Construction Silica Exposures and Solutions

Construction sites are dusty places, but does that make them dangerous? Concrete and other rock materials are cut, ground, and drilled every day. Construction workers worry about breathing the dust and how it will affect their health. Research shows these concerns are well founded. One study showed silicosis deaths in the construction industry are higher than any other U.S. industry.

Construction workers are clearly at risk of developing silicosis and other lung diseases if they breathe high levels of concrete and rock dust. Are rock dust levels high on construction sites? This is not an easy question to answer. Air monitoring on construction sites is challenging because of the changing nature of the work.

To gather enough information about the wide range of construction activities, several groups that have air monitoring information pooled their findings. Groups included regulators from Washington, Oregon, and the Chicago OSHA office, universities and other research groups, and several construction contractors. This information was collected and analyzed at the University of Washington.

The purpose of this report is to help construction managers anticipate and control silica exposures. The report describes what was learned from the pooled sampling findings and other University of Washington research on the effectiveness of silica dust controls on construction sites and offers solution options for controlling exposure.

What is silica?

Silica is one of the most common minerals in the earth's crust. Glass, beach sand, silicone, and granite are all silica materials. There are two forms of silica – crystalline and non-crystalline. Crystalline silica is a bigger worry for the health of our lungs. The most common form of crystalline silica is quartz, which is found in sand, gravel, clay, granite, diatomaceous earth, and many other forms of rock. Non-crystalline silica is found in glass, silicon carbide, and silicone. These materials are much less hazardous to the lungs.

When we talk about silica exposure we are talking about crystalline silica or quartz. Construction workers could be exposed to silica when cutting, grinding, drilling, sanding, mixing or demolishing materials containing silica.

The size of the airborne silica particles determines the amount of risk. Smaller particles can be inhaled deep into the lungs where they can cause damage. Larger particles, such as beach sand, are not as great a concern because they are too large to inhale.

What happens if you are exposed to too much silica?

Breathing silica deep into the lungs can cause silicosis. With silicosis, silica particles lodge in the lung tissue, causing scarring. The lungs become less flexible, making it difficult to breathe and do hard work. Once silicosis develops, **the damage is permanent**. There is no recovery.

In the 1700s, an early medical scholar, Isbrand van Diemerbroeck, said autopsied lungs of stonecutters contained "so much sand that cutting through the pulmonary vesicles felt like cutting a body of sand." Things haven't changed. In 1994 a NIOSH pathologist said "His lungs were hard as rock. I couldn't cut them with a scalpel", after examination of a deceased silicosis victim's lungs.

Breathing silica dust can also cause lung cancer and increase the chance of developing tuberculosis. Studies have shown that construction workers exposed to silica dust have an increased risk of silicosis and other lung diseases.

What did we find?

University of Washington researchers collected 1,374 samples from regulators, research groups, private contractors, and consultants. Over half of the information came from regulators. These samples represent a wide range of activities for both commercial and road construction. On average, the silica exposure was 0.13 mg/m^3. This is **above the Washington State allowable limit** or permissible exposure limit (PEL) of 0.10 mg/m^3.

Average silica exposures were over the Washington limit for 7 of 12 tools. The highest exposures were surprisingly high and this occurred when using a variety of common construction tools. The Maximum levels are shown below.

Silica Exposure for Construction Tools

Tool	**Average* (mg/m^3)**	**Maximum (mg/m^3)**	**No. of samples**	**% of samples over WA Limit**
Tuck point grinder	0.61	76.10	102	89%
Surface grinder	0.28	18.20	123	79%
Abrasive blaster	0.24	11.26	56	73%
Rock drill	0.21	16.00	93	70%
Jackhammer/chipping gun	0.15	3.86	178	58%
Hand-held saw	0.13	14.15	65	52%
Road mill	0.11	1.36	48	52%
Walk-behind saw	0.09	1.64	33	45%
Table mount masonry saw	0.07	2.75	51	35%
Concrete mixer	0.04	0.55	32	25%
Broom or shovel	0.03	1.19	49	14%
Backhoe/excavator/bulldozer/bobcat	0.01	0.12	28	7%
compare to Washington Limit of: for full shift samples	**0.10**			

*geometric mean

Why are some exposures so high?

There are several things that make a difference:
- What tool is used?
- How enclosed is the environment (outside, size of room, ceiling height, windows and doors installed, stairwells)?
- Are dust control techniques used (water, ventilation, isolating the dusty work)?
- Is the dusty work constant or intermittent?

Where do I start to control silica dust on my construction site?

The first thing you need to know is how much silica is in the air during dusty work. The traditional way to determine this is to do air monitoring for each worker. With construction work, that is challenging because it can be several days before you receive the results from sampling. By then the work may be finished.

An alternative is to use information already gathered from air monitoring on construction sites to estimate exposure. If you do this, **it's important to know the details of the dusty activity**. Knowing the tool and looking it up on the list provided here is not enough. You also need to consider how enclosed the work space is, whether dust control techniques are used, and whether the dusty work is constant. If these features indicate that the work will be especially dusty, then you will need to estimate higher than the average exposure level shown in the table on page _. If the work space is very enclosed, such as a stairwell, your estimate will need to be much higher.

How can silica dust be controlled?

Water, ventilation, or isolation can reduce the dust getting into the air. Respirators can protect the worker from breathing the dust.

Water is often the best option for dust control. It works best when a water spray is directed right at the point of cutting or grinding. A fine mist is generally more effective than a water stream. Wetting the surface before starting is not very effective because almost immediately cutting or grinding will get below the wet surface, generating dust.

Table saws are one tool that usually uses water for silica dust control. This explains why exposures for table saws are lower than many other tools. Maintenance of the saw's water reservoir is very important for good water flow and control.

We have done studies at UW to test how well vacuums attached to tools control silica dust. For a tuck point grinder, surface grinder, and brick saw, dust was reduced by 80-90% when working on flat surfaces. Control will be somewhat less when working on columns or edges, when the tool moves over the edge. For good dust control the vacuum needs to be powerful – rated at 90 cfm airflow or better. The vacuum bag needs to be changed often.

Isolation of the dusty activity, by tenting off or otherwise separating the worker doing the dusty work from others on the site, is good for controlling silica exposure for other workers on the site. It can, however, significantly increase the dust level for the worker inside the enclosure. A good way to reduce the dust inside the enclosure is to exhaust dust out of the enclosure using a fan with flexible ducting. A filter sock can be attached to the exhaust end of the duct to collect the dust.

Respirators – Which One is Right for the Job?

There are four respirator styles that would be good choices for controlling silica dust on construction sites. They are:

- a dust mask designated as an N95 respirator
- a half face elastomeric respirator with P100 filter
- full face elastomeric respirator with P100 filter
- powered air-purifying respirator (PAPR) with P100 or HEPA filter.

On most construction sites the most commonly used respirator is a two-strap dust mask or N95 respirator. Many subcontractors have a box of these masks in the job shack for anyone who thinks they want one for dusty work. Some contractors require that they be used for certain activities. If the dust or silica exposure is over the allowable limit, occupational health regulations require that the respirator be fit tested for each wearer to insure that it fits that worker's face without leaking. With N95 respirators, it is difficult to get a good fit. Often several N95 respirator styles have to be tested before one is found that fits well. Fit testing is not done very often on construction sites so there's a good chance that the N95 respirator someone picks out of a box in the job shack won't fit well.

Each respirator type is assigned a **protection factor** that designates the highest dust level that will be protective with this respirator type. For these protection factors to be effective, it is assumed that the respirator fits the wearer well. Respirator fit testing is how good fit is assured. The respirator protection factors used by Washington L&I are:
N95 dust mask – 10
Half face respirator – 10
Full face respirator – 100
PAPR – 25 to 1000 depending on the hood or mask style

For a respirator with a protection factor of 10, the wearer can work in a dust level up to 10 times the allowable silica limit. For higher dust levels, a full face respirator could be used for up to 100 times the limit or a PAPR with full face mask would be appropriate for up to 1000 times the limit.

An N95 dust mask that has not been fit tested is not as likely to fit as well as a half face respirator that has not been fit tested. **Without fit testing for an N95 mask, a protection factor of 5** is probably more appropriate.

We used the air monitoring information we collected to show how often the respirators used by different tool users will adequately protect the worker. The chart below can be used to help select the best respirator for a given task.

The Right Respirator for the Tool

Tool	None	Dust Mask	Half Face	Full Face	PAPR
G r e a t e r P r o t e c t i o n » » » » » » » » **more enclosed, no dust controls, constant dusty work » » »**					
Tuck point grinder	x	xxxxxxxxxxx	xxxxxxxxxxxx	xxxxxxxxxxx	xxxxxxxxx
Surface grinder	x	xxxxxxxxxxx	xxxxxxxxxxxx	xxxxxxxxxxx	xx
Rock drill	xx	xxxxxxxxxxx	xxxxxxxxxxxx	xxxxxxxxxxx	xxx
Jackhammer/chipping gun	x	xxxxxxxxxxx	xxxxxxxxxxxx	xxxxxxxxxxx	
Hand held saw	xx	xxxxxxxxxxx	xxxxxxxxxxxx	xxxxxxxxxxx	x
Road mill	xx	xxxxxxxxxxx			
Walk behind saw	xxx	xxxxxxxxxxx	xxxxxxxx		
Table saw	xxx	xxxxxxxxxxx	xxxxxxxx		
Concrete mixer	xxxx	xxxxxxxxxxx	xxx		
Broom or shovel	xxxxx	xxxxxxxxxxx	xx		
Backhoe/excavator/dozer	xxxxxxxxx	xx			

For all tools shown above working without a respirator would usually result in some overexposures. For grinder, jackhammer, rock drill, and hand held saw users, even a full face respirator sometimes is not enough! A powered air-purifying respirator (PAPR) or airline respirator would be the right respirator for high dust levels for these tools. The degree of enclosure, any dust control techniques used, and whether the work is constant or intermittent will affect the dust level and which respirator is best.

Summary

Silica exposures on construction sites are on average high and can be extremely high. This is true for a broad spectrum of tools commonly used in construction.

The controls typically used do not adequately protect workers doing dusty work, but there are effective dust control choices available. Water and vacuum controls can be attached to tools, and dusty work can be isolated and controlled with ventilation. More protective respirators are available than those commonly used now in construction. In higher dust levels, a combination of tool controls and respirators may be necessary.

It is the industry's challenge to implement these controls more rigorously to protect workers from the harmful effects of silica dust.

For additional information

About UW study on silica
http://depts.washington.edu/silica
or contact the Field Research and Consulting Group at 206-543-9711

Publications:

G. Croteau, S. Guffey, M. Flanagan, and N. Seixas. The Effect of Local Exhaust Ventilation Controls on Dust Exposures During Masonry Activities. AIHA Journal 63:458–467 (2002)

Flanagan ME, Loewenherz C, Kuhn G. Indoor wet concrete cutting and coring exposure evaluation. Appl Occup Environ Hyg. 16(12):1097-100 (2001)

Flanagan M.E., N. Seixas, M. Majar, J. Camp, M. Morgan. Silica Dust Exposures During Selected Construction Activities. AIHA Journal 64:319–328 (2003)

Croteau G., M. E. Flanagan, J. Camp and N. Seixas..The Efficacy of Local Exhaust Ventilation for Controlling Dust Exposures During Concrete Surface Grinding. Annals of Occupational Hygiene 48(6):509-518 (2004)

Flanagan M.E., N. Seixas, P. Becker, B. Takacs, and J. Camp. Silica Exposure on Construction Sites: Results of an Exposure Monitoring Data Compilation Project. Journal of Occupational and Environmental Hygiene 3(3):144-52 (2006)

For more information about silica, its effects on health, and control options
OSHA web page: http://www.osha.gov/SLTC/etools/silica/index.html
NIOSH web page: http://www.cdc.gov/niosh/topics/silica/default.html
Electronic Library of Construction Occupational Safety and Health:
http://www.cdc.gov/elcosh/docs/hazard/chemical_silica.html