HHS Public Access
Author manuscript
Min Eng. Author manuscript; available in PMC 2017 September 01.

Published in final edited form as:
Min Eng. 2017 July ; 69(7): 105–109.

Quick fixes to improve workers' health: Results using engineering assessment technology

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Abstract

Personal respirable dust sampling and the evaluation of control technologies have been providing exposure information to the mining industry but not necessarily in a way that shows how technology can be integrated to provide organizational support and resources for workers to mitigate dust sources on site. In response, the U.S. National Institute for Occupational Safety and Health (NIOSH) used previously developed Helmet-CAM technology to design and engage in a behavioral/engineering cooperative intervention to initiate and enhance mine site conversations about the risks and potential occurrences of respirable silica dust exposures on the job as well as provide impetus and solutions for mitigating higher sources of dust. The study involved 48 workers from five mine sites, who agreed to participate between April 2015 and September 2016. Using the Helmet-CAM in this series of longitudinal interventions revealed several exposure trends in respirable silica dust sources and, in many cases, simple quick-fix strategies to reduce their sources. This paper focuses on several specific identified sources of dust that were elevated but could be reduced through basic engineering fixes, low-cost resources, and supportive communication from management to remind and engage workers in protective work practices.

Introduction

Despite advances in ways to lower sources of respirable silica dust at mine sites, miners continue to experience periods of elevated exposure while performing their jobs. Previous surveillance data have shown that exposure to high levels of silica over time can result in silicosis, lung cancer, pulmonary tuberculosis and other airway diseases (Centers for Disease Control and Prevention, 2002). Because of these serious health outcomes, U.S. regulatory agencies have consistently been lowering the permissible exposure levels of respirable silica. Most recently, the Occupational Safety and Health Administration of the U.S. Department of Labor (2016) announced a new rule titled "Occupational Exposure to Respirable Crystalline Silica" (81 FR 16285), the key provision of which is a reduction in the permissible exposure limit for respirable crystalline silica from 100 μg/m^3 to 50 μg/m^3 of air, averaged over an eight-hour shift. The rule also outlines other action items, including:

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- Appropriate use of engineering controls to reduce exposure.
- Use of respirators when engineering controls cannot adequately limit exposure.
- Requirements to limit access to high exposure areas.
- Offering of medical exams to highly exposed workers.
- Training of workers on silica risks and ways to limit their exposures.

Effective June 23, 2016, the rule contains various enforcement dates by industry. Enforcement obligations begin June 23, 2017 for the construction industry under Title 29 of the Code of Federal Regulations (29 CFR), Section 1926.1153(k), and June 23, 2018 for the general and maritime industries under 29 CFR, Section 1910.1153(I)(3)(i).

It is not unreasonable to assume that the Department of Labor will extend this to the mining industry and lower the respirable silica level to 50 μg/m^3, regulated by the U.S. Mine Safety and Health Administration. Due to this anticipated change, the mining industry could benefit from quick and economic controls to reduce workers' sources of respirable dust exposure. Personal respirable dust sampling and the evaluation of control technologies have been providing exposure information to the industry but not necessarily in a way that shows how technology can be integrated to provide organizational support and resources for workers to mitigate dust sources on site. This gap in practical solutions was recently addressed in a series of U.S. National Institute for Occupational Safety and Health (NIOSH) studies using Helmet-CAM assessment technology.

Using health assessment technology to facilitate change

Several gaps in engineering controls have been identified to date, allowing organizations to make upgrades to their facilities to reduce or even eliminate dust sources (Cecala et al., 2012). However, any health and safety effort, including dust sources, also need to be mitigated through organizational and personal factors (Hoyos and Zimolong, 1988). Similarly ongoing formative efforts led NIOSH researchers to hypothesize that several subtle fixes that were quick and fairly easy to implement existed, but these fixes required buy-in and action from site-level management and workers to actually reduce the workers' exposure (Haas, Willmer and Cecala, 2016).

To this end, several years ago, Unimin Corp. (New Canaan, CT) and NIOSH developed an assessment technology called Helmet-CAM (Cecala and O'Brien, 2014; Cecala et al., 2013). Helmet-CAM is a lightweight video recording system used in conjunction with an instantaneous respirable dust device, allowing miners to record their activities while monitoring their exposure. Previously, this technology was used to assess how, when and where workers were being exposed to respirable silica dust. Since developing this technology, NIOSH has engaged in a behavioral/engineering cooperative study to apply Helmet-CAM technology as a risk management tool to improve site-wide awareness and communication between workers and management (Haas, Cecala and Hoebbel, 2016; Haas and Cecala, 2015). In this way, NIOSH researchers applied the technology as a mechanism to improve worker participation and control in their own health outcomes — a strategy recommended as part of an overall health and safety program (Harrisson and Legendre, 2003).

Materials and methods

Helmet-CAM technology intervention

The Helmet-CAM intervention aimed to initiate and enhance mine site conversations about the risks and potential occurrences of respirable silica dust exposures on the job as well as provide an impetus and solutions for mitigating higher sources of dust. The study involved 48 workers from five mine sites who agreed to participate between April 2015 and September 2016. Mine sites were asked to select job tasks they felt were more susceptible to respirable silica exposure in order to provide the organizations with desired and relevant information. Table 1 lists the mined commodities, the number of workers who participated and their job positions.

The workers wore the Helmet-CAM, which is equipped with a person-wearable video camera and a real-time data-logging respirable dust monitor, during part of their work shifts while completing routine tasks. After wearing the Helmet-CAM for approximately one to two hours, the footage was downloaded into the NIOSH-developed Enhanced Video Analysis of Dust Exposure (EVADE) software, which synchronizes the video footage and respirable dust exposure data (NIOSH, 2014).

This harmonization of camera footage and exposure data allowed for easy review by the participating workers and site-level management. Specifically, EVADE could present potential dust hazards and illustrate the severity of those dust sources by providing the highest exposure peaks throughout the workers' lengths of wearing the Helmet-CAM. In the majority of cases, data were reviewed with workers and members of management together in an effort to initiate discussions about protective health behaviors that could reduce the identified dust exposures as well as potential engineering controls that could be explored to improve current dust control methods.

These activities occurred during two separate visits, approximately six to eight weeks apart at each mine site, for a total of 10 visits and approximately 90 worker assessments. Additionally, throughout the duration of the intervention, feedback was provided to participating mine site health and safety personnel and management through email or phone or in person about elevated exposure areas, issues associated with elevated exposures, and considerations to possibly reduce exposures. As a result, between NIOSH visits, site-level management could explore new engineering controls and communicate with workers about possible work practices that may help reduce exposure, which were then reassessed at the follow-up visit. This study design allowed for the identification, mitigation, response and reassessment of varying risks on site (Baker, Ponniah and Smith, 1999).

Results

Using the Helmet-CAM in a series of longitudinal interventions at the five mines revealed several exposure trends in respirable silica dust sources and, in many cases, simple, quick-fix strategies to reduce their sources. Several engineering controls were also identified that could be improved or replaced. Although these engineering controls are optimal for the long-term health of the entire workforce and highly recommended, results from follow-up assessments with participating mine sites showed that these fixes can, in some cases, take a long time to be approved, budgeted, planned and installed. In response, this paper focuses on specific identified sources of dust that were elevated but could be reduced through basic engineering fixes, low-cost resources, and supportive communication from management to remind and engage workers in protective work practices.

Exposure source 1: Sitting or moving on cloth seats while operating mobile equipment or light fleet vehicles, and sitting on cloth office chairs

At each mine site, elevated levels of respirable dust occurred when workers got in and out of mobile equipment and moved around on cloth chair seats located in offices or breakrooms. These exposures varied from a quick spike whenever workers got on and off a seat, to higher levels the entire time they were driving, entering data in an office or having a meeting. This was especially evident when the cloth material was worn through and the foam seat padding was exposed.

Case example—While assessing exposures in various mobile cabs at one site, a worker who operated the cab in mobile equipment that was cleaner had an approximately 78 percent lower exposure level, with dust peak of 110 $\mu g/m^3$, than a worker whose cab was dirtier or more dusty, with dust peak of 500 $\mu g/m^3$. These two haul truck drivers were operating their cabs on the same day, at the same time, driving the same route. Their exposure sources came when they were getting in and out as well as moving around in the cabs of their equipment, showing the excess dust liberated in the dirtier cab. The absence of exposure peaks for the driver in Fig. 1 shows that keeping up with cleanliness appears to make a significant difference in exposures while in vehicles.

Organizational quick fix—Replace any cloth chairs in offices or breakrooms with vinyl, leather or, for a cheaper option, plastic chairs to reduce excess dust in these areas.

Place vinyl covers over mobile equipment and light vehicle seats to help prevent dust absorption and liberation during worker movement.

Worker quick fix—Encourage and participate in general cleanliness inside the mobile cabs and vehicles, including post-shift. Specifically, work groups who shared mobile equipment reported being more mindful of cleaning out the cab for each other when a shift is ending upon seeing the exposure results.

In a similar vein, workers at several sites preferred to use a foam pad to kneel on while completing routine maintenance tasks and equipment repairs. Although a functional and cost-effective ergonomic fix, these foam pads can also accumulate dust. When maintenance workers kneeled on these pads or picked them up to carry to another location, respirable dust was liberated and exposed the worker to elevated levels. Placing a vinyl cover over these foam pads can help prevent dust absorption and liberation.

Exposure source 2: Dusty clothes worn by workers

Clean work clothes have been proven to keep workers' respirable dust exposures lower and also limit dust contamination in breakrooms (Cecala et al., 2008). Therefore, it was not surprising that dusty clothes, gloves and subsequently hands resulted in elevated exposures when workers rubbed their faces with their sweatshirts or had to frequently move around while completing a task. Workers who had on more layers of clothes tended to have higher exposures as well. Assessments demonstrated that in the winter months especially, workers' clothes may hold an excess amount of dust, resulting in consistent elevated exposures, because the clothes were laundered less frequently. Specifically, two maintenance workers who were working side by side throughout their job tasks had a significant difference in peak exposures, with one worker who was wearing a dirty hoodie having several peaks over the 100 $\mu g/m^3$ standard while the other worker with laundered clothing had minimal peaks.

Organizational quick fix—Consider a clothes-cleaning technique when clothes become contaminated through the workday. One consideration could be the installation of a clothes-cleaning booth system designed and tested by Unimin Corp. and NIOSH. To lower costs, this technology can also be constructed by the site using instructions provided by Cecala et al. (2007).

Managers reported purchasing and encouraging the use of leather gloves for workers in follow-up assessments because leather gloves absorb significantly less dust than cloth gloves and are easier to keep clean.

Worker quick fix—Keep work clothes clean throughout the workday and use clothes-cleaning technology that is available on site, especially post-shift. Laundering all clothing, including sweatshirts and coats, post-shift is also extremely important. In addition, housekeeping efforts, which are critically important for all operations, should be performed at the very end of the work shift.

Exposure source 3: Tying bulk bags — folding the bag loading collar toward the worker, resulting in very brief, elevated exposures

Case example—Folding the bulk-bag loading collar in a different direction from the worker resulted in up to 92 percent reduction in the peak exposure spike (92 $\mu g/m^3$) compared with the peak exposure spike that resulted from folding the collar toward the worker while tying off the bag (1,137 $\mu g/m^3$). These results show that changing work habits to fold the loading collar in varying directions (Fig. 2) while tying bags throughout the day appears to make a significant difference in these brief, yet high, exposure peaks.

Organizational quick fix—Offer continued encouragement to modify work practices in terms of how bags are tied throughout a worker's career.

Worker quick fix—Some workers discussed creating new habits to either fold the loading collar in the opposite direction or even to the side, which can significantly reduce respirable dust being emitted toward a worker's breathing area throughout the shift.

Exposure source 4: Spraying/hosing down areas around the plant site

During various site assessments, exposures were higher when workers were using forceful water nozzle patterns, in a tight cone pattern, and especially when spraying upward or toward beams on the ceiling, or hosing down dusty equipment, such as a crusher. Obviously, work conditions indoors can be different from one visit to the next. However, because the exposure spikes were lower on the second visit, upon using different water nozzles, respective sites may be able to glean from this and explore at their own locations.

Organizational quick fix—Conduct tailored pilot tests to determine if different hose nozzles affect the amounts of dust liberated. Follow-up assessments have shown that using different variable spray nozzle types may help reduce the amounts of dust liberated while spraying.

Worker quick fix—Apply water before housekeeping to wet down dust in areas to help minimize fugitive dust emissions before hosing everything down. When beginning housekeeping efforts of hosing down, begin with a fan spray pattern to wet everything down before modifying to a more concentrated and forceful cone spray pattern.

Exposure source 5: Dust-laden objects that workers use or maneuver while performing tasks, such as opening handles or bolts, picking up or grabbing screens, or stacking bags

Many workers’ job tasks regularly involve moving and maneuvering certain objects to complete a task. Some of these tasks routinely contribute to higher, brief exposure peaks. Examples of such situations assessed using the Helmet-CAM included:

- Manually moving pallets in preparation for loading, including placing cardboard on a pallet before stacking bags.
- Placing and readjusting stacks of unloaded 23-kg, 36-kg or 45-kg (50-lb, 80-lb or 100-lb) bags on a belt before laying them flat on the belt line for automated bag-filling systems.
- Having new materials and supplies, such as screens, located in cardboard boxes right at the work site. This can cause significant liberations of dust from moving and opening the boxes because of the substantial layers of dust that can accumulate on the boxes over time.
- Opening handles and unbolting while changing screens and picking up screens.

Although unavoidable, there are certain objects that can accumulate more dust. However, several inexpensive solutions were assessed that could be implemented by management and workers to solve some of these issues.

Organizational quick fix—If a product is being bagged that had been shown to create elevated respirable dust concentrations and exposures, require that workers keep their respirators on and perform housekeeping activities, such as cleaning the belt and watering the area, more frequently.

Purchase plastic totes to store new and dirty screens to help prevent dust accumulation and liberations during installation and to aid in the overall cleanliness of the area.

Worker quick fix—Implement some type of technique or method or storage area to keep unloaded pallets from becoming soiled with dust before use.

Investigate methods to more thoroughly clean the bag--stacking table and conveyor during housekeeping duties. Workers on follow-up visits who reported cleaning and maintaining the belt better than during previous visits had lower exposures.

Implement some type of technique or storage area to keep unloaded paper bags from becoming soiled with dust before being stacked for loading.

Discussion

Several common sources of dust were described as well as quick and cost-effective fixes that could be implemented on behalf of the organization and the workers to reduce exposures over a period of time. Of note is that several of the workers' initiatives involved improved housekeeping of some sort. The Helmet-CAM assessments also showed that, pertaining to housekeeping, dry sweeping is usually a last resort when cleaning. Normally, any type of vacuuming or wet application is preferred over dry sweeping. Additionally, it is important to remind employees of the dust clouds they create when cleaning and moving around mobile equipment. Encouraging them to avoid walking through or staying in these dust clouds can also help to ensure that the housekeeping duties have their intended effect.

Although the dust sources discussed were regular trends among the participating sites, other issues may arise to varying degrees at different sites. In this study, only metal/non-metal operations participated because the Helmet-CAM technology is not permitted for underground coal use at this time. However, as the technology and software are further refined, implementing this technology at underground coal operations could be useful in the future.

The results indicate that Helmet-CAM assessment technology can be used to identify elevated dust sources and subsequently test potential solutions to reduce workers' exposures. Organizations can choose to implement quick, simple fixes while planning and budgeting for more major engineering fixes or installations. Although using Helmet-CAM requires active participation from management, as they have to facilitate the use of Helmet-CAM, discuss video footage with workers and help mitigate potential risks, the updated EVADE 2.0 software is making this tool easier to use during a normal workday. The software can be downloaded at http://www.cdc.gov/niosh/mining/Works/coversheet1867.html.

Conclusion

Previous research has debated how continual changes in organizational management, technologies and job processes affect worker health over time within an overall management system (Harrisson and Legendre, 2003; Heller et al., 1998; Jonker and Karapetrovic, 2004). With changes in organizational innovations and integrated approaches to system safety across mine sites, it can be easy to overlook how these changes could increase workers' exposures while completing their routine tasks. Continuing to assess dust sources during times of change will remain important both to protect workers and in light of new regulations. Assessment technologies such as the Helmet-CAM allow workers to play an active role in their own health and safety management.

These intervention studies revealed the interest and diligence of workers in making an effort to manage their own exposures and risks, upon knowing and understanding their primary dust sources. Several workers inquired whether they could do anything differently and were eager to test possible solutions to see if the solutions made a difference when they completed the tasks a second time. This high level of interest through increased levels of worker engagement shows that consistent support and communication from leadership can result in new and enhanced decision-making among workers that will ultimately protect their health while lowering exposure levels throughout the organization.

Acknowledgments

NIOSH would like to thank the mines and workers who participated in this study.

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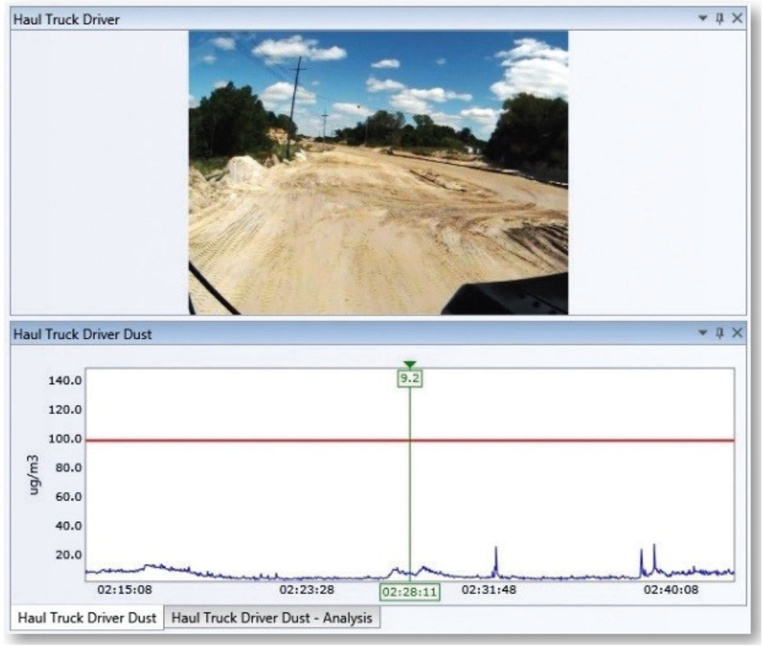

Figure 1.
Haul truck driver completing task in clean mobile equipment.

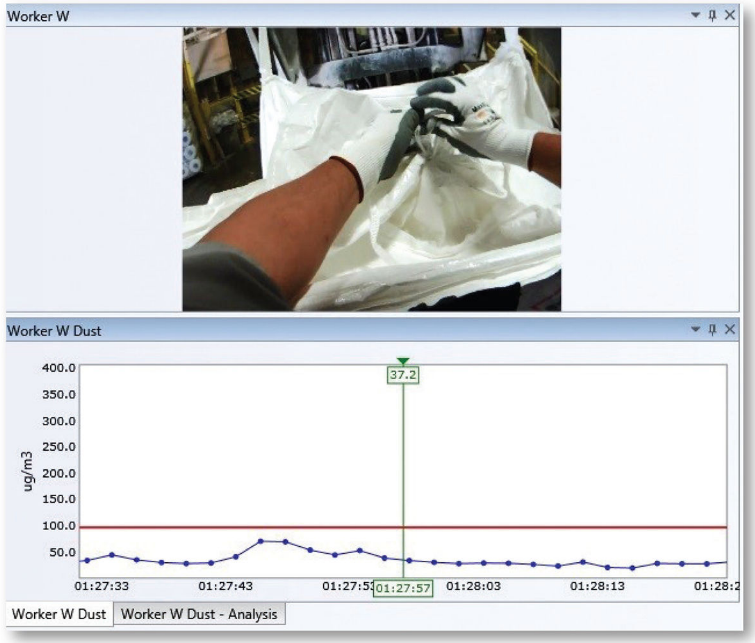

Figure 2.
Bagging operator folding the bag's loading collar to the side while tying his bulk bag.

Table 1

Helmet-CAM intervention participants.

Mined commodity	Number of participating workers	Job positions (as described by the workers)
Industrial minerals/aggregates	11	Loader operator, rail loader, lab technician, dry maintenance, clean-up, mine operator
Metal	9	Assay lab technician, maintenance, blaster
Industrial minerals/aggregates	9	Maintenance, electrician, utility/process operator, load truck operator
Industrial minerals/aggregates	12	Bagging operator–bulk and mini bags, clean-up, maintenance
Industrial minerals/aggregates	7	Bagging operator–bulk and mini bags, lift truck operator, load truck operator