Dust Underfoot

Enclosed cab-floor heaters can significantly increase operator's respirable dust exposure

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Many types of heavy equipment used in the mining and construction industries use enclosed cabs to protect equipment operators from dust and noise exposure. Normally, when the equipment is new, manufacturers' designed controls are effective at keeping the operator's exposure at acceptable levels. However, as equipment becomes older and many components of the enclosure deteriorate, such as gaskets and seals, the effectiveness of the enclosed cab can be greatly reduced. This can cause excessive and dangerous exposures to respirable dust, especially when the ore or overburden contains crystalline silica.

In a survey of a number of coal surface mining operations in Pennsylvania a few years ago, high exposure to crystalline silica for surface drill operators was shown to cause an excessive incidence of silicosis. During a recent study to investigate methods to retrofit older cabs with effective control measures, a floor heater in an enclosed cab was documented to be a significant source of high dust exposure to the equipment operator.

Figure 1: *Location of the heater near the feet of the drill operator in the enclosed cab.*

Research background

A cooperative research study with a mining company and a cab filtration company was conducted to evaluate the effectiveness of retrofitting an older surface drill with two controls to lower the drill operator's respirable dust exposure. Four days of background dust levels were measured as a baseline. These baseline measurements were taken in May when air temperatures ranged from 60° to 70°F. When this was completed, the two controls were implemented.

The first control was an improved air-filtering and pressurization system on the enclosed cab. Ideally, the incoming air filter should be 99% efficient in removing from the airflow particles with an aerodynamic diameter of 0.3 mm or greater. The installed control was composed of a two-stage pre-filter, a blower and a respirator-medium secondary filter.

Since the secondary filter was on the positive side of the fan, all air delivered into the enclosed cab had to pass through this secondary filter. After the filtering system was installed, the cab was pressurized to a static pressure of 0.01 inches of water (w.g.).

The second control was to seal the cab. New door gaskets were installed and all cracks and holes in the shell of the enclosure were plugged. This increased the cab pressurization to approximately 0.1 in. w.g. In order to prevent wind from forcing contaminated air through holes in the cab, the cab's static pressure must be greater than the wind's velocity pressure.

With these changes implemented and everything working properly, the identical dust analysis was repeated to determine the effect on the drill operator's dust exposure. The post-testing dust measurements consisted of two and a half days of testing in November and two days of testing in January. Since this testing took place in winter conditions with low outside air temperature, the cab had to be heated. The heater unit used in this enclosed cab was a radiator type heater located near the floor (Figure 1). This type of heater is commonly used in heavy equipment during the winter months.

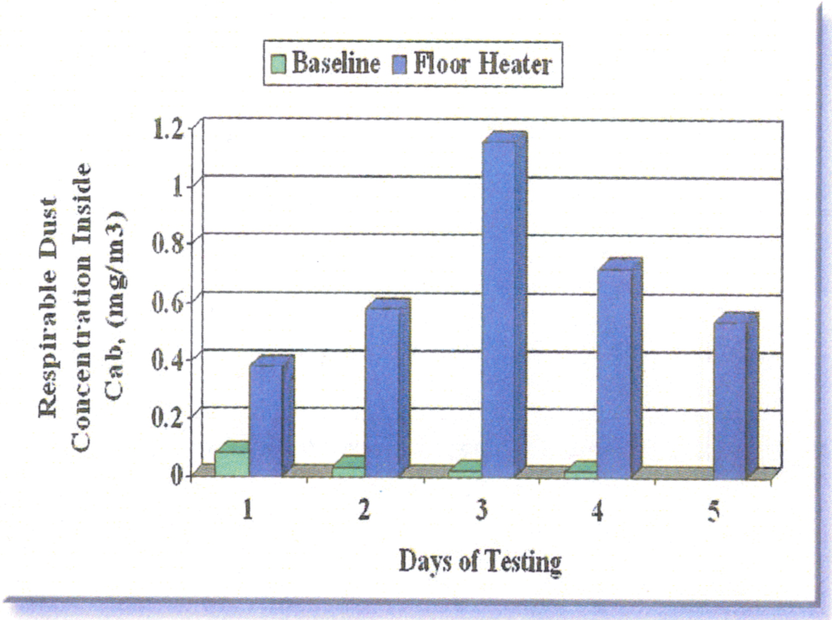


Figure 2: *Drill operator's respirable dust exposure with and without use of the floor heater.*

Figure 2 shows the respirable dust levels inside the enclosed cab for both pre- and post-testing. NIOSH anticipated that post-tests dust levels would decrease because of the improvements made to the cab with the new filtration and pressurization system, and from the new gaskets and seals. Instead, respirable dust levels increased 17 times, from an average concentration of 0.04 mg/m^3 in pre-testing to 0.68 mg/m^3 in post-testing.

Why so much dust?

First of all, background dust levels were lower than expected. It was believed that this was caused by the air conditioning unit on the drill cab being used for a substantial portion of each day of testing. As the cab air travels through the condenser unit in the air conditioning, a good portion of the dust can be removed.

NIOSH also hypothesized that the floor heater in the cab was the primary cause of dust increase during the follow-up testing. It was believed that dust was generated from the drill operator's boots grinding and stirring up material on the floor and from dust being blown off of the operator's clothing. After seeing the increase in dust levels inside the cab—even with improvements to the system—the only factor to account for this increase was the floor heater in the cab.

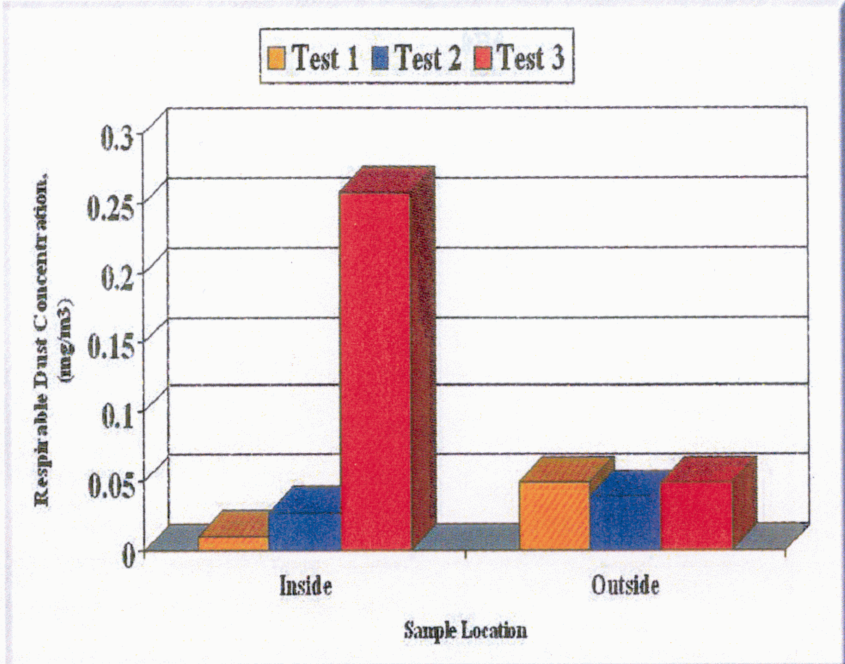
The drill was taken into the shop and testing was performed with two multi-channel optical particle counters to evaluate whether the floor heater was the significant source of respirable dust exposure to the drill operator. The first test was to monitor particle levels with only the air filtration and pressurization system operating (Figure 3—Test #1). Next, the recirculation system was operated, which also provides air conditioning to the cab in the summer months (Test #2). The recirculated air in this second ventilation system was not filtered. Finally, both systems were operated along with the floor heater (Test #3).

Once this test series was completed, another series was repeated with the particle-counting instruments switched from outside to inside of the cab to minimize the effects of instrument biases. The results verified that the floor heater was indeed the dust source.

Dust concentrations inside the cab averaged 0.01 mg/m^3 for Test #1, 0.03 mg/m^3 for Test #2, and 0.26 mg/m^3 for Test #3, when the floor heater was operating. This is a nine-fold increase over Test #2, and a 27-fold increase over Test #1. Figure 3 also indicates that respirable dust levels inside the cab were higher than outside the cab when the floor heater was used.

To combat this floor heater dust-generation source, a floor-sweeping compound was field tested to suppress dust inside the cab. Since a sweeping compound would be applied on the enclosed cab floor throughout the shift, the compound ingredients were of particular concern so as not to create other health hazards for the drill operator.

Figure 3: *Shop testing to determine the increase in the drill operator's respirable dust exposure with use of the floor heater.*



Sweeping compounds commonly use sawdust or cellulose as the main bulk material with oil or wax added for dust adhesion purposes. Another ingredient that is sometimes added to increase bulk density is sand. Sweeping compounds with sand are commonly used to sweep up concrete floors while those without sand (usually referred to as gritless) are used to sweep up smooth finished floors.

Most of the oils and waxes used for the adhesive ingredient are petroleum based and can have an irritating odor. People sensitized to petroleum distillates could have allergic reactions to these sweeping compounds. These compounds are commonly recommended for use in well ventilated areas.

Sweeping compound material safety data sheets (MSDS) were examined for their ingredients and precautions. Only gritless sweeping compound (without sand) was used during this study, eliminating the addition of another potential silica source inside the cab. A few companies also offer non-petroleum-based sweeping compounds, using either a natural oil or chemical additive for dust adhesion. A natural canola oil-based sweeping compound was selected that had a slight wood scent.

Three more drill dust sampling shifts were completed with a ¼- to ½-in.-thick layer of the canola oil sweeping compound applied to the floor with the heater operating (Figure 4). Figure 5 shows the results of the average dust level measured inside the cab for these three

Figure 4: *A ¼- to ½-in.-thick layer of gritless, canola oil-based sweeping compound was spread on the floor of the enclosed cab during three shifts.*

shifts with the sweeping compound and for the five shifts previously measured without the sweeping compound (see Figure 2).

The sweeping compound notably reduced the dust levels inside the enclosed cab. Further statistical analysis of exterior and interior cab dust levels for this seven-shift comparison showed with good statistical certainty that the sweeping compound had a significant effect on interior dust levels, while the exterior dust levels did not have any measurable impact on the interior cab dust levels. This analysis indicates that the two earlier cab controls of improved cab filtration and sealing reduced the outside influence of exterior dust levels on interior cab dust levels, while isolating the floor heater effect inside the cab.

The perspective on enclosed cabs has always been to provide clean air into the enclosure and maintain pressurization to keep dust from entering into the cab from outside. The floor heater problem identified in this research adds a new perspective to providing dust protection to the operator in the enclosed cab.

The floor heater introduces a significant problem. The floor is the dirtiest part of the cab because the operator brings a significant amount of dirt into the cab floor on his work boots. The operator's feet stir up dust which is then blown throughout the enclosure by the fan on the floor heater. The floor heater fan also has a tendency to stir up dust that may be on the drill operator's clothes because it is located very close to him.

Recommendations

Because of the significant increase in dust levels with use of floor heaters, NIOSH recommended that they not be used in their present location. If needed, they should be repositioned to a higher area in the cab where they are less prone to pick up dust from the floor and the operator's clothes. Probably the best solution would be to implement a heating and air-conditioning unit into the clean air and pressurization system.

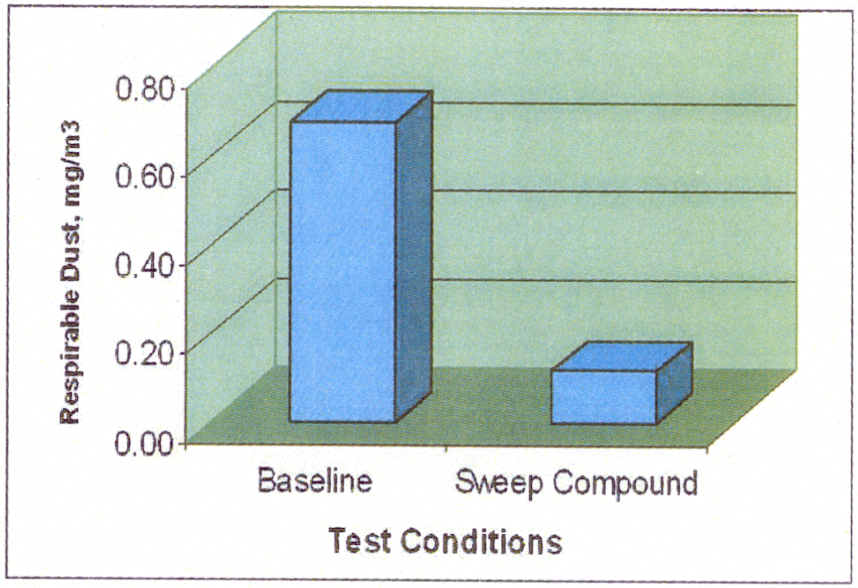


Figure 5: *Average dust levels measured inside the cab during three shifts using the sweeping compound were significantly lower than previously measured for the five shifts without use of the sweeping compound.*

In addition to removing cab heaters from the floor, this study identified other methods to minimize the problem of dust generation inside of cabs:

- use a highly efficient recirculation filtration system to capture dust that is generated by the operator or other sources inside the cab;
- practice good housekeeping in terms of keeping the floor and other internal cab surfaces clean as possible;
- keep the operator's clothing and boots as clean as possible; and
- apply a gritless (without sand), natural-base sweeping compound to the floor to help bind up the dirt and soil tracked into the cab.

If a company chooses to use a sweeping compound, it is highly recommended to use a natural-based type compound to reduce any possible operator irritation allergic reactions to odors from petroleum-based oils and wax compounds. And, before using any sweeping compound, review its MSDS for hazardous ingredients and precautions.

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