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Case Studies

Silica Exposure for Concrete Workers and Masons

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Introduction

The widespread use of concrete in construction of buildings, roads, and in an array of structures and products, presents the potential for exposure to respirable crystalline silica during construction work. Varying percentages of crystalline silica may be found in the sand and rock used in concrete, concrete block, and mortar. Construction laborers may be exposed to respirable silica during many routine tasks involving concrete. Drilling holes through concrete walls, grinding concrete surfaces, cutting through concrete floors, walls, or pipe, or power cleaning concrete forms, all present the opportunity for silica exposure. Concrete finishers are a specialty trade of construction most likely at risk from these activities. Masons also have potential for high exposure to crystalline silica. The building of structures with concrete block routinely requires cutting of the block with the potential for release of respirable dust. Masons may also need to smooth surfaces of mortar and block or remove mortar for restoration by using powered grinders which predictably results in the release of clouds of fine dust when uncontrolled.

References over the years have pointed to the risks of silica in foundries, mining, quarrying, tunneling, sandblasting, glass and pottery manufacturing, and, to a lesser extent, construction. A 1975 National Institute for Occupational Safety and Health (NIOSH) Criteria Document on silica did not specifically address construction,[1] though, a 1978 NIOSH health and safety guide for masonry, stonework, tilesetting, insulation, and plastering contractors did.[2] The guide included the following warning: "Dusts generated by brick and masonry saws and tuckpointer's grinders may contain potentially hazardous levels of silica." A summarization of the federal Occupational Safety and Health Administration (OSHA) inspection data collected between 1979 and 1982 for employers in SIC codes 16 (heavy construction other than building construction) and 17 (construction, special trade) showed that silica exposures exceeded the permissible exposure limit for about half of the inspections where test samples were taken.[3] More recently, NIOSH published an alert on silica exposure for sandblasting, stating that construction employed the largest number of sandblasters.[4] An alert was also issued for silica exposures for rock drillers, including those involved in caisson, tunnel, highway, and dam construction.[5] Excepting sandblasting and rock drilling, the level of exposure associated with specific construction activities has not been well characterized in the literature. Also absent from the literature are epidemiological studies of construction trades and exposure to silica.

Data accumulated from inspections by the State of Washington OSHA program for a number of construction activities involving concrete and masonry work and presented in this report have shown a pattern of exposure to crystalline silica in excess of the Washington Industrial Safety and Health Act (WISHA) and OSHA permissible exposure limit (PEL). Though this case study itself presents a limited number of samples on only a portion of construction tasks where silica-containing dust may be released, the data confirm the risks of silica-induced lung diseases and cancer that concrete workers and masons throughout the United States still face in the 1990s.

Methods

Evaluation of silica exposure was initiated as a result of WISHA inspection activity. The data were collected over a period of 18 months from 1991 to 1993 from various construction sites throughout the state. A total of 12 inspections are represented. Data were collected for the sole purpose to determine compliance with existing WISHA and OSHA standards. Inspectors performed personal sampling on workers judged to have the potential for respirable crystalline silica (quartz) exposure above the PEL of 0.1 mg/m³ as an 8-hour time-weighted average (TWA). Some sampling times include break time or tasks with no exposure. Inspectors were not able to conduct full-shift monitoring in each case. Personal samples were collected on preweighed filters at 1.7 L/min using a 10 mm nylon cyclone in accordance with the state's operations manual. Samples were analyzed by the State of Washington's American Industrial Hygiene Association accredited laboratory. Personal samples were analyzed using Fourier transform infrared analysis (FTIA) and reported as milligrams of respirable quartz per cubic meter of air. Bulk samples were analyzed by FTIA and/or Talvitie colorimetric method and the estimate of quartz reported as percent dry weight.

Results and Discussion

The data presented in Table I correlate construction activity with exposure to respirable quartz (crystalline silica) for the time monitored. Environmental conditions for each activity are listed, as is a description of the silica-containing material being worked. When obtained, the analysis for percent quartz on bulk samples of the dust left from the activity is also displayed.

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TABLE I. Construction Activity and Respirable Quartz Exposure

Activity	Environmental Conditions	Silica Material	Quartz in Bulk (%)	Personal Exposure to Respirable Quartz* Minutes	mg/m³
Concrete finishing, grinding on walls and ceilings, dry, electric grinder	Large tunnel, natural draft	Concrete	—	377	0.8
				430	1.1
				71	1.2
Grinding on ceiling, dry, electric grinder	Small room, fan at doorway	Concrete	—	109	1.4
Grinding on wall, dry, electric grinder	Outdoors, light to no wind	Concrete	6-7	135	1.2
Grinding on ceiling, dry, electric grinder	Indoors on scaffold, fans providing some general ventilation	Concrete	—	212	0.50
				167	0.41
				149	0.39
				233	0.24
Sewer pipe cutting, 12" diamond blade gas powered saw, wet	Roofed, open sided, natural ventilation	Concrete	—	105	0.11
Wall drilling, pneumatic and electric drills, dry, 3/4" bit	Lower floor parking area, poor draft	Concrete	12	457	0.30
				110	0.26
				177	0.11
Concrete block finishing, grinding surface of block, hand-held air powered grinder, dry	Indoors, large room, poor draft	Concrete block	—	56	8.7
Dry wall installation, near concrete grinding activity, dry	Indoors, large room, poor draft	Concrete block	—	71	0.25
Concrete block cutting, masonry saw, dry	Against wall, outdoors, windy	Concrete block	11	56	7.3
	Outdoors, windy	Concrete block	11	118	0.17
Helper, near saw at times	Near wall, outdoors, windy	Concrete block	11	50	0.43
Concrete floor sawing, 14" and 18" hydraulic floor saws, wet	Indoors, large room, general ventilation	Concrete	14	205	<0.06
				127	<0.09
Concrete wall cutting, 20" hydraulic hand saw, wet	Indoors, hallways and rooms, poor ventilation	Concrete block	—	194	0.25
				168	0.23
Brick mortar restoration (tuckpointing), hand chiseling and grinding, electric grinder, dry	Outdoors, light wind 3rd-4th stories	Mortar	4-5	222	0.18
				194	0.40
Grinding, electric grinder, dry	Outdoors, light wind, ground floor	Mortar	4-5	123	1.8
				115	2.0
				102	2.6
				96	1.1

*The State of Washington and federal OSHA permissible exposure limit for respirable quartz is 0.1 mg/m³ as an 8-hour TWA.

In all but two of the activities the sampled values together with the inspector's observations indicated exposure to crystalline silica above state and federal OSHA 8-hour TWA limits. Workers judged to have no exposure or likely to have exposure less than the limit were not sampled. All powered, dry activity that created fine dust from concrete and products of concrete resulted in excessive exposure within a matter of hours; in some cases excessive exposure resulted within minutes.

Environmental conditions were a factor, but as shown for the dry cutting or grinding of concrete or concrete block, even in an outdoor setting the activity still presented the potential for excessive exposure. Further variables included the percentage of quartz in the material being worked on, duration of the activity, number of dust-generating activities occurring at any one time, as well as differences in tools and work practices.

The worst exposures were found for dry grinding or cutting in enclosed areas, presenting the potential for exposure to exceed by 50 times the PEL. Sampling of other trades working nearby the dustier operations were found to have lesser but yet excessive exposure.

Efforts to control the silica exposure were inadequate or lacking for most activities. The use of water for dust suppression was observed. The saws used for the cutting of sewer pipe, floors, and walls were found to use water for cooling and dust control. Exposures were found from two to three times greater than to below the PEL. Though representing only a limited number of data points, the samples indicate that the use of water should not be relied upon as a complete method of control in all instances. Water was not observed for hand-held powered grinding. Water was observed for a masonry saw in use outdoors, though the operator was not monitored.

Dry cutting and grinding without local exhaust or adequate respiratory protection was observed. Some contractors commented that dry cutting on concrete blocks is routinely performed. It was stated that wet blocks can present problems when setting in place on the mortar and certain work needs did not allow time to dry blocks (others related they routinely used water on their masonry saws). None of the saws, drills, or grinders was observed with local exhaust. A contractor stated he had never seen a masonry table saw fitted with a dust collection system and none was found on the inspections conducted. One manufacturer of a masonry saw stated that they equip their saws with a water application system but do not offer a local exhaust ventilation option. The use of respirators varied from none, to disposable dust, to elastomeric half face dust filter respirators without fit testing or training. Some attention was found to control the more gross levels of dust through positioning of the equipment or worker with respect to the drift of the dust cloud.

Invariably, hazard communication on respirable silica was absent. Workers were not informed of the health hazard they or others were creating. Though bagged sand was found adequately labeled, pallets of concrete block were either not labeled or the label lacked information on the chronic hazards of respirable silica.

The inspections resulted in violations over respirator use, engineering control, hazard communication, and, for manufacturers of the concrete block, labeling and material safety data sheets.

Conclusion

The inspections characterized in this case study do not represent a comprehensive survey of silica exposure in the construction industry. Many silica dust-producing operations were not evaluated. Further, it should be remembered that the work sites were not selected by random, but rather by a report of possible health violations. Other work sites where good control and compliance may exist were not inspected. The data collected, though, demonstrate that exposure to respirable quartz in excess of the state and federal OSHA PELs likely occurs on a widespread basis for certain specialty trades, such as concrete workers and masons. Other construction activity and specialty trades may also present the potential for excessive exposure where their work generates dust from concrete products. Workers nearby such operations not utilizing engineering controls may also have overexposure.

The level of exposure found above the 0.1 mg/m^3 8-hour TWA used by state and federal OSHA programs is of great concern. Exposure at times may exceed 1 mg/m^3, surpassing the protection factor of 10 assigned to half face negative pressure respirators. Worst case exposures, resulting from cutting or grinding indoors throughout a shift, would likely exceed by 50 times the PEL. NIOSH recommends a limit of 0.05 mg/m^3 averaged over a work shift of up to 10 hours per day, 40 hours per week.[1] ACGIH has recommended a threshold limit value (TLV) as adopted by OSHA but with the following qualification: "Since the margin of safety of the quartz TLV is not known, it is recommended that quartz concentrations be maintained as far below the TLV as current practices will permit."[6]

Control of silica dust exposures may be achieved through standard industrial hygiene techniques, including water application, local exhaust, general dilution ventilation, work practice, as well as use of air supplied or other respirators that provide approved protection.

Water freely applied to the blade, tool, or work surface can result in a marked reduction in airborne dust levels. Water should be used whenever it is feasible and safe. Some masonry and concrete tools come equipped for water application to the blade. Grinders may not, but water applied to the working surface with periodic cleaning of the grinding wheel can reduce the airborne dust level. However, water may not always serve as a complete control method and respirators may also be needed.

As an alternative to water, exhaust ventilation and portable air cleaners are commercially available for many types of equipment, including hand-held grinders, masonry saws (table and hand-held), concrete saws (floor and hand-held), concrete slab grinders, planers, and scabblers. Many tools can be retrofitted with local exhaust. The ACGIH *Industrial Ventilation Manual* provides ventilation specifications for both table-mounted saws and hand-held grinders.[7] The use of local exhaust equipment was not observed during these inspections and thus no data were collected to show effectiveness. Demonstration by a vendor of a local exhaust and air cleaner system manufactured for a masonry saw indicated capture of the visible dust released from cutting a concrete block.

Where engineering controls are not feasible or completely effective, or during their development, respirators may be used. NIOSH most recently has recommended high efficiency particulate air filters for air purifying respirators, where permitted, and the use of type CE abrasive blasting respirator operated in the positive-pressure mode for blasting operations involving crystalline silica.[4] NIOSH further recommends the use of "the most protective respirator that is feasible and consistent with the tasks performed." An air-supplied respirator is likely feasible for most activities.

It is urged that air sampling be performed to show the effectiveness of any adopted engineering control and to select appropriate respiratory protection.

The general conclusions presented in this case study are not unique. They have been repeated before by others, unpublished and published.[3,8-10] But as shown by the recent data and observations presented here, the conclusions are clearly in need of repeating once again. Affected trade associations, employers, and unions must make a greater effort toward controlling the silica hazard in construction. Industrial hygienists and safety professionals who may perform work for the construction industry will need to continue their vigilance toward identifying and controlling the still-prevalent risk of disease from exposure to crystalline silica in the construction trades.

The WISHA industrial hygiene program utilizes a targeting system that includes construction. A recent article published in a state-sponsored employer newsletter informed the construction industry of the silica hazard associated with concrete and concrete products and the methods of control.[11]

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