Silica Dust Controls in Concrete Construction

By Alan Echt

Crystalline silica is found in several construction materials, such as block, mortar and concrete, usually in the form of quartz. Tasks that cut, break, grind, abrade or drill those materials can result in overexposure to dust containing respirable crystalline silica (RCS). RCS 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 less than approximately 10 micrometers in diameter. Workplace exposure to RCS can cause silicosis, a progressive lung disease marked by scarring and thickening of the lung tissue, as well as autoimmune diseases, chronic kidney disease and other lung diseases. Controlling RCS exposures to levels below occupational exposure limits is essential to protecting the health of construction workers.

THE HIERARCHY OF CONTROLS

Industrial hygienists anticipate, recognize, evaluate and control hazards in the workplace. They use a hierarchy of controls to lessen workplace hazards in this order of preference: engineering controls, work practices, administrative controls and personal protective equipment.

Engineering controls include substitution of a less hazardous process or substance, isolation of the worker or process (for example, placing the worker in an enclosed cab) and ventilation. Ventilation can dilute a contaminant or contain the contaminant at its source; control at the source is called local exhaust ventilation. In construction, mining and mineral processing, dust suppression with water or other liquids is sometimes used to control hazardous dust at its source.

Work practices and administrative controls are sometimes considered together when industrial hygienists use the hierarchy of controls. Administrative controls include training and worker rotation. Personal Protective Equipment (PPE) means things like respirators, gloves and hearing protection. PPE must be worn properly and continuously while the worker is exposed to the hazard, must be selected based on the hazard, requires worker training in its use, must fit the worker and must be replaced or cleaned and maintained on a regular basis. Regulations often mandate written programs to govern the administration of those processes for personal protective equipment.

THE HISTORY OF SILICA DUST CONTROL IN CONSTRUCTION

Among the first recorded engineering controls for silica dust was a patent granted in 1713 in England to Thomas Benson for a method for wet-grinding flints after it was recognized that the dry process harmed workers. Dust control in construction is not new either. A Public Health Service publication from the 1950s shows rock drills being used and fitted with a water hose. The operator controlled the water flow with a valve near the handle of the drill. A force cup from a toilet plunger was used to direct the water downward and away from the operator.

Further back still, during the 1930s, journal articles were published showing local exhaust ventilation systems for rock drills that used a portable pneumatically-powered dust collector (an air mover and cleaner), a length of flexible exhaust hose and a hood that surrounds the drill steel at the emissions source. A hood, duct work, air cleaner and air mover (usually a fan) are the components of any local exhaust ventilation system. In construction, vacuum cleaners are often used as air movers for local exhaust ventilation.

DUST CONTROL METHODS

In concrete construction, water is often used to cool and lubricate the diamond blades that cut concrete to extend blade life while suppressing hazardous dust. However, water creates a slurry that must be cleaned up after the job is complete. Using local exhaust ventilation to control dust, on the other hand, requires bringing more equipment to the worksite such as vacuums, hoses and generators.

Construction often takes place outdoors or in large spaces giving the perception that diluting hazardous dust can control exposures. While the construction environment seems like an ideal setting to rely upon dilution to control the dust, this is problematic for several reasons.

- Workers are often positioned too close to the source of the contaminant for dilution to be effective.
- The rate at which the contaminant is generated is too great for dilution to reduce it to safe levels.

- The wind is variable, as is the rate at which the contaminant is generated.
- Other workers are often downwind of the emissions source.
- Dilution should only to be used to control hazards if the toxicity of the contaminant is low.

Either local exhaust ventilation to capture dust at its source or water to suppress dust generation at the point of operation are preferred to relying upon the wind or the volume of the work space to dilute silica dust to acceptable concentrations.

HIGHLIGHTS OF CURRENT RESEARCH IN SILICA DUST CONTROLS FOR CONSTRUCTION

VACUUM CLEANER SELECTION

Recently, researchers at the University of Iowa studied the relationship between dust collection, flow rate and pressure loss across the filter in four vacuum cleaners used in construction. They were interested in controlling dust from tuck pointing, a masonry construction task that uses grinders to remove mortar from brick walls. They compared vacuum cleaners that used cyclones to those that used bags.

The researchers found that debris accumulation affected the performance of cyclone-type vacuums only minimally, while the performance of bag-type vacuums fell as debris filled the bags. For tasks that generate large amounts of debris, they recommended using cyclone-type vacuums over bag-type vacuums to preserve the air flow rate and prevent the filter from clogging. The researchers noted that while cyclone-type vacuum cleaners are more expensive initially, the cost saved by buying a cyclone-type vacuum cleaner may be offset by the cost of the bags and the labor cost of changing them frequently. They also recommended research to determine task-specific air flow rate specifications to aid in selecting appropriate vacuum cleaners. Finally, the researchers recommended using vacuum cleaners with static pressure gauges and training workers to use static pressure readings to determine when maintenance is required to restore proper air flow.

JACKHAMMERS

Some tasks performed by specialty concrete contractors result in RCS exposures that exceed occupational exposure limits. One of those tasks is breaking concrete pavement, walls and floors with jackhammers. Researchers in New Jersey found that 24 of 25 samples collected while workers broke concrete pavement exceeded the NIOSH Recommended Exposure Limit (REL) of 0.05 milligrams of RCS per cubic meter of air (mg/m^3). The highest recorded exposure found in the study was 12 times the NIOSH REL. Additionally, a British researcher found that breaking concrete walls resulted in silica exposures four times the REL, while breaking concrete floors resulted in exposures three to four times the REL.

Dutch researchers investigated the effectiveness of using water sprays for jackhammer dust control while three workers broke concrete slabs indoors. The Dutch study found that two hollow-cone spray nozzles, each supplied with 0.085 liters of water per minute (L/min) reduced RCS exposures by 64%, to an average concentration of 0.17 mg/m^3. Since the average exposure with the control still exceeded acceptable levels, the researchers recommended optimizing the design of the controls to improve their effectiveness.

NIOSH researchers also worked with partners in industry and labor to test jackhammer dust controls while workers broke up concrete highway barriers at a contractor's yard. Water applied using a solid cone nozzle at a flow rate of 0.3 L of water per minute (about 1-1/4 cups) resulted in a 77% reduction in RCS exposure to an average of 0.085 mg/m^3. Extrapolating to a full shift, that means that on average, a worker could use the jackhammer with the water spray for 4 hours and 45 minutes in an 8-hour shift without exceeding the NIOSH REL for RCS (an example of combining an engineering and administrative control). One of the NIOSH partners, the New Jersey Laborers Health and Safety Fund, posted do-it-yourself plans for the jackhammer dust control on its website, **http://www.njlaborers.com/health/pdfs/other/jackhammer.pdf**.

CUT-OFF SAWS

Cutting concrete with a hand-held abrasive cutter (a cut-off saw) can also result in overexposure to RCS. Data reported by the Occupational Safety and Health Administration revealed that sawing concrete dry resulted in a RCS exposure nearly 40 times the NIOSH REL for a 39 minute sample, or nearly twice the NIOSH REL when extrapolating to an eight hour shift with no further RCS exposure. Although task-specific exposures can be short, they can be very high.

British scientists also performed a laboratory study of dust suppression on cut-off saws with water by measuring dust emissions at various water flow rates. They found that optimal dust control (> 96% reduction) was achieved at 0.5 L/min (about a pint of water), although a respirator is still required to protect the worker. This research formed the basis of an RCS dust control campaign in Great Britain to identify a range of practical interventions, including the use of alternate work methods, designs to minimize the number of cuts needed, and substitute materials. One of the campaign's leaflets can be found at **http://www.hse.gov.uk/pubns/misc830.pdf**. A video from the campaign can be viewed at **http://www.hse.gov.uk/construction/cleartheair/**.

GRINDING CONCRETE

Another concrete construction task that has been the subject of engineering control research is grinding poured concrete walls after the forms are stripped. Researchers at the University of Washington studied the use of tool-mounted ventilation shrouds to control dust from hand-held concrete surface grinders (angle grinders). They found that shrouds reduced RCS exposures 89%–94%, from an average of 0.25 mg/m^3 without dust control to an average of 0.034 mg/m^3 when the shrouds were used. They also reported that 26% of the RCS samples with the control exceeded the REL. The air flow rate used with the dust control shrouds was about 70 cubic feet per minute.

THE FUTURE OF SILICA DUST CONTROL RESEARCH

Silica dust control in construction is an area of ongoing research at NIOSH and around the world. At NIOSH, scientists and engineers are continuing to work with partners in industry and labor to evaluate engineering control technology for asphalt milling machines, concrete floor polishers and grinders, and saws used to cut fiber cement siding. To learn more about NIOSH research in silica dust control for construction or to partner with the organization in an upcoming study, visit **http://www.cdc.gov/niosh/topics/engcontrols/** or **http://www.cdc.gov/niosh/topics/silica/constructionControlMain.html**. NIOSH can also be contacted by phone at 513-841-4221.

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