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OSHA's ENFORCEMENT OF SILICA STANDARDS in the Construction Industry

By Bryan Seal and Christopher Janicak

CRYSTALLINE SILICA CAN BE FOUND in many materials and processes used in the construction industry. It is a common mineral found in construction materials such as sand, stone, concrete, brick and mortar (OSHA, 2017). Crystalline silica can also be found in abrasives used in abrasive blasting. In other words, if you work with a substance taken from the earth, there is a good chance it contains some crystalline silica.

Within its respirable crystalline silica (RCS) standard for the construction industry, OSHA created a table identifying job tasks that require control measures when working with materials containing crystalline silica. After reviewing available workplace sampling data, OSHA determined the potential worker exposure. This list of everyday job tasks includes 18 different tasks, ranging from using handheld power tools to using heavy equipment and crushing machines.

1. stationary masonry saws
2. handheld power saws
3. handheld power saws for cutting fiber-cement board
4. walk-behind saws
5. drivable saws
6. rig-mounted core saws or drills
7. handheld and stand-mounted drills
8. dowel drilling rigs for concrete
9. vehicle-mounted drilling rigs for rock and concrete
10. jackhammers and handheld powered chipping tools
11. handheld grinders for mortar removal (i.e., tuck-pointing)
12. handheld grinders for uses other than mortar removal
13. walk-behind milling machines and floor grinders
14. small drivable milling machines
15. large drivable milling machines
16. crushing machines
17. heavy equipment and utility vehicles used to abrade or fracture silica-containing materials or used during demolition activities involving silica-containing materials
18. heavy equipment and utility vehicles for tasks such as grading and excavating but not including demolishing, abrading or fracturing silica-containing materials

The list is not all inclusive and many more construction tasks exist that are not noted in the table, such as hand feeding/mixing raw materials and residential flooring.

Silica Properties

Silica or silicon dioxide (SiO_2) is naturally occurring in crystalline and noncrystalline (amorphous) forms and is ubiquitous in the earth's crust. Amorphous silica is an inorganic material. Due to its unique properties, amorphous silica is essential for a broad range of applications: chips, optical fibers and telescope glasses manufacturing.

There are several forms of crystalline silica; three forms occur under normal atmospheric pressures: quartz, cristobalite and tridymite. Cristobalite and tridymite typically occur in high temperatures and can be found near volcanic activity. Coesite and stishovite are less common and only occur at high pressures (Moore, 1999).

Quartz is the most abundant form of crystalline silica and accounts for approximately 12% the earth's crust by weight. Crystalline silica is virtually insoluble in water. However, it has a high affinity for water. Ceramics, chemicals and building materials are all significant uses of crystalline silica. Crystalline silica can also be found in paints, abrasives and filters (Moore, 1999).

Adverse Health Effects

There have been case studies of short but profound exposures to silica that produced a condition known as acute silicosis. One example is the West Virginia Hawks Nest Tunnel disaster in the 1930s. This disaster is often considered among the top industrial catastrophes in recent history (Lancianese, 2019). The project drilled 3 miles of 30-ft diameter tunnel through solid rock to divert water from New River for use at a steel plant in Alloy, WV. At the project's height of production, nearly 5,000 workers were on site. Due to deplorable conditions, it is estimated that between 300 and 764 workers died of acute silicosis within 2 years (Sultan, 2016).

The health hazards from crystalline silica have been known for decades. As far back as 1997, the World Health Organization's International Agency on Cancer Research first classified silica as a known human carcinogen (Pelucchi et al., 2006). Crystalline silica can damage the lungs. Of primary concern are respirable dust particles (< 5 microns). These are small enough to reach the alveolar region of the lungs. According to the National Toxicological Program's (NTP, 2016) 14th edition of the Report on Carcinogens, health hazards associated with excessive exposure to RCS include emphysema, obstructive airway disease and silicosis. Workers who develop silicosis are also at risk of developing tuberculosis; however, silica exposure does not directly cause tuberculosis (NTP, 2016). Originally in 1991, NTP listed RCS as "reasonably anticipated to be a human carcinogen" and revised the listing in the 9th edition of the Report of Carcinogens (NTP, 1999) to "known to be a human carcinogen."

Hazard Identification & Industrial Hygiene Monitoring

Industrial hygienists use a primary system to approach almost every workplace hazard. They anticipate, recognize, evaluate, then control the hazard. Finally, they monitor the control measures to ensure that the problem does not recur. Plog and Quinlan (2012) simply call this system the industrial hygiene process. Due to the nature and abundance and many uses of crystalline silica, it is easy to anticipate silica being present on a construction jobsite. Understanding that many job tasks are performed in construction that use, handle or otherwise manipulate crystalline silica-containing products, we can recognize the potential for exposure. We also know that RCS can cause several respiratory illnesses, including cancer.

To evaluate the worker's exposure, the industrial hygienist must sample the air according to standard methodology dictated by NIOSH's 7,500 sampling and analytical method. Using a size-selective adapter, typically a cyclone,

KEY TAKEAWAYS

- **This article describes the hazards of respirable crystalline silica (RCS) in the construction industry.**
- **It summarizes the legislative history of OSHA's RCS standards in the construction industry. The discussion provides context as to the development and modifications to the standards.**
- **Information is provided about the control measures OSHA requires in the workplace for workers exposed to RCS in the construction industry.**
- **OSHA's enforcement history of the RCS standard (29 CFR 1926.1153) in the construction industry is also discussed.**

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the industrial hygienist collects only the fraction of silica that is respirable, or less than 5 microns. The industrial hygienist must calibrate the sampling pump to a set flow as determined by the manufacturer of the cyclone adapter (e.g., 1.7 L per minute for the MSA 10-mm nylon cyclone and 2.5 L per minute for the SKC aluminum cyclone). The industrial hygienist uses X-ray diffraction to analyze air samples for the presence of silica types.

OSHA's Silica Standard Background

For years, occupational exposure limits to RCS in the construction industry were enforced by OSHA (2016) under 29 CFR 1926.55, which established the permissible exposure limits (PELs) based on the 1970 American Conference of Governmental Industrial Hygienists' threshold limit values of airborne contaminants.

In 2016, OSHA amended its existing standards for RCS. In the construction industry, these standards appear under 29 CFR 1926.1153 with the final rule taking effect June 23, 2016. There was a phased implementation of all parts of the standard except for methods of sample analysis, beginning on June 23, 2017. The requirements for methods of sample analysis began on June 23, 2018 (OSHA, n.d.).

This final rule established a new PEL of 50 micrograms of RCS per cubic meter of air (50 µg/m^3) as an 8-hour time-weighted average in all industries covered by the rule. It also included other provisions to protect employees, such as requirements for exposure assessment, methods for controlling exposure, respiratory protection, medical surveillance, hazard communication and recordkeeping. OSHA issued two separate standards—one for general industry and maritime, and one for construction—to tailor requirements to the circumstances found in these sectors (OSHA, 2016).

OSHA's Request for Information

In 2019, OSHA requested through its proposed rulemaking process information on the effectiveness of engineering and work practice control methods not currently included for the tasks and equipment listed in Table 1 of the RCS standard for construction (OSHA, 2019).

The agency also requested information on tasks and equipment involving exposure to RCS that are not currently listed in its Table 1, along with information on the effectiveness of engineering and work practice control methods in limiting worker exposure to RCS when performing those tasks.

OSHA is now requesting information and comments on whether there are additional circumstances where it would be appropriate to permit employers covered by the RCS standards for general industry and maritime to comply with the silica standard for construction (OSHA, 2019).

Standard Requirements

Under 29 CFR 1926.1153, OSHA defines RCS as quartz, cristobalite or tridymite contained in airborne particles that are determined to be respirable by a sampling device designed to meet the characteristics for respirable-particle-size-selective samplers specified in International Organization for Standardization (ISO) 7708:1995, Air Quality—Particle Size Fraction Definitions for Health-Related Sampling (OSHA, n.d.).

The standards require employers whose employees are exposed to airborne RCS in excess of the action level to be protected from such exposures by implementing appropriate engineering controls, work practices, respiratory protection and combinations of the three. The "action level" means a concentration of airborne RCS of 25 µg/m^3, calculated as an 8-hour time-weighted average (OSHA, n.d.). The employer shall ensure that no employee is exposed to an airborne concentration of RCS in excess of the PEL, which is 50 µg/m^3, calculated as an 8-hour time-weighted average (OSHA, n.d.).

Control Measures

The construction industry standards specify the exposure control methods that should be used when performing work materials containing RCS. Control methods include engineering and work practice control methods for 18 task or equipment exposures. In some situations, depending on the length of the work shift, respiratory protection with a minimum assigned protection factor may also be required.

An assigned protection factor signifies the workplace level of respiratory protection that a respirator or class of respirators is expected to provide to employees when the employer implements a continuing and effective respiratory protection program (OSHA, 2009). Table 1 provides some

TABLE 1

EXCERPT FROM TABLE 1 OF 29 CFR 1926.1153

Equipment/task	Engineering and work practice control methods	Required respiratory protection and minimum assigned protection factor (APF) ≤ 4 hours/shift	> 4 hours/shift
(i) Stationary masonry saws	• Use saw equipped with integrated water delivery system that continuously feeds water to the blade • Operate and maintain tool in accordance with manufacturer's instructions to minimize dust emissions	None	None
(ii) Handheld power saws (any blade diameter)	• Use saw equipped with integrated water delivery system 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	APF 10
	When used indoors or in an enclosed area	APF 10	APF 10

Note. Adapted from "Specified Exposure Control Methods When Working With Materials Containing Crystalline Silica" Table 1, 29 CFR 1926.1153, Respirable Crystalline Silica, by OSHA, n.d., https://bit.ly/300MO2d.

examples of control measures. The employer is required to implement alternative control measures when situations occur that are not addressed in Table 1 of the OSHA standard. Alternative control measures are also required when the control measures specified in OSHA's Table 1 are ineffective in controlling exposures below the PEL. The first approach an employer should use is an engineering approach to keep exposures below the PEL. The next is to utilize engineering and administrative controls. When these approaches do not bring exposures below the PEL, supplemental respiratory protection will be required. When respirators are required under 29 CFR 1926.1153, the employer shall also ensure that it is in compliance with OSHA's respiratory protection standards as described under 29 CFR 1910.134.

Certain housekeeping methods can increase employees' exposures to RCS. Therefore, activities such as dry sweeping and using compressed air to clean, which could create a dust cloud, should not be used (OSHA, 2017). Administrative program requirements under 29 CFR 1926.1153 include a written exposure control plan, medical surveillance, hazard communication and recordkeeping. A written exposure control plan identifies tasks that pose an exposure to RCS, appropriate control measures, housekeeping requirements and procedures to control access to hazardous areas. The plan should be reviewed and evaluated on an annual basis and updated to ensure that it is effective. OSHA requires employers to have a competent person perform inspections of jobsites, materials and equipment to implement the written exposure control plan. The employer must officially designate the competent person and provide this person with the authorization to take prompt corrective measures (Stanley, 2017).

A medical exam that includes a health history, a physical exam with emphasis on the respiratory system, a chest X-ray, a pulmonary function test and a tuberculosis test are required initially after assignment to a job task that has exposure to RCS in excess of the action limit and every 3 years. Additional tests and more frequent medical exams may be recommended by a physician or other licensed healthcare professional.

The silica standard requires employers to train employees and provide them with training and information about RCS. Employees who may be exposed to RCS should have knowledge about the health hazards of RCS, tasks that could result in exposure, and the various control measures that have been implemented including engineering controls and respiratory protection (OSHA, n.d.).

Finally, under 29 CFR 1926.1153(j), OSHA requires employers to keep records as part of the RCS standards. The records required include medical surveillance records, air monitoring data, data on the types of crystalline silica-containing material, and testing protocol and results of testing (OSHA, n.d.).

National Emphasis Programs

OSHA has a national emphasis program (NEP) in effect for RCS. Directive No. CPL 03-00-023 (OSHA, 2020) has been in effect since Feb. 4, 2020. The NEP addresses inspection priorities for the general, maritime and construction industries. Targeting criteria includes NAICS codes, local knowledge of establishments, commercial directories, referrals from the local health department and previous OSHA inspection history (OSHA, 2020). Sites may also be deleted from NEP inspections based on previous inspec-

TABLE 2

TARGETED INDUSTRIES IN CONSTRUCTION BY 2017 NAICS CODE

NAICS code	Industry
236100	Residential building construction • 236115 New single-family housing construction (except for-sale builders) • 236116 New multifamily housing construction (except for-sale builders) • 236117 New housing for-sale builders • 236118 Residential remodelers
236200	Nonresidential building construction • 236210 Industrial building construction • 236220 Commercial and institutional building construction
237100	Utility system construction • 237110 Water and sewer line and related structures construction • 237120 Oil and gas pipeline and related structures construction • 237130 Power and communication line and related structures construction
237200	Land subdivision • 237210 Land subdivision
237300	Highway, street, and bridge construction • 237310 Highway, street, and bridge construction
237900	Other heavy and civil engineering construction • 237990 Other heavy and civil engineering construction
238100	Foundation, structure and building exterior contractors • 238110 Poured concrete foundation and structure contractors • 238120 Structural steel and precast concrete contractors • 238130 Framing contractors • 238140 Masonry contractors • 238150 Glass and glazing contractors • 238160 Roofing contractors • 238170 Siding contractors • 238190 Other foundation, structure, and building exterior contractors
238200	Building equipment contractors • 238210 Electrical contractors and other wiring installation contractors • 238220 Plumbing, heating and air-conditioning contractors • 238290 Other building equipment contractors
238300	Building finishing contractors • 238310 Drywall and insulation contractors • 238320 Painting and wall covering contractors • 238330 Flooring contractors • 238340 Tile and terrazzo contractors • 238350 Finish carpentry contractors • 238390 Other building finishing contractors
238900	Other specialty trade contractors • 238910 Site preparation contractors • 238990 All other specialty trade contractors

Note. Adapted from "National Emphasis Program: Respirable Crystalline Silica (Directive No. CPL 03-00-023)," by OSHA, 2020.

TABLE 3
SUMMARY OF TOP 10 CITED INDUSTRIES BY NAICS CODE

Summary of top 10 most frequently cited industries by NAICS code, June 30, 2017, to March 9, 2022.

NAICS code	Frequency (*N*)	Percentage (%)
Masonry contractors (238140)	445	33.5
Commercial and institutional building construction (236220)	109	8.2
Highway, street and bridge construction (237310)	100	7.5
Poured concrete foundation and structure contractors (238110)	84	6.3
Site preparation contractors (238910)	82	6.2
Water and sewer line and related structures construction (237110)	50	3.8
All other specialty trade contractors (238990)	47	3.5
Siding contractors (238170)	46	3.5
Roofing contractors (238160)	31	2.3
Drywall and insulation contractors (238310)	25	1.9
Total	**1,019**	**77.0**

TABLE 4
SUMMARY OF VIOLATIONS CITED IN CONSTRUCTION BY INSPECTION TYPE

Summary of 29 CFR 1926.1153 violations cited in the construction industry by inspection type, June 30, 2017, to March 9, 2022

Inspection type	Frequency (*N*)	Percentage (%)
Planned	1,089	32.7
Complaint	878	26.3
Referral	519	15.6
Unprogrammed related	371	11.1
Programmed related	354	10.6
Fatality/catastrophe	52	1.6
Programmed—other	30	0.9
Accident	14	0.4
Unprogrammed—other	11	0.3
Monitoring	8	0.2
Follow-up	8	0.2
Total	**3,334**	**100.0**

tion history addressing RCS hazards. Table 2 (p. 19) shows the construction industry NAICS codes targeted by OSHA.

OSHA Inspection Data

Data from all OSHA inspections that resulted in violations of 29 CFR 1926.1153 were identified and downloaded from the U.S. Department of Labor's (n.d.) OSHA Enforcement Data website. Using the inspection activity numbers, the corresponding violation data was then downloaded and matched to the inspection records. The date of the data download was April 6, 2022, with the first recorded inspection that resulted in violations of 29 CFR 1926.1153 occurring on June 30, 2017, and the latest occurring on March 9, 2022. During this period, 1,330 inspections resulting in 3,334 violations occurred. A summary of the inspections by the top 10 most frequently cited industries by NAICS code is shown in Table 3. These 10 industries accounted for approximately 77% of all inspections that resulted in violations of 29 CFR 1926.1153. Slightly more than one-third of all inspections that resulted in RCS violations occurred in the masonry contractor industry alone. To provide context as to how often 1926.1153 standards are cited in the masonry contractor industry, from October 2020 through September 2021, violations of 1926.1153 ($N = 165$) were the second most cited standard in this industry behind 29 CFR 1926.451, General Requirement, Scaffolding ($N = 748$; OSHA, 2021b). Types of work being performed in the masonry contractor industry include establishments engaged in masonry work, stone setting, bricklaying and other stonework (OMB, 2017). For many of the industries listed in Table 3, violations of the 1926.1153 standards were in top 10 most frequently cited standards in each industry.

OSHA conducts workplace inspections for various reasons. The NEP for RCS is just one of these reasons. NEP inspections fall under the planned inspection category as well as inspections targeting specific high-hazard industries or occupations (OSHA, 1993). Other types of inspections include those due to employee complaints; inspections as the result of referrals such as from consultation programs and health departments; and unprogrammed related inspections, which are inspections of employers at multiemployer work sites whose operations are not directly addressed by the subject of the conditions identified in a complaint, incident or referral (OSHA, 2021a).

OSHA inspection data from June 30, 2017, to March 9, 2022, identified 3,334 violations of the RCS standard in the construction industry. As could be expected, the most frequently identified type of inspection in which the RCS standard was cited was a planned inspection (32.7%;

TABLE 5
SUMMARY OF TOP 10 CITED VIOLATIONS OF 29 CFR 1926.1153

Summary of top 10 most frequently cited violations of 29 CFR 1926.1153, June 30, 2017, to March 9, 2022.

OSHA standard	Frequency (*N*)	Percent (%)	Average initial penalty ($)
1926.1153(c)(1), exposure control measures	826	24.8	2,467
1926.1153(d)(2)(i), employee exposure assessment	700	21.0	702
1926.1153(g)(1), written exposure control plan	571	17.1	866
1926.1153(i)(1), hazard communication	265	7.9	672
1926.1153(i)(2)(i), employee demonstration of knowledge	194	5.8	845
1926.1153(g)(4), competent person designated	117	3.5	633
1926.1153(e)(2), respiratory protection program	91	2.7	1,124
1926.1153(d)(1), employee exposed to excess of PEL	63	1.9	1,626
1926.1153(f)(1), prohibit dry sweeping	52	1.6	2,139
1926.1153(e)(1), respirators comply with 1910.134	40	1.2	1,433
Total	**2,919**	**88.0**	

Table 4). This may indicate the NEPs for silica and other forms of planned inspections were effective in identifying violations of the 1926.1153 standards. The large percentage of planned inspections resulting in violations of the RCS standard is an indication of the targeting criteria used by OSHA in that the industries they target for these hazards do in fact have exposures.

The second most frequently identified type of inspection that resulted in violations of 29 CFR 1926.1153 were employee complaints (26.3%). The number of inspections conducted for this category could be due to two factors: the emphasis OSHA places on conducting inspections as the result of complaints and employees' level of knowledge and awareness of the hazards related to RCS.

OSHA Violation Data

Examining the specific RCS OSHA standards that were violated, the top 10 most frequently cited violations of 29 CFR 1926.1153 accounted for approximately 88% of all violations involving RCS (Table 5). Violations of 29 CFR 1926.1153(c)(1), "Failure to implement appropriate control measures based upon the type of equipment or task," accounted for the greatest number of violations (24.8%). Not far behind are violations of 29 CFR 1926.1153(d)(2)(i), Employee Exposure Assessment, with 21.0% and violations of 29 CFR 1926.1153(g)(1), Written Exposure Control Plan, with 17.1%. These three standards accounted for 62.9% of all violations.

OSHA violations can be further classified by type of violation. The type classifications are:

> Willful: A willful violation is defined as a violation in which the employer either knowingly failed to comply with a legal requirement (purposeful disregard) or acted with plain indifference to employee safety.
>
> Serious: A serious violation exists when the workplace hazard could cause an accident or illness that would most likely result in death or serious physical harm, unless the employer did not know or could not have known of the violation.
>
> Repeated: A federal agency may be cited for a repeated violation if the agency has been cited previously for the same or a substantially similar condition and, for a serious violation, OSHA's regionwide . . . inspection history for the agency lists a previous OSHA notice issued within the past 5 years; or, for an other-than-serious violation, the establishment being inspected received a previous OSHA notice issued within the past 5 years.
>
> Other-than-serious: A violation that has a direct relationship to job safety and health, but is not serious in nature, is classified as other-than-serious. (OSHA, 1996)

TABLE 6
SUMMARY OF VIOLATIONS BY TYPE IN CONSTRUCTION

Summary of violations by type in the construction industry, June 30, 2017, to March 9, 2022.

Type	Frequency (*N*)	Percentage (%)
Serious	2,503	75.1
Other-than-serious	792	23.8
Repeat	30	0.9
Unknown	6	0.2
Willful	3	0.1
Total	**3,334**	**100.0**

More than 75% of the violations were classified as serious (Table 6). Along with the potential health ramifications serious violations can have on an employee, serious violations also have implications on the penalties that are imposed. In 2022, inspectors may assess OSHA fines of up to $14,502 for each serious violation. They can adjust penalties based on the seriousness of each violation, as well as the employer's previous history, the size of the business and the good faith of the employer (Chron contributor, 2020). These findings suggest that most RCS exposures were of a significant level that would most likely result in death or serious physical harm. Examples of adverse outcomes from exposure include silicosis, lung cancer, chronic obstructive pulmonary disease and kidney disease (OSHA, 2021c).

Discussion & Conclusions

RCS poses serious health hazards to workers in the construction industry. The health effects can result in serious injury and death in the forms of silicosis and lung cancer. RCS exposure in the construction industry has been widely documented with exposures occurring in various industries that have workers engaged in work activities involving crystalline silica containing materials. Work activities involving grinding and cutting have been shown to create RCS hazards.

To address these hazards, OSHA promulgated the 29 CFR 1926.1153 RCS standards as a means to protect workers from these hazards. Responsibilities of employers under these standards include implementing engineering controls to limit employee exposure to levels below the established PELs. When these controls are ineffective, employers are further required to implement work practice controls and respiratory protection.

An analysis of the OSHA enforcement of the RCS standards indicates that many violations of 29 CFR 1926.1153 standards occurred in industries with significant exposures to RCS. These industries include masonry contractors; commercial and institutional building construction; and highway, street and bridge construction, to name a few. It is also these industries that OSHA targets in its NEP for RCS exposure in the construction industry. While most inspections that resulted in violations of the RCS standards were due to planned inspections, which could be the result of the NEP targeting, one should take note that the second most frequently identified type of inspection was employee complaints. This may indicate that employees are aware of the hazards of RCS and, as a result, filed a complaint with OSHA regarding working conditions.

The OSHA enforcement data also found that employers were most often cited for lacking appropriate exposure control measures, conducting employee exposure assessments and having written exposure control plans in place. Violations of these three areas could signify the degree to which some employers lack the foundation of a basic program components for controlling RCS exposure in the workplace. Employers that may have employees with RCS exposures should avail themselves to the requirements under 29 CFR 1926.1153 and the various hazard control resources. Abiding by the standards and implementing effective control measures can improve working conditions and reduce the potential for adverse health effects including employee deaths. PSJ

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