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Proximity Detection Systems for Mobile Machines in Underground Mines

Comment On: MSHA-2014-0019-0091
Proximity Detection Systems for Mobile Machines in Underground Coal Mines

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Comment from Craig Ross, Barrick Gold

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General Comment

See attached file(s)

Attachments

Barrick comments MSHA PR Proximity Detection Systems 2015

AB78-COMM-5

BARRICK

(November 22, 2015)

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Re: Docket No. MSHA-2014-0019, RIN 1219-AB78

Barrick comments regarding MSHA proposed rule for Proximity Detection Systems for Mobile Machines in Underground Mines – 30 CFR Part 75 published in the Federal register September 2, 2015.

On behalf of Barrick, we first want to state that we are supportive of MSHAs desire for proximity detection for heavy mining equipment based on a structured, limited focused phased in approach.

Poor visibility (blind spots) or not being aware of personnel, equipment or other facilities within close proximity is the primary causal factor for most mobile mining equipment collisions. At Barrick we have been identifying, evaluating and testing proximity detection system (PDS) technologies since 2011 in an effort find a reliable, accurate sustainable technology to address the problem of visibility to help prevent heavy mobile equipment accidents.

Prior to our implementation of a structured approach in 2011 to find such a PDS, several of our mine sites were installing and trying different PDS that were offered based on supplier claims of performance effectiveness. At a significant cost, our mine sites were installing the systems only to discover they did not perform as advertised. Eventually these PDS were abandoned due to escalating costs and resource requirements in attempts to resolve these performance issues. Lack of equipment operator acceptance due to low confidence in performance and nuisance or erroneous alarms was also a significant issue. It is this reason that Barrick established a corporate led structured approach in 2011 to find a reliable, accurate PDS solution.

This structured approach has resulted in a clear understanding by Barrick with regards to performance requirements necessary for an effective PDS. In addition we have communicated and partnered with the most promising PDS suppliers to clarify understanding of the performance needs to ensure an effective reliable PDS is developed that will mitigate the risks under real operating conditions. At Barrick, we believe we are close to achieving this objective.

Below is a summary of the worked performed by Barrick since 2011 followed by specific comments requested by MSHA regarding the current proposed rule for PDS.

In 2011 Barrick initiated a desktop study to determine what PDS technology currently existed and its state of readiness. A total of 26 PDS were evaluated. The desktop study revealed very little published test validation data from mine site testing or evaluation. Most proximity detection/collision avoidance systems were not formally field-tested. Our desktop study revealed 5 PDS as high-potential, collision avoidance technologies for field testing.

Following the desktop study, in 2012 field testing was conducted in one underground mine in Nevada, 2 surface mines in Nevada and one surface mine in Argentina. The baseline field-test results revealed that the three PDS identified in the desktop study performed significantly better (high accuracy and high precision). Accuracy relates to how well the system correctly detecting threats (performance). Precision relates to the repeatability, reliability, and variability of the performance.

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The following questions were used to evaluate proximity detection/collision avoidance systems:

1. Can the vendor/manufacturer provide the product globally, in a timely manner with resources and supply chain support?
2. Does the technology accurately identify hazards and alert the operator?
3. Does the technology change operator behavior and eliminate collisions?
4. What is required (time, cost, training, etc.) to install and use the technology?
5. Does the technology perform at a high level yet remain cost effective?
6. Does the system capture valid data?
7. Do site operators and management find value in the technology?

All of the PDS experienced detection failures to some extent.

In 2013, based on results obtained from the most promising PDS evaluated in the field testing, Barrick designed and conducted a comprehensive pilot of one PDS at a large surface mine. The system chosen for the pilot had field tested as having the best results for accuracy and short-range threat detection. In addition, the PDS was chosen due to its application in underground and surface applications. The PDS generators and proximity modules installed on equipment would create an electromagnetic field around the machine. The field could be adjusted for two levels of threat (warning and danger). When an electromagnetic field from one generator contacts a proximity module installed on another piece of equipment, the level of threat is identified and an alarm is issued. The electromagnetic fields could also be customized for different operating environments to minimize nuisance alarms and maximize safe distances. The system was also designed to detect identification tags worn by ground personnel, warning an operator and ground personnel. And in theory, could also be programmed to automatically slow or stop a machine.

The objectives of the pilot test include:

1. Review the sustainability of the System
2. Monitor the installation of the System in time, cost and resources needed
3. Measure baseline and installation slow speed warning and hazard frequency by equipment type
4. Optimize electromagnetic field sizes and identify surface equipment benefitting from installation of the technology
5. Track system failures, root causes of failure and reliability of the system
6. Evaluate site acceptance and site requirements

Operators and supervisors were given an opportunity to comment on the PDS. 60% of the respondents felt the system made them safer and about 30% felt the systems made it easier to identify hazards. Approximately 25% of the respondents did not like the alarm sound and a number of respondents would like larger field sizes.

A few respondents suggested they would like automatic equipment stops. Barrick has not tested automatic equipment slowing or stops because accuracy and reliability issues would have to be resolved before such an invasive approach could be undertaken. In addition, this step would require approval and cooperation of multiple OEMs. Without OEM approval, asking the PDS vendor to allow their technology to interface with mobile equipment operational functions could create unintended

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consequences and could potentially result in legal liability issues. Once the PDS were proven as accurate and reliable, then we felt we could take this next step with necessary OEM involvement.

Barrick spent $1,751,883 to complete this pilot study with the hope and expectation the pilot would be successful and result in implementation at other Barrick sites. The PDS experienced significant failures in the pilot. Technician errors, mechanical failure and installation issues all contributed to failures. The proximity hardware presented the most difficulty and rated poor due to wiring, installation, location of equipment and vibration issues. The Supplier committed to make improvements to reliability of the system.

By the end of 2013 Barrick had expended considerable expense and time to evaluate what was currently available in PDS and collision avoidance technology. The field tests combined with lessons learned during the pilot project demonstrated the strengths and weaknesses in the technology. Unfortunately the work demonstrated the PDS available did not yet currently meet Barrick requirements.

However, the field studies and pilot project resulted in a much clearer understanding of what Barrick must consider when further evaluating PDS and collision avoidance technology, including the need for multiple layers of detection technologies.

During 2014 additional evaluation was conducted based on these learnings knowing that the technology was improving to address performance issues that were present in previous testing.
Barrick in coordination with sales engineers from each of the leading PDS companies again conducted a desktop analysis of the new or improved leading technologies. The desktop analysis evaluated system accuracy and precision, ability to integrate with Barrick fleet management system (i.e. Jigsaw), in-cab operator interface, event data management and the operator performance monitoring improvements. The highest rated PDS were then reviewed during field validation with visits to Codelco Mina Sur Mine and Anglo American Los Bronces Mine in Chile.

In 2015 the project team identified the leading technology we felt was most likely to be successful in preventing mobile equipment related incidents. A field trial of the PDS was developed and executed at a Barrick Mine in North America which incorporated the improved evaluation parameters into the process.

We had learned throughout this process the primary purpose of any PDS /collision avoidance technology is to enhance situational awareness. Situational Awareness is the perception of current or future potential hazards in the surrounding environment and predicting how the hazards and environment will change with time. An operator's awareness of surroundings in a changing mining environment is critical to decision making. Lacking or inadequate situational awareness is one of the primary factors in incidents attributed to human error. Enhanced Situational Awareness is the ability to enhance an operator's senses with the aid of technology. According to Barrick's incident data, nearly half of the heavy mobile equipment incidents investigated in North America during 2014 may have been preventable with the installation of a collision avoidance/ PDS. Barrick reviewed vehicle collision incident reports and found that 90% of the events occurred at slow speeds (less than 10 kph/6 mph) with a significant portion of the collisions occurring when one vehicle reverses into another.

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The focus of this trial in 2015 was on haul truck and light vehicle operator awareness to improve the following aspects.

a. Assess the ability of the combined layers of technology (GPS, radar and camera) to significantly assist and improve operator skill in avoiding incidents
b. Evaluate the ability to PDS equipment in all of the Barrick designed scenarios
c. Identify mine locations where most frequent unwanted events occur
d. Recognize and record events outside of established normal operating procedures
e. Determine ability for the system to self-diagnose and calibrate system health
f. Review ability to integrate with Jigsaw

Minimizing nuisance warnings in both static and dynamic high traffic situations was a significant requirement of the trial. The trialed PDS has the ability to establish a geo-fence where a configurable electronic boundary automatically orders the system to change operating parameters when the boundary is crossed. For example; to eliminate nuisance alarms when a haul truck moved into a shop environment, the system would automatically adjust the front radar field so that a smaller area of detection was activated.

The Trialed collision avoidance system for mobile equipment included three technologies (GPS, Radar & Cameras) with two in-cab displays. The smaller LED display shows the GPS Collision Avoidance System (CAS) and radar alerts and the larger LCD monitor includes a graphical representation radar display and camera views. Audible alarms and visual displays are configurable to minimize nuisance alarms and visual distractions.

Three layers of technology provided a comprehensive avoidance system:

- Layer 1- Traffic Awareness using GPS CAS to provide 360-degree visibility (will never alarm). Layer 1 locates other GPS CAS equipped vehicles in the operating area of a vehicle. This layer provides the operator increased visibility to better assess what system fitted equipment is around them. The GPS CAS does not identify objects, personnel or vehicles not equipped with like equipment. Radar and cameras are needed to detect personnel and objects that the GPS CAS cannot.
- Layer 2 - GPS CAS Dynamic Field is defined as a rectangular shape, slightly larger than a vehicle that increases in size only in the direction of travel based upon speed of the vehicle. Layer 2 will alarm when the field breaches another CAS Dynamic Field and will increase in frequency and volume as the vehicle moves closer to a collision.
- Layer 3 - Radar and cameras that activate only at 7kph/5mph or less that alarm louder as the vehicle approaches a vehicle, an object or personnel.

Scenario Test Conclusions of the trialed Collective Collision Avoidance Systems

- Use on haul trucks and water trucks yielded the maximum value. The system effectively enhanced situational awareness in both active mining and ready line and shop areas. Radar and cameras were the most effective technologies. The trial demonstrated the ability to configure

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the radar and cameras to meet operations requirements in strategic areas of the mine. Alarms were configured to meet and mitigate risks associated with operating large equipment.

- The most value for light vehicles was achieved in active mining areas. GPS alarming was excessive in light vehicles while moving forward. Light vehicle operators preferred the traffic awareness visual (no alarming) to be able to see haul trucks around berms, blind corners and hills. The project team recommends the scope display for light vehicles, especially for supervisors and maintenance vehicles. That display allows drivers to see all equipment within 1600 ft., which is a great tool for finding personnel and equipment without increasing radio traffic.
- Nuisance alarms in auxiliary equipment such as blades and dozers were significantly high due to their work in close proximity to other equipment. Operators of auxiliary equipment preferred Traffic Awareness Layer 1 technology alone.
- A 994 loader operators saw the most value in Traffic Awareness Layer 1 technology combined with Layer 3 rear radar and camera.

Conclusions

The trial was more rigorous, as stated by the CAS vendor consultants, than any previously conducted by other customers in a similar environment.

> *"As the North American Sales manager for our products, and after consulting with the our project lead, I would like to state that the Barrick trial has been one of the best trials executed to date in North America."*

The CA system is highly configurable and was successful in reducing nuisance alarms without increasing risk to operators. The equipment withstood the weather conditions during the trial and but has yet to be tested in snow conditions. The radar remained effective in heavy rain.

The combination of Collision Avoidance System, radar and cameras provides significant improvement in operator situational awareness. Operator acceptance of the technology is positive as demonstrated by the Pre and Post-assessment surveys. The system as tested is capable of configuration that meets operational needs. What this system can do for Barrick on a large scale is unknown. The next step for Barrick is to evaluate a large-scale pilot of the CAS based on these trial results.

Specific Comments to MSHA proposed rule for Proximity Detection Systems for Mobile Machines in Underground Mines

1. **Slowing or stopping mobile equipment** - Requiring a machine to slow or stop based on current technology present several challenges:
    a. Based on field studies referenced above we have learned that setting the detection field distances must take into account several factors. The proposed rule requires a performance requirement of stopping before striking a miner. Discussion on this rule indicated 3 feet would be a good minimum distance. The problem is how to ensure the machine stops when the operator is no less than 3 feet from the machine. The issue we discovered relates to the speed of the mobile machine and the speed the worker is

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traveling while taking into consideration the current limitations of electromagnetic detection. Our testing on the surface with this technology demonstrated that the technology was only effective at 5kph or less. Based on the equipment size, speed, operator reaction time and braking distance, we configured the detection field to maximum size. Testing results were conclusive that if the equipment was driving above speeds of 5 kph (3mph) the operators would not have enough distance to stop prior to the 3 ft minimum distance. The byproduct of maximizing the fields was the creation of significant amounts of nuisance alarming. Based on our surface testing, the maximum field size places limitations on the maximum speed at which the equipment can safely stop prior to a collision. (This may also vary equipment type to equipment type) In addition, due to the elliptical shape of the field, every time equipment passed each other under normal operational circumstances each vehicle encountered an in-cab alarm.

b. We do not recommend current schedule requiring automatic equipment slowing or stops because accuracy, performance and reliability issues need to be resolved before such an invasive approach should be undertaken. In addition this step would require approval and cooperation of multiple OEMs. Without OEM approval, asking the PDS supplier to allow their technology to interface with mobile equipment operational functions could create unintended consequences resulting in potential legal liability issues. Once the proximity detection systems were proven as accurate and reliable, then take next step with necessary OEM involvement. We recommend at minimum adjusting the phase in to not requiring equipment slowing or stop for at least 36 months.

2. **Working vs. Non-Working Sections of the mine**
    a. In the previous mentioned studies above we found that the most successful Proximity Technologies were those that had GPS and could be configured to utilize a Geo-fence that could automatically adjust detection alarming and field sizes according to scenario needs
    b. Ex. We were able to create geo-fences to designate the working areas vs. non-working areas, and increased/decreased field sizes as well as turn off or on alarming based on location
    c. MSHA should consider that without GPS triangulation in the U/G environment relying on the operators to turn the detection fields on/off is not manageable. The only feasible way would be through radio/wireless infrastructure which would require additional research and development, additional resources and additional cost constraints to install & maintain the infrastructure, due to frequent work section movement

3. **Diesel vs. Electrical Machines-**

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a. It is well stated that the difference between the two equipment types is significant, further to that point-
    i. In introduction section B. it referenced an electro-magnetic system observed in South Africa as providing great accuracy at "close distances for slower moving machines". Our research on the surface supports the above and our findings demonstrate that the most effective technology installed on diesel surface equipment, was most effective at speeds of 5 mph or less
b. The challenges to overcome for proximity technology providers on diesel equipment include-
    i. Ability to sense the speed of multiple converging equipment traveling in any direction, in order to provide adequate reaction time & stopping distance based on vehicle weight and size
    ii. Our research demonstrated that electro-magnetic fields are incapable of morphing the field adequately to shrink the sides of the elliptical field and then push them in the direction of travel in order to limit nuisance alarms and provide adequate warning in order to prevent an incident
    iii. Our current research suggests there is only one OEM to date (Sanvik) that is actively developing an interface that would allow 3rd party proximity supplier to connect that can send and receive signals back and forth in order to slow or stop equipment based on the specifics surrounding an interaction
    iv. Development of the intelligence necessary for Proximity suppliers to send the signal to slow or stop a machine
c. Our comment to MSHA would be to consider extending the phase in period in order to have ample time for Proximity suppliers to work with the OEMs to develop the technologies to incorporate the above inputs into an intelligent solution
    i. Phase I might be collecting the frequency of proximity events with the alarms silenced
    ii. Phase II adjusting parameters based on Phase I and then enabling the alarms to collect operator feedback as well as frequency of proximity events
    iii. Phase III adjusting parameters to include slowing and stopping

4. Detection Methods other than Electro-Magnetic-

a) We agree with commenters regarding the accuracy of electro-magnetic technology, as we mentioned above we tested it at a surface mine, and found very minimal deviations in accuracy and precision, however calibration was something that needed to be frequently checked and adjusted as the fields would get out of calibration and not be as large as they needed to be.

b) Radar – we have recently performed significant testing on the surface with a proximity radar detection technology that proved very valuable.

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i. Using the technologies configuration options, the system uses an algorithm which tells the system processor to ignore designated areas of the detection field in order to prevent nuisance detections and define a specific detection area.
ii. With the right radar supplier, we are optimistic that this technology could be useful at slow speeds as its use at higher speeds is not practical

a) RF ID detection technologies are also rapidly improving and there are a few providers that are working on speed based detection methodology
   a) Our own testing of this technology in an underground environment demonstrated a 5 sec detection delay which forced us to increase the fields to maximum, which yielded too many nuisance alarms. This technology we also found was incapable of changing the detection field based on speed.
b) Our comment to MSHA would be that in order to obtain a successful proximity detection system for the underground environment for diesel equipment, there will most likely need to be multiple layers of detection technologies to cover specific needs.
   i. For example – on the surface we use GPS for higher speed detections and then for lower speeds we use radar.
   ii. For the underground it may be that for human to human detection electro-magnetic is best but for equipment to equipment another detection method might provide better value.
   iii. These systems will need to be able to communicate to each other and be configurable to ignore each other in certain circumstances, to prevent unneeded alarming

1. Maintaining the Proximity System-

a) Maintenance of these systems is one of the most highly underestimated aspects of implementation. To achieve success we believe MSHA should take into consideration the following-
   i. Remote Diagnostics- when proximity systems fail, not only should the operators and those around them be informed but also maintenance and administrators of the system. We can't rely on the operators to inform maintenance or management of downed PDS, and operators should not have access to by-pass. The systems should have the intelligence to wirelessly and automatically transmit diagnostic information back to the control room when the system needs repair.
   ii. Training- In this document it refers to training being offered to maintenance personnel for 4 hrs., this is not enough time. When dealing with these technologies they can be quite complex and each has its unique software and diagnostic tools which can be complicated and take time to learn.

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Therefore it is our opinion that a week's worth (40 hrs.) of technical training would provide the necessary skill set to adequately be certified to maintain these systems. The last thing a miner would want is to have these systems fail time after time, just due to lack of skill set to keep them healthy and operational.

Conclusion

As it relates to future proposed regulation of proximity detection in the metal/non-metal mining environment. Our research to date suggests that these technologies are not yet intelligent and reliable enough for the metal/non-metal environment, especially due to the increased amount and types of diesel equipment. Our recommendation is supported by the comments above. Continued research and development work between MSHA, the miners, proximity suppliers and OEMs are crucial to further develop the technology to an effective and reliable level. We are hopeful with continued research and development by PDS suppliers and OEMs, that a much needed effective and reliable system will be available to all mines in the near future.

Sincerely,

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