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Prevention of silicosis in concrete and masonry workers

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ABSTRACT: Respirable crystalline silica dust is a respiratory hazard commonly found in the construction industry. When concrete or other masonry is disturbed by either sawing, grinding or hammering, dust controls such as water application or local exhaust should be used to reduce or eliminate the high concentrations of respirable crystalline silica that are generated. Since power equipment produces high concentrations of dust in a short time, if not properly controlled, working in enclosed or partially enclosed areas which are not ventilated increases exposures. A number of National Institute for Occupational Safety and Health (NIOSH) field studies have found a need for improved control of respirable crystalline silica during sawing and drilling of masonry material. For example, NIOSH obtained a measurement of 14.2 mg/m^3 of respirable crystalline silica dust, while a plumber used a handheld masonry saw on a concrete floor, without dust control, inside an unventilated office building that was being renovated.

1. INTRODUCTION

Respirable crystalline silica dust is a respiratory hazard commonly found in the construction industry. Crystalline silica is found in abundance in the earth's crust. Silicosis is permanent lung damage caused by breathing dust containing extremely fine particles of crystalline silica. The three major forms of crystalline silica are quartz, cristobalite and trydimite.

Quartz is by far the most common form of crystalline silica found at construction sites and is the focus of this discussion. Quartz is a constituent of several common building materials including concrete, concrete blocks, mortar, and bricks. The source of quartz in these materials is the sand and/or rock that are used to make them. Many types of power tools are used to grind, saw, plane, chip, hammer, core and drill concrete and other masonry. Some of these tools are available with dust collection or for use with water, but some types of tools or models may not be designed to help control respirable dust. Even tools with vacuum or fan type dust collection systems may not be designed to effectively eliminate the respirable quartz dust hazard. Concrete finishers and masons use many of these tools. For example a concrete finisher may use an angle grinder to smooth poured concrete walls and ceilings as well as a floor grinder. They may also use a chipping hammer to remove excess concrete after concrete forms have been removed. During highway construction they may use a concrete saw. Masons may use either a hand-held or table masonry saw. Masons also use special grinders or joint cutters to remove mortar from between bricks during repointing of masonry. Masons or their helpers mix silica sand with Portland cement and water to make mortar. They may also be exposed to abrasive blasting of masonry walls during cleaning or refurbishment. If silica sand is used as the abrasive, quartz dust will be generated from both the abrasive and the masonry.

The key to silicosis prevention is to prevent dust from being in the air through the use of proper dust control. Crystalline silica overexposures occur frequently in some parts of the construction industry as evidenced by the Occupational Safety and Health Administration (OSHA) sampling data. Air sample data in the OSHA Integrated Management Information System (IMIS) indicate that during the years 1980 to 1995, for Standard Industrial Classification (SIC) 1741- Masonry, Stone Setting, and Other Stone Work, 39% of the OSHA silica samples were over the Permissible Exposure Limit (PEL) (Linch 1997). A recent NIOSH examination of the OSHA compliance data indicates that the more general SIC 174 - Masonry, Stonework, Tile Setting, and Plastering- may have more workers exposed to crystalline silica dust than any other 3-digit SIC (excluding mining & agriculture). This study estimates that 13,800 (1.8%) workers employed in SIC 174 in 1993 were exposed at levels of 10 times or more the NIOSH Recommended Exposure Limit (REL) of 0.05 mg/m^3 (Linch 1998). This data agrees with the NIOSH finding that, with the exclusion of the coal mining industry, the construction industry is indicated on death certificates with mention of silicosis more often than any other industry (NIOSH 1996a).

Since building materials containing crystalline silica are so common, there are numerous ways in which construction workers can become exposed to respirable crystalline silica. However, construction companies can protect workers through: judicious specifications of masonry materials; implementation of a strong hazard communication program; use of all feasible engineering controls and respiratory protection (NIOSH 1996b).

In order to better understand the crystalline silica exposure potential for construction workers who use concrete and masonry saws, air samples of respirable crystalline silica dust were obtained from construction sites where this type of work was being performed.

In addition to the dust hazard discussed here, contractors must be concerned with the carbon monoxide poisoning risk associated with the use of gasoline powered tools such as masonry saws in situations where adequate ventilation is not present (Earnest 1997).

2. SAMPLING AND ANALYTICAL METHODS

NIOSH obtained personal breathing zone and general area air samples during various concrete sawing operations to determine the potential exposure concentrations of respirable crystalline silica dust. The personal respirable dust samples were taken using 10-mm nylon cyclone pre-separators, 37-mm PVC filters, and constant-flow pumps calibrated at 1.7 lpm. Area samples were collected using tripods and baskets to hold the sampling equipment or by mounting the basket of equipment on the saw housing. The area respirable dust samples were obtained by using the same sampling method as the personal samples with the exception that sometimes a high-volume sample was also obtained. The high volume samples were collected on 37-mm PVC filters using a ½ inch metal cyclone at its designed flow rate of 9.0 lpm. At some of the work sites samples of settled dust (bulk dust) was collected and analyzed.

The air samples were analyzed at the NIOSH contracted laboratory in Salt Lake City, Utah. The analysis included total weight gain by gravimetric analysis according to NIOSH Method 0500. The limit of detection for this procedure is 0.02 mg. The air samples were then analyzed for quartz and cristobalite using X-ray diffraction as per NIOSH Analytical Method 7500. The limit of detection for quartz on the filters is 0.01 mg and the limit of quantification is 0.03 mg. The limit of detection for cristobalite on the filters is 0.015 mg and the limit of quantification is 0.03 mg. The bulk samples of settled dust were analyzed also by the use of X-ray diffraction. A two-milligram portion of the bulk sample was weighed onto a PVC filter prior to analysis per NIOSH method 7500.

Samples 1-4 in Table 1 were taken during the renovation of a multi-story office building. Each floor of the building had been gutted. A plumber was using a hand-held gasoline powered circular masonry saw to saw the concrete floor around floor drains. An indentation in the concrete floor around each floor drain was desired. The masonry saw was used to make several cuts into the concrete around the drain holes so that a jackhammer could then be used to gouge out the indentation. This procedure needed to be performed where new rest rooms were to be installed on each of the 16 floors of the building. Since the pedestrian sidewalk at ground level was open for use, the general contractor did not want any windows to be open for fear of falling objects. Special permission was given to have one window open on the floor that the concrete sawing was being done. A floor stand fan was situated in an attempt to blow the dust out of the building through the open window. No other means of controlling the dust was used. The worker wore a single use particulate filter respirator during the task. Visible clouds of dust were generated while he sawed. The resulting respirable quartz concentration was measured at 14.15 mg/m^3. If no exposure is assumed for the unsampled portion of the work shift the 8 hr time weighted average (TWA) for this sample is 10.3 mg/m^3 respirable quartz. This concentration is over 200 times the NIOSH REL. Analysis of three samples of bulk settled dust indicated a mean quartz content of 43%. The area samples were obtained at a distance of approximately 25 feet from the saw. The area samples indicate that workers not involved with this particular task may be temporarily exposed to significant levels of crystalline silica dust. Since it is common for many sub-contractors to be engaged in work at a large work site it is important that each contractor control dust at the point of generation so that others are not exposed.

Hand-held gasoline powered masonry saws of this type can be purchased that are equipped to provide water to the diamond impregnated saw blade and should be used whenever feasible. If water is not available at the site, drums of water can be used by either gravity feeding or pumping the water to the saw.

As seen in Table 1 when concrete is sawed with water being applied to the blade to cool and prevent wear of the blade there is the added benefit of reduced respirable dust being released into the air. Samples 5-11 in the table were obtained during the sawing of expansion joints in fresh concrete during interstate highway construction. The area sample (sample 8) was obtained from a basket attached to a tripod that was moved as the work progressed. A large walk behind saw is used for this type of work. Since the saw blades are expensive most contractors that do this type of work take care to make sure that they only saw with water. Concrete which is curing still contains water in it and so may not produce as much dust as old concrete. Analysis of six samples of bulk settled dust indicated a mean quartz content of 20%. For expansion joint sawing the entire thickness of the concrete pavement is not sawed; therefore, the dust generation rate for this work is probably lower than when entire blocks of pavement are sawed and removed during repair work.

Samples 12-23 were taken during the use of a walk behind concrete saw in which old concrete pavement was sawed in order to remove blocks of it from the roadway. The area samples were obtained from baskets attached to the saw housing.

3. SUMMARY & CONCLUSIONS

The provision of water to diamond impregnated masonry saw blades is intended to protect the blade; however, it also has the beneficial effect of reducing respirable dust containing quartz. Some saws, for example electric saws or saws with composite blades, are not suitable to be used with water. When concrete or other masonry is sawed dry and without effective respirable dust collection, very high concentrations of respirable dust containing crystalline silica in the form of quartz must be expected. If the dust from these operations is not controlled at the source, workers not involved with the task may also be exposed at unacceptable levels.

The scientific literature does not offer guidance on how much water should be supplied in order to assure that respirable quartz dust is not released into the working environment while concrete is being sawed; therefore, care should be taken to assure that plenty of water is used. Since a large amount of respirable dust can be generated very quickly with these saws, diligence in the use of water on the blades is recommended. It should also be noted that, since the amount of quartz in concrete varies from application to application, the results of sawing other concrete may be significantly different. It is typical for contractors to allow the slurry of water and

Table 1. Dust containing crystalline silica generated from concrete sawing.

Sample number	Type p/a[a]	Flow rate (lpm)	Sample duration (min.)	Respirable dust (mg/m^3)	Respirable quartz (mg/m^3)	Dust control
1	p	1.7	350	28.89	14.15	none
2	a	9.0	350	9.13	4.11	none
3	a	1.7	350	7.68	3.36	none
4	a	1.7	350	8.07	3.19	none
5	p	1.7	240	0.02	nd[b]	water
6	p	1.7	242	0.05	nd[b]	water
7	p	1.7	238	0.07	nd[b]	water
8	a	1.7	160	nd[2]	nd[b]	water
9	p	1.7	545	0.05	nd[b]	water
10	p	1.7	545	0.05	nd[b]	water
11	p	1.7	535	0.03	nd[b]	water
12	a	1.7	176	0.33	nd[b]	water
13	a	1.7	174	0.71	nd[b]	water
14	a	9.0	170	0.31	0.02	water
15	p	1.7	271	0.43	nd[b]	water
16	a	9.0	275	0.30	0.02	water
17	p	1.7	231	0.89	(0.05)	water
18	a	9.0	230	0.93	0.10	water
19	p	1.7	369	0.72	(0.03)	water
20	a	9.0	261	0.49	0.05	water
21	a	9.0	112	1.40	(0.10)	water
22	p	1.7	383	0.32	nd[b]	water
23	a	9.0	383	0.27	0.01	water

a. p = personal, a = area. b. Denotes "not detected".

( ) Denotes that the value is between the limits of detection and quantification.

concrete dust to dry on the concrete surface. In the case of highway pavement work, this dried slurry is often reintroduced into the air by mobile equipment and construction vehicles. Ideally, the slurry should be removed before it is allowed to dry. This can be done with a vacuum made to pick up water.

Respirators should not be used as the primary means of preventing or minimizing exposures to airborne contaminants. Effective source controls, such as substitution, automation, enclosed systems, local exhaust ventilation, wet methods, and good work practices, should be implemented to minimize worker exposure to silica dust. Such measures should be the primary means of protecting workers. However, when dust source controls cannot keep exposures below the NIOSH REL, controls should be supplemented with the use of respirators.

When respirators are used, the employer must establish a comprehensive respiratory protection program as outlined in the NIOSH Guide to Industrial Respiratory Protection (NIOSH 1987) and as required in the OSHA respiratory protection standard (29 CFR 1910.134), (29 CFR 1926.103). Some important elements of this standard are:

- periodic environmental monitoring,
- regular training of personnel,
- selection of the proper NIOSH-approved respirators,
- an evaluation of the workers' ability to perform the work while wearing the respirator,
- respirator fit testing,
- maintenance, inspection, cleaning, and storage of respiratory protective equipment.

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