In-Depth Survey Report

Removing mortar with a powered chisel

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Southern Ohio-Kentucky Regional Training Center

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Contents

Disclaimer iii
Abstract v
Background v
Assessment v
Results v
Conclusions and Recommendations v
Introduction 1
Background for Control Technology Studies 1
Background for this Study 1
Plant and Process Description 3
Occupational Exposure Limits and Health Effects 5
Crystalline Silica Exposure Limits 6
Methodology 7
Results 10
Discussion 11
Conclusions and Recommendations 12
References 13
Appendix 16

Abstract

Background

Workplace exposure to respirable crystalline silica can cause silicosis, a progressive lung disease marked by scarring and thickening of the lung tissue. Crystalline silica is found in several construction materials, such as brick, block, mortar and concrete. Construction tasks that cut, break, grind, abrade, or drill those materials have been associated with overexposure to dust containing respirable crystalline silica. Tuckpointing (repointing) removes damaged mortar from joints in masonry walls and replaces it with new mortar to restore the wall. The use of grinders to remove mortar results in worker overexposure to respirable crystalline silica. NIOSH scientists are conducting a pilot study to assess the respirable crystalline silica exposures associated with mortar removal when tools other than grinders are used.

Assessment

NIOSH staff visited the Bricklayers and Allied Craftworkers Southern Ohio-Kentucky Regional Training Center, Batavia, Ohio on October 29, 2015 and performed industrial hygiene sampling, which measured exposures to respirable dust and respirable crystalline silica while an apprentice bricklayer used a powered chisel to remove type N mortar from a brick wall. The NIOSH scientists also collected weather data and observed the work process in order to understand the conditions that contributed to the measured exposure.

Results

Personal breathing zone respirable crystalline silica concentrations measured during 15-minute-long periods of mortar removal ranged from less than the limit of detection (LOD) to 0.13 mg/m^3. Personal breathing zone respirable dust concentrations collected on filter samples ranged from 0.21 mg/m^3 to 1.0 mg/m^3. The lower value in the range was a sample result between the LOD and limit of quantitation (LOQ), which is considered a trace value with limited confidence in its accuracy.

Conclusions and Recommendations

The chisel tested here produced respirable crystalline exposures less than those reported when grinders were used with local exhaust ventilation under similar test parameters. If the powered chisel can remove mortar with the speed and quality required by contractors and is acceptable to workers, it represents an alternative to the use of grinders. However, if the chisel was used for a full shift and dust levels remained constant, the highest quartz concentration measured during use of the chisel, 0.13 mg/m^3, would be 2.6 times the OSHA PEL and NIOSH REL, requiring the use of a respirator with an assigned protection factor of 10, such as an N-95 filtering facepiece respirator. On the other hand, a quartz exposure of 0.13 mg/m^3 would permit a worker to use the chisel under these conditions for more than 3 hours (up to 185 minutes) in an 8-hour shift with no other exposures to quartz

without exceeding the REL or PEL. Full-shift sampling on job sites should be conducted to validate these findings. In the meantime, additional research will be conducted to assess the effectiveness of tool-mounted local exhaust ventilation on reducing respirable dust and crystalline silica exposures associated with the use of this powered chisel.

Introduction

Background for Control Technology Studies

The National Institute for Occupational Safety and Health (NIOSH) is the primary Federal agency engaged in occupational Safety and health research. Located in the Department of Health and Human Services, it was established by the Occupational Safety and Health Act of 1970. This legislation mandated NIOSH to conduct a number of research and education programs separate from the standard setting and enforcement functions carried out by the Occupational Safety and Health Administration (OSHA) in the Department of Labor. An important area of NIOSH research deals with methods for controlling occupational exposure to potential chemical and physical hazards. The Engineering and Physical Hazards Branch (EPHB) of the Division of Applied Research and Technology has been given the lead within NIOSH to study the engineering aspects of health hazard prevention and control.

Since 1976, EPHB has conducted a number of assessments of health hazard control technology on the basis of industry, common industrial process, or specific control techniques. Examples of these completed studies include the foundry industry; various chemical manufacturing or processing operations; spray painting; and the recirculation of exhaust air. The objective of each of these studies has been to document and evaluate effective control techniques for potential health hazards in the industry or process of interest, and to create a more general awareness of the need for or availability of an effective system of hazard control measures.

These studies involve a number of steps or phases. Initially, a series of walk-through surveys is conducted to select plants or processes with effective and potentially transferable control concept techniques. Next, in-depth surveys are conducted to determine both the control parameters and the effectiveness of these controls. The reports from these in-depth surveys are then used as a basis for preparing technical reports and journal articles on effective hazard control measures. Ultimately, the information from these research activities builds the data base of publicly available information on hazard control techniques for use by health professionals who are responsible for preventing occupational illness and injury.

Background for this Study

Crystalline silica refers to a group of minerals composed of silicon and oxygen; a crystalline structure is one in which the atoms are arranged in a repeating three-dimensional pattern [Bureau of Mines 1992]. The three major forms of crystalline silica are quartz, cristobalite, and tridymite; quartz is the most common form [Bureau of Mines 1992]. Respirable crystalline silica refers to that portion of airborne crystalline silica dust that is capable of entering the gas-exchange regions of the lungs if inhaled; this includes particles with aerodynamic diameters less than approximately 10 micrometers (μm) [NIOSH 2002]. Silicosis, a fibrotic disease of

the lungs, is an occupational respiratory disease caused by the inhalation and deposition of respirable crystalline silica dust [NIOSH 1986]. Silicosis is irreversible, often progressive (even after exposure has ceased), and potentially fatal. Because no effective treatment exists for silicosis, prevention through exposure control is essential. Silicosis is associated with a higher risk of tuberculosis and other lung disease [Parks et al. 1999]. Silica has been classified as a known human carcinogen by the International Agency for Research on Cancer [IARC 1997]. Occupational exposure to respirable crystalline silica has been associated with autoimmune diseases, such as rheumatoid arthritis, and kidney disease [Parks et al. 1999, Stratta et al. 2001].

Crystalline silica is a constituent of several materials commonly used in construction, including brick, block, and concrete. Many construction tasks have been associated with overexposure to dust containing crystalline silica [Chisholm 1999, Flanagan et al. 2003, Rappaport et al. 2003, Woskie et al. 2002]. Among these tasks are tuckpointing, concrete cutting, concrete grinding, abrasive blasting, and road milling [Nash and Williams 2000, Thorpe et al. 1999, Akbar-Kanzadeh and Brillhart 2002, Glindmeyer and Hammad 1988, Linch 2002, Rappaport et al. 2003].

Tuckpointing (repointing) removes damaged mortar from joints in masonry walls and replaces it with new mortar to restore the wall and improve its resistance to the weather, prolonging its life and preventing water from penetrating the building envelope and causing damage to the structure [Gerns and Wegener 2003]. Mortar is typically removed to a depth of at least ¾-inch (in) (19 millimeters [mm]) using electric grinders, although hammers and chisels can be used [Gerns and Wegener 2003]. Other power tools are also available, including mortar routers, a die grinder with diamond tools, a hammer drill and mortar chisel, and a saw [Yasui et al. 2003, ICS 2016, Robert Bosch Tool Corporation 2016, Arbortech 2016]. Mortar mixes contain Portland cement, lime, and sand in various proportions depending on the strength required. Type N mortar is durable and flexible enough to be used to replace deteriorated mortar in most walls [Gerns and Wegener 2003].

The use of grinders to remove mortar results in worker exposure to respirable crystalline silica 2 to 1500 times the NIOSH Recommended Exposure Limit (REL) of 50 micrograms per cubic meter (µg/m^3) [OSHA 2013]. Even with engineering controls (i.e., on-tool local exhaust ventilation [LEV]), the use of a respirator with an assigned protection factor of 10 is still required [Collingwood and Heitbrink 2007]. In the Preliminary Economic Analysis for its Proposed Rule for Occupational Exposure to Respirable Crystalline Silica [OSHA 2013], the Occupational Safety and Health Administration (OSHA) reported the results of 151, 8-hour samples for respirable crystalline silica for tuckpointers in three exposure categories: outdoors, uncontrolled; outdoors, some form of LEV dust control; and, under other working conditions (e.g., with limited air movement, or with inadequate attempts at dust control). Respirable crystalline silica exposures for uncontrolled, outdoor tuckpointing (83 samples) ranged from 12 to 12,616 µg/m^3, with a mean of 1,601 µg/m^3 and a median of 631 µg/m^3; 59 (71%) of the samples exceeded 250 µg/m^3. Tuckpointers working outdoors with some form of LEV (56 samples) experienced

respirable crystalline silica exposures from 10 to 6,196 µg/m^3, with a mean of 368 µg/m^3 and a median of 70 µg/m^3. Fifteen (27%) of those samples were greater than five times the NIOSH REL. Workers tuckpointing in other conditions (12 samples) had respirable crystalline silica exposures from 146 to 75,153 µg/m^3, with a mean of 7,198 µg/m^3 and a median of 793 µg/m^3. Ninety-two percent (11) of the samples in that category exceeded 250 µg/m^3.

The tuckpointing study by Collingwood and Heitbrink [2007] reported several conditions that must be met in order for tool-mounted LEV on tuckpointing grinders to be effective, "The distance between the exhaust take-off and the uncut mortar must be minimized…the grinding wheel needs to be moved against its natural rotation so the debris is directed in the exhaust take-off…the worker must periodically stop grinding and take action to maintain [vacuum cleaner] airflow." The authors also noted that exposures increased when the distance between the tool-mounted LEV and the mortar surface increased, such as during plunge cuts, and when deteriorated, missing mortar provided a means for dust to escape. The OSHA sampling data for tuckpointers working outdoors with some form of LEV and the conditions that must be met for the LEV to be effective indicate that there is a need to either improve the LEV for grinders or identify tools other than grinders that may be used to remove mortar effectively and efficiently while minimizing tuckpointers' silica exposures.

Plant and Process Description

A brick wall that is in the shape of a backwards letter F when viewed from above was built outside the training center for this project (Figure 1). The wall at the base of the F was an existing wall and was not included in the project. The wall is approximately 5 feet (ft) (1.5 meters [m]) high. The stem of the F is composed of two 10-ft (3 m) long sections, while the arm of the F is 11 ft (3.4m) long and the bar of the F is 6 ft (1.8 m) long. The wall was constructed of 18 courses of standard bricks and type N mortar. The mortar was allowed to cure for at least 21 days before it was removed. An apprentice bricklayer removed mortar from the wall while air samples were collected to assess his exposures to respirable dust and respirable crystalline silica. The apprentice wore a half-mask air-purifying respirator (6000 series, 3M, St. Paul, MN) with P-100 filters, safety glasses, ear plugs, and a hardhat. The respirator was worn properly, well-maintained, and appropriate for the task.

Figure 1 - Brick wall outside training center (NIOSH photo)

The apprentice bricklayer removed mortar using a 1⅛ in (28.6 mm) special direct system plus (SDS-plus) rotary hammer (model RH228VC, Robert Bosch Tool Corp., Mt. Prospect, IL) and a ¼ in (6.4 mm) mortar removal chisel (model HS1400 ¼ in Mortar Knife SDS-plus® Bulldog™ Hammer Steel, Robert Bosch Tool Corp., Mt. Prospect, IL). He was instructed to use the tool to remove mortar from head and bed joints and include inside corners. Samples were collected as described below while the apprentice bricklayer removed the mortar. The tool is shown in Figure 2.

Figure 2 - Chisel Tool and Rotary Hammer (NIOSH photo)

Occupational Exposure Limits and Health Effects

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH investigators use mandatory and recommended occupational exposure limits (OELs) when evaluating chemical, physical, and biological agents in the workplace. Generally, OELs suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects even though their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the exposure limit. Combined effects are often not considered in the OEL. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus can increase the overall exposure. Finally, OELs may change over the years as new information on the toxic effects of an agent become available.

Most OELs are expressed as a time-weighted average (TWA) exposure. A TWA exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limit (STEL) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from higher exposures over the short-term.

In the U.S., OELs have been established by Federal agencies, professional organizations, state and local governments, and other entities. The U.S. Department of Labor OSHA PELs [CFR 2003] are occupational exposure limits that are legally enforceable in covered workplaces under the Occupational Safety and Health Act. NIOSH recommendations are based on a critical review of the scientific and technical information available on the prevalence of health effects, the existence of safety and health risks, and the adequacy of methods to identify and control hazards [NIOSH 1992]. They have been developed using a weight of evidence approach and formal peer review process. Other OELs that are commonly used and cited in the U.S. include the Threshold Limit Values® (TLVs®) recommended by the American Conference of Governmental Industrial Hygienists (ACGIH®), a professional organization [ACGIH 2016]. ACGIH TLVs are considered voluntary guidelines for use by industrial hygienists and others trained in this discipline "to assist in the control of health hazards." Workplace Environmental Exposure Levels (WEELs) are recommended OELs developed by the American Industrial Hygiene Association, another professional organization. WEELs have been established for some chemicals "when no other legal or authoritative limits exist." [AIHA 2007].

OSHA requires an employer to furnish employees a place of employment that is free from recognized hazards that are causing or are likely to cause death or serious physical harm [Occupational Safety and Health Act of 1970, Public Law 91–596, sec. 5(a)(1)]. Thus, employers are required to comply with OSHA PELs. Some hazardous agents do not have PELs, however, and for others, the PELs do not reflect the most current health-based information. Thus, NIOSH investigators encourage employers to consider the other OELs in making risk assessment and risk management decisions to best protect the health of their employees. NIOSH investigators also encourage the use of the traditional hierarchy of controls approach to eliminating or minimizing identified workplace hazards. This includes, in preferential order, the use of: (1) substitution or elimination of the hazardous agent, (2) engineering controls (e.g., local exhaust ventilation, process enclosure, dilution ventilation) (3) administrative controls (e.g., limiting time of exposure, employee training, work practice changes, medical surveillance), and (4) personal protective equipment (e.g., respiratory protection, gloves, eye protection, hearing protection).

Crystalline Silica Exposure Limits

When dust controls are not used or maintained or proper practices are not followed, respirable crystalline silica exposures can exceed the NIOSH REL, the OSHA PEL, or the ACGIH TLV. NIOSH recommends an exposure limit for respirable crystalline silica of 0.05 mg/m^3 as a TWA determined during a full-shift sample for up to a 10-hr workday during a 40-hr workweek to reduce the risk of developing silicosis, lung cancer, and other adverse health effects [NIOSH 2002]. When source controls cannot keep exposures below the NIOSH REL, NIOSH also recommends minimizing the risk of illness that remains for workers exposed at the REL by substituting less hazardous materials for crystalline silica when feasible, by using appropriate respiratory protection, and by making medical examinations available to exposed

workers [NIOSH 2002]. In March 2016, OSHA issued a new PEL of 0.05 mg/m^3 for 8-hr TWA exposures [81 Fed. Reg.* 16285 (2016)]. The ACGIH TLV for α-quartz and cristobalite (respirable fraction) is 0.025 mg/m^3 [ACGIH 2016]. The TLV is intended to mitigate the risk of pulmonary fibrosis and lung cancer.

Methodology

Personal breathing zone (PBZ) and area air samples for respirable dust and respirable crystalline silica were collected while an apprentice bricklayer used a powered chisel to remove mortar from the brick wall at the training center. The apprentice bricklayer repeated the mortar removal process during six sampling periods, each approximately 15 minutes long.

Personal breathing zone air samples for respirable particulate were collected at a flow rate of 9 liters/minute (L/min) using a battery-powered sampling pump (Leland Legacy sampling pump, SKC, Inc., Eighty-Four, PA) calibrated before and after sampling. A sampling pump was clipped to the apprentice's belt (Figure 2). The pump was connected via Tygon® tubing fitting to a pre-weighed, 47-mm diameter, 5-micron (µm) pore-size polyvinyl chloride (PVC) filter supported by a backup pad in a three-piece conductive filter cassette sealed with a cellulose shrink band (in accordance with NIOSH Methods 0600 and 7500) [NIOSH 1998, NIOSH 2003]. The front cover of the cassette was removed and the cassette was attached to a respirable dust cyclone (BGI GK 4.162 cyclone, MesaLabs, Butler, NJ). At a flow rate of 9 L/min, the GK 4.162 cyclone has a 50% cut point of (D_{50}) of 3.91 µm, and conforms to the respirable sampling convention at flow rates between 8.5 and 9.5 liters per minute [HSL 2012]. D_{50} is the aerodynamic diameter of the particle at which penetration into the cyclone declines to 50% [Vincent 2007]. The cyclone was clipped to the apprentice's sweatshirt near his head and neck within the breathing zone (Figure 3). Area air samples were collected using the same sampling method, except that the sampling pump and cyclone were placed in holders mounted atop two tripods at about breathing zone height, 60 in (1.5 m) above the ground. A tripod with the sampling apparatus was placed at either end of the brick wall. A bulk sample of mortar dust was also collected in accordance with NIOSH Method 7500 [NIOSH 2003].

* *Federal Register.* See Fed. Reg. in references.

Figure 3 - Samplers in the Breathing Zone (NIOSH photo)

The filter samples were analyzed for respirable particulates according to NIOSH Method 0600 [NIOSH 1998]. The filters were allowed to equilibrate for a minimum of two hours before weighing. A static neutralizer was placed in front of the balance and each filter was passed over this device before weighing. The filters were weighed on an analytical balance (model MT5, Mettler-Toledo, LLC, Columbus, OH). The limit of detection (LOD) was 20 µg/sample. The limit of quantitation (LOQ) was 58 µg/sample.

Crystalline silica analysis of the respirable particulate samples was performed using X-ray diffraction according to NIOSH Method 7500 [NIOSH 2003] with modifications. Each filter was removed from the sampling cassette and transferred to a 15-milliliter (mL) vial. The particulate loadings on the filters were low and there was no visible dust on the interior walls of the cassettes. The interior surfaces of the cassettes were not wiped. The filter was dissolved by addition of 7 mL of tetrahydrofuran (THF) to each sample vial. The samples were mixed by vortex. The sample vial was covered with aluminum foil and placed in an ultrasonic bath for ten minutes. The sample suspension was transferred to a silver-membrane filter, as follows: First, a silver-membrane filter was placed in the vacuum filtration unit. Next, 2 mL of THF solvent was placed onto the filter. The sample suspension was vortexed and immediately added onto the silver membrane filter. The sample vial was rinsed with three separate portions of 2 mL THF. Each rinse was added to the sample on top of the silver membrane filter. Finally, vacuum was applied to deposit the sample suspension onto the filter. The silver-membrane filter was transferred to an aluminum sample plate and placed in the automated sample changer for analysis by X-ray diffraction. The LOD for quartz on a 47-mm PVC 5 µm filter was 5 µg/sample. The LOQ was 17 µg/sample. The LOD and LOQ for cristobalite were the

same as those for quartz. For tridymite, the LOD was 10 µg/sample and the LOQ was 33 µg/sample.

In this sample set, the maximum air sample volume collected was 164 L. At the LOD for quartz of 5 µg/sample, the minimum detectable quartz concentration was 0.03 mg/m^3, less than the NIOSH REL of 0.05 mg/m^3. The minimum quantifiable quartz concentration at the LOQ of 17 µg/sample was 0.10 mg/m^3, or twice the NIOSH REL of 0.05 mg/m^3.

Approximately 1 gram (g) of the bulk sample was ground to a fine powder using a planetary ball mill with a tungsten carbide grinding vial. The ground powder was wet-sieved through a 10 µm sieve using 2-propanol. The alcohol was evaporated in a drying oven, and the dried sample was stored in a desiccator. About 2 mg of the sieved and dried sample was weighed into a 15-mL test tube. Roughly 10 mL of 2-propanol was added to the test tube to create a suspension. The test tube was placed in an ultrasonic bath for around 10 minutes until agglomerated particles were broken up. The sample suspension was vortexed and immediately re-deposited onto a 25-mm diameter silver membrane filter, as follows: First, a silver membrane filter was placed in the vacuum filtration unit. Next, 2 mL of 2-propanol was added into the filtration funnel, followed by the sample suspension and test tube rinses. Finally, vacuum was applied to re-deposit the suspension onto the filter. The silver membrane filter was transferred to an aluminum sample plate and placed in the automated sample changer for analysis by X-ray diffraction. The LOD for quartz was 0.3% by weight and the LOD for quartz was 0.83% by weight. The LOD and LOQ for cristobalite were the same as those for quartz. The LOD for tridymite was 0.5% by weight and the LOQ was 1.7% by weight.

Real-time PBZ respirable dust sampling was performed using an aerosol photometer (SidePak AM510 aerosol monitor, TSI Inc., Shoreview, MN) with a 10-mm nylon respirable dust cyclone. The instrument's internal sampling pump was calibrated before and after each day's use to operate at a flow rate of 1.7 L/min. The SidePak was clipped to the worker's belt and the cyclone was clipped to his sweatshirt in his breathing zone. A length of Tygon tubing connected the cyclone and the instrument. The SidePak was set to log data every second during the sampling period.

The NIOSH researchers used a data-logging weather station (Kestrel 4500, Nielsen-Kellerman, Boothwyn, PA) mounted on top of a tripod to assess weather conditions at the site. The weather meter was approximately 60 in (1.5 m) off the ground. The weather meter was programmed to record data every 10 minutes. Airport weather observations were gathered from the Internet as a back-up. Average wind direction was calculated from the logged data [EPA 2000].

Results

The bulk sample of brick and mortar dust contained 49% quartz by weight. No cristobalite or tridymite were found in the bulk dust sample. The results of personal breathing zone air sampling are presented in Tables 1 and 2 below. No cristobalite or tridymite were found in any of the air samples. No quartz was found in any of the area air samples. Personal breathing zone quartz concentrations ranged from less than the limit of detection to 0.13 mg/m^3. No respirable dust was detected in any of the area air samples. Personal breathing zone respirable dust concentrations collected on filter samples ranged from 0.21 mg/m^3 to 1.0 mg/m^3. The lower value in the range was a sample result between the LOD and LOQ, which is considered a trace value with limited confidence in its accuracy. Average real-time personal breathing zone respirable dust samples during each sampling period ranged from 0.36 mg/m^3 to 0.87 mg/m^3. The differences in the respirable dust results from the two sampling methods were not statistically significant (p=0.5673).

Table 1 – Respirable Dust and Respirable Quartz Results

Sampling Period	Duration (min)	Respirable Dust (mg/m^3)	Respirable Quartz (mg/m^3)
1	16	0.56	(0.069)
2	15	(0.37)	(0.081)
3	15	(0.22)	(0.052)
4	16	1.04	0.13
5	15	0.59	(0.081)
6	16	(0.21)	ND

Notes: values in parentheses indicate results between the limit of detection and the limit of quantification. These are trace values with limited confidence in their accuracy. ND means not detected, a value below the limit of detection.

Table 2 – Direct-Reading Respirable Dust Results

Sampling Period	Duration (min:sec)	Average (mg/m^3)	Minimum (mg/m^3)	Maximum (mg/m^3)
1	14:21	0.512	0.003	13.7
2	15:35	0.605	0.003	12.6
3	15:05	0.375	0.005	11.3
4	15:54	0.874	0.005	19.1
5	14:37	0.503	0.004	15.0
6	16:10	0.363	0.004	6.3

The average temperature during the six sampling periods was 57 °F (13.9 °C) (range 53 °F [11.7 °C] to 60 °F [15.6 °C]), while the average wind speed was 1.9 miles per hour (mph) (0.85 m/second) (range 1.5 mph [0.67 m/s] to 2.3 mph [1.0 m/s]) and the average relative humidity was 53% (range 46% to 63%). The average wind direction was 223° (SW) during the first sampling period, and 93°

(E), 159° (SSE), 98° (E), 120° (ESE), and 109° (ESE) during the second through the sixth sampling periods, respectively.

During the first sampling period, the apprentice removed the mortar from the head and bed joints from four courses of mortar, each 10 ft (3.0 m) long. He removed the mortar from four more 10 ft (3.0 m) long courses of mortar during the second sampling period. During the third sampling period, the apprentice removed mortar from both sides of an inside corner, removing the mortar from seven courses to 3 ft (0.91 m) from the corner on one side and to 16 in (0.41 m) from the corner on the other side. During the fourth sampling period, he removed mortar from eight courses of mortar, each 44 in (1.1 m) long. During the fifth sampling period, the apprentice removed mortar from an inside corner; eight courses were removed from one side and five from the other, the length was 16 (0.41 m) and 36 in (0.91 m). The length of mortar removed during the sixth sampling period was not recorded.

Discussion

The powered chisel tool without local exhaust ventilation was able to remove mortar from head and bed joints while producing less respirable dust and respirable quartz than a grinder. For example, Meeker et al. [2009] evaluated two tuck-pointing grinders with and without LEV. Trials with LEV lasted about 25 minutes. The mean PBZ respirable quartz concentration for one grinder was 0.47 mg/m^3 (range 0.28 mg/m^3 – 0.85 mg/m^3); for the other grinder, the mean PBZ respirable quartz concentration was 0.33 mg/m^3 (range 0.19 mg/m^3 – 0.50 mg/m^3) [Meeker et al. 2009]. In comparison, the mean PBZ respirable quartz concentration for the chisel tested here was 0.073 mg/m^3 (the value of LOD/sqrt2 was used in place of the sample mass to calculate the concentration for period 6 to compute the average [Hornung and Reed 1990]). That represents a 78% reduction compared to one of the LEV-equipped grinders and an 84% reduction compared to the other LEV-equipped grinder in the Meeker et al. [2009] study. However, even with that reduction, if the chisel was used for a full shift and dust levels remained constant, the highest quartz concentration measured during use of the chisel, 0.13 mg/m^3 would be 2.6 times the OSHA PEL and NIOSH REL. That exposure would require the use of a respirator with an assigned protection factor of 10, such as an N-95 filtering facepiece respirator. On the other hand, a quartz exposure of 0.13 mg/m^3 would permit a worker to use the chisel under these conditions for more than 3 hr (up to 185 minutes) in an 8-hr shift with no other exposures to quartz without exceeding the REL or PEL. Finally, a wind speed less than 5 mph (2.2 m/s) is considered calm [ACGIH 2016], so it is unlikely that the exposure reduction compared to grinding, and the lack of any detectable quartz on the area samples was due solely to the breeze recorded at the site.

Conclusions and Recommendations

The powered chisel tested here without LEV produced respirable quartz exposures less than those reported when grinders were used with LEV. If the chisel can remove mortar with the speed and quality required by contractors and is acceptable to workers, it represents an alternative to the use of grinders. However, if the observed short-term exposures are representative of those expected over a full shift, then tuckpointing with a powered chisel for more than 185 min in an 8-hr workday requires the use of a respirator. Full-shift sampling should be conducted while the chisel is used by trained bricklayers on enough job sites to determine how well this tool works under actual working conditions. In the meantime, additional research will be conducted to assess the effectiveness of tool-mounted local exhaust ventilation on reducing respirable dust and crystalline silica exposures associated with the use of this powered chisel.

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Appendix

Table A-1 Quartz Sampling Results

Sampling Period	Type	Quartz (ug/sample)	Start	Stop	Duration (min)	Vol (L)	Quartz (mg/m3)
1	pbz	(10)	9:48	10:04	0:16	144	(0.069)
2	pbz	(11)	10:30	10:45	0:15	135	(0.081)
3	pbz	(7)	11:01	11:16	0:15	135	(0.052)
4	pbz	18	12:36	12:52	0:16	144	0.13
5	pbz	(11)	1:07	1:22	0:15	135	(0.081)
6	pbz	ND	1:41	1:57	0:16	144	ND
1	area	ND	9:48	10:04	0:16	146	ND
1	area	ND	9:48	10:04	0:16	146	ND
2	area	ND	10:30	10:46	0:16	146	ND
2	area	ND	10:30	10:46	0:16	146	ND
3	area	ND	11:01	11:17	0:16	146	ND
3	area	ND	11:01	11:16	0:15	137	ND
4	area	ND	12:38	12:53	0:15	137	ND
4	area	ND	12:39	12:53	0:14	127	ND
5	area	ND	1:07	1:24	0:17	155	ND
5	area	ND	1:07	1:25	0:18	164	ND
6	area	ND	1:43	1:58	0:15	137	ND
6	area	ND	1:43	1:59	0:16	146	ND

Notes: µg means micrograms, L means liters, min means minutes, and mg/m^3 means milligrams per cubic meter. Numbers in parentheses were between the limit of detection and the limit of quantitation. These are trace values with limited confidence in their accuracy. ND indicates a result less than the limit of detection. Pbz means a personal breathing zone sample.

Table A-2 Respirable Dust Sampling Results

Sampling Period	Type	Respirable Dust (ug/sample)	Start	Stop	Duration (min)	Vol (L)	Respirable Dust mg/m3
1	pbz	80	9:48	10:04	0:16	144	0.56
2	pbz	(50)	10:30	10:45	0:15	135	(0.37)
3	pbz	(30)	11:01	11:16	0:15	135	(0.22)
4	pbz	150	12:36	12:52	0:16	144	1.04
5	pbz	80	1:07	1:22	0:15	135	0.59
6	pbz	(30)	1:41	1:57	0:16	144	(0.21)
1	area	ND	9:48	10:04	0:16	146	ND
1	area	ND	9:48	10:04	0:16	146	ND
2	area	ND	10:30	10:46	0:16	146	ND
2	area	ND	10:30	10:46	0:16	146	ND
3	area	ND	11:01	11:17	0:16	146	ND
3	area	ND	11:01	11:16	0:15	137	ND
4	area	ND	12:38	12:53	0:15	137	ND
4	area	ND	12:39	12:53	0:14	127	ND
5	area	ND	1:07	1:24	0:17	155	ND
5	area	ND	1:07	1:25	0:18	164	ND
6	area	ND	1:43	1:58	0:15	137	ND
6	area	ND	1:43	1:59	0:16	146	ND

Notes: µg means micrograms, L means liters, min means minutes, and mg/m^3 means milligrams per cubic meter. Numbers in parentheses were between the limit of detection and the limit of quantitation. These are trace values with limited confidence in their accuracy. ND indicates a result less than the limit of detection. Pbz means a personal breathing zone sample.

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