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Protecting Tuckpointing Workers from Silica Dust: Draft Recommendations for a Ventilated Grinder

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Abbreviations

cfm	cubic feet per minute
fpm	feet per minute
mg/m^3	milligrams per cubic meter
NIOSH	National Institute for Occupational Safety and Health
OSHA	U.S. Occupational Safety and Health Administration
PEL	OSHA permissible exposure limit
REL	NIOSH recommended exposure limit

Note: The information presented here reflects the best technical judgment of the authors. For further details on the study contact the researchers at: William-Heitbrink@uiowa.edu, 319-335-4213.

Disclaimer: Mention of equipment brand names in this report does not imply a preference over other products or an endorsement by the authors or CPWR.

Contents

This report presents draft recommendations for using a ventilated grinder to reduce the silica dust exposures of workers who remove old mortar from masonry, a process called "tuckpointing." The dust control equipment consists of an industrial vacuum cleaner and hose affixed to a hood ("shroud") that partially encloses the grinding disc. The study of the ventilated grinders is not complete, and the authors caution that even the best equipment does not completely eliminate the silica dust hazard. But in field trials the use of the ventilated grinder greatly reduced silica dust levels during tuckpointing. Given the magnitude of the silica hazard and the urgent need to protect tuckpointing workers, the Center to Protect Workers' Rights (CPWR) and the authors have decided to share their preliminary findings rather than waiting until the final report is available.

The draft recommendations come with these important qualifications:

- Some of the vacuum cleaners clog quickly and show a sudden and steep drop in their ability to capture dust.
- Proper work practices are crucial for effective dust control.
- The equipment does not work well on uneven surfaces or on masonry with a lot of missing mortar.
- Workers still need to wear respirators while tuckpointing with the ventilated grinders. The good news is that a respirator with an assigned protection factor of 10, such as a half-facepiece air-purifying respirator, should provide adequate protection where work conditions are similar to those at the study sites. Such respirators are less cumbersome than the respirators typically required for tuckpointing without dust control. For more information on respirators, see the Occupational Safety and Health Administration (OSHA) website at http://www.osha.gov/SLTC/etools/respiratory/index.html, and the CPWR Hazard Alert on air-purifying respirators in construction at http://www.cpwr.com/Hazardalert.htm.

Background

Tuckpointing, the process of removing old mortar with hand-held grinders, is among the dustiest of all construction jobs. The task puts workers at grave risk of developing silicosis, a disabling, permanent, and ultimately fatal lung disease caused by inhaling large amounts of dust containing respirable crystalline silica. Silicosis causes scarring of the internal surface of the lungs, severely limiting the lungs' ability to transport life-sustaining oxygen to the blood (Meijer, Kromhout, and Heederick 2001).

Silica dust released during tuckpointing is notoriously difficult to control. Silica levels greater than 5 milligrams per cubic meter (mg/m^3) were found in a study of tuckpointing workers removing mortar without dust controls (Shields 1999). These levels are 100 times higher than the recommended exposure limit (REL) of 0.05 mg/m^3 for respirable crystalline silica, developed by the National Institute for Occupational Safety and Health (NIOSH). And these levels are about 50 times higher than the OSHA permissible exposure limit (PEL) of approximately 0.1 mg/m^3. (The PEL is calculated based on the concentration of crystalline silica present in the respirable dust sample. According to the PEL formula, a sample that is 100% respirable crystalline silica dust would have a PEL of about 0.1 mg/m^3. As of 2004, OSHA was in the process of revising this PEL, which has been in effect since the 1970s. For more information see http://www.osha.gov/SLTC/silicacrystalline/index.html.)

The authors maintain that the local exhaust ventilation provided by the vacuum cleaner equipment is the best option for controlling the extremely high levels of silica dust generated during tuckpointing. Water spray, used as a dust suppressant in some construction tasks, cannot be applied during tuckpointing because its use poses an electric shock hazard; water leaking into the unsealed grinder motor could cause a short-circuit. In addition to reducing the silica hazard, the dust removal provided by the vacuum cleaner provides a clearer view of the work surface and reduces time spent on clean-up, according to the authors. Still, some contractors have been reluctant to use the ventilated grinders because of concerns that the extra equipment would get in the way of the work and slow down the job. But a contracting firm that has been using a ventilated grinder for two years told the authors that the dust control system they've used has not affected the rate of work for their company. This firm does not consider it necessary to include in their contract proposals additional time allowances for use of the dust control equipment.

Research Methods

For this study the researchers conducted laboratory and field trials of several grinder exhaust systems, all containing the following components:

- A shroud partially enclosing the grinding disc
- An industrial vacuum cleaner providing air flow and filtration
- A flexible hose between the shroud and the vacuum cleaner/filter.

Previous experimental studies have shown that the vacuum cleaner needs to maintain a minimum air flow volume of 80 cubic feet per minute (cfm) for optimal dust control (Heitbrink and Watkins 2001). The vacuum cleaner's ability to maintain this air flow is influenced by the grinder shroud design, the type and size of hose, the mass of dust removed, and the build-up of dust on the filter. For this study, the researchers evaluated the degree to which each of these factors affects the exhaust air flow. (*See* annex A for further discussion.)

In addition to laboratory tests, the researchers measured the silica dust exposures of workers removing mortar with the ventilated grinders, and at the same time measured air flow through the vacuum cleaner units. The researchers also conducted video exposure monitoring, in which a video camera filmed the tuckpointing worker's activities while an aerosol photometer measured dust levels near the worker. This real-time monitoring provided a visual depiction of the capabilities and limits of the dust control systems.

Preliminary Findings

Exposure monitoring results

The researchers reported on 22 respirable crystalline silica exposure results obtained for tuckpointing workers using the ventilated grinders. The silica levels in these samples ranged from 0.01 mg/m^3 (the analytical limit of detection) to 0.86 mg/m^3, all substantially lower than the levels of 5 mg/m^3 that were found during uncontrolled tuckpointing (Shields 1999). Nine of the 22 readings were at or below the NIOSH REL of 0.05 mg/m^3. Eight readings exceeded the OSHA PEL or 0.1 mg/m^3, but all were still less than 10 times the PEL. These field results indicate that a respirator with an assigned protection factor of 10 (such as a half-facepiece air-purifying respirator) would provide sufficient protection from the silica dust hazard under conditions similar to those present at the study sites.

The video exposure monitoring showed that the ventilated grinders effectively captured the dust during many routine tuckpointing tasks, but the systems provided noticeably incomplete dust capture during the following activities:

- Grinding on a surface with partially missing mortar (*see* annex B)
- Inserting and removing grinder blades from the wall
- Repeating a cut in the same joint
- Working in an area with poor natural ventilation, such as an enclosed corner
- Operating the grinder too long, thus allowing mortar debris, so-called “pre-filter cake,” to accumulate in the cartridge filters or the vacuum cleaner bags.

Factors affecting air flow

The researchers found that the diameter of the hose affected the vacuum cleaner’s ability to maintain adequate air flow. Vacuum cleaners equipped with 2-inch-diameter hoses were able to maintain air flows of at least 65 cubic feet per minute (cfm), whereas vacuum cleaners with 1.5-inch-diameter hoses were able to maintain flows of only 40 cfm. In one trial, the researchers replaced the 1.5-inch-diameter hose with a 2-inch hose and the workers thought they had changed vacuum cleaners because the system with the 2-inch hose performed so much better!

The researchers also observed that air flow through the system dropped as the vacuum cleaner filters collected debris, but found that this trend could be reversed by dislodging the pre-filter cake that accumulates on the surface of the filter media. Occasionally the build-up could be dislodged by simply moving or shaking the vacuum cleaner or by turning the motor off and on a few times. In some cases, dislodging the pre-filter cake was achieved by repeatedly blocking the vacuum cleaner inlet, causing the filter to pulsate and release the debris.

Draft Recommendations

These initial findings indicate that a vacuum cleaner exhaust system affixed to a grinder can greatly reduce the silica exposures of tuckpointing workers, thereby lowering their risk of developing silicosis. But the authors caution that the use of such a system must be part of a comprehensive silica control program containing the following elements:

- *Exposure monitoring* is needed to evaluate whether the control measures are providing adequate worker protection.
- *Equipment maintenance* ensures that the vacuum cleaner moves an adequate amount of air. Final filters in many vacuum cleaners will eventually become plugged and need to be replaced to maintain sufficient flow rates.
- *Adequate respiratory protection*. The study's exposure monitoring results suggest that respirators with an assigned protection factor of 10, such as half-facepiece air-purifying respirators, would provide sufficient protection under conditions similar to those in the field trials. But tuckpointing can create extremely high silica dust levels and the respirator must be appropriate for the conditions. Exposure measurements must be collected to determine the type of respirator necessary to provide adequate protection.
- *Workers must receive training* on the proper use of the available control measures, both respirators and exhaust systems, as well as proper work practices (listed below).

Guidelines for purchasing grinder exhaust components

<u>Vacuum cleaner:</u> All of the tested systems provide some degree of dust control. The vacuum cleaners come in a range of prices and designs and all draw at least 10 amps (the power necessary to overcome filter loading). The choice depends on the type of job, anticipated length of service, and equipment durability. (The authors did not evaluate the durability of the vacuum cleaners.) For a short-term job (such as one season), a 12-amp ShopVac is a relatively inexpensive option, though presumably less durable than the more expensive equipment tested, such as the Dustcontrol unit. The ShopVac was more sensitive to pressure loss than the Dustcontrol 2700 and did not maintain air flow as effectively.

The ideal vacuum cleaner is one equipped with a pressure gauge, which the worker can monitor to determine when the flow rate is too low to be effective (below about 65 cfm). Currently only one brand (Dustcontrol) offers this feature. To use this feature, one needs to know the relationship between static pressure and air flow. This information is available in the Dustcontrol catalog (Dustcontrol 2003). For vacuum cleaners without pressure gauges, workers can monitor the air flow by visually inspecting the dust plume. If dust is escaping under the exhaust shroud take-off (entry point) when the gap between the exhaust take-off and the intact mortar is small, then it is time to dislodge the pre-filter cake or to change vacuum cleaner bags or filters. (One manufacturer offers an optional cyclone as a dust pre-collector. The cyclone is a tapered tube that spins the air and removes much of the dust before it reaches the filters, thus reducing filter loading and clogging.)

Hose: The researchers recommend using a 2-inch diameter hose with a length of 10 to 15 feet and a relatively smooth interior surface. The hose should be set up to have as few elbows or sharp turns as possible.

Shroud: The shroud can be purchased separately or as a unit with the vacuum cleaner and hose. The shroud should totally enclose the spaces around the exhaust take-off (entry point for hose). The leading edge and the front side of the blade can probably be exposed without reducing dust capture efficiency. The exhaust shroud's take-off should have a 2-inch diameter.

Note: The test data for the equipment evaluated during this study are available from the authors. Contact information is provided on the inside front cover of this report.

Work practices

To ensure that the ventilated grinder provides adequate dust control, tuckpointing workers should follow these work practices:

- Keep the exhaust take-off flat against the work surface.
- Shake the hose as needed to loosen settled dust and prevent the hose from clogging.
- Throughout the operation, visually check to make sure no dust is escaping from the shroud. If dust escapes, turn off the unit and clean or change the filter, as recommended by the vacuum cleaner manufacturer. Occasionally the build-up on the filter can be dislodged by simply moving or shaking the vacuum cleaner, or turning the motor off and on a few times. Build-up on filters slows down the air flow through the system and diminishes dust capture.
- Work against the natural rotation of the blade. The tool must be positioned so that the debris from grinding is blown into the exhaust take-off.
- Change vacuum cleaner bags before they break. Overloaded vacuum cleaner bags can be ruptured because of the pressure differences in the system. This may be a significant limitation of less expensive equipment.
- Position the vacuum cleaner below the level of the work, to keep dust from falling out of the hose.
- Be aware of the potential for elevated exposure when working in poorly ventilated areas (such as in corners or inside buildings), as well as when tuckpointing on surfaces in poor condition. The test data were collected during tuckpointing outdoors. During work indoors, there will be less dilution ventilation, which results in elevated exposures. Respirators with a protection factor of 250 or more may be necessary during these conditions, even with the use of the ventilated grinder. Exposure monitoring is necessary to determine which respirator is required.

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Annex A. Evaluation of Grinder Ventilation Systems

The ventilation system consists of an industrial vacuum cleaner, flexible hose, and hood ("shroud") that partially encloses the grinder. The vacuum cleaner motor moves air through the hood, the hose, and the filters that remove the dust from the air. The friction caused by these components reduces the amount of air flow through the system. This friction is expressed as a pressure loss, stated in terms of "inches of water column." This pressure, which is below atmospheric pressure, is measured just before the air flow enters the vacuum cleaner motor.

Vacuum cleaner manufacturers can express the relationship between air flow and pressure loss by using fan curves or pump curves. Figure A provides a schematic illustration of such a curve for a vacuum cleaner motor. As pressure loss (measured in inches of water column) increases, the vacuum cleaner's air flow decreases. Vacuum cleaners are sometimes marketed on the basis of "water lift" and air flow. The water lift is the static pressure measured just upstream of the vacuum cleaner inlet when the inlet to the vacuum cleaner is totally blocked. The air flow is sometimes specified when the vacuum cleaner is operated with a hood, hose, or filter media. In reality, the amount of air flow delivered by the vacuum cleaner will always be less than the specified air flow.

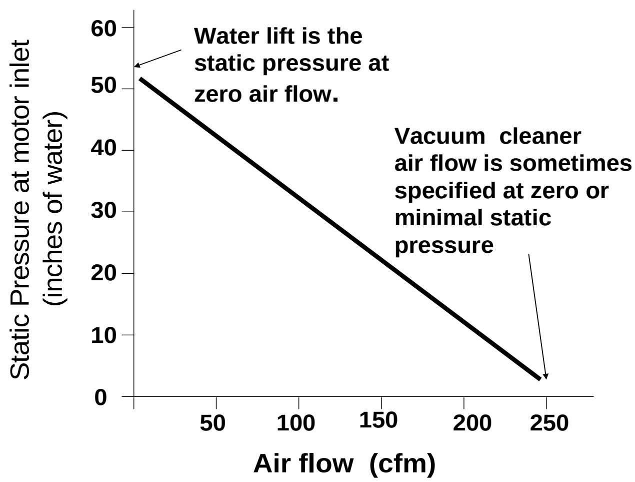
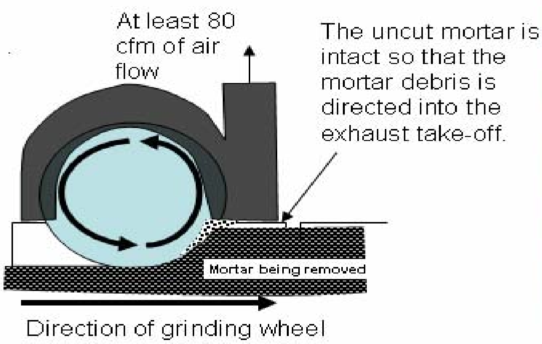


Figure A. Illustration of pump or fan curve

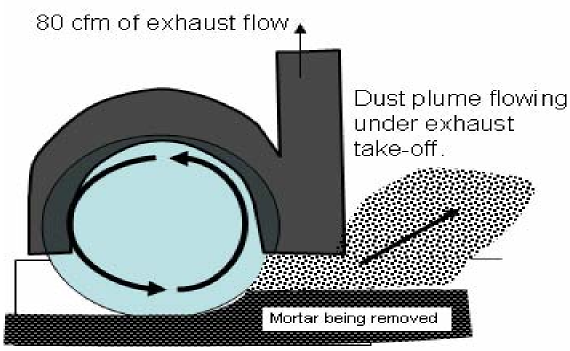
During field trials, the air flows maintained by vacuum cleaners were measured by experimentally determining the relationship between air flow and vacuum cleaner static pressure in the laboratory. Air flows were measured with Venturi meters and static pressures were measured with a U-tube manometer. Fan curves similar to the one in figure A were prepared. During field trials, air flows were monitored by using a 12-bit digital barometer to measure and record absolute pressure between the final filter and the vacuum cleaner motor inlet. This instrument has a resolution of approximately 0.5 inches of water. For further information on the laboratory and field measurements, contact the researchers at: William-Heitbrink@uiowa.edu, 319-335-4213.

Annex B. Effect of Work Surface on Air Flow

Figure 1 below illustrates the importance of keeping the exhaust take-off (entry) flat against the work surface. The 4-inch diameter grinding wheel is turning faster than 10,000 revolutions per minute (rpm), and the mortar debris has a velocity of 11,000 feet per minute (fpm), about 120 miles per hour. The air flow into the exhaust shroud is only 4000 fpm (about 45 mph). As a result, the exhaust shroud can only capture the dust that is directed into the exhaust take-off. When the mortar is intact and the exhaust take-off is flush against the surface, the dust is effectively captured (A). When there is a gap between the work surface and the exhaust take-off, dust escapes from the system (B).



A. Schematic illustration of grinder hood capturing the mortar debris. About 80 cfm of air is exhausted through the grinder. The uncut mortar is intact and directs the mortar debris into the exhaust take-off.



B. When the gap between the mortar and the exhaust take-off is too large, mortar debris escapes between the exhaust take-off and the mortar. In the picture on the right, the grinder take-off is not flush against the wall and a dust plume is faintly visible between the exhaust take-off and the wall.

Figure 1. The hood captures the dust that is directed into the exhaust take-off.