Clearing the Air

UNIDIRECTIONAL FILTRATION/PRESSURIZATION SYSTEM PROTECTS EQUIPMENT OPERATORS FROM DUST EXPOSURE

BY ANDREW CECALA AND JOHN ORGANISCAK

Miner's exposure to dust remains a top concern among regulatory agencies, particularly at production facilities with high levels of silica. This respirable dust is present in almost all operations and is a direct cause of the deadly disease silicosis. Silica is one of the most abundant minerals on Earth and is a threat at all operations, especially granite and sand and gravel facilities.

The National Institute for Occupational Safety and Health continues to analyze silica's threat. The institute's research indicates that heavy-equipment operators have an increased risk to dust exposure, especially when drilling or breaking rock, even when working from an enclosed cab. However, there are methods to reduce an operator's exposure further, according to recent NIOSH research, which is detailed in its report, Improving Air Quality in Enclosed Caps with Uni-Directional Filtration/ Pressurization System.

NIOSH indicates that when surface mining equipment is new, the operator's dust exposure is normally at acceptable levels. As the equipment ages and components such as gaskets and seals deteriorate, the level of protection can degrade to a point where it is no longer acceptable. However, the institute indicates that at least two critical factors necessary for an effective system.

THE FIRST FACTOR is an effective cab-filtration system composed of both a recirculation and clean make-up air system. Approximately 75% of the air inside the enclosed cab should be recirculated through a high-quality filter and mixed with the make-up air before being returned. The make-up air is pulled from outside the cab and also should be filtered before being mixed with recirculated air. The make-up air creates the positive pressure inside the enclosed cab.

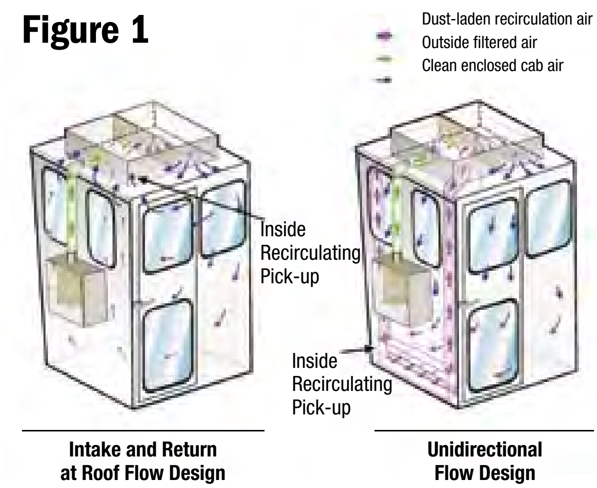
The second critical factor for an effective system is cab integrity, which is necessary to achieve pressurization. It has been shown that installing new door gaskets and seals, along with plugging and sealing cracks and holes in the shell of the cab, has a major impact on achieving cab integrity, and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

The retrofit filtration and pressurization system evaluated in this study used a unidirectional design, which was a continuous top-down clean-air flow pattern in the enclosed cab. In most recirculation systems, the intake and discharge air vents are located at the roof of the cab.

In theory, this conventional design has two shortcomings. First, some of the clean air discharged can immediately short circuit back into the recirculation intake vent without ever flowing through the enclosed cab. Second, dust-laden air from the inside walls of the cab, the floor, and the operator's clothing is drawn up over the operator's breathing zone as it travels into the recirculation pick-up location at the roof of the cab. A design, which may eliminate these flaws, brings all the filtered air brought in at the roof of the cab and expels all the recirculated air near the floor of the cab. (SEE FIGURE ONE)

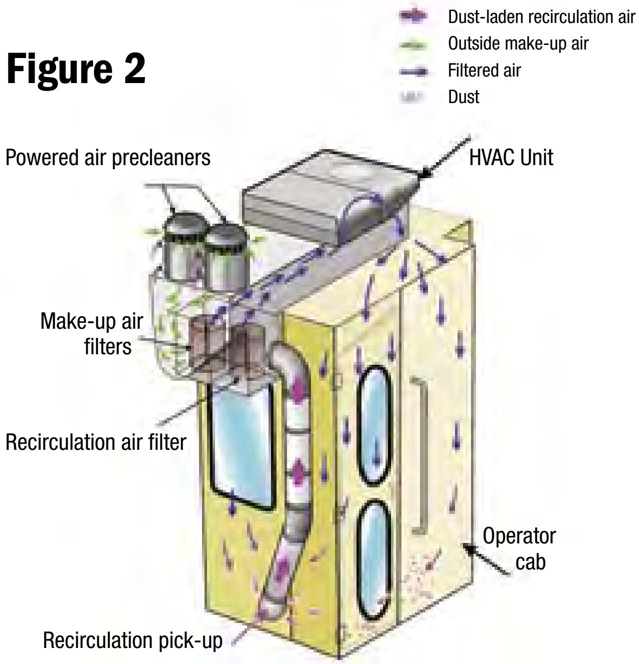
To test the unidirectional filtration system, NIOSH Physical Scientist Technician Jeanne Zimmer teamed with Sy-Klone International Vice President David Moredock and Vulcan Materials Co. Safety Representative Misty Hillis.

Figure 1



The installation of a unidirectional filtration system can greatly reduce a worker's exposure to harmful dust.

Figure 2



Vulcan reviewed its internal dust records to identify a cab and filtration system that was performing poorly, essentially a worst-case scenario. It chose a pneumatic rotary drill at one of its limestone operations near Birmingham, Ala.

The first task was to take baseline dust measurements on the drill before any changes or modifications were made to the unit. This drill still had the heating, ventilation and air conditioning unit (HVAC) that was provided by the original equipment manufacturer.

The HVAC unit, as well as the cab's gaskets and seals, deteriorated to a point where they needed to be replaced or refurbished. Dust levels remained within the acceptable federal and state standard. After baseline testing was completed, the old unit was removed and a new Red Dot 9777 HVAC unit with a Sy-Klone International unidirectional filtration and pressurization system was installed.

Figure 2 shows the components of this unidirectional filtration and pressurization system. Baseline testing was performed on this drill for three days. Upon the completion of this testing, the old air filtration system was removed and the new unidirectional filtration and pressurization unit was installed.

The new retrofit system is composed of a make-up and a recirculation air component. The make-up air unit takes outside air and draws it through two parallel pre-cleaners. Each pre-cleaner unit delivers at least 40 cfm of air, making the potential make-up air quantity a minimum of 80 cfm. These pre-cleaners use a centrifugal design to spin off dust particles larger than 5 micron. After the pre-cleaners, the air passes through a canister filtering cartridge before entering a plenum where it is mixed with the recirculation air. This combined air then travels through the HVAC unit where it is conditioned for temperature before being blown through air vents into the enclosed cab.

The recirculation component was designed to incorporate a return-air duct—which captures the recirculated air near the floor of the cab—isolate it from the cab and transport it to the filtering unit. This recirculated air also passed through a similar canister filtering arrangement as with the make-up air. The actual filter efficiency for both the recirculation air and the make-up was determined to be greater than 99% for particles 0.3 micron and larger, as determined by field testing. This recirculated air then entered the same plenum with the make-up air. The approximate quantity of air recirculated was 300 cfm.

After the retrofit unidirectional filtration and pressurization system was installed and determined to be working properly, the postevaluation was performed. Three separate post-tests were performed to evaluate the retrofitted cab over eight months.

The postevaluations mirrored the dust analysis performed during baseline testing. Tests were taken near the top and the floor of the enclosed cab, on the outside of the cab at the far side of the pneumatic leveling cylinder and near the rearview mirror. The two inside sample locations were used to provide the respirable dust levels that the drill operator would be exposed to while performing drilling functions.The sampling racks were composed of two gravimetric samplers and a pDR instantaneous respirable dust monitor.

Table 1 shows the average respirable dust concentrations obtained by averaging the two gravimetric dust units

Table 1

Respirable dust concentrations measured at sampling locations inside and outside the enclosed cab. The measurements are micrograms per cubic meter.

	Outside Cab		Inside Cab	
	rear	left	top	floor
Baseline				
Day 1	0.84	1.06	0.43	n/a
Day 2	1.62	2.73	0.95	n/a
Day 3	1.68	0.33	0.54	n/a
Posttest 1				
Day 1	3.64	4.76	0.22	0.19
Day 2	0.54	1.23	0.06	0.06
Posttest 2				
Day 1	1.52	5.48	0.23	0.19
Day 2	0.70	6.12	0.23	0.18
Day 3	0.44	0.93	0.21	0.16
Posttest 3				
Day 1	1.01	2.27	0.09	0.14
Day 2	2.52	8.71	0.14	0.13

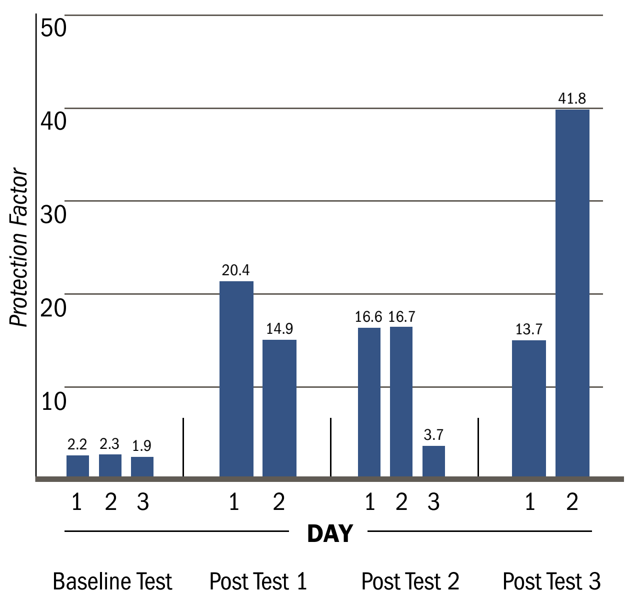
at each sampling location. The values in this table include the entire day of testing from drilling the first hole to the completion of the last hole at the end of the shift. It must also be noted that this time frame included periods of downtime and breaks, which lowers the overall dust levels.

PROBABLY THE MOST important aspect to consider when evaluating the effectiveness of the new retrofit system is to compare dust levels inside the enclosed cab between baseline and posttesting. During baseline testing, the average respirable dust concentration ranged from 0.43 to 0.95 micrograms per cubic meter inside the cab for the three days of testing. This compares to the range of 0.06 to 0.23 cubic micrograms for the seven days of posttesting at the top sampling location in the cab. These results illustrate the improvement to the air quality with the new filtration and pressurization unit.

Figure 3 shows the calculated protection factor for each day of testing for both the baseline and postevaluations. Protection factor is to quantify cab performance; it is a ratio of the outside dust concentration divided by the inside concentration. The larger the protection factor value, the greater protection to the operator inside the enclosed cab. For baseline testing, the protection factor averaged 2.1 for the three days of testing. This compares to an average Protection Factor of 17.7, 12.3, and 27.8 for the first three posttestings with an average of 18.3 for all the days of posttesting.

When comparing the roof to floor sample locations during posttesting, as shown in Table 1, there appears to be very little difference between these two sample locations.

Figure 3



These drill operators are busy installing a new unidirectional filtration and pressurization system.

This indicates a uniform airflow throughout the cab that prevented elevated dust levels from building up in any region of the cab. One potential reason for the lack of a significant difference could have been due to the amount of times that the drill operator opened the door of the enclosed cab. Each time the door was opened, dust to enter the cab, equally impacting dust levels at the roof and at the floor of the cab.

This suggests the need for additional technology and methods to limit an operator's need to open the door to dust. Yet, these results show that harmful dust can be removed, assuring workers longer and healthier lives.

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