CDC NIOSH Workplace Safety and Health
Technology News
No. 528 Milestones in Mining Safety and Health Technology October 2007

Recirculation Filter Is Key to Improving Dust Control in Enclosed Cabs

Objective

Improve the dust control effectiveness of enclosed operator cabs on surface mining equipment.

Background

Overexposure to airborne respirable crystalline silica (or quartz) dust can cause debilitating or fatal respiratory disease. The workers most frequently overexposed to silica dust at surface mines are overburden drillers and operators of mobile excavating equipment, such as bulldozers, front-end loaders, and trucks. Enclosed cabs with heating, ventilation, and air conditioning (HVAC) systems are typically integrated into the drills and mobile equipment to protect the operator from the outside environment. Air filtration is often part of the HVAC system as an engineering control of airborne dusts.

The basic HVAC system mainly recirculates cab interior air through the heat exchangers for effective heating and cooling of the cab, with some additional makeup air drawn by the recirculation fan(s) through an exterior inlet. Filtration is usually performed on the exterior intake air and sometimes on the interior recirculation air of the HVAC system. Cab air filtration performance depends on the efficiency of the air filters, airflow through the filters, dust loading on the filters, exterior air leakage around the intake filter, and wind penetration of outside air into the cab enclosure. Numerous filtration system designs have been observed on surface mine equipment cabs with varying degrees of success for limiting dust exposure.

Approach

The National Institute for Occupational Safety and Health (NIOSH) has investigated various cab filtration system factors on a basic HVAC system in the laboratory to evaluate their effects on overall cab dust protection performance. The factors experimentally investigated were intake filter efficiency, intake air leakage, intake filter loading (filter flow resistance), recirculation filter use, and wind penetration. A lower- and higher-efficiency intake filter were tested without and with a perforated plate on the filter exit to simulate each filter in an unloaded and a loaded condition. These intake filter test conditions were also conducted with a ½-inch inside-diameter hole closed or opened to examine leakage effects around the intake filter. All of the intake filter and leakage configurations were further tested in combination with and without an inside cab recirculation filter. These cab filtration system test factors (16 combinations) were conducted within a mine entry gallery under calm conditions and challenged under 10-mph wind conditions. Three 1-in-diam holes were located on the front door and similarly on the back of the cab to allow the intake air to exit the cab under positive pressure. Figure 1 illustrates the front view of a laboratory cab test apparatus (~72-ft^3 volume) facing into the wind in the NIOSH Pittsburgh Research Laboratory's longwall test gallery, which was capable of delivering a 10-mph wind velocity around the cab.

Cab dust or particulate protection performance was determined by relative comparisons of portable HHPC–6 channel (ATRI or Met One) particle counter concentrations inside (C_1) and outside (C_3) the cab, which was challenged with ambient air particles. The largest fraction of ambient air particles was in the submicron size range (0.3–1.0 µm); these particle counter channels were summed to determine cab performance. Cab protection factors (C_3 / C_1) were determined over a 15-min period of stable interior cab concentrations. Cab intake air particle concentrations (C_2) were also measured, allowing for the intake filter efficiency to be determined for the same size range under no-leak conditions around the filter. Cab differential pressure, filter differential pressure, intake leakage, intake airflow, recirculation airflow, and wind velocities were measured to quantify the cab conditions during airborne particulate performance testing.

Results

Table 1 shows the average cab protection factors (C_3 / C_1) and cab operating conditions achieved for the intake and recirculation filter combinations. The lower-efficiency intake filter used was a single-stage pleated round cartridge filter (7-in-diam by 13-in-high) with an average measured efficiency of 38% in the 0.3- to 1.0-µm size range. The higher-efficiency intake filter used was a multistage round cartridge filter (7-in-diam by 12-in-high) with an average measured efficiency of greater than 99%

in the 0.3- to 1.0-µm size range. A rectangular panel recirculation filter (12-in-high by 24-in-wide by 4-in-deep nominal size) was also used, which had an American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) minimum efficiency reporting value (MERV) of 15, or 85%–94.9% in the 0.3- to 1.0-µm size range.

The use of the recirculation filter remarkably improved the average cab protection factor by an order of magnitude over what was provided by the intake filter itself because of multiplicative filtration of the cab interior air. The cab protection factor increased from 1.7 with the low-efficiency intake air filter to 13.4 with the addition of the recirculation filter. The cab protection factor also increased from 13.3 with the high-efficiency intake filter to 168.4 with the addition of the recirculation filter. It should be noted that recirculation filter use also decreased recirculation airflow somewhat, with a corresponding increase in the intake airflow and cab differential pressure. Although the increase in intake filter airflow was met with a higher filter differential pressure and higher percentage of intake leakage, the recirculation filter yielded the better cab protection factors because of the much higher airflow filtration rate of the cab interior.

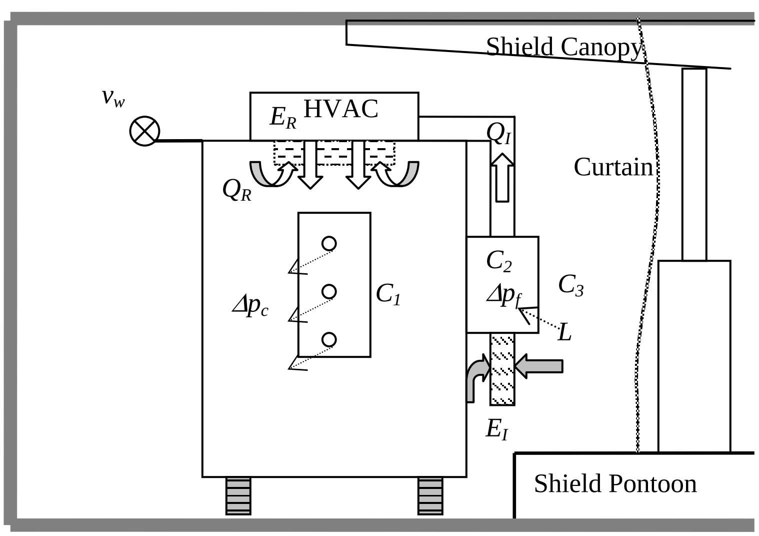
Further, the recirculation filter noticeably decreased the time needed for the cab interior concentrations to go down and stabilize after the cab door was closed. The average stabilization time decreased from 17 min and 29 min, respectively, with the low- and high-efficiency intake filters to 8 min with the addition of the recirculation filter. This decrease in stabilization time was also achieved at a higher cab protection factor. Thus, a cab recirculation filter subsequently reduces respirable dust concentrations and time of exposure inside the cab.

For More Information

For more information about filtration in enclosed operator cabs, contact John A. Organiscak (412–386–6675, JOrganiscak@cdc.gov) or Andrew B. Cecala (412–386–6677, ACecala@cdc.gov), NIOSH Pittsburgh Research Laboratory, P.O. Box 18070, Pittsburgh, PA 15236–0070.

To receive NIOSH documents or for more information about occupational safety and health topics, contact: **1–800–CDC–INFO** (1–800–232–4636), **1–888–232–6348 (TTY)**, e-mail: **cdcinfo@cdc.gov**, or visit the NIOSH Web site at **http://www.cdc.gov/niosh**

Mention of any company name or product does not constitute endorsement by the National Institute for Occupational Safety and Health.



C_1 – Inside cab concentration, counts/liter
C_2 – Intake air concentration, counts/liter
C_3 – Outside air concentration, counts/liter
PF – Protection factor, C_3 / C_1
Q_I – Intake air quantity or cab discharge air quantity, ft^3/min
Q_R – Recirculation air quantity, ft^3/min
E_I – Intake filter efficiency, % reduction
E_R – Recirculation filter efficiency, % reduction
L – % intake air leakage, % of Q_I
Δp_f – Intake filter differential pressure, inches w.g.
Δp_c – Cab differential pressure, inches w.g.
v_w – Wind velocity

Figure 1.—Laboratory cab test apparatus used in longwall test gallery.

Table 1.—Average cab performance values for filter combinations tested

Filters: Intake	Filters: Recirculation?	PF (C_3 / C_1)	Q_I (cfm)	Δp_f (inches w.g.)	L (% of Q_I)	Q_R (cfm)	Δp_c (inches w.g.)	Stabilization time (min)
Lower E_I	No	1.7	37.3	0.30	2.0	366	0.17	17
Lower E_I	Yes	13.4	41.0	0.47	2.6	328	0.19	8
Higher E_I	No	13.3	18.1	0.52	3.6	386	0.07	29
Higher E_I	Yes	168.4	23.2	0.70	4.9	338	0.08	8

DHHS (NIOSH) Publication No. 2008–100