IN-DEPTH SURVEY REPORT: CONTROL OF SILICA EXPOSURE IN CONSTRUCTION SCABBLING CONCRETE

at

Frank Messer and Sons Construction Company
Hebron, KY

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ABSTRACT

Scabbling concrete involves dressing the surface of the concrete to remove surface imperfections or surface coatings Analysis of a novel control designed and constructed by the site superintendent for use with a small, gasoline-powered, walk-behind scabbler showed that it was effective at reducing employee exposure to respirable dust and, should also be effective in reducing exposure to crystalline silica The control consisted of a 15-inch spray bar made from ¾-inch schedule 40 polyvinyl chloride pipe with 15 slots cut in it spaced ¾ to 1-inch apart The spray bar was attached to a lifting handle on the front of the scabbler with hose clamps, and oriented with the slots facing downward, toward the work surface An elbow connected the spray bar to a length of flexible hose mounted on the upright of the handle of the scabbler, with a valve mounted about midway down the handle The hose mounted on the scabbler was fitted with a standard garden hose fitting to allow it to be connected to a water supply hose An 80% reduction in mean exposure levels of respirable dust was found with the use of the water control, from 3 88 mg/m^3 to 0 64 mg/m^3 This difference was statistically significant at the p=0 05 level The difference was detected with 50% power in the 10 pairs of samples using a standard two-group t-test for equality of means

INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH) is located in the Centers for Disease Control and Prevention (CDC), under the Department of Health and Human Services (DHHS) NIOSH was established in 1970 by the Occupational Safety and Health Act, at the same time that the Occupational Safety and Health Administration (OSHA) was established in the Department of Labor (DOL) The OSHAct legislation mandated NIOSH to conduct research and education programs separate from the standard-setting and enforcement functions conducted by OSHA 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 (DART) has been given the lead within NIOSH to study and develop engineering controls and assess their impact on reducing occupational illness Since 1976, EPHB (and its forerunner, the Engineering Control Technology Branch) has conducted a large number of studies to evaluate engineering control technology based upon industry, process, or control technique The objective of each of these studies has been to evaluate and document control techniques and to determine the effectiveness of the control techniques in reducing potential health hazards in an industry or for a specific process

This is the report of a project to investigate the reduction in respirable dust and crystalline silica exposures to construction workers that resulted from the use of a novel control that was conceived of and built by the site superintendent to suppress the dust generated from the use of a concrete scabbler Scabbling concrete involves dressing the surface of the concrete to remove surface imperfections or surface coatings This report is one of a series of reports from a larger project to examine engineering controls to reduce respirable dust and crystalline silica exposures associated with the use of hand-held tools in construction Exposures and controls associated with tuck-pointing, which typically involves removing mortar from brick and block walls with grinders, concrete grinding, ready-mix truck cleaning, brick chipping, hand demolition, and building renovation are described in other EPHB reports from this project

OCCUPATIONAL EXPOSURE TO CRYSTALLINE SILICA

Silicosis is an occupational respiratory disease caused by inhaling respirable crystalline silica dust Silicosis is irreversible, often progressive (even after exposure has ceased), and potentially fatal Exposure to silica dust occurs in many occupations, including construction Because no effective treatment exists for silicosis, prevention through exposure control is essential When proper practices are not followed or controls are not maintained, silica exposures can exceed the NIOSH Recommended Exposure Limit (REL) or the OSHA Permissible Exposure Limit (PEL)[1,2]

The NIOSH REL for respirable crystalline silica is a 10-hour, time-weighted average level of 0 05 mg/m^3 NIOSH has classified crystalline silica as a potential occupational carcinogen

Therefore, NIOSH recommends that employers make efforts to reduce silica exposures below the REL

The OSHA PEL for respirable dust containing 1% quartz or more is expressed as an equation

$$\text{Respirable PEL} = \frac{10}{(\%\ \text{Silica}) + 2}$$

Thus, if the dust contains no crystalline silica, the PEL is 5 mg/cubic meter (m^3), and if the dust is 100% crystalline silica, the PEL is 0 1 mg/m^3 For tridymite and cristobalite (other forms of crystalline silica), OSHA uses half the value calculated using the formula for quartz

METHODS

Personal breathing zone samples were collected at a flow rate of 4 2 liters/minute using a battery operated sampling pump connected via Tygon tubing to a BGI GK 2 69 nickel-plated aluminum cyclone and a pre-weighed, 37-mm diameter, 5-micron (µm) pore-size polyvinyl chloride filter supported by a backup pad in a three-piece filter cassette sealed with a cellulose shrink band, in accordance with NIOSH Methods 0600 and 7500 [3] In addition to the personal samples, bulk samples of settled dust were collected in accordance with NIOSH Method 7500

Gravimetric analysis for respirable particulate was carried out with the following modifications to NIOSH Method 0600 1) The filters and backup pads were stored in an environmentally controlled room (21±3 °C and 50±5% relative humidity) and were subjected to the room conditions for at least two hours for stabilization prior to tare and gross weighing, and, 2) Two weighings of the tare weight and gross weight were performed The difference between the average gross weight and the average tare weight is the result of the analysis The limit of detection for this method is 0 02 milligrams (mg)

Crystalline silica analysis was done using X-ray diffraction NIOSH Method 7500 was used with the following modifications 1) Filters were dissolved in tetrahydrofuran rather than being ashed in a furnace, and, 2) Standards and samples were run concurrently and an external calibration curve was prepared from the integrated intensities rather than using the suggested normalization procedure These samples were analyzed for two forms of crystalline silica, quartz, and cristobalite The limits of detection for air samples for quartz and cristobalite are 0 01 and 0 02 mg, respectively The limit of quantitation for air samples is 0 03 mg for both quartz and cristobalite Bulk samples were collected and analyzed qualitatively for quartz and cristobalite by X-ray diffraction to determine if any interferences were present in the material The limits of detection in bulk samples are 0 8% for quartz and 1% for cristobalite The limit of quantitation is 2% for both forms of crystalline silica in bulk samples

A direct reading instrument and video exposure monitoring techniques were also used to characterize exposure [4] The worker being sampled wore a HazDust II real-time personal dust monitor with a respirable particulate pre-separator, while his actions were recorded using a digital video camcorder mounted on a tripod The HazDust II was equipped with a pre-weighed, 37-mm diameter, 5- µm pore-size polyvinyl chloride filter supported by a backup pad in a two-piece filter cassette sealed with a cellulose shrink band in-line after the sensor This filter was analyzed as noted above in order to determine the percentage of crystalline silica in the sample In the laboratory, the data collected with the personal dust monitor were overlaid onto the video recording

Preliminary "range-finding" sampling in order to observe the effectiveness of the control and determine the need for more sampling was conducted on June 28, 2001 This sampling consisted of four brief trials of personal breathing zone sampling and video exposure monitoring Two trials were conducted while an employee operated the scabbler with the control in use, and two trials were conducted without the use of the control Additional personal breathing zone sampling and video exposure monitoring were conducted on July 12, 2001 Sixteen samples were collected in eight paired tests, where one of the tests in each pair was performed with the use of water and one test in each pair was performed without the use of water (control "on" or control "off") The order of the test in each pair was determined randomly Eight samples each of control "on" and control "off" were considered the optimal number to detect a reduction in exposure levels when the control was used compared to when it is not, assuming a significance (alpha) of 05 and power of between 90 and 95% to detect a reduction

The flow rate of water supplied to the tool was measured using a 1-gallon bucket and a stop-watch The time required to fill the bucket was measured and recorded

RESULTS

In this case the scabbler was used to remove high spots and foot prints from the surface of a parking deck under construction at an airport terminal Figure 1 shows the scabbler (model SP8 G, Terex Bartell, Brampton, Ontario, Canada), a walk-behind gas-powered tool (also known as a surface grinder or scarifier), that uses a small gasoline engine and belt drive to turn a horizontal shaft As the shaft rotates, cutting tips on the shaft strike the concrete surface, removing material The scabbler has an 8-inch cutting width, with a working depth of up to ⅛-inch per pass The control evaluated was designed and built by the site superintendent It consisted of a 15-inch spray bar made from ¾-inch schedule 40 polyvinyl chloride pipe with 15 slots cut in it spaced ¾ to 1-inch apart The spray bar was attached to a lifting handle on the front of the scabbler with hose clamps, and oriented with the slots facing downward, toward the work surface An elbow connected the spray bar to a length of flexible hose mounted on the upright of the handle of the scabbler, with a valve mounted about midway down the handle The hose mounted on the scabbler was fitted with a standard garden hose fitting to allow it to be connected to a water supply hose Figure 2 shows the control in place on the scabbler

The results of the preliminary sampling performed on June 28 are presented in Table 1 These results illustrated the ability of the control to reduce employee exposures to respirable dust and crystalline silica and demonstrated the need for additional sampling to quantify the extent of the reduction in exposure

Table 1 also presents the results of the sampling conducted on July 12 In four of eight trials conducted on July 12, respirable dust results were less than the LOD (0 02 mg) for both the control "on" and control "off" conditions While one would expect results less than the LOD for the control "on" condition the reasons for these results when in the control "off" condition were not readily apparent when we conducted the sampling Perhaps the wind direction changed, or the sampler inlet was blocked by a fold of the employee's shirt For the four other trials, the control "on" samples were all ND, while the control "off" samples ranged from 0 12 to 0 57 mg/sample, or 5 7 mg/m^3 to 27 mg/m^3 for a 21 L sample For the four control "off" samples where respirable dust was found, the amount of quartz on the filters were ND, 0 01 mg/sample, 0 02 mg/sample, and 0 045 mg/sample An 80% reduction in mean exposure levels of respirable dust was found with the use of the water control, from 3 88 mg/m^3 to 0 64 mg/m^3 This difference was statistically significant at the p=0 05 level The difference was detected with 50% power in the 10 pairs of samples using a standard two-group t-test for equality of means

Comparable results were not obtained for quartz levels, since all but 2 measurements were below the limit of quantification and the correction factor commonly used $(LOQ/\sqrt{2})$ was not appropriate in this case The garden hose supplied water at a rate of about 15 gallons per minute

The results from the direct reading instrument measurements collected on June 28 are presented in Figure 3 The sample times in the graph were truncated at 300 seconds for clarity, although actual sample times ranged from 348 seconds for the first control "off" trial to 982 seconds for the last control "on" trial This is a plot of the logarithms of the data This allows data with orders of magnitude differences to be displayed in a convenient way In order to take the logarithm of these data, 0 001 was added to the zero measurement with the control "on" at 285 seconds, before taking the log These results show a substantial reduction in the concentration of respirable dust when the control is used For the two control "off" trials, the average respirable dust values were 16 mg/m^3 and 11 mg/m^3, while the average respirable dust values for the two control "on" trials were 0 21 and 0.54 mg/m^3, with maximum values of 66 and 40 mg/m^3 for the control "off" trials, and maximum values of 0 85 and 1 9 mg/m^3 for the control "on" trials. The direct reading results from July 12 contained many missing values, and are not included in this report As was the case with the pump and filter sampling, the reasons for these questionable results were not readily apparent at the time samples were collected Figure 3 shows the scabbler in use with the control "on "

Review of the video exposure monitoring from June 28 showed that peak exposures were associated with repeatedly going over the same area, aerosolizing dust that had been produced during previous passes over the concrete surface, and with changes in the wind direction that caused the cloud of dust to blow into the operator's breathing zone

CONCLUSIONS AND RECOMMENDATIONS

This study demonstrated the ability of a simple, job-built control to achieve an 80% reduction in exposures to respirable dust, and by inference, to reduce exposures to respirable crystalline silica Additional studies could be performed to determine the minimum water application required to achieve acceptable dust control Detailed studies of the effects on dust control of slot size or the use of holes or nozzles vs slots in the spray bar could also be conducted to optimize water use Obviously, this control is best suited for use in warm weather, where freezing temperatures will not affect the use of the control or present a slipping or cold hazard to employees The manufacturer of this scabbler offers an optional dust collector The performance of this dust collector should be evaluated for its use with the scabbler in cold weather Finally, although this parking structure was open on all sides, for other projects, employers should be aware of the potential hazard for carbon monoxide exposure posed by the use of small gasoline engines in enclosed spaces

REFERENCES

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4 NIOSH [1992] Analyzing workplace exposures using direct reading instruments and video exposure monitoring techniques Cincinnati, OH U S Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No 92-104

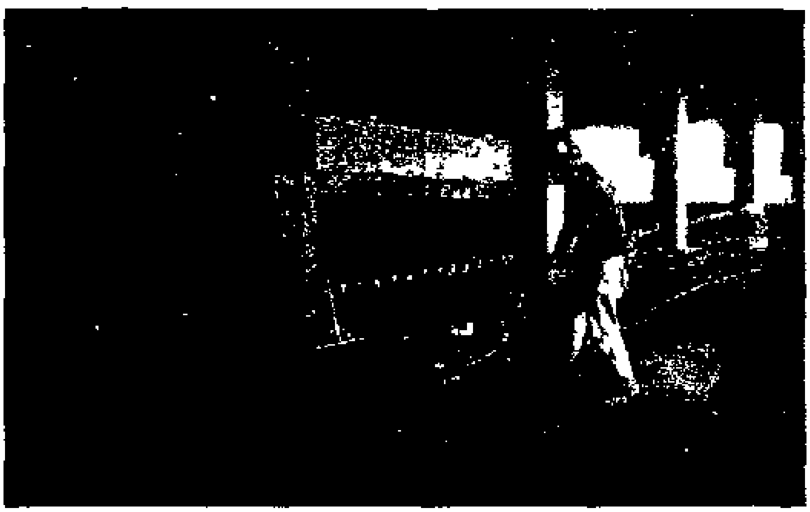

Figure 1 The scabbler in use without the control

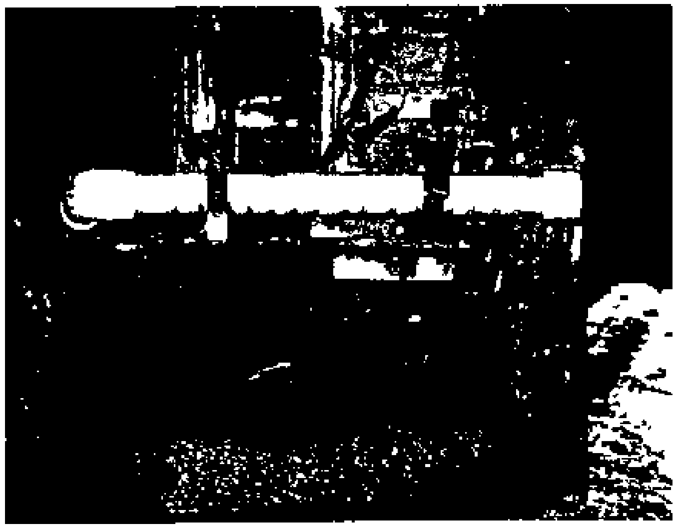

Figure 2 Close-up of the control Note the slots, and the hose clamps that hold the spray bar in place

Figure 3. The scabbler in use with the control in place Note the spray bar, and the valve on the handle

Table 1 Results of Air Sampling to Evaluate Control Effectiveness

PAIR	CONDITION	TIME (min)	VOLUME (m^3)	RESPIRABLE DUST (mg)	QUARTZ (mg)	RESPIRABLE DUST (mg/m^3)	QUARTZ (mg/m^3)
				June 28, 2001			
	dry	8	0 034	0 57	0 069	17	2 1
	dry	7	0 029	0 39	0 050	13	1 7
	wet	11	0 046	nd	na		
	wet	16	0 067	0 027	na	0 40	
				July 12, 2001			
1	wet	5	0 021	nd	na		
	dry	5	0 021	nd	na		
2	wet	5	0 021	nd	na		
	dry	5	0 021	nd	na		
3	dry	5	0 021	0 12	na	5 7	
	wet	5	0 021	nd	na		
4	dry	5	0 021	nd	na		
	wet	5	0 021	nd	na		
5	dry	5	0 021	0 17	(0 01)	8 1	0 48
	wet	5	0 021	nd	na		
6	dry	5	0 021	nd	na		
	wet	5	0 021	nd	na		
7	dry	5	0 021	0 28	(0 02)	13	0 95
	wet	5	0 021	nd	na		
8	dry	5	0 021	0 57	0 045	27	2 1
	wet	5	0 021	nd	na		

nd = not detected
na = not analyzed because respirable dust values were less than the silica LOQ
numbers in parentheses were between the LOD and the LOQ, and should be regarded as trace values with limited confidence in their accuracy

Figure 3: Scabbler Control Test, June 28, 2001