Closing the Door to Dust *when Adding Drill Steels*

UNI-DIRECTIONAL CAB FILTRATION AND PRESSURIZATION SYSTEM TESTED

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During a recent National Institute for Occupational Safety and Health field evaluation of a newly designed filtration and pressurization system for an enclosed cab of a surface drill, it was determined that the drill operator's respirable-dust exposure was significantly increased during time periods when the cab door was opened to manually guide another section of drill steel into place to achieve additional cutting depth.

Although no dust cloud was visible when the door was opened to perform this task, the drill operator's exposure was documented (over a three-day test period) to be nine times higher than when the cab door was closed. Even at this higher respirable-dust concentration, the drill operator's exposure remained well below the permissible exposure limit governed by the federal dust standard; however, an alternative method is being investigated to guide the drill steel in place in order to eliminate this increased exposure.

BACKGROUND

Enclosed cabs are used on mining, construction and agricultural equipment to protect operators from safety and health hazards. One primary concern is overexposure to respirable dust. When equipment is new, the operator's dust and noise exposure normally is at acceptable levels. As the equipment ages and components such as gaskets and seals deteriorate, the level of protection can degrade to a point that is no longer acceptable. A compromised level of protection can become a serious issue when respirable dust is involved, especially when the dust contains crystalline silica.

In an effort to improve the air quality in older enclosed cabs on mining equipment, NIOSH has been working with the mining industry and manufacturers of cab filtration and pressurization systems. This cooperative research has identified two critical components necessary for an effective system.

The first critical factor is an effective cab filtration system, which should be composed of both a recirculation and clean (outside) make-up air system. Approximately 75% of the air inside an enclosed cab should be re-circulated through a high-quality filter and mixed with the make-up air before being delivered back into the enclosed cab. The make-up air is pulled from outside the cab and should also be filtered before being mixed with recirculated air. The make-up air is what creates the positive pressure inside the enclosed cab.

The second critical factor for an effective system is cab integrity, which is necessary to achieve some level of pressurization. Testing has shown that installing new door gaskets and seals, and then plugging and sealing cracks and holes in the shell of the cab, has a major impact on achieving positive cab pressurization.

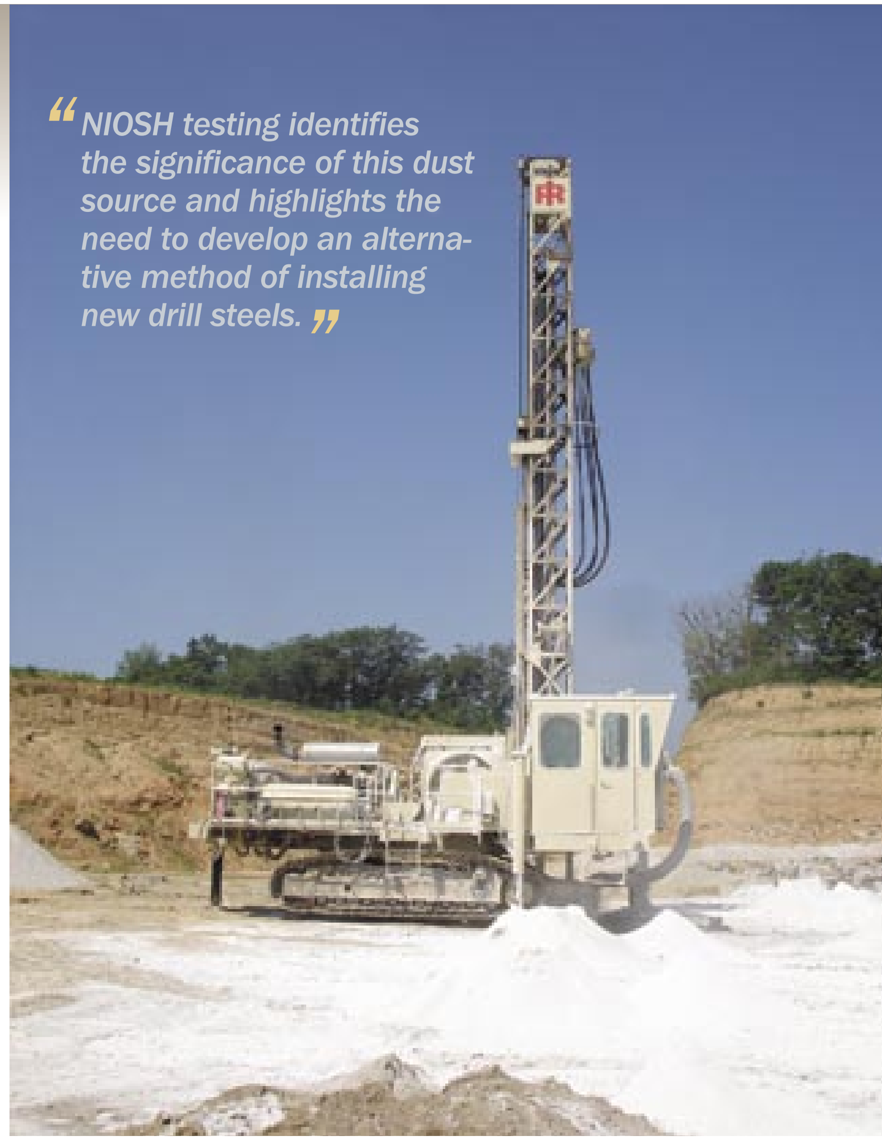
NIOSH has been working with Vulcan Materials Co. and Sy-Klone International to retrofit one of Vulcan's surface drills with a new filtration and pressurization system that uses a uni-directional airflow design. This new airflow design is better than current systems because all clean, filtered air is brought in at the cab roof, while all dust-laden recirculated air is drawn from the floor. NIOSH believes this is a superior design when compared with most current designs that deliver the filtered air, as well as exhaust the recirculated air, at the roof of the cab. In addition, since recirculated air is removed at the floor of the cab in the new design, it eliminates the dust-laden air being drawn over the equipment operator's breathing zone.

In an effort to test this concept, NIOSH entered into a cooperative working relationship with Sy-Klone International to design and build a filtration and pressurization system capable of the uni-direction flow pattern. Vulcan Materials agreed to work with NIOSH to evaluate this new system at one of its sites.

A baseline study originally was performed to determine respirable-dust concentrations inside the enclosed cab of one of Vulcan's rotary percussion drills. After this baseline testing was completed and the new uni-directional filtration and pressurization unit was installed, the exact same dust analysis testing was performed to evaluate the effectiveness of the new system.

While performing this analysis, it was noted that the drill operator repeatedly opened the cab door. Upon closer examination, it was determined that the operator was doing this so he could manually guide the next drill steel into place each time an additional section was needed. Since no drilling was occurring and no dust cloud was visible as the operator opened the cab door, the impact of respirable-dust concentrations in the cab was thought to be minor. However, when this issue was investigated by analyzing the instantaneous dust monitor results inside the enclosed cab, a large increase in respirable-dust concentrations was noted during periods when the door was open.

"NIOSH testing identifies the significance of this dust source and highlights the need to develop an alternative method of installing new drill steels."



TESTING

Three days of testing was performed from March 13 to 15, 2007, to evaluate the effectiveness of the uni-directional flow filtration and pressurization system. In order to truly determine effectiveness, it was necessary to take respirable-dust measurements inside the enclosed cab on the drill. A sampling rack was positioned inside the enclosed cab, immediately behind the head of the drill operator. This sampling rack was composed of two gravimetric dust-sampling packages and a pDR instantaneous dust sampler.

Both of these dust-sampling instruments measure respirable dust (particles that are 10 microns or smaller and able to enter a worker's lungs).

The personal Data RAM (pDR, Thermo Electron Corp., Franklin, Mass.) used in this study is a real-time aerosol sampler that measures a relative respirable-dust concentration based upon the light scatter of particles in an internal sensing chamber. This instrument was operated in the passive mode, in which dust particles traveled through the sampling chamber naturally with no mechanical ventilation assistance. An average respirable-dust concentration was taken every 30 seconds and recorded on an internal data-logger. At the end of each day of testing, these stored average concentrations were downloaded to a laptop computer for data storage and analysis.

By using the average respirable-dust concentration from the two gravimetric samples, a correction factor was then calculated by dividing the pDR average concentration value into the average gravimetric value. This calculated correction factor was then multiplied by all the dust measurements taken with the pDR device in an Excel spreadsheet.

Using both types of respirable-dust-monitoring equipment provided a good profile of average dust concentrations throughout the sampling period, as well as variations and changes in respirable-dust concentrations throughout the day. The values taken with the pDR dust monitor also were used to evaluate respirable-dust concentrations inside the drill cab when the cab door was open and when it was closed.

In addition to the respirable-dust instrumentation, a TSI Model 8705 DP-Calc Micromanometer (TSI Inc., Shoreview, Minn.) was placed inside the drill cab to record differential pressure between the inside of the drill cab and outside environment. This pressure device also had an internal data-logger and was set to record an average pressure measurement every 30 seconds, and thus made the sampling time identical to that of the instantaneous respirable-dust monitor.

When the cab door was closed, the filtration and pressurization system created a positive cab pressure of approximately 0.4 inches of water-gauge static pressure. When the cab door was open, the differential pressure dropped to zero. Calculating dust concentrations for those time periods when the cab pressure was zero corresponded with times when the cab door was open.

PROBLEM IDENTIFIED

While evaluating the effectiveness of the new uni-directional cab filtration and pressurization system, it was noted that the drill operator repeatedly opened the cab door to manually guide the drill steel into place each time an additional section was needed. During this evaluation, the operator was drilling holes 110 feet deep. Since the drill steels are 25-feet long, five steels are required to drill a hole to this depth.

When the drill steel was advanced the entire 25-foot length, the operator activated a locking mechanism that attaches to the advanced drill steel. This allowed him to rotate the powered drive head counter-clockwise to un-thread it from the drill steel. Once disconnected, the powered drive head was raised to the top of the drill boom and the drill steel storage mechanism was swung into place.

The next drill steel was then positioned under the powered drive head and threaded until it was completely tightened. After this occurred, the drill steel storage mechanism was swung back, out of the way, to the storage position. The newly attached drill steel was then lowered down to be threaded into the previous secured steel.

At this point, the operator opened the cab door, leaned out and (with his left arm) manually guided the drill steel into the previous steel (Figure 1). Once he had manually positioned the drill steel over the threaded portion of the previous steel, the operator lowered

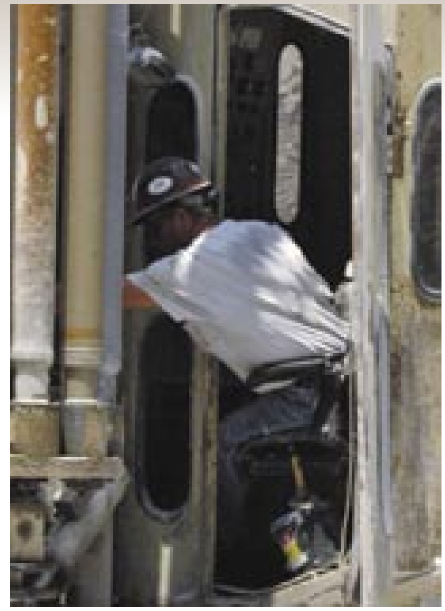


Figure 1 – A drill operator reaches out of the cab door to guide new drill steel into place.

the steel a little further and began to thread the new steel in place. When it was completely threaded down tight, the drill operator closed the cab door and began drilling again. Total time to add a new drill steel was approximately three minutes. About two minutes into the process, the drill operator opened the cab door to guide the next drill steel into place. The door was normally open between 30 and 45 seconds before being closed again.

RESULTS

Figure 2 shows the respirable-dust concentrations inside the enclosed cab during time periods when the cab door was open during the first day of testing. The accompanying graph (Figure 2) shows the magnitude of increased respirable-dust concentrations inside the enclosed cab. The extent of this increase is surprising when one considers that drilling had ceased approximately two minutes before the cab door was open and that no dust cloud was visible during these periods. Although this graph presents the results for only one of the three days of testing, it is consistent with the two other test days.

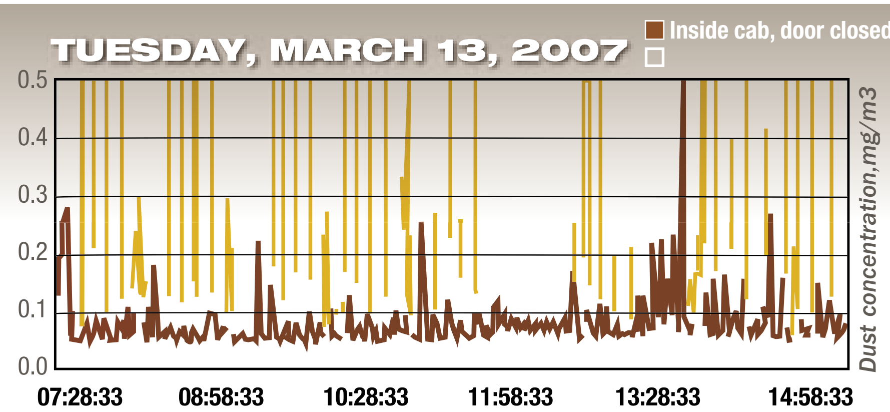


Figure 2 – Respirable-dust concentration inside enclosed cab during periods with cab door closed and open.

The impact of this increase in respirable-dust concentrations can be seen in Figure 3. The graph shows the average respirable-dust concentrations inside the enclosed cab of the drill (for all three days of testing) for time periods when the cab door was closed and open. The average concentration for all three days of testing was 0.09 mg/m3 with the cab door closed and 0.81 mg/m3 with the cab door open.

Despite the fact that no dust cloud was visible when the cab door was open, respirable-dust concentrations were nine times higher than when the door was closed. Further adding to the problem, once dust enters the enclosed cab and coats the inside surfaces, it also becomes a dust source to the drill operator when it is later disturbed and becomes airborne.

Even at the 0.81 mg/m3 respirable-dust concentration within the enclosed cab with the door open, the drill operator's exposure remained below the permissible exposure limit (PEL) federal dust standard as established by the Mine Safety and Health Administration. Also, the drill operator at this site was both experienced and competent—performing the task the way he had been trained to drill. Another factor that had an impact on these results was the extremely clean air within the enclosed cab under normal conditions, a result of implementation of the (new prototype) uni-directional cab filtration and pressurization system.

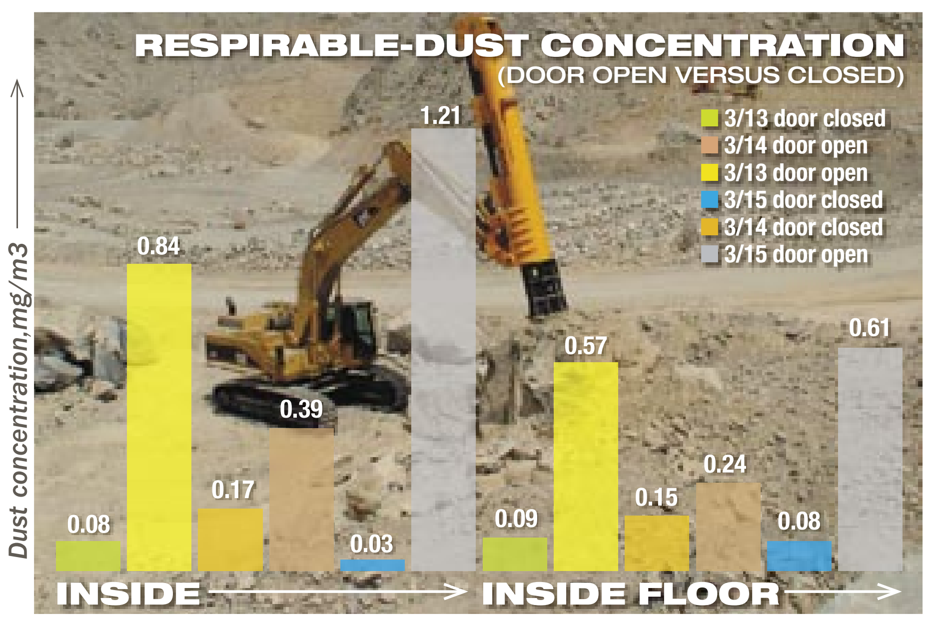
CONCLUSION

NIOSH has been working for a number of years to improve the air quality inside enclosed cabs on surface mobile equipment. Part of this research effort has involved working with cab filtration and pressurization manufacturers, as well as mining companies, to design effective retrofit systems for older mining equipment. In a recent cooperative effort with Sy-Klone International and Vulcan Materials, a uni-directional system was installed on the enclosed cab of one of Vulcan's surface drills. It appears that this uni-directional filtration and pressurization system is working well. Once testing is completed, a future report will describe further improvements in air quality inside the drill cab.

During this testing, it was noted that the drill operator's respirable-dust exposure was significantly increased during periods when he opened the cab door to manually guide an additional drill steel into place. Although no dust cloud was visible when the door was open to perform this task, the drill operator's exposure was documented to be nine times higher than when the door was closed.

This testing identifies the significance of this dust source and highlights the need to develop an alternative method of installing new drill steels into place while eliminating the drill operator's need to open the cab door. Any mining operation that uses this method to change drill steels should take notice of this dust hazard and work with the drill manufacturer to develop an alternative method to perform the task.

Figure 3 – Average respirable-dust concentration inside drill cab during periods with cab door closed and open during three days of testing.



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