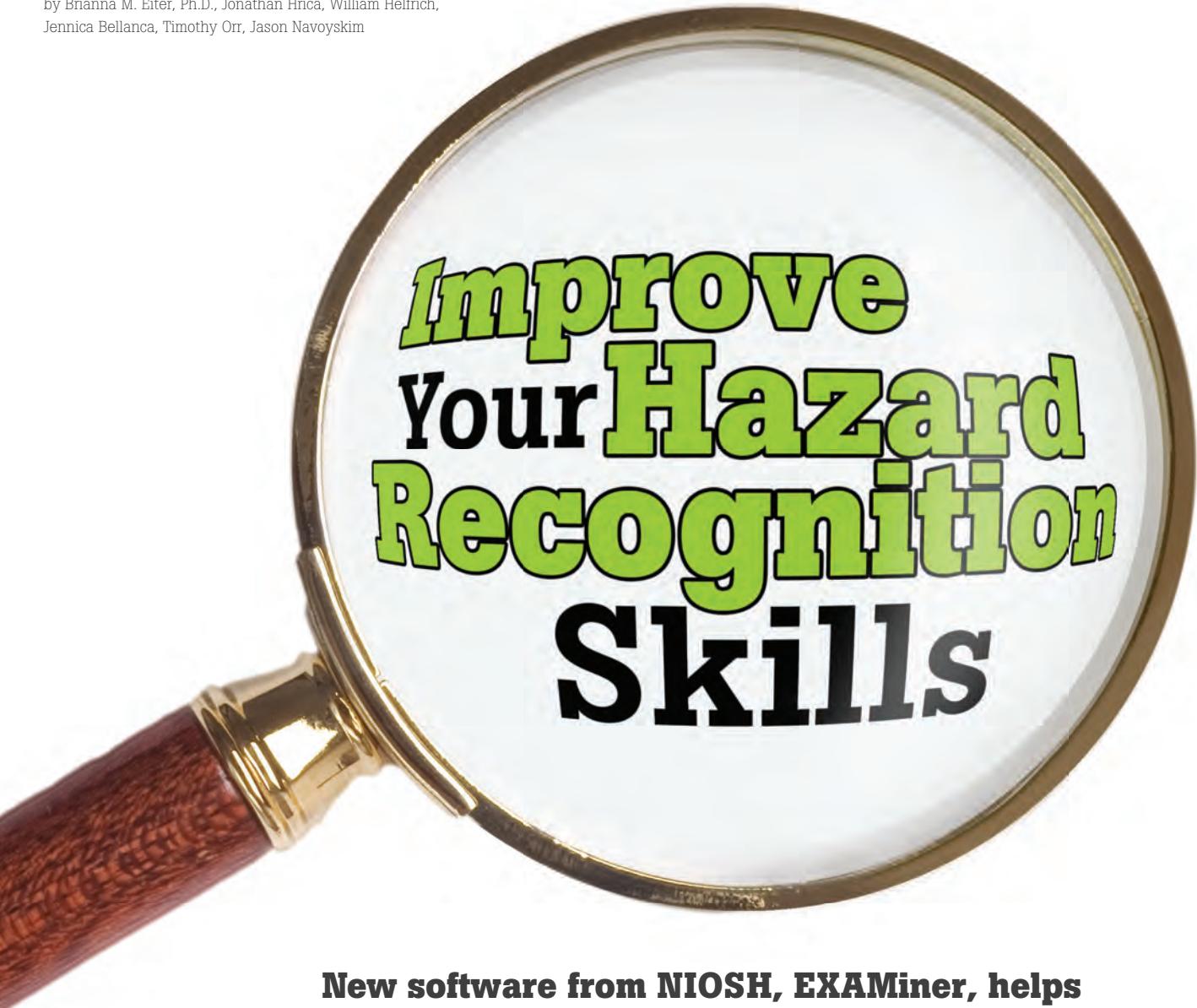


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Improve Your Hazard Recognition Skills

**New software from NIOSH, EXAMiner, helps
mineworkers recognize hazards at their sites.**

As the metal/non-metal (M/NM) mining industry prepares for the enforcement of the Mine Safety and Health Administration (MSHA) final rule on Examinations of Working Places (30 CFR Part 56/57.18002), researchers at the National Institute for Occupational Safety and Health (NIOSH) are developing programs designed to help mineworkers improve their hazard recognition abilities. Hazard recognition is critical for mineworkers' health and safety; however, recent laboratory research shows that mineworkers are not identifying a significant number of hazards.

Hazard recognition in the laboratory

NIOSH researchers conducted a laboratory study to identify the impact of mineworker experience on hazard

recognition ability. Experienced and inexperienced mineworkers, mine safety professionals, and mining engineering students performed a simulated workplace examination by searching through 32 true-to-life-size panoramic pictures of typical locations (e.g., pit, plant, haul roads, and shop) at a surface limestone mine for hazards. This simulated workplace examination took place at NIOSH's Virtual Immersion and Simulation Laboratory (VISLab). Study results show that even the most experienced mine safety professionals were only able to accurately identify 61 percent of the hazards included in the images, which is well below the 90 percent standard for mastery.

EXAMiner: Moving from laboratory to field

In order to address potential deficiencies in hazard rec-



Figure 1 shows a potential slip, trip, and fall (STF) hazard identified in EXAMiner software. The mineworker does not have three points of contact while climbing the front-end loader.

ognition ability within the mining industry, NIOSH researchers focused efforts on developing practical solutions from NIOSH's research findings. One practical solution is EXAMiner – software that gives mineworkers the opportunity to perform a simulated workplace examination, in much the same way participants in the NIOSH laboratory study performed workplace examinations in the VISLab.

There are several proven training strategies incorporated into EXAMiner. The first is to provide mineworkers with a *simulated task* that is immersive and recreates part of the mining work experience. Within EXAMiner, mineworkers perform a simulated workplace examination by searching high-fidelity panoramic pictures for hazards as if they were at a mine site. NIOSH researchers created this simulated task with the aim of improving information retention and enhancing transfer of knowledge from training to application in the workplace.

A second training strategy included in EXAMiner is *practice*. EXAMiner gives mineworkers the opportunity to practice searching for and finding hazards in the panoramic pictures. Figure 1 shows a panoramic photo from the software. Using a keyboard and mouse, mineworkers can identify the hazards by clicking on them. Previous research shows that realistic and relevant practice increases the likelihood that critical skills and concepts will transfer to the job.

A third training strategy is to provide mineworkers with *feedback* about their performance on the hazard recognition search task. EXAMiner provides a debrief session where mineworkers receive accuracy scores as well as specific information about hazards, including a brief description, accident and injury statistics, and information from the *Code of Federal Regulations*. Debrief sessions are critical during training because

feedback increases the impact of simulation and practice on learning.

Critical hazard recognition competencies

EXAMiner addresses four competencies critical for hazard recognition ability. These competencies were chosen because they are important basic competencies that all mineworkers should have.

General hazard recognition knowledge in mining is the knowledge of hazards found at most mine sites. For example, mineworkers have to be knowledgeable that slip, trip, and fall (STF) hazards can be caused by the build-up of material on a stairwell or catwalk. STF hazards have the potential to occur at most mine sites, regardless of the type of material mined.

Site-specific hazard knowledge is knowledge of hazards that are unique to mining operations. For instance, mineworkers operating front-end loaders and haul trucks in quarries and pits have to be knowledgeable about the unique geological characteristics of the material they are mining at their site. Improving general and site-specific hazard knowledge will better prepare mineworkers to recognize hazards when they are present. Both general and site-specific hazard knowledge is represented in EXAMiner by the hazards chosen to be included in the panoramic pictures. These competencies are also reinforced during the debrief session with information about the specifics of the hazards.

Visual search skills are critical contributors to hazard recognition ability because mineworkers must also be able to efficiently and effectively search their workplace and surroundings. To address this competency, EXAMiner gives mineworkers the opportunity to practice searching for hazards using panoramic pictures.



Figure 2 shows a larger, more noticeable hazard of a mineworker walking under an unsecured toolbox and a smaller, less obvious hazard of a broken step. The larger hazard was correctly identified 93 percent of the time during the NIOSH laboratory study while the smaller hazard was only identified 20 percent of the time.

Finally, EXAMiner targets *pattern recognition* because mineworkers must also be able to recognize patterns and changes in normal operation patterns that reflect normal activities or are an abnormality. For instance, there are safe and acceptable locations of equipment or personnel during operations, and there are typical cycles of changes in a mine environment over time. Changes to these patterns can signify when something is out of place or “does not look right,” which may trigger the mineworker to recognize a hazard. To address this competency, the panoramic pictures include multiple examples of the same hazard. For instance, there are several different hazards related to fire extinguishers, including missing extinguishers where there is signage present, but the fire extinguisher is missing, blocked, or obstructed. This approach should increase the likelihood that a mineworker will be able to recognize a fire extinguisher hazard in the future, even if it was not specifically included in a training session.

Considering mining industry training needs

NIOSH researchers designed EXAMiner so that users can easily adopt it into current training programs. EXAMiner will be available as downloadable software that, once installed, will not require an internet connection and can be used with any device running the Windows 10 operating system. EXAMiner was designed to be used during an instructor-led Part 46 annual refresher or new miner training held in a classroom setting and can be used during other training situations as well (e.g., during monthly training meetings or toolbox talks). EXAMiner gives trainers the ability to customize training scenarios either by creating their own training scenarios or by choosing to create random scenarios from the panoramic images included with the software. Finally, EXAMiner includes

scenarios focused on specific types of hazards (e.g., electrical or slip, trip, fall) and enough content to last for Part 46 annual refresher and new mining training classes for several years.

EXAMiner in the field

NIOSH provided several trainers who are leading MSHA Part 46 annual refresher training with a beta version of EXAMiner to gain preliminary industry feedback on the usability of the software and identify ways that trainers could incorporate EXAMiner into their training plans. Overall, feedback on software usability has been positive, and NIOSH researchers have observed trainers using EXAMiner in a variety of ways with their training classes.

Trainers allocated between 30 and 45 minutes of their 8-hour training sessions to using EXAMiner. Trainers used the software with groups that range from five to 25 mineworkers. These classes were held in conference rooms with integrated projector systems and mechanical shops with a portable projector and screen. Trainers used EXAMiner either in conjunction with a review of hazard recognition and the current workplace examination rule, or at the end of their training day as an evaluation tool. Using EXAMiner as an evaluation tool gives trainers a means to assess mineworker knowledge of the training they just completed and to identify any potential gaps in mineworker hazard knowledge that can be addressed during future training (e.g., monthly safety meetings or toolbox talks). It also gives mineworkers the opportunity to put their Part 46 annual refresher training into practice, which is critical for transferring knowledge from the classroom to implementation in the workplace.

Feedback from both trainers and mineworkers is that EXAMiner provides an opportunity for interaction and discussion,



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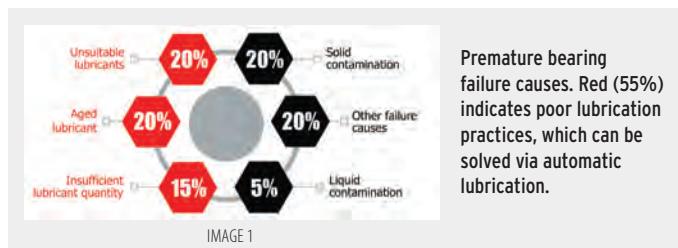
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Lower Cost per Ton - Automatic Lubrication Systems

To maintain competitiveness, aggregate quarries must maximize production output while minimizing long-term operating costs. A key component to achieve this is the implementation of preventative maintenance strategies, which extend equipment service life and minimize the downtime required for maintenance, repair and operation (MRO). Success in this area reduces the total cost of production assets, and ultimately improves business performance.

Cost and downtime due to premature wear is significant. For grease-lubricated bearings, well-considered lubrication strategies have a dramatic effect on extending bearing service life and therefore reducing costs and improving equipment reliability. The chart (Image 1) provides proportion estimates of premature bearing failure causes. Major causes are poor lubrication practices and contamination.



Premature bearing failure causes. Red (55%) indicates poor lubrication practices, which can be solved via automatic lubrication.

In recognition of this, leading construction-industry businesses invest in automatic lubrication systems for the purpose of bearing re-lubrication and contaminant exclusion, because these systems deliver superior reliability results compared to manual lubrication. Reliability results such as:

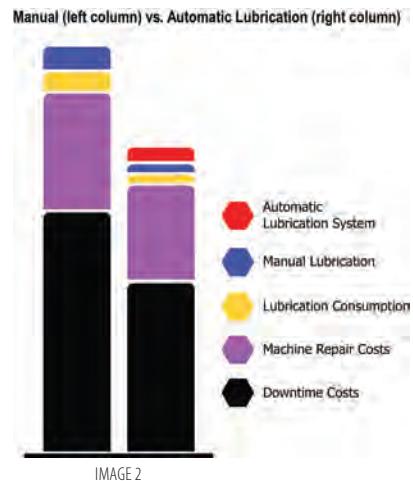
- Continuous production processes and predictable maintenance intervals
- Continuous, low-maintenance, long-term lubrication
- Permanent supply of lube-points with fresh lubricant
- Consistently high lubricant quality guarantees
- High equipment availability
- Energy cost reduction

Bearing re-lubrication addresses the need to maintain sufficient fresh grease around the working components of bearings as they rotate. Insufficient or infrequent re-lubrication leads to deterioration of lubrication conditions, lubricant starvation, and premature wear. Meanwhile, for high-speed bearings, the rapid supply of excessive amounts of grease can cause over-lubrication, which leads to degradation of grease condition and threatens the service life of bearings.

The longest bearing service life is achieved when grease is added in small amounts at short intervals. When implemented correctly, this regime of grease delivery maintains a steady state of lubrication protection where over-lubrication and lubricant starvation do not occur.

Factors which reduce the service life of grease include high speeds, elevated operating temperatures, vibration and high loads. When operating conditions such as these prevail, the benefits of delivering small amounts of grease at short time intervals are at their greatest.

Image 2 demonstrates the differences between re-lubrication methods which deliver small amounts of grease at short intervals and those which deliver large amounts at extended intervals.



Too much grease

- Potential for elevated operating temperature and rapid degradation of grease for high speed bearings
- Less efficient use of fresh grease
- Potential to damage contact type seals

Too little grease

- Starvation causing premature wear
- Accelerated degradation of remaining grease
- Increased potential for contamination entry due to lack of lubricant purge

To determine if automated grease system could be a cost-saver for your aggregate site, engaging a qualified third party could help you get on track. For more information on automatic lubrication systems, contact your local Motion Industries servicing branch.



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which can enhance the learning experience. In one class, mineworkers actually got out of their seats and approached the projector screen to physically point out hazards they identified to the instructor. This interaction led to in-depth discussions about hazards: What is the difference between a safety hazard and a situation that is a potential MSHA citation? What are our site-specific safety policies, and how do those policies potentially differ from those at other mine sites? In addition, trainers were typically able to incorporate points brought up during the hazard search task into the debrief sessions.

In all the sessions NIOSH researchers observed, trainers using EXAMiner included debrief sessions and provided mineworkers with feedback on the hazards they found and those they missed. Interestingly, in a majority of the classes, mineworkers spent time during the debrief session discussing additional potential hazards found in the images, as well as their own site-specific safety policies. As one example, the mine site depicted in the panoramic pictures did not have a specific chocking policy or glove policy, but several of the mining companies NIOSH observed did. Trainers noted all of the instances where mineworkers identified missing chocks and gloves and hazards, then discussed their site-specific policies relative to MSHA regulations, reasons why mineworkers should chock vehicles, and the gloves that are required for different tasks.

Changes you can make now

Based on observations of the use of EXAMiner in its beta version, we suggest the following when discussing what mineworkers and workplace examiners should keep in mind when searching their workplace for hazards.

- *Encourage mineworkers to slow down and take their time.* EXAMiner keeps track of the time spent searching for hazards for each panoramic picture as feedback during the training session debrief. NIOSH chose to include search time with other feedback variables because the amount of time spent searching can have an impact on the number of hazards mineworkers and workplace examiners find during inspections. As an example, NIOSH laboratory research study showed that less experienced mineworkers and mining engineering students searched for hazards for significantly less time than safety professionals and found significantly fewer hazards. Therefore, it is important to remind mineworkers, especially those who are new and inexperienced, to take their time while inspecting their

workplace, because they will not find hazards if they do not take the time to search.

- *Remind mineworkers to look beyond the obvious.* The EXAMiner software includes a variety of hazards in the panoramic pictures. Some of the hazards are large and easily noticeable. For instance, there are hazardous situations that include haul trucks and front-end loaders that should immediately pop out at the mineworker. There are also smaller, more obscure hazards such as a damaged or missing step or handrail. During the NIOSH laboratory research study, these smaller, obscure hazards were missed more often than the larger, more noticeable hazards (see Figure 2). It is important to remind mineworkers and workplace examiners to look beyond the obvious when inspecting their workplace, because there may be other less apparent hazards present that require mitigation.

Availability of EXAMiner

A beta version of the EXAMiner software will be available on the NIOSH Mining website (www.cdc.gov/niosh/mining/) on Dec. 1. NIOSH researchers are also evaluating the effectiveness of EXAMiner as a training tool. For further information, contact Brianna Eiter at beiter@cdc.gov. **AM**

NIOSH Disclaimer

The findings and conclusions in this paper are those of the authors and do not necessarily represent the official position of the National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention.



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