In-Depth Survey Report

Mixing thinset mortar in a 5 gallon bucket with a dust control

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Abstract

Background

Workplace exposure to respirable crystalline silica can cause silicosis, a progressive lung disease marked by scarring and thickening of the lung tissue. Several construction materials, such as brick, block, mortar and concrete contain crystalline silica. Construction tasks that cut, break, grind, abrade, or drill those materials have been associated with overexposure to dust containing respirable crystalline silica.

Assessment

NIOSH staff visited the Bricklayers and Allied Craftworkers' Southern Ohio-Kentucky Regional Training Center, Batavia, Ohio on December 19, 2017 and performed industrial hygiene sampling, which measured exposures to respirable dust and respirable crystalline silica while an experienced bricklayer used a handheld electric mixer to mix thinset mortar and water in a 5 gallon plastic bucket with and without a dust control attached to the rim of the bucket.

Results

Personal breathing zone respirable dust measurements showed that the dust control reduced exposure by 84%. Unfortunately, the sampling periods were too short to measure the reduction in quartz exposures.

Conclusions and Recommendations

Full-shift sampling should be conducted during a tile setting job to determine how well this control works under actual working conditions.

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 kidney disease and autoimmune diseases, such as rheumatoid arthritis [Stratta et al. 2001, Parks et al. 1999].

Crystalline silica is a constituent of several materials commonly used in construction, including sand, 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].

Thinset mortar is a mixture of sand, cement, and a water retention compound [Tile Council of North America 2018]. A thin layer (typically 3/16 of an inch) of thinset mortar is used to bond tile to its substrate [Tile Council of North America 2018] Thinset mortar is also known as drybond mortar and dryset mortar [Tile Council of North America 2018].

Plant and Process Description

The BAC training center resources include expert trainers and skilled apprentices to test tools and provide feedback about their utility and acceptability, as well as a suitable environment in which to assess the tools' performance and associated exposures. In addition, the trainers are experienced in vocational training curriculum development and assessment.

Air samples for respirable dust and respirable crystalline silica were collected while an apprentice bricklayer mixed thinset mortar and water in a five gallon plastic bucket inside the training center. The bricklayer wore a full-facepiece, air-purifying respirator (model 6700, 3M, St. Paul, MN) with 3M model 2091 P100 filters. Training, fit-testing, and medical clearance were performed by his employer. He donned and wore the respirator correctly and it appeared to be maintained properly. He also wore a hard hat, work boots, and work gloves (see Figure 1)

Figure 1 - Apprentice bricklayer (NIOSH Photo)

The bricklayer used ½ inch (13 mm) Compact Hole Shooter drill (model 1660-1, Milwaukee Electric Tool Corp, Brookfield, WI) and mixing attachment to mix the mortar and water. He mixed about one half of a 50 pound (22.7 kilograms) bag of Mapei Large Floor Tile Mortar White (Mapei Corp, Deerfield Beach, FL) with 3 quarts (2.8 liters) of water for each sampling period (see Figures 2 and 3). Air samples were collected as described below while the bricklayer mixed the mortar.

Figure 2 – Adding thinset mortar to bucket (NIOSH photo)

Figure 3 - Mixing thinset mortar and water with drill (NIOSH photo)

An exhaust hood designed for use with 5 gallon buckets (WaleTale, Beaton Innovations, LLC, Elmira, NY) was attached to the rim of the bucket using the slot molded into the hood. The WaleTale hood's slot inlet is approximately 1.4 in (35 mm) high and 8.1 in (20.5 cm) long. It is molded in a curve to fit the shape of the bucket's rim. The internal diameter of the hose connection is 2.3 in (58 mm). Figure 4 shows the WaleTale hood.

Figure 4 - WaleTale hood, view of the underside. Slot is used to attach hood to bucket (NIOSH photo)

The purpose of this investigation was to assess the effectiveness of the WaleTale to control the bricklayer's exposure to thinset mortar dust while he mixed mortar and water in the bucket. Twelve tests were conducted. Six tests were performed while the bricklayer mixed mortar without using the WaleTale. Three tests were carried out with the WaleTale mounted on the bucket and attached to a 16 gallon 6.5 horsepower shop vacuum cleaner (model 19OLN650C, Shop-Vac Corp, Williamsport, PA). Three tests were carried out with the WaleTale mounted on the bucket and attached to an industrial vacuum cleaner (model 2900 ECO, Dustcontrol AB, Norsborg, Sweden). The order of the tests were three without the control, followed by three with the WaleTale and shop vacuum, then three without control, followed by three with the industrial vacuum cleaner.

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 2018]. 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-hour (hr) workday during a 40-hr workweek to reduce the risk of developing silicosis, lung cancer, and other adverse health effects [NIOSH 2002]. When substituting less hazardous materials for crystalline silica (where feasible) and 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 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.[1] 16285 (2016)]. The ACGIH TLV for α-quartz and cristobalite (respirable fraction) is 0.025 mg/m^3 [ACGIH 2018]. 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 mixed thinset mortar and water in a 5 gallon bucket at the training center. The bricklayer repeated the mortar mixing process during 12 sampling periods, each approximately 5 minutes long. Figure 5 shows the bricklayer mixing the material while wearing air samplers in his personal breathing zone.

[1] *Federal Register.* See Fed. Reg. in references.

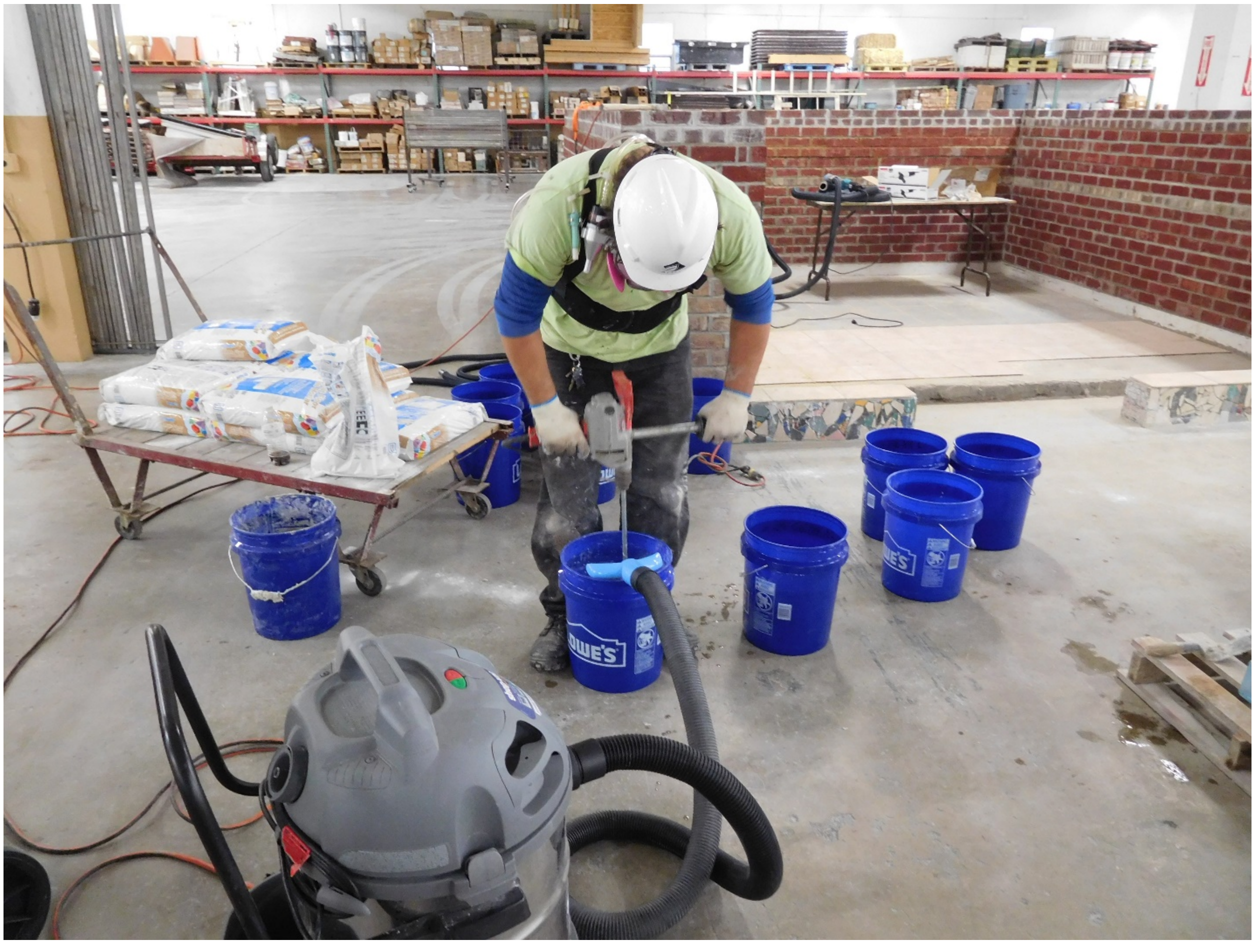

Figure 5 - Air sampling during thinset mortar mixing (NIOSH photo)

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. The sampling pump was attached to the waistband of a back-support vest (Model 1650, Ergodyne, St. Paul, MN). The pump was connected via Tygon® tubing 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 suspender strap of the back-support vest near the bricklayer's head and neck within the breathing zone (Figure 5). A bulk sample of thinset mortar was also collected in accordance with NIOSH Method 7500 [NIOSH 2003].

The filter samples were analyzed for respirable particulates according to NIOSH Method 0600 [NIOSH 1998]. The PVC 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 a Mettler balance, model number XP6 (Mettler-Toledo, LLC, Columbus, OH). The sequence specific limit of detection (LOD) and the limit of quantitation (LOQ) were determined using the seven media blanks. The LOD is three times the standard deviation of the media blank weight differences. The LOQ is ten times the standard deviation of the media blank weight differences. The limit of detection (LOD) was 20 µg/sample. The limit of quantitation (LOQ) was 76 µg/sample.

Samples for airborne respirable crystalline silica were prepared and analyzed following NIOSH Method 7500 (NMAM 4th Edition). Each filter was removed from the air sampling cassette and folded two times into a quadrant to form a pocket to contain the particulate inside. For each sample, a drop of 2-propanol (IPA) was added to the inside of the cassette lid and the back side of the sample filter was used to wipe the interior of the sampling cassette. The filter was then transferred to a 15-mL sample vial. Next, the filter was dissolved by addition of 8 mL of tetrahydrofuran (THF) to the sample vial and the sample was mixed by vortex. The sample vial was then covered with aluminum foil and placed in an ultrasonic bath for ten minutes. The resulting sample suspension was transferred to a silver-membrane filter. 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 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 a 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 18 µg/sample. The LOD and LOQ for cristobalite were 5 µg/sample and 17 µg/sample, respectively. 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 54 L. At the LOD for quartz of 5 µg/sample, the minimum detectable quartz concentration was 0.093 mg/m^3, nearly twice the NIOSH REL of 0.05 mg/m^3. The minimum quantifiable quartz concentration at the LOQ of 17 µg/sample was 0.31 mg/m^3, or about 6 times the NIOSH REL of 0.05 mg/m^3. The minimum detectable respirable dust concentration on the filter samples at the LOD of 20 µg/sample was 0.37 mg/m^3, while the minimum quantifiable concentration at the LOQ of 76 µg/sample was 1.4 mg/m^3.

A qualitative x-ray diffraction scan was acquired using a portion of the bulk sample, strained through a 45 um sieve. Approximately 0.5 g of sample was ground and wet sieved through a 10 um sieve using 2-propanol. The alcohol was evaporated in a drying oven. Approximately 1 mg of sieved-dried sample was weighed into a 15-

mL test tube. Approximately 10 mL of 2-propanol was added into the test tube to create a suspension. The test tube was placed in an ultrasonic bath for about 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 a sample plate and placed in the automated sample changer for analysis by X-ray diffraction. The LOD for quartz and cristobalite in the bulk dust sample was 0.5%. The LOD for tridymite was 1%. The LOQ for quartz and cristbobalite was 1.7%. The LOQ for tridymite was 3.3%

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 bricklayer'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.

A data-logging weather station (Kestrel 4500, Nielsen-Kellerman, Boothwyn, PA) mounted on top of a tripod recorded temperature, relative humidity, and air speed near the work area. The weather meter was approximately 60 in (1.5 m) off the ground. The weather meter was programmed to record data every minute.

Following the site visit, the airflow through the system consisting of the hood mounted on the bucket, hose, and vacuum cleaner was measured in the laboratory by inserting a delta tube (model 307BZ-11-A0, Midwest Instrument, Sterling Heights, MI) in line in the hose between the hood and the vacuum cleaner, in accordance with the manufacturer's recommendations. The differential pressure across the delta tube was measured with a Magnehelic pressure gauge (model 2050, Dwyer Instruments, Inc., Michigan City, IN), and the reading was used to calculate the airflow rate in accordance with the delta tube manufacturer's manual.

Results

The bulk sample of thinset mortar contained 58% quartz by weight. No cristobalite or tridymite were found in the bulk dust sample. The analysis suggested the presence of alite, a mineral component of Portland cement [MIT CSHub et al. 2013]. No cristobalite or tridymite were found in any of the air samples. Quartz was only found in one air sample, during test number 9, without the control. That sample contained 8.6 µg/sample of quartz (between the LOD and LOQ), a trace value with limited confidence in its accuracy. Based on an air sample volume of 45 L, this sample contained 0.19 mg/m^3 of quartz.

The results of personal breathing zone air sampling for respirable dust are presented in Table 1 below. Real-time personal breathing zone respirable dust results are summarized in Table 2. Personal breathing zone respirable dust concentrations collected on filter samples without the hood in place ranged from less than the limit of detection to 5.0 mg/m^3. With the shop vacuum and hood in use, respirable dust results ranged from less than the limit of detection to 4.4 mg/m^3. No respirable dust was detected in the samples collected with the hood and industrial vacuum in use.

Table 1 – Personal Breathing Zone Respirable Dust Results

Test	Condition	Result (µg/sample)	Duration (min)	Volume (L)	Concentration (mg/m^3)
1	No control	87	5	45	1.9
2	No control	ND	4	36	---
3	No control	120	5	45	2.7
4	Hood + shop vacuum	ND	5	45	---
5	Hood + shop vacuum	(27)	4	36	(0.75)
6	Hood + shop vacuum	200	5	45	4.4
7	No control	130	5	45	2.9
8	No control	180	4	36	5.0
9	No control	190	5	45	4.2
10	Hood + industrial vacuum	ND	6	54	---
11	Hood + industrial vacuum	ND	3	27	---
12	Hood + industrial vacuum	ND	4	36	---

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. Dashed lines means the concentration was not calculated because the result was less than the limit of detection

Average real-time personal breathing zone respirable dust samples during each sampling period ranged from 0.103 mg/m^3 to 0.395 mg/m^3. All but two of the real-time average concentrations were less than the minimum detectable concentration of the filter samples 0.22 mg/m^3. The highest average real time respirable dust measurement and filter-sample result both occurred during the third test.

Table 2 – Direct-Reading Respirable Dust Results

Sampling Period	Condition	Duration (min:sec)	Average (mg/m^3)	Minimum (mg/m^3)	Maximum (mg/m^3)
1	No control	5:15	0.759	0.179	15.5
2	No control	4:35	0.531	0.189	13.2
3	No control	4:39	1.11	0.191	10.9
4	Hood + shop vacuum	4:44	0.284	0.185	2.23
5	Hood + shop vacuum	4:09	0.295	0.183	1.41
6	Hood + shop vacuum	4:51	0.678	0.188	13.5
7	No control	4:47	0.866	<0.001	14.3
8	No control	4:39	1.39	0.197	17.0
9	No control	4:30	0.835	0.190	14.9
10	Hood + industrial vacuum	4:35	0.235	0.173	0.726
11	Hood + industrial vacuum	4:55	0.279	0.182	1.18
12	Hood + industrial vacuum	4:12	0.270	<0.001	1.96

<0.001 mg/m^3 indicates a result less than the manufacturer's reported sensitivity of the instrument.

The bricklayer mixed 12 batches of thinset mortar in water. The hood may not have been properly attached (to the full depth of the slot) during test 6, the third test with the shop vacuum.

The average temperature was 58 °F, and the average relative humidity was 57%. The weather meter did not detect any air movement. Lower readings may be taken down to 79 ft/min (0.4 m/sec) with the weather meter used here.

Airflow through the hood mounted on the bucket with the shop vacuum was 124 cfm (3.5 m^3/min). Airflow through the hood mounted on the bucket with the industrial vacuum was 109 cfm (3.1 m^3/min). Both vacuums used a hose that was 2 in (5 cm) in diameter. The calculated average velocity in a 2 in (5 cm) diameter hose at a flow rate of 124 cfm (3.5 m^3/min) is approximately 5684 feet per minute (fpm) (28.9 m/sec). The calculated average velocity in a 2 in (5 cm) diameter hose at a flow rate of 109 cfm (3.1 m^3/min) is approximately 4996 fpm (25.4 m/sec).

Discussion

The differences in the respirable dust results between the direct reading instrument and the gravimetric samples may be due to the fact that the The SidePak AM510 is calibrated against a gravimetric reference using the respirable fraction of standard ISO 12103-1, A1 test dust (Arizona Test Dust), which has a different composition and size distribution, and thus different light scattering characteristics than the thinset mortar dust.

Excluding the results of test 6, when the hood may not have been fully attached to the bucket, the results were comparable with either vacuum cleaner. Both showed a marked reduction compared to no control. The use of either vacuum cleaner resulted in an 84% reduction in respirable dust exposure, when the average of all six no control tests were compared to the average PBZ results from tests 4, 5 and 10-12. A value of the LOD /sqrt(2) was used in place of the ND results to calculate the averages [Hornung and Reed 1990]. The higher respirable dust concentrations in the gravimetric samples without the hood in place in trials 7, 8, and 9 may reflect a buildup of dust in the area because the shop vacuum did not have a HEPA filter, and was recirculating dust into the air.

The transport velocity with either vacuum cleaner should prevent clogging due to dust settling in the duct. The ACGIH industrial ventilation manual recommends a transport velocity of 3500 to 4000 fpm for “average industrial dust” (e.g., granite or limestone dust, brick cuttings, silica flour) [ACGIH 2013]. Conducting the evaluation indoors eliminated the effects of the wind on the operation. The WaleTale’s manufacturer recommends a flow rate of 100 to 150 cfm [WaleTale 2015]. Both vacuum cleaners tested operated within that range.

Based on the one detectable quartz result in test 9 of 8.6 µg/sample and a respirable dust mass in that sample of 190 µg/sample, one could speculate that the dust contained 4.5% quartz. Using the value of LOD/sqrt(2) to estimate the respirable dust concentrations in tests 4, 5, and 9-12, and multiplying that result by 0.045 (i.e., 4.5% quartz), an estimate of the average respirable quartz concentration during the five tests with the WaleTale was 0.02 mg/m^3. This result is speculative and should be evaluated with additional tests. In addition, while these short term tests can demonstrate the effectiveness of the dust control, the results should not be compared to an exposure limit based on an 8 or 10-hr TWA

A limitation of this report is the short sampling times, which led to small sample volumes and a minimum detectable quartz concentration above the OSHA PEL and NIOSH REL of 0.05 mg/m^3. A better approach would have been to utilize a second pump and sampler to collect an air sample while the bricklayer mixed several batches of thinset mortar under each test condition.

Figure 6 - Rim of the bucket partially occludes hood (NIOSH photo)

Conclusions and Recommendations

The method of attaching the WaleTale to the bucket results in the rim of the bucket blocking about 20% of the hood where it attaches to the vacuum cleaner hose (Figure 6). Perhaps the WaleTale could be modified to attach the hood to the bucket without blocking the airflow. In addition, the sharp edges of the hood may lead to turbulence and entry losses. The dust capture performance of the hood could probably be improved by the addition of a flange around the entry to the hood. Nevertheless, use of the WaleTale with a vacuum cleaner in the flow range recommended by the manufacturer resulted in an 84% reduction in respirable dust exposure. Based on the apparent build up in background dust concentrations during the use of the shop vacuum, a vacuum with HEPA filtration should probably be used when mixing thinset mortar. Full-shift sampling should be conducted during tile setting jobs to determine how well this control works to reduce exposure to respirable crystalline silica under actual working conditions.

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