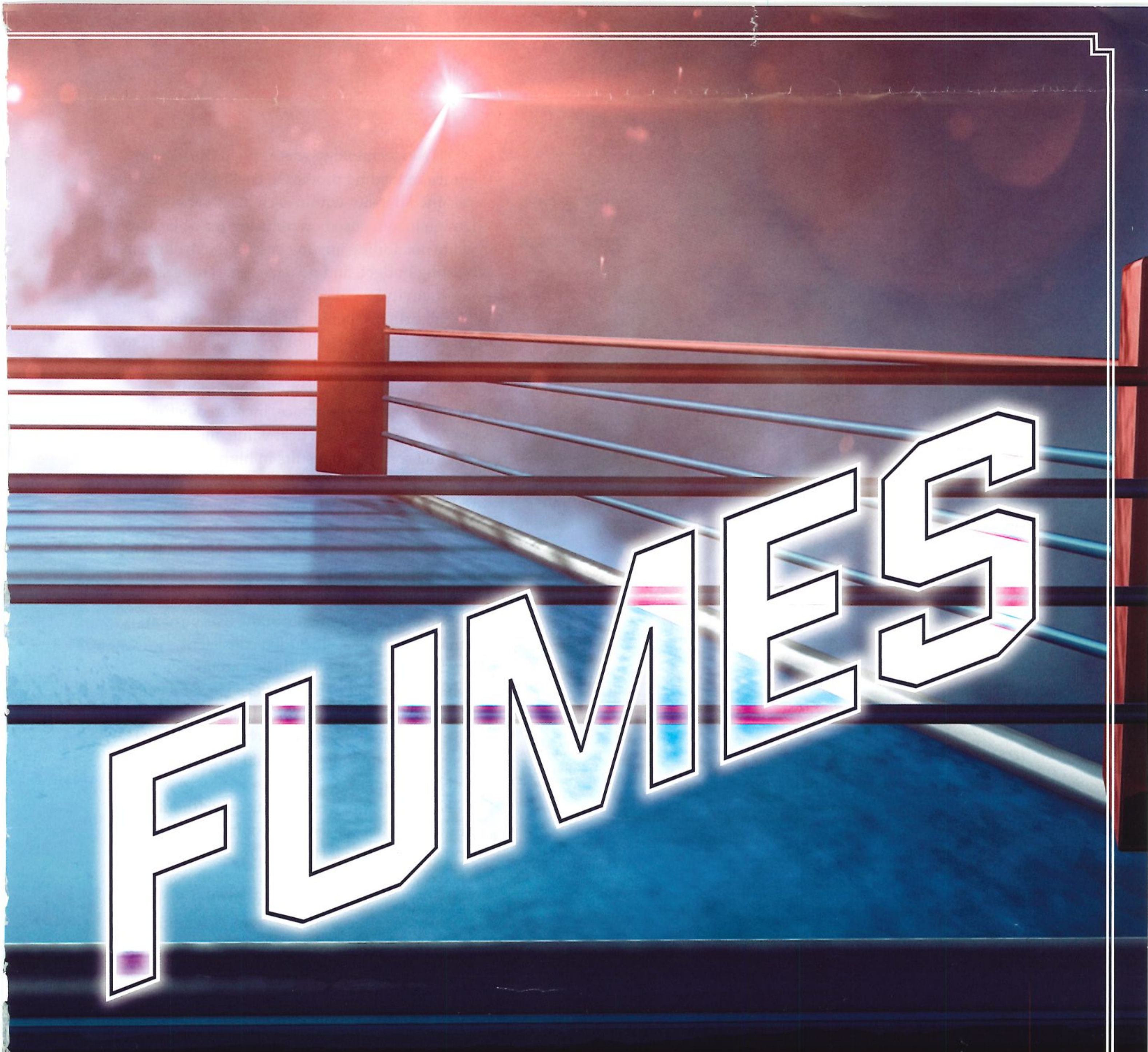
A Wyoming opencast coal mine required a solution to reduce post-blast fumes, as it was to continue to expand near public roads. **Baron Fidler, Dyno Nobel, USA,** details the mine operator's actions.

A Wyoming opencast coal mine determined the time to start planning for future mine progression was before the long-term mine plan took them closer to the public county road, located adjacent to their permit boundary.

At this time, the mine used a 40/60 HANFO augured blend with good results, but with sporadic post-blast fumes. In the past, the mine had struggled with its results when introducing new technology that did not deliver on its promises. Possible post-blast fumes as the mine advanced closer to the county roads was an area of concern with the chance of fumes travelling in this direction and sometimes creating a blast delay.

The goal of reducing post-blast fumes has been part of blasting focused continuous improvement projects in the past but renewed focus has made this a higher priority. Most technology advances occur when the right people with the right need place value on trying technology with hope that a better blasting practice will result.

The coal blast pattern that was being used at the mine was 36 x 33 x 64 with 11 in. dia. holes holding 28 ft of drill cuttings in the stemming zone. Coal strata was uniform and was typically blasted for rope shovel digging so forward movement from the face was limited. The density of the 40/60 HANFO blend was 1.25 g/cc loading out to 50.6 lb/ft. Calculated powder factor for the coal blasts was 0.55 lb/t. Primary tracking of the coal blasts was muckpile



flow, slab coal from the top down to the shovel, or feeder break plugs from slab coal.

It was not common for the rope-shovel to encounter varied digging conditions but more common for coal to stand in pillars and not flow during the digging process. Material flow is an operator tracking metric.

The truck/shovel overburden blast pattern was 38 x 40 x 60 with 11-in. dia. holes holding 22 ft of drill cuttings in the stemming zone.

Overburden strata varied from wet sandy soil to clay soils, and was typically blasted for rope shovel digging. Forward movement from the face was limited, especially with muck bound blast patterns. The 40/60 HANFO loads at 51 lb/ft. Calculated powder factor for the overburden blasts were 0.51 lb per blasted cubic yard (bcyd). Primary tracking of the truck and shovel blasts were done through shovel operator comments while meeting planned production.

The mine's primary goals when looking for a new solution included a reduction in post-blast fumes, a reduction in the powder factor per blast event and an improvement in dig rates while maintaining blast performance. The use of drone video along with a post blast-fumes comparison scale was used to compare TITAN® blast events to HANFO loaded blast events. Primary goals to consider included TITAN bulk emulsion loading density technology to reduce post-blast NO_x, maintaining or reducing drilling and blasting costs, and maintaining or improving rope shovel productivity.

The first blast was designed to be cost-neutral looking at modification of the explosive energy distribution within the hole. This was accomplished using the TITAN DIFFERENTIAL ENERGY™ Calculator. This calculator considers up to four emulsion segments based on emulsion final cup density, hole angle, hole depth,

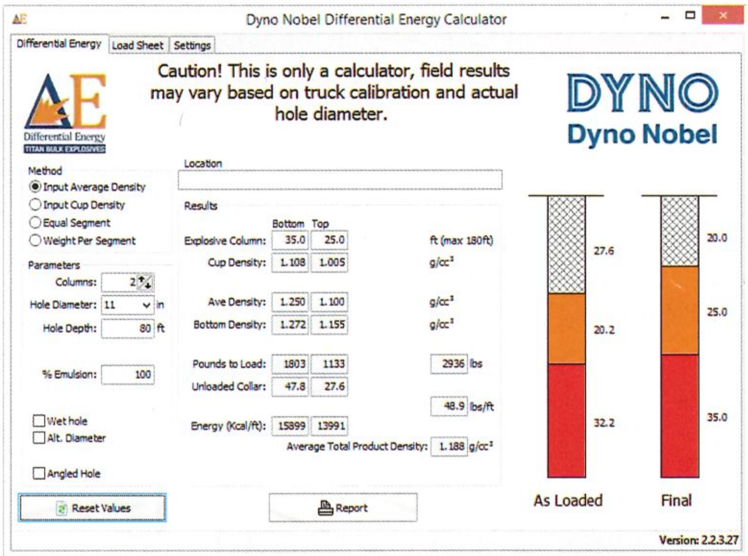
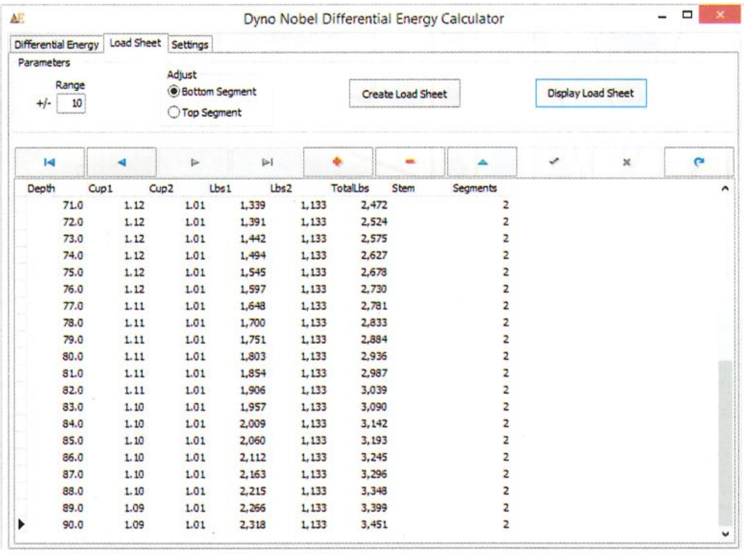


Figure 1. A sample read from Dyno Nobel's TITAN DIFFERENTIAL ENERGY Calculator.



Depth	Cup1	Cup2	Lbs1	Lbs2	TotalLbs	Stem	Segments
71.0	1.12	1.01	1,339	1,133	2,472		2
72.0	1.12	1.01	1,391	1,133	2,524		2
73.0	1.12	1.01	1,442	1,133	2,575		2
74.0	1.12	1.01	1,494	1,133	2,627		2
75.0	1.12	1.01	1,545	1,133	2,678		2
76.0	1.12	1.01	1,597	1,133	2,730		2
77.0	1.11	1.01	1,648	1,133	2,781		2
78.0	1.11	1.01	1,700	1,133	2,833		2
79.0	1.11	1.01	1,751	1,133	2,884		2
80.0	1.11	1.01	1,803	1,133	2,936		2
81.0	1.11	1.01	1,854	1,133	2,987		2
82.0	1.11	1.01	1,906	1,133	3,039		2
83.0	1.10	1.01	1,957	1,133	3,090		2
84.0	1.10	1.01	2,009	1,133	3,142		2
85.0	1.10	1.01	2,060	1,133	3,193		2
86.0	1.10	1.01	2,112	1,133	3,245		2
87.0	1.10	1.01	2,163	1,133	3,296		2
88.0	1.10	1.01	2,215	1,133	3,348		2
89.0	1.09	1.01	2,266	1,133	3,399		2
90.0	1.09	1.01	2,318	1,133	3,451		2

Figure 2. A report from TITAN DIFFERENTIAL ENERGY Calculator.

wet or dry hole, designed stem height and length of the loaded emulsion segment.

TITAN bulk emulsion technology offers TITAN XL 1000 and TITAN 1000ΔE delivered into the hole at a loading rate of up to 2000 lb/min. This delivery rate is similar to augered HANFO. All wet holes are dewatered prior to loading either blasting agent.

This technology provides a new value experience for the coal customer with improved product performance using the same amount or fewer pounds of blasting agent per loaded blasthole. Detonation velocity is greater than (20 000 fps) compared to solid sensitised emulsions greatly increasing the detonation pressure on hard material. The emulsion is shipped as a 5.1 oxidiser and loaded into the blasthole as a 1.5 blasting agent. This is a benefit to the mine as they have greater restrictions with storing blasting agent volumes.

TITAN technology was applied during the emulsion loading process to consistently load the designed density within each blasthole segment. Design load focused on reducing post-blast NO_x, while not adding any increase to the drilling and blasting budget, and no decrease in rope shovel productivity.

The primary benefit of the application of TITAN emulsion technology was being able to note on the post-blast reports that no NO_x fumes were present. Added benefits included: increased water resistance, increased actual energy yield vs theoretical value, increased product sensitivity results in high order detonation, ability to control density and redistribute energy, increased detonation pressure, maintained cost per loaded foot and the ability for emulsion to be loaded to a lower density in highwall row, resulting in the same pounds stretched to a greater height.

Success measurements in the overburden truck/shovel blasts included consistent productivity (bucket fill times and bucket volumes) even in harder material located below the sandy strata, reduced post blast NO_x fumes based on fume classification chart, few shovel operator complaints, and equal or reduced drill and blast budget.

17 blast events were completed without NO_x fumes. Pounds per loaded foot had been reduced from 51 with 40/60 HANFO to 46 range loading TITAN XL1000. Average difference in pounds per foot was 10% when the goal was 7.5%. Stemming height was reduced from 22 ft to 21 ft to improve surface material displacement.

Success measurements in the coal blasts included no roll crusher plugs from slabs, improved shovel production through uniform fragmentation, and equal or reduced drill and blast budget. 10 blasts completed over a five week period had no post-blast fumes. The blasts also had good material movement, uniform fragmentation and no complaints or negative comments from shovel operators (with the exception that one blast had too much face movement resulting in low muckpile profile). Average difference in pounds per foot was 10% when the goal was 4.5%. TITAN 1000ΔE pounds per loaded foot averaged 46 compared to 51 with HANFO.

Regular customer meetings were held to review the drone captured blast videos, blast data and blast event cost comparisons. General comments were that the material was dug without complaints from shovel operators and there was no change in production. Continuous evaluation of the product density placement and stemming heights are currently being evaluated to help fine-tune the surface disturbance and muckpile profiles. This is one advantage of TITAN Emulsion Technology providing various levers to pull for improving blast results. WC bearing wear. An operating temperature as high as 194°F (90°C) was reducing lubricant viscosity, which was causing leaks within the bearing assemblies. To help extend bearing life and improve productivity, the company approached Cosan Lubrificantes e Especialidades – ExxonMobil's exclusive local distributor – for a more effective lubrication answer.

Cosan recommended a switch to Mobilith SHC™ 220, a high performance synthetic grease with a proprietary additive system and advanced lithium complex thickener designed to perform in demanding applications and at extreme temperatures. As a result of the change, the company saved US$4 269 076 over four years due to reduced lubricant consumption and the prevention of premature equipment failure.

ExxonMobil also has helped an opencast mine in the US save more than US$2.1 million annually by switching to its high performance synthetic gear and bearing oil, Mobil SHC™ 630. The lubricant helped optimise the performance of almost 50 CAT 793 haul trucks, leading to fuel economy, productivity and safety gains.

The operator reported that Mobil SHC 630 helped reduce drivetrain operating temperatures and improve fuel economy by 5.5%. The enhanced protection also helped minimise maintenance, reduce costs and enhance safety by reducing HMI by 326 hr.

A machinery health check

A carefully managed used oil analysis programme can provide detailed insights into the condition and performance of both the lubricant and the equipment it helps to protect. This information can help users detect issues, such as contamination, deposit build-up and wear, before they become problems, helping improve equipment reliability.

The Mobil Serv Lubricant Analysis service from ExxonMobil takes predictive maintenance to a new level. In addition to its 25 testing options, the service features a mobile app, scan-and-go bottles and flexible analysis capabilities, all of which are designed to provide a platform that is fast, convenient and easy to use.

Mining expertise and product knowledge

The coal mining industry faces a host of challenges, including fluctuating commodity prices and tightening margins. It is, therefore, essential that mine operators optimise productivity through the most cost-effective and efficient use of their mining equipment. ExxonMobil possesses a wide-ranging knowledge of the lubrication needs of the mining industry, as well as the products and services to support its customers realise their operational objectives. WC