Coal Miner Responses to the Personal Dust Monitor

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Since 1999, the CWP level among miners with 25 years or more experience, for instance, has risen from slightly more than 4% to 9% (See Figure 1). While it is obviously necessary to protect all miners' lungs, there is now a technology to improve the chances that new miners' lungs will be protected from the day they begin work.

A new personal dust monitor (PDM) can help miners to be better aware of the respirable dust levels in their environment. The PDM differs significantly from the present sampling system with its gravimetric pump. Today's miners may not have access to dust exposure measurements until several days after the sample is taken. Also, the current sampling program only measures dust concentrations in the environment of an occupation being sampled. It does not necessarily reflect an individual miner's dust exposure. With the PDM, miners will be provided with near real time dust exposures during their work shift, enabling individuals and management to be more proactive in preventing overexposures.

The PDM was previously field tested at 10 mines; it was found to be durable and reliable. Test results demonstrated that the PDM could measure respirable dust levels as accurately as the current sampler. To fulfill its intended purpose, however, it must be used correctly. Therefore a project was developed that would systematically document how workers react to wearing the PDM and evaluate how it is used on the job.

To make the unit more convenient for miners to wear it is combined with a cap lamp battery into a single piece. There is no extra hardware to carry around. The PDM has several components that are shown in Figure 2. The inlet of the sampler is built into the cap lamp itself. Air is drawn into the inlet at a flow rate of 2.2 liters a minute (l/min). The air travels through a rubber tube that runs alongside the lamp cord. Internal electronics calculate respective concentrations based on flow rates and times. These data are shown on a display screen on top of the battery housing. At the same time, concentration data are recorded to internal memory so that it can later be downloaded to a computer. In normal operation, the PDM will be programmed to automatically start, stop, and record an entire shift of data. No person can alter the programmed functioning of the PDM until it is reconnected with a computer by a responsible person in charge of the mine's sampling.

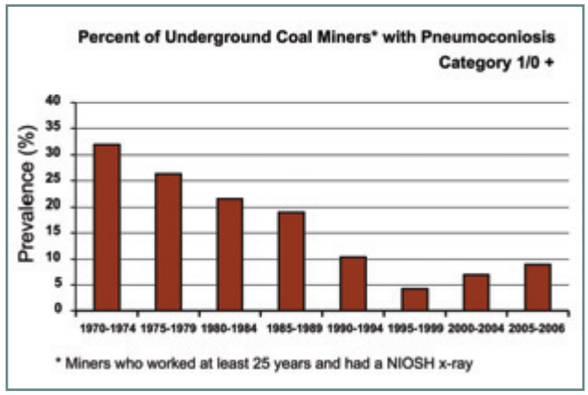

Figure 1: Black lung trends among examinees, 1970-2006.

There are parts of the PDM, however, with which miners may interact. These include the two switches and display on top of the unit. The switches allow workers to toggle through screens that provide feedback on the concentration of respirable dust to which they are being exposed. For instance, one screen provides the mass concentration value for the past 30 minutes, the average mass concentration from the beginning of the shift, and the projected mass concentration for the entire shift. Another screen displays a bar chart showing concentrations in milligrams per cubic meter (mg/m^3) in 30 minute averages. A new bar is added to this chart every 30 minutes. A miner's interactions with the PDM display buttons during his or her work will have no effect on the ability of the instrument to measure and record exposure data. The miner cannot accidentally alter the preprogrammed functioning of the PDM.

In-Mine Testing

To begin the present study, four mines were selected by NIOSH and members of a PDM partnership committee comprised of representatives from the aforementioned organizations. The mines sampled were in Utah and West Virginia. They all were parts of larger operations, with mining seams ranging from 4.5 feet (ft) to 8.5 ft in height.

The manufacturer provided a technical manual to accompany the prototype PDMs used in the study. because the manual was too complex to be used for most training purposes, the authors decided to make their own training materials. The materials are as close to "off the shelf" products as possible. The reasoning was that there will be no special classes or individualized instruction provided for trainers whose job will be to teach miners how to use the device. Their only resource is likely to be whatever training aids the original equipment manufacturer develops to accompany the device.

The final product is a "how-to" video to show the miners. The video is accompanied by an instructor's manual. There is also a short document introducing the device, and a "memory jogger" card (to reinforce points made in the video) that can be carried in the miner's shirt pocket. Because the scroll buttons must be pushed both singly and in combination to move from screen to screen, it was hoped that these materials would be used as the basis of a comprehensive hands-on training session to make the miners thoroughly familiar with the PDM and its use.

The PDMs and accompanying training materials were delivered to each mine's safety director several days before the miners were to start wearing them. So that the trainers would have time to become familiar with the PDMs and hopefully develop some sort of hands-on training program based on information contained in the instructor's guide and shown in the video. Just before miners were asked to start wearing a PDM, the safety director trained them. NIOSH researchers observed the training and evaluated various aspects of the instruction. Training consisted primarily of showing the video and asking if there were any questions. At one operation the trainer distributed the devices before showing the video. Rather than watch-

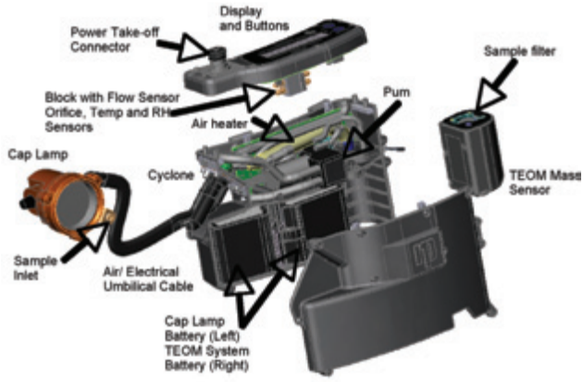

Figure 2: PDM internal components.

ing the video, the miners busied themselves with examining the PDMs. None of the trainers provided hands-on training.

Miners wore the PDM for four weeks. Researchers returned at the end of the fourth week to interview them about their reactions to the device. The interview questions were intended to elicit information on ways the PDM was used to reduce their dust exposure, and any problems that were encountered while they were wearing the device. A total of 30 hourly workers participated in the interviews. Their particular assigned tasks represented all of the major job categories performed in the face areas of underground coal mines in the U.S.

Despite the less than optimal training that was provided, almost all of the miners made some use of the device. The authors were primarily interested in the particular ways the PDM was used to: diagnose a problem; plan an action to alleviate the problem; and evaluate whether or not that action had any effect.

Diagnosis

Regarding diagnosis, it is necessary to assume that the persons wearing the PDM get a reading that is high enough to cause concern. The miners were asked several questions pertaining to diagnosis: "During a typical shift, how many times do you look at the numbers on your PDM?" A total of 25 miners gave numerical estimates from one to 20. The median estimate was six times. Five miners said they looked at the numbers "frequently or "several times." When asked how often they looked at their dust exposure number just before they turned their PDM in at the end of the day, 20 workers responded that they checked every day, while eight more said they looked at the numbers most days. Assuming the miners knew what the various numbers mean, this use of the PDM is encouraging.

Miners were reminded that the PDM has different screens that provide different types of information. The initial screen provides three types of data expressed as mg/m^3. The mass concentration value for the past 30 minutes is shown as MC0 on the screen. This short-term figure will fluctuate and can go above the permissible exposure limit (PEL) without exceeding the long term, full shift limit, which is 2 mg/m^3 assuming no silica is present. The average mass concentration from the beginning of the shift to the present (CUM0) will also fluctuate and can go above the PEL without exceeding the long term, full shift limit. If either MC0 or CUM0 go above the PEL, steps can be taken to prevent exceeding the PEL before the shift ends. The projected mass concentration for the shift (PROJ) is different. If PROJ goes above the PEL that means the exposure limit has been exceeded for the shift and there is no way to get back in compliance. As a check on their comprehension the miners were asked whether PROJ in excess of 2 mg/m^3 means the standard has been exceeded. More than one-half responded incorrectly. The implication here could be that either the question was confusing or some of the miners did not know what the numbers were indicating. Much of this confusion undoubtedly stemmed from the fact that 10 of the 30 miners were not able to recall that the standard is 2 mg/m^3, and therefore did not have a good frame of reference for evaluating the numbers they saw on the screen.

Another screen displays a bar chart showing mg/m^3 in 30 minute averages. A new bar is added to this chart every 30 minutes. When asked how often they looked at this screen, 20 miners responded that they looked at it more than three times per day, and another six looked at it at least once per day. The miners were next asked whether they noticed the numbers fluctuate during the shift. A total of 27 of the 30 miners said "yes." Interestingly, when asked if it was usually clear to them what was making the numbers go up and down, all said "yes." In response to a question that asked if they were ever surprised or concerned by what the numbers on the PDM display were telling them, 17 miners replied "yes." A total of 16 said the numbers seemed too high. One miner said he was surprised the numbers were so low because he was cutting rock. The 16 miners who thought the numbers were too high were also able to recall the most recent time this happened, and what they were doing. The types of activities they mentioned were: returning from the tailgate on a longwall; cutting coal with a continuous miner; operating a scoop in the return; and roof bolting.

It is possible to start and stop second samples at any time during a shift without affecting the primary sample. The purpose of this "sample within a sample" is to let management and miners see quickly whether the particular actions taken are reducing exposure to respirable dust. This capability was not used to any great extent and only 11 of the 30 miners said they had tried the second sample feature. Of those individuals who tried, most said they used it just once or twice.

Taking Action

Once miners believe they have diagnosed the cause of a high dust reading they are likely to start thinking of ways to deal with the source. Assuming they have the time and resources to do so, the miners may attempt to take care of the problem themselves. If this doesn't work, they may involve management in order for engineering or administrative controls to be initiated. Not one of the individual miners in the present study reported direct involvement of management. However, upper management at some of the original test mines did encourage their line managers to use the testing as an opportunity to educate and reduce worker exposure. That brings up an important point: while the PDM will provide invaluable information to the wearer, it is management that will continue to have the primary responsibility for proper use of the device and for staying in compliance with standards. In the present study mine management encouraged full miner participation in the monitoring process.

When asked if they had tried to do anything to reduce their dust exposure, 27 actions were reported: 15 changed positions; three changed face ventilation; four changed both position and ventilation; and one wore his respirator more often. Regarding positioning, continuous miner and longwall operators said they stood a few feet further back from the dust than usual, roof bolters said they waited for the continuous miner to finish cutting before bolting, and shuttle car operators reported that they stayed behind the

tilation curtain in intake air longer. Ventilation changes consisted of keeping the curtains up closer to the face, and keeping them tighter. In regards to respirators, one miner on a longwall said he began wearing a respirator during certain phases of his job. One super section manager took the initiative and told the crew to wear respirators until air flow to the section could be increased.

Evaluation

After making a change to try to reduce their exposure, miners are likely to try to evaluate whether the change helped. The way to do that is to check the PDM to see if the numbers go down. When the miners reported making any changes to reduce their dust exposure, they were asked if they looked at the numbers to see if they went down after the change. In 22 cases the miner said "yes." In all but two of these cases, the miner reported seeing the numbers go down. When asked how much they thought the change would reduce their overall exposure there were four responses of "small," 16 of "moderate," and four of "large."

In one case mine management conducted evaluations and shared the exposure data with NIOSH. Analysis of the data confirmed that this crew's exposure steadily declined throughout the month they were wearing the PDMs. By the end of the test, their exposure had declined by 60%.

In sum, there is evidence that several of the 30 miners were able to use the PDM as intended. Some others may not have had a good frame of reference for interpreting the numbers, but still could base their actions on whether the numbers were going up or down. No one failed to use the device at all. The goal, however, should be to have an informed workforce who can take advantage of all the PDM's capabilities, including using second samples. In order to achieve this goal, there should be hands-on training along with a thorough grounding in what the various numbers mean and how to interpret them.

Disclaimer

The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health.