OSHA's Respirable Crystalline Silica Rule on Shotcrete Operations – Revisited

By Charles Hanskat

This is a revised version of the original article printed in the Summer 2016 of Shotcrete magazine before the OSHA rule was put in place. This revision has added site measured values for air monitoring of crew members on shotcrete projects, as well as ASA's response to OSHA's request for information in August 2019. Also, included is a short section on applicable respirators. With this revision our intent is to put the current information you need about the OSHA rule and its impact on shotcrete operations in one place for ready reference.

BACKGROUND

The Occupational Safety and Health Administration (OSHA) rule dealing with worker exposure to crystalline silica has been in force for just over three years. The rule represented years of effort by OSHA to develop a standard that is intended to help protect over two million construction workers from respirable crystalline silica. This is one of the biggest rules OSHA has developed, and it is addressed to two different workplace environments – construction and general industry/maritime operations. Our field shotcrete operations fall into the construction category. This is a very comprehensive standard addressing not only permissible levels of exposure, but also exposure monitoring, medical surveillance, and housekeeping.

Crystalline silica has been a known health hazard for decades. Significant levels of exposure can lead to silicosis, lung cancer, other respiratory diseases, and kidney disease. How is one exposed to respirable crystalline silica? Common job site concrete work including cutting, drilling, jackhammering, chipping, grinding, or sand blasting of concrete present the highest potential for exposure above the safe limits established in the rule.

The rule was published June 23, 2016, and OSHA started enforcement September 20, 2017. The rule deals with all exposures of respirable crystalline silica, except those environments that have proven exposure less than an action level of 25 µg/m^3 over an 8-hour time weighted average (TWA).

So, what about silica fume, a common supplemental cementitious material widely used in shotcrete? ACI defines silica fume, in CT-18 ACI *Concrete Terminology*, as "very fine non-crystalline silica produced in electric arc furnaces as a byproduct of the production of elemental silicon or alloys containing silicon." The key here is that silica fume is a NON-CRYSTALLINE material. However, most producers of silica fume do note that trace amounts of crystalline silica, less than 0.5% of the overall silica fume material, are present in their materials.

The OSHA rule significantly reduced the permissible exposure limits (PEL) in construction environments from the previous 250 µg/m^3 over an 8-hour TWA to 50 µg/m^3. Thus, even trace amounts of crystalline silica in silica fume may impact our shotcrete crew's exposures. All our shotcrete mixes use sand as an aggregate, so handling of quantities of sand in site batching operations, or from rebound may also produce small amounts of crystalline silica that add to the worker exposure. Also, many of our shotcrete projects involve repair of existing concrete, so surface preparation techniques may produce crystalline silica.

In the August 15, 2019 Federal Register OSHA publicly asked for further guidance on the effectiveness of engineering and work practice control methods not currently included for the tasks and equipment listed on Table 1 of the Respirable Crystalline Silica standard for construction. The agency also requested information on tasks and equipment involving exposure to respirable crystalline silica that are not currently listed on Table 1, along with information on the effectiveness of engineering and work practice control methods in limiting worker exposure to respirable crystalline silica when performing those tasks. Both dry-mix and wet-mix shotcrete were included in the OSHA request for information.

TWO ALTERNATIVE APPROACHES FOR COMPLIANCE PROVIDED IN THE RULE

The new rule offers two ways to be in compliance. The first method, and the one OSHA expects most contractors to use, provides a table (Table 1) that predefines specific equipment and associated exposure conditions, along with control and respiratory protection measures required. The second method applies to any tasks that are not listed in Table 1 and can be selected as an alternative by the Contractor for tasks in Table 1. Unfortunately, shotcrete is not covered in Table 1, so active monitoring is the only option available to shotcrete placement. However, for those shotcrete contractors doing repair or surface preparation that involves sawing, drilling, grinding, or hammering of hardened concrete many of those operations are covered in Table 1.

Work Tasks Covered by Table 1 - If your work environment is covered in Table 1, and you meet the specified engineering and work practice control methods, along with the required respiratory protection, you do not need to monitor for crystalline silica or comply with the PEL. It is also noted that if combined tasks from Table 1 sum more than 4 hours, the over 4-hour respiratory protection must be used.

Excerpt from Table 1: Specified Exposure Control Methods When Working with Materials Containing Crystalline Silica			
Equipment/Task	Engineering and Work Practice Control Methods	Required Respiratory Protection and Minimum Assigned Protection Factor (APF)	
		≤ 4 hours per shift	> 4 hours per shift
Jackhammers and handheld powered chipping tools	Use tool with water delivery system that supplies a continuous stream or spray of water at the point of impact.		
	– When used outdoors.	None	APF 10
	– When used indoors or in an enclosed area.	APF 10	APF 10
	OR		
	Use tool equipped with commercially available shroud and dust collection system.		
	Operate and maintain tool in accordance with manufacturer's instructions to minimize dust emissions.		
	Dust collector must provide the air flow recommended by the tool manufacturer, or greater, and have a filter with 99% or greater efficiency and a filter-cleaning mechanism.		
	– When used outdoors.	None	APF 10
	– When used indoors or in an enclosed area.	APF 10	APF 10
Handheld power saws (any blade diameter)	Use saw equipped with integrated water delivery system (Fig. 1) that continuously feeds water to the blade.		
	Operate and maintain tool in accordance with manufacturer's instructions to minimize dust emissions.		
	– When used outdoors.	None	None
	– When used indoors or in an enclosed area.	APF 10	APF 10
Handheld grinders for mortar removal (i.e., tuckpointing)	Use grinder equipped with commercially available shroud and dust collection system.	APF 10	APF 25
	Operate and maintain tool in accordance with manufacturer's instructions to minimize dust emissions.		
	Dust collector must provide 25 cubic feet per minute (cfm) or greater of airflow per inch of wheel diameter and have a filter with 99% or greater efficiency and a cyclonic pre-separator or filter-cleaning mechanism.		

Figure 1: Using water with a cutoff saw when cutting materials that contain crystalline silica substantially reduces the amount of dust created during these operations.

Active Monitoring - This method requires monitoring for crystalline silica at times and with activities that represent the highest exposure conditions if the amount of silica may be at or above the action level of 25 µg/m^3.

- Measure and record the amount of silica that workers are exposed to over an 8-hour TWA for all the tasks the employee may be reasonably exposed to (Fig. 2). Exposure assessments must be repeated every six months or less if the exposure is above the action level, but below PEL. If exposures are above the PEL assessments must be every three months or less.
- Protect workers from exposure to crystalline silica above the PEL of 50 µg/m^3 over an 8-hour TWA. If control of the PEL below the 50 µg/m^3 is not feasible, supplemental respiratory equipment may be needed.
- Use dust controls to protect from silica exposures above the PEL of 50 µg/m^3.
- Provide proper respirators to workers when dust control measures are not adequate to limit exposures to the PEL.

Figure 2: Worker with cutoff saw and personal air monitoring equipment.

The monitoring option further requires employees to be notified in writing of the assessment results of the monitored levels of crystalline silica within five days. Also, if the PEL of 50 µg/m^3 is exceeded, the employees must receive written notification of the corrective actions taken. Additionally, the employee (or their designated representative) MUST be allowed to observe the monitoring. The observer must also be provided clothing and equipment to protect them from exposure at no cost to the observer.

ADDITIONAL REQUIREMENTS FOR BOTH ALTERNATIVES

The construction employer must:

- Produce, and implement a written exposure control plan. The plan must identify tasks that produce exposure, and engineering and work practice methods used to protect workers. This may include restricting access to particular work areas where high exposures may occur. Also, the plan must include housekeeping methods for dust control.
- Designate a "competent person" to implement the written exposure control plan in the workplace, with frequent and regular inspections to verify compliance. The competent person must be capable of identifying existing and foreseeable respirable crystalline silica hazards and have authorization to take prompt corrective measures to eliminate or minimize them.
- Implement housekeeping methods to control and limit dust that may contain silica. This includes prohibiting any dry sweeping or brushing, and no cleaning of clothes or surfaces with compressed air. Wet sweeping or HEPA-filtered vacuuming are allowable options.
- Must offer medical exams including chest X-rays and lung function tests every three years for workers who are required to wear a respirator for 30 or more days a year. The medical exams must be conducted by a physician or other licensed health care professional (PLHCP) who's legally permitted scope of practice allow them to independently provide these medical evaluations. Employers must make available an initial baseline medical exam within 30 days after the initial assignment to the work covered by the rule. The PLHCP provides a written medical report to the employee within 30 days that includes: the results of the exam indicating any medical condition that would increase their risk after material exposure to silica; any recommended limitations on employee's use of respirators; and recommended limits on the exposure to silica; and if there are concerns about the results of the chest X-ray where additional evaluation by a specialist is appropriate. The PLHCP must give the employer a report with much more limited information including only: the date of the exam; a statement they have met the requirements of the OSHA rule, and any recommended limitations on the employee's use of respirators.
- Communicate to all workers potentially exposed to silica the health hazards associated with exposure to respirable crystalline silica and identify all MSDS that include crystalline silica. The employer must communicate at least the potential hazards that result in cancer, lung effects, immune system effects and kidney effects.

- Provide information and training sessions that identify: work operations that could produce silica exposure; specific measures the employer implemented to protect employees from exposure to silica; the identity of the competent person; and the purpose and description of the medical surveillance program. The contractor must further ensure that each employee can demonstrate knowledge and understanding of the training.
- Maintain accurate records for 30 years of:
  - » All exposure measurements – including name, social security number (SSN), and job classification of all employees represented by the monitoring, and indicating those employees who were actually monitored.
  - » The objective data – including the crystalline-containing material, the source of the data, and the testing protocol with results of the testing.
  - » Each employee covered by medical surveillance including name, SSN, all PLHCP reports and information provided by employer to the PLHCP.

OSHA REQUEST FOR INFORMATION – AUGUST 2019

In the August 15, 2019 Federal Register, OSHA publicly asked for further guidance on the effectiveness of engineering and work practice control methods not currently included for the tasks and equipment listed on Table 1 of the Respirable Crystalline Silica standard for construction. OSHA also requested information on tasks and equipment involving exposure to respirable crystalline silica that are not currently listed on Table 1, along with information on the effectiveness of engineering and work practice control methods in limiting worker exposure to respirable crystalline silica when performing those tasks. This gave us an opportunity to provide OSHA input on potential shotcrete-specific revisions to the rule.

ASA put out a request for input to our corporate members and received some testing results documenting their crew exposure limits on specific projects. The results on three different wet-mix jobs were quite variable:

Nozzleman	12, 32, and 34 µg/m^3
Pump Operator	11.5 µg/m^3
Finisher	9, 12, and 24 µg/m^3
Blowpipe	17 µg/m^3

With those results our response to OSHA included:

"Thank you for the opportunity to comment on Item 23 - Application of Dry-Mix or Wet-Mix Shotcrete.

Shotcrete placement uses two different processes, wet-mix and dry-mix. Wet-mix uses premixed concrete and then accelerates from the nozzle at the end of the delivery line with air. Dry-mix uses relatively dry concrete materials conveyed by air through the delivery line and adds water at the nozzle to create the wet concrete mix and accelerate into place.

Wet-mix has less dust than dry-mix as water is added much earlier in the process. However, there are shotcrete accessories that pre-dampen the dry-mix materials or add water earlier in the flow of materials through the delivery line to reduce dust and improve mixing.

Shotcrete placement is always conducted on a concrete construction job site. Shotcrete placement is sometimes conducted indoors or in confined spaces, but more commonly is exposed to the outdoor environment. As a result, wind can affect the material stream and movement of dust from the placement location. However, to prevent stray material and dust from reaching adjacent areas often shotcrete placement is contained by plastic sheeting or tarps.

Thus, you can see we have many variables as a result of material, equipment, placement techniques and job site conditions. It is hard to envision a single Table 1 entry that covers shotcrete, or even two that covers our two processes.

Our Association is the largest international group dedicated to high quality, efficient and safe shotcrete placement. A large majority of our members are shotcrete contractors or field crew members conducting work throughout North America. We are investigating how to work together with our members to support collecting of representative data industry-wide in formats and quantities needed for OSHA consideration.

Several of our members have independently conducted onsite monitoring of their shotcrete crews during shotcrete placement. Those crew members not in close proximity to the nozzle, such as the concrete pump operator in wet-mix, have experienced 8-hour TWA concentrations well below the 25 µg/m^3 Action Level for respirable crystalline silica. Crew members close to the nozzle stream (nozzlemen, blow pipe operators, hose draggers) have experienced levels from below the 25 µg/m^3 AL level to as high as 34 µg/m^3 (still below the 50 µg/m^3 PEL). Variations coincide with the location (indoor or outdoor), equipment, nozzleman, process and environmental conditions such as wind. Shotcrete contractors generally provide respirators to their crew most directly exposed to the dust from shotcreting operation.

We'd like guidance on how we could document specific tasks for potential inclusion in Table 1 or in the "Alternative Exposure Control Methods" portion of the standard. It appears this would require collecting "objective data" with air monitoring data from industry-wide surveys demonstrating employee exposure to silica associated with a specific process, task, or activity. OSHA states that the data must reflect workplace conditions closely resembling, or with a higher exposure potential than, the processes, types of material, control methods, work practices, and environmental conditions in the employer's current operations.

The terminology "workplace conditions closely resembling" is rather hard to quantify. How closely do the conditions need to be the same? How many different aspects of the site conditions would need to be documented for each site monitoring data collection? How many individual samples and locations would need to be collected to be acceptable to OSHA for documenting exposure for a specific task and exposure?

Ultimately with an investment in time and effort we hope to make it easier for our member contractor companies and crew members to meet the OSHA requirements for their shotcrete work. To help us accomplish this task we would appreciate your input on how we can best approach developing, documenting and conducting an industry-wide survey that would meet OSHA's requirements."

We have not as of this date had a response from OSHA. However, given the impact of COVID-19 and the government and construction industry in March 2020 it may well have delayed any response.

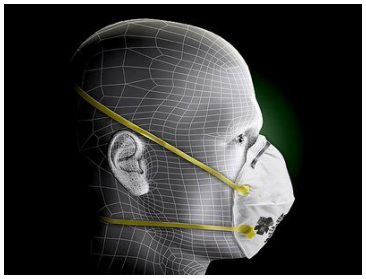

Figure 3: 3M N-95 Particulate Dust Mask

DUST MASKS AND RESPIRATORS

For workers under the 25 µg/m^3 actionable limit no respirator is required. However, a N-95 dust mask (Fig. 3) can provide the crew member better protection against dust encountered during an 8-hour workday. The double rubber band paper mask meets OSHA and NIOSH minimum requirements. The N series is for environments free of oil aerosols. The R series is resistant to oil mist for up to an 8-hour shift, and the P series is oil proof with time use restrictions specified by the manufacturer.

The problem with the double rubber band dust masks is when the worker breathes, the exhaust breath has nowhere to escape but upward around the nose causing the worker's safety glasses to fog up. Another issue with the paper mask is that a worker can go through many paper masks in one day. Moist breath, sweat or other types of contamination in the air can necessitate one or more new masks during the workday.

When evaluating the costs of disposable dust masks compared to the cost of a fitted half-face mask respirators, many companies find the fitted half mask respirator is more cost effective. The half mask respirators are made to be reusable, so it can be cleaned and disinfected on a regular basis. The only ongoing cost is the cartridges and prefilters.

For workers between the 25 µg/m^3 actionable and 50 µg/m^3 PEL the Assigned Protection Factor (APF) 10 level of respiratory protection can be met by a fitted half-face air-purifying respirator fitted with P100 particulate filters (Fig. 4). Fitted respirators require both a qualitative and quantitative fit test and generally need the worker to be clean shaven for best efficiency.

For those workers or companies looking for more protection, higher APFs can be met by:

- Full facepiece air purifying respirator (APF 50) (Fig. 5)
- Powered Air-Purifying Respirator, half-mask (APF 50) or full facepiece (APF 1000)
- Supplied-Air Respirator or Airline Respirator (APF 10 to 1000)
- Self-Contained Breathing Apparatus (APF 10 10,000)

Refer to OSHA CFR 1910.134 – Respiratory Protection for more input on respirators and their protection levels.

Figure 4: 3M Half-face Air Purifying Respirator with P100 Filters

Figure 5: 3M Full-face Respirator

SUMMARY

OSHA's rule for control of exposure to crystalline silica is very comprehensive and intended to protect workers on our job sites. This is one of the most comprehensive rules OSHA has promulgated and introduced extensive medical monitoring and recordkeeping requirements that will require a significant increase in the contractor's required duties that will certainly require more staffing to implement. In this article, we have introduced most of the key points, however you should visit the OSHA website (www.osha.gov/silica-crystalline) where extensive documentation on the rule, along with FAQ, and the text of the rule are readily available.

The rule has been in full effect since 2017. You should certainly review all the provisions of the rule and determine what your company needs to do to meet the requirements. At this time, site monitoring seems to be the only method that meet the OSHA requirements. Regarding our request to OSHA for more guidance on producing a "standard engineering control method" for our variety of shotcrete placement activities progresses, we will keep you informed.

The key here is that silica fume is a NON-CRYSTALLINE material. However, most producers of silica fume do note that trace amounts of crystalline silica, less than 0.5% of the overall silica fume material, are present in their materials.

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