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HMX Based Electronic Initiation System for Blasting in High Temperature Ground and/or Extremely Reactive Ground

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ABSTRACT

Blasting in geothermally high temperature ground and/or extremely reactive ground is an increasing common challenge for surface and underground mines. Many current PETN based non-electric and electronic detonators have manufacturer published in-hole temperature limits ranging from 55°C to 65°C (131°F to 150°F). When confronting blasthole temperatures above the manufacturer published limits, operations may request site-specific guidance and qualification for use. The advised safe loading window for in-hole PETN based detonators is often too short to be practicable for production blasting.

To overcome limitations of PETN based initiation systems, surface mines with high temperature ground and/or reactive ground are known to load blastholes with a qualified high temperature bulk emulsion that are top primed with a cartridge of temperature qualified detonator sensitive emulsion plus an RDX detonating cord downline. As there is no in-hole delay detonator in this system, blasthole timing is accomplished with surface delays. Although this system is safe, top priming and surface delaying does influence floor quality and top size fragmentation, and safe loading windows times reduce blast block size and increase blasting frequency.

A mining company with a site characterized by geothermally high temperature ground plus highly reactive ground employed a blasting system like the one described above. The site desires to improve blasting performance by moving to an in-hole delay initiation system that can withstand the site ground conditions. At the request of the mining house, DynaEnergetics developed an electronic initiation system for application in geothermally high temperature ground and/or extremely reactive ground conditions.

The DynaEnergetics IGNEO high temperature electronic initiation system is rated for in-hole use in ground up to 150°C (302°F) for 48 hours. The detonator consists of a high strength detonator with an HMX base charge and thermally resistant downline. To make up a primer, the detonator is inserted into a booster charge assembly that is fitted with a small HMX shape charge. This high energy primer is designed to be compatible and reliable for firing bulk emulsions, including those with high percentages of urea inhibition to combat reactive ground. Up to 1000 detonators may be programmed in 1 ms increments up to 1500 ms. The system is controlled by a digital firing panel that can be used with either a wired or wireless trigger.

The system enables high temperature and/or reactive ground sites to utilize in-hole delay initiation and realize the associated performance benefits.

TRADITIONAL BLASTING METHODS IN HIGH TEMPERATURE AND/OR EXTREMELY REACTIVE GROUND

Reactive ground is a term used in the mining industry to describe the condition where an exothermic chemical reaction can occur between sulphide bearing rock and blast holes loaded with nitrate-based explosives. Reactive ground conditions increase the risk of explosives deflagration and/or unplanned detonations.

Blasting in geothermally high temperature ground and/or extremely reactive ground is an increasing common challenge for surface and underground mines. Many current PETN based non-electric and electronic detonators have manufacturer published in-hole temperature limits ranging from 55°C to 65°C (131°F to 150°F). When confronting blasthole temperatures above the manufacturer published limits, operations may request site-specific guidance and qualification for use. The advised safe loading window for in-hole PETN based detonators is often too short to be practicable for production blasting.

To overcome limitations of PETN based initiation systems, surface mines with high temperature ground and/or reactive ground are known to load blastholes with a qualified high temperature bulk emulsion that is top primed with a cartridge of temperature qualified detonator sensitive emulsion plus an RDX detonating cord downline (typically 8 g/m, 40 gr/ft). The primer assembly of emulsion cartridge and detonating cord is sometimes used in conjunction with a thermally resistant plastic shell. The exposure time of this primer assembly is typically qualified for 8 hours at a maximum temperature of 150°C (302°F).

As there is no in-hole delay detonator in this system, blasthole timing is accomplished with surface delays. Although this system is safe, top priming and surface delaying does usually negatively influence floor level quality, muckpile fragmentation uniformity, and top size. Additionally, product safe loading windows times reduce blast block size and increase blasting frequency.

DYNAENERGETICS IGNEO HIGH TEMPERATURE ELECTRONIC INITIATION SYSTEM

Newcrest Mining Limited desires to improve blasting performance at the Lihir Mine in Papua New Guinea by moving to an in-hole delay initiation system that can withstand the geothermally high temperature ground and extremely reactive ground characteristic to the mine. The Lihir Mine is in the crater of a inactive volcano and is the hottest open cut gold mine in the world. In mid-2017, Newcrest approached DynaEnergetics to develop a very high temperature electronic initiation system that would enable in-hole timing delays as opposed to surface timing delays. Since this time, DynaEnergetics has developed an HMX (High Melting Explosive) based in-hole electronic initiation system specifically for blasting in geothermally hot and/or extremely reactive ground conditions. Restrictions due to the pandemic paused field evaluations of the system at the Lihir site, and this work is anticipated to resume in 2023.

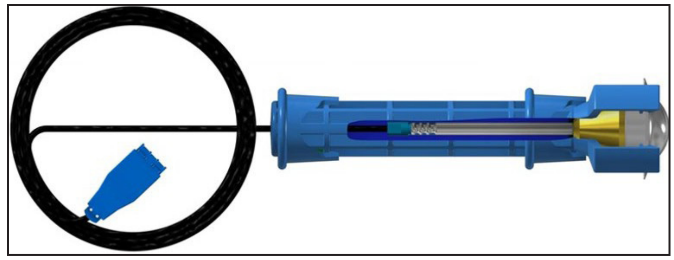

Figure 1. IGNEO HT150 electronic detonator and booster charge assembly

DynaEnergetics is a provider of well-completion and well de-commissioning solutions to the global oil and gas industry. DynaEnergetics integrated perforating systems are recognized by the unconventional oil and gas sector as being safe, efficient, and reliable. DynaEnergetics perforating systems include a intrinsically safe initiation system that is immune to voltage, stray current, and radio frequency energy. Key components of the system include an igniter, surface tester, and firing panel. Electronic detonators for oil field applications can withstand temperatures up to 260°C (500°F) for a limited time.

DynaEnergetics has adapted their seismic perforation system technology to a very high temperature electronic initiation system designed for the mining industry. The IGNEO system can withstand in-hole temperatures up to 150°C (302°F) for up to 48 hours. It is intrinsically safe from stray current, stray voltage, and radio frequency energy. In the field, the system handles very much like other electronic initiation systems.

The foundation of the system is the HT150 high temperature electronic detonator. The detonator has an HMX base charge that is encapsulated in a copper shell with an anti-corrosion coating. HMX has a decomposition temperature of 287°C (549°F) as compared to PETN with a decomposition temperature of 202°C (396°F). The downline is double coated thermally resistant wire with a harness wire surface connector clip. The detonator is pressure rated to 3 Bar. The time delay is user programable from 1 ms to 1500 ms in 1 ms intervals. The detonators are Class 1.4B and can be shipped by air.

The system also has a unique booster charge to complete the primer assembly. The business end of the booster charge is made of an encapsulated 20+ gram HMX perforating shaped charge. The detonator and booster charge assembly measures 6.5 cm x 23.0 cm (2.6 in x 9.1 in). The booster charges are Class 1.4D and suitable for air cargo shipment. See Figure 1 and Figure 2.

The shape charge generates a high pressure, high velocity jet that reliably detonates bulk emulsion charges,

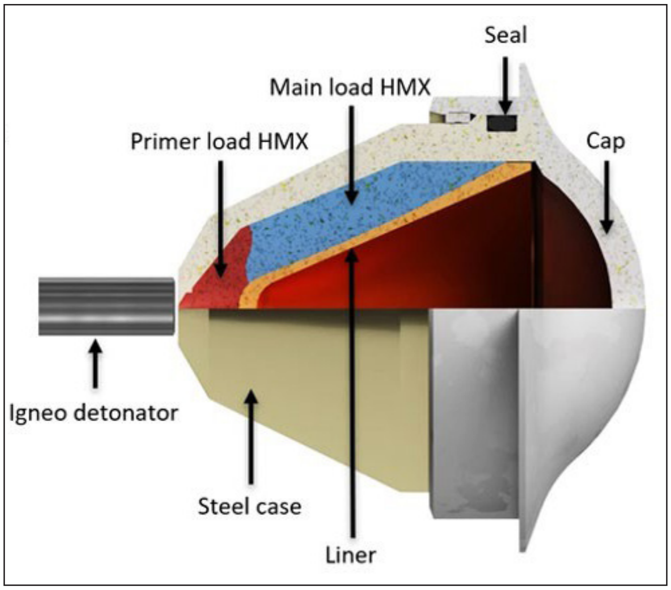

Figure 2. IGNEO booster charge – X Section

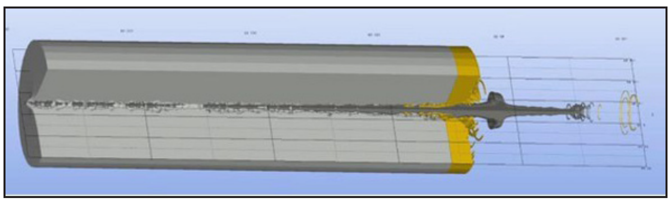

Figure 3. Shape charge detonation computer model

including those with high percentages of urea inhibition to combat reactive ground. See Figure 3.

The programming and testing device is intrinsically safe, and the housing is made of aluminum and designed to withstand challenging operating conditions. Detonator programming is done after hooking up the detonator to the harness line. Detonator timing may be assigned by the programming device or by a computer- generated blast design file. Up to 50 detonators may be tested while connected to the same harness line. See Figure 4.

The firing panel is intrinsically safe and has an intuitive user interface. The firing panel can control up to 1000 detonators and has wired or wireless trigger capability. See Figure 5.

APPLICATIONS FOR HMX BASED HIGH TEMPERATURE INITIATION SYSTEM

High percentage urea inhibited nitrated based emulsions that are qualified for geothermally hot and/or reactive blasting applications up to 150°C (302°F) are available from several manufacturers. In the case of reactive ground, the safe in-hole residence time for inhibited emulsions is temperature and time exposure dependent and determined by

Figure 4. IGNEO programming and testing device

Figure 5. IGNEO firing panel

reactive ground versus nitrate based explosive isothermal testing. While high temperature emulsions have been available for over 25 years, the choice of initiation systems to use with these products has been limited.

In the USA, unrestricted sleep time of in-hole detonators with PETN base charges is limited to ground temperatures 65.5°C (150°F) or below. In the USA, with explosive manufacturer qualification and MSHA variance, a blasting system consisting of an in-hole PETN based non-electric detonator, packaged detonator sensitive emulsion, and inhibited bulk emulsion may be used be up to 80°C (175°F) for 4 hours. In the USA and Canada, under qualification and approval, in-hole PETN based electronic detonators have been used underground in ground temperatures up to 85°C (185ºF) for 4 hours. Other countries have similar high temperature and/or reactive ground blasting qualifications and regulations and should be confirmed before use.

When blasting in hot and/or reactive ground with temperatures greater than 80°C to 85°C (175°F to 185°F), the global go to initiation system for priming has been the RDX detonating cord and high temperature emulsion cartridge emulsion previously described.

With the introduction of an electronic HMX detonator and HMX primer, it is now possible to pair this initiation system with a qualified high temperature emulsion, for an in-hole delayed blasting system rated for ground temperatures up to 150°C (302°F) for 48 hours. In-hole bottom initiation as compared to top priming and surface delaying is known to improve muckpile fragmentation uniformity and reduce oversize. For blasting in ground temperatures from 65.5°C to 85°C (150°C to 185°C), the HMX electronic initiation can expand the blast window from 4 hours to 48 hours. This allows operations to significantly increase blast block size and/or reduce blasting frequency.

Numerous mining operations can benefit from the utilization of a HMX based initiation system. Underground precious and base metal mines with geothermally hot ground may not have to shut down development headings for days at time to allow them to cool down before blasting. Surface operations characterized by high temperature reactive ground may be more able to blast through unexpected zones of extremely reactive, high temperature ground without resorting to mechanical breakage. Surface coal operations with reactive hot overburden and/or burning coal seams now have an initiation system option that permits safer and improved blasting of hot blocks.

CONCLUSIONS AND FUTURE WORK

1. An HMX based electronic initiation system has been developed and introduced to the mining industry that has the potential to improve blast performance and efficiencies in operations with high temperature ground and/or extremely reactive ground.
2. When combined with a qualified high temperature emulsion, the HMX initiation system enables blasting in ground temperatures up to 150°C (302°F) for 48 hours. This extended loading window enables blasting of larger blocks and/or decreased blasting frequency.
3. The HMX based electronic initiation system permits bottom in-hole delaying in ground temperatures above 80°C (175°F). As compared to top priming and surface delaying, in-hole bottom delaying is known to improve floor quality, muckpile fragmentation uniformity and reduce oversize.
4. Field evaluation of the HMX initiation system at the Lihir Mine is continuing.
5. Work on the next generation of the HMX initiation system is underway and will bring with it expanded application range and flexibility.

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24-052

Impacts of ESG on the Copper Supply Chain—The New Critical Mineral

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INTRODUCTION

Copper, the newest addition to the critical mineral list, is an essential metal whose electrical and heat conductive properties label it as a vital mineral for the creation of renewable energy sources and the reduction of Greenhouse Gases (GHGs). However, despite copper's leading role in the transition to sustainable energy and mining practices, the mining industry has faced various battles in the extraction of this valuable material. These challenges are based on mining's negative reputation and extensive impact on the environment, nearby communities, and human rights. To ensure the survival of mining in the future and achieve mineral demands, an emerging topic that has initiated the revolution of the traditional sector into a more environment-friendly and transparent industry, is Environmental, Social, and corporate Governance (ESG).

ESG has motivated companies to seek growth opportunities and standardize risk accountability and transparency based on its collective framework that creates, modifies, and implements local, national, and international standards. These standards focus on improving environmental, social, and governance issues faced by companies and their projects. ESG has served as a guideline that investors utilize to assess companies and promote sustainability, responsibility, and disclosure to create positive and balanced relationships with stakeholders and the environment. Nonetheless, concerns have been rising which state that ESG is negatively impacting the mining industry by targeting what fuels the industry and world: ore deposits and their resources. Therefore, this research focused on answering the following research questions: what are the impacts of ESG on the copper supply chain and how will stricter ESG standards affect future copper production?

METHODOLOGIES

We commenced this study by understanding ESG, its emergence, and its role across industries including mining. Then, a literature review was conducted to establish a baseline for the research by understanding what questions have already been answered and what gaps have been left. Third, we dissected the copper supply chain to showcase the stages needed from the identification of an ore deposit to the recycling of the goods produced from the copper mined.

The next stage connected the copper supply chain to ESG and determined ESG's impact on the copper supply chain stages. The connection was developed by collecting and analyzing current local, national, and international environmental, social, and governance standards and pairing them up with a copper supply chain stage. Once paired, the effect of the standard was determined by looking at risk mitigation, project improvements, number of injuries/fatalities, community acceptance, etc.