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A PILOT STUDY TO ASSESS THE IMPACT OF THE PROPOSED CRYSTALLINE SILICA STANDARD IN THE CONSTRUCTION INDUSTRY

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by

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Abstract

No worker should have to suffer a life altering or fatal illness for the sake of a job, yet thousands of workers have died or developed a disabling illness from occupational exposure to silica. The Occupational Safety and Health Administration (OSHA) has not updated the permissible exposure limit (PEL) for silica since 1971. The current PEL for respirable crystalline silica in the construction industry is 250 mppcf/ (%SiO_2 + 5) TWA which is adjusted per the amount of silica in the sample. This exposure limit is known to cause silicosis, a disease developed from silica exposure. The construction industry uses multiple processes and materials that contain and generate hazardous silica dust. OSHA has proposed a silica standard that reduces the PEL and provides ancillary provisions to protect the health and safety of workers.

Engineering controls are proven to reduce the exposure of silica during certain construction activities. The OSHA has developed a table titled 'Exposure Control Methods for Selected Construction Operations' which lists controls that can be used to certain silica generating activities. In the proposed standard, the control methods in this table can be followed in place of sampling.

Personal exposure monitoring was conducted to determine the effectiveness of engineering controls on certain silica-generating activities listed in OSHA's table 'Exposure Control Methods for Selected Construction Operations.' Eight out of 10 (80 %) of the samples collected in this pilot study revealed crystalline silica exposures below the proposed PEL and 2 samples (20 %) revealed both sample weighted and 8 hour time weighted average concentrations above the proposed PEL. While the number of samples in this pilot study are limited, these results suggest that further evaluation should be performed to ensure workers in the construction industry are adequately protected.

Keywords: Silica, silica generating activity, personal sampling**,** permissible exposure limit**,** engineering controls

Dedication

I dedicate my report to my family and friends. I wish to thank my dad and mom, Mike and Julie Lyons, and sister, Katie Lyons, for their motivation, guidance, and support.

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I would like to express my gratitude to Marni Hogen and Erik Youngquist of M.A. Mortenson Company for their financial support of this project. I would also like to thank my graduate committee, Julie Hart and Terry Spear, for their insightful comments and guidance in completing this paper.

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Glossary of Terms

Term	Definition
OSHA	Occupational Safety and Health Administration, an agency of the US federal government under the Department of Labor.
PEL	Permissible Exposure Limit, a regulatory limit on the amount or concentration of a substance.
TWA	Time weighted average, the average to any hazardous substance based on an eight-hour workday or 40 hour week.
Silica generating activity	Any activity that produces silica dust by physical or mechanical means.

Introduction

Construction is a dangerous industry, exposing millions of workers to various types of safety and health hazards every day. Tools rotate at thousands of revolutions per minute, workers are exposed to great heights, and thousands of pounds of materials are lifted every day. Safety hazards are often the main focus in construction - the type of hazards that have an immediate impact if an incident were to occur; however, many overlook the potential health hazards employees may be exposed to. Health hazards may arise from exposure to physical, chemical, and other workplace hazards. There are physical hazards such as power tools and electricity, or physical agents such as loud noise and vibration. Health hazards may include heavy metals, dusts, and gases that workers can be exposed to by different routes of entry (i.e. inhalation, absorption, ingestion) and cause changes which affect the body (National Institute of Environmental Health Sciences, 2013). These changes are indicated by the signs and symptoms in the exposed employee, which generally have a long latency period before they appear and are difficult to measure. These non-measurable changes result in the determination of health hazards to be more difficult and less precise than safety hazards.

> The Occupational Safety & Health Administration (OSHA) states, "The goal of defining precisely, in measurable terms, every possible health effect that may occur in the workplace as a result of chemical exposures cannot realistically be accomplished. This does not negate the need for employees to be informed of such effects and protected from them" (Occupational Safety & Health Administration, a).

One of the common health hazards for many trades in the construction industry is crystalline silica, which approximately 1.85 million U.S. workers are currently exposed to. Crystalline silica can be found in the form of quartz or, less frequently, cristobolite or tridymite.

Silica is a significant component of the Earth's crust and found in soil, sand, granite, and many other minerals. Silica dust is also found in numerous building materials, such as concrete, masonry block, and stone. Exposure to this dangerous dust occurs during a variety of different activities on a construction site including abrasive blasting, jack hammering, concrete mixing, grinding, cutting and sawing (Occupational Safety & Health Administration, b, 2002).

The health hazards associated with silica exposure are very dangerous, resulting in disabling illnesses and fatalities, which continue to occur at a high rate in construction. Crystalline silica is listed as a human lung carcinogen and may also result in a disabling, or even fatal, disease called silicosis. This disease occurs when respirable silica enters the lungs and creates scar tissue, and as a result, reduces the lungs' ability to take in oxygen (Occupational Safety & Health Administration, b, 2002). Respirable silica is the fraction of silica dust which enters the body through inhalation. Respirable dust particles (<10 μm) are small enough to penetrate deep into the respiratory system and lungs, generally passing the body's natural clearance mechanisms. Respirable silica dust is more likely to be retained, leading to adverse health effects (Occupational Safety & Health Administration, h, n.d.) Silicosis is generally a chronic occupational disease resulting from exposure to silica for ten years or more; however, exposure to high levels of silica may result in an accelerated or an acute form of silicosis (DOL/OSHA, 2014). Silicosis is non-reversible and there is no cure (Occupational Safety & Health Administation, b, 2002). The only way to prevent the disease is to prevent exposure.

The current OSHA Permissible Exposure Limit (PEL) for respirable crystalline silica (quartz) in construction is a formula based on an outdated particle counting technology method (250 million of particles per cubic foot of air (mppcf) / %SiO_2 + 5) that is approximately equivalent to 250 μg/m^3 (Occupational Safety & Health Administration, c, 2013). The National

Institute for Occupational Safety and Health (NIOSH) recommends an exposure limit of 50 $\mu g/m^3$ and ACGIH of 25 $\mu g/m^3$ (Occupational Safety & Health Adnnistration, c, 2013).

It has been recognized that the current standard for respirable crystalline silica is out of date and that a comprehensive standard is needed with provisions for exposure monitoring, respiratory protection, medical surveillance, and worker training (DOL/OSHA, 2014). Due to the outdated standard, OSHA expects that the proposed silica standard will reduce significant risk and has determined that it is technologically and economically feasible to do so. OSHA states, "Available evidence indicates that employees exposed to respirable crystalline silica well below the current PELs are at increased risk of lung cancer mortality and silicosis mortality and morbidity" (Occupational Safety & Health Administration, c, 2013). This statement indicates the current respirable crystalline silica standard is out of date and provisions must be put into effect to protect the health and safety of workers exposed to this dust. On August 23, 2013, OSHA published a federal register notice of proposed rulemaking for occupational exposure to respirable crystalline silica.

The Occupational Safety and Health Administration's proposed silica standard will drastically reduce the permissible exposure limit of this hazardous dust. OSHA has also provided controls for certain construction activities in which silica is often generated from. If the controls OSHA lists in the table titled 'Exposure Control Methods for Selected Construction Operations' for certain activities are followed, exposure monitoring will not be required (Occupational Safety & Health Administration, 2013).

Objective

The objective of this I.H. Report was to determine if the exposure control methods OSHA lists are adequate to reduce the exposure below the proposed PEL of 50 micrograms of respirable crystalline silica per cubic meter of air (μg/m^3), averaged over an 8-hour work day. Personal exposure monitoring of three construction activities was conducted to accomplish this purpose. Engineering controls, such as using a vacuum to collect dust and suppressing dust by use of water, were used by workers to control silica-containing dust.

Toxicology

Silica exposure can lead to adverse health effects, most commonly resulting in the initiation of silicosis. Crystalline silica exposure may also enhance susceptibility to pulmonary tuberculosis and lung cancer (Klaassen, 2011). Silica exposure has also recently been associated with kidney damage. IT has been discovered that workers exposed to silica have a 5% higher risk of developing end-stage renal disease (Vupputuri, S., Parks, C. G., Nylander-French, L. A., Owen-Smith, A., Hogan, S. L., & Sandler, D. P., 2012). However, the exposure to silica dust has also been associated with several immune alterations including decreased antibody and T- and B-cell parameters have been reported. Dose, duration, and route of exposure are important factors in determining the effects on the immune system as silica is toxic to macrophages. As silica cannot be digested by macrophages, parts of the lung become chronically inflamed. There is a known correlation between exposure and increased susceptibility to infectious pathogens (Klaassen, 2001).

The particle size of respirable silica dust is critical, as peak dust inhalation occurs with particles less than 3 microns (μm) in diameter. This size dust is able to bypass pulmonary clearance mechanisms and reach deep into the alveolar sacs, which creates scar tissue and inhibits the oxygen flow in the lungs (Hethmon, 2005). Acute, accelerated, and chronic silica exposure results in respiratory illnesses by restricting breathing in workers exposed. Chronic silicosis occurs after exposure to respirable crystalline silica over periods 20 years or more and is the most common form. Accelerated silicosis occurs overly relatively shorter periods of time, 5 – 15 years, when exposed to higher concentrations of respirable crystalline silica. Acute silicosis onsets after weeks to less than two years after extremely high exposures (Hethmon, 2005).

Background

1. Current Respirable Crystalline Silica Rule

Although there is currently not a specific standard for the hazardous dust, silica exposure is addressed in 29 CFR 1926.55 - Gases, vapors, fumes, dusts, and mists, Appendix A, as well as 29 CFR 1926.57 - Ventilation. 29 Code of Federal Regulations 1926.55 directs employers to implement engineering or administrative controls when feasible, and protective equipment to reduce exposure within the exposure limit when other controls are not feasible. When respirators are used to protect workers, their use must comply with the Respiratory Protection standard - 1926.103. The current PEL for respirable crystalline silica in construction has not been updated since OSHA's creation in 1971 and was based on an obsolete particle counting method. Currently, employers must measure exposure and implement effective engineering, administrative, and personal protection controls to reduce that exposure below the PEL. There are additional requirements for respiratory protection, medical surveillance, and record-keeping (Occupational Safety & Health Administration, f).

2. Proposed Respirable Crystalline Silica Rule

The Occupational Safety and Health Administration has proposed two new crystalline silica rulings to protect workers: one for construction, and the other for maritime and general industry. In the construction industry, there are nearly two million workers exposed to respirable crystalline silica. OSHA has estimated that over 640,000 of these workers are exposed to levels of silica above the proposed permissible exposure limit (PEL). Many construction activities generate silica dust, such as using masonry saws, grinders, and rotary hammers; as well as some drywall finishing and earthmoving with heavy equipment. OSHA proposes the new respirable crystalline silica rule in construction will prevent approximately 1,080 cases of silicosis each year and save nearly 560 lives once the final rule is in full effect (Occupational Safety & Health Administration, d, 2013).

For the construction rule, OSHA has proposed a PEL of 50 $\mu g/m^3$ Time Weighted Average (TWA - average over an 8-hour day), a significant reduction from the current PEL which is equivalent to approximately 250 $\mu g/m^3$ (Occupational Safety & Health Administration, 2013). OSHA has preliminarily determined that the proposed PEL is feasible for most of the affected activities during construction operations. During the few operations or activities that the proposed PEL is not technologically feasible while workers are using engineering and work practice controls (abrasive blasting and tuck pointing/grinding), respirators may be supplemented to achieve levels at or below the proposed PEL (DOL/OSHA, 2014).

OSHA has proposed several major provisions for construction employers in the silica rule. In addition to the lowered permissible exposure limit, worker's exposure must be measured if the amount of silica exposure is at or above an action level of 25 $\mu g/m^3$ TWA. Worker's access must be limited to areas where they may be exposed to high levels of respirable crystalline silica. Engineering dust controls must also be in place to protect workers when exposures are above the PEL, and employers must provide appropriate respirators to workers when these controls cannot limit the exposures to the PEL. Employers will also be responsible for offering medical exams every three years for any worker exposed above the PEL for 30 days or more per year at no cost to employees. In addition, employers will be required to keep records of these exams and exposure, as well as train workers on silica generating operations, ways to limit exposure, and hazard communication (Occupational Safety & Health Administration, d, 2013). OSHA's proposed ancillary provisions are expected to reduce the risk of exposure beyond what can be achieved by a PEL alone. However, the benefits of the proposed rule will not be attained if employers do not implement these provisions (DOL/OSHA, 2014).

There has been a great deal of criticism on the proposed standard. Many are blaming OSHA for not fully enforcing the current PEL, and claiming the new rule is significantly flawed and will do little to protect the health and safety of the work force (The Associated General Contractors of America, 2014). The Construction Industry Safety Coalition (CISC) believes OSHA has not shown that the proposed PEL is technologically feasible and the rule significantly underestimates the true cost and impact of the proposal (Construction Industry Safety Coalition, 2014). Others believe this rule is long overdue. While it has been proven that the current PEL will not protect employees, a new standard lowering the PEL will only be effective if utilized.

2.1 Alternative Method for Compliance

OSHA requires the hierarchy of controls - engineering, work practice controls, and lastly personal protective equipment, when protecting workers from crystalline silica. The proposed standard will require employers to implement engineering and work practice controls to reduce the exposure below the permissible exposure limit. When these controls are insufficient, they must still be implemented and supplemented with a respiratory protection program (DOL/OSHA, 2014).

The construction industry is given two options for compliance under the proposed silica rule. The first option is to monitor exposure and implement effective controls to reduce exposure to at/or below the permissible exposure limit. The second option would allow employers to follow the exposure control methods for selected construction operations as outlined in Appendix A (DOL/OSHA, 2014). OSHA's specific exposure control methods provide employers with a simply laid out table containing engineering, work practice, and respirator requirements for a variety of construction activities. These dust control methods can be used to limit worker exposures to respirable silica for each construction operation. The methods listed in the table titled 'Exposure Control Methods for Selected Construction Activities' (provided in Appendix A of this report) are known to be effective in reducing silica exposure. Employers would not be required to measure worker's silica exposure if they chose to follow this table (Occupational Safety & Health Administration, d, 2013).

This table is not an all-inclusive list of construction activities, however. While this table will make it easier on employers for the operations mentioned, exposure assessments will need to be conducted for other construction tasks that are not listed.

2.2 Ancillary Provisions

OSHA has prepared ancillary provisions as part of the proposed silica rule. These provisions are expected to reduce the risk of exposure beyond what can be achieved by a PEL alone. The ancillary provisions are described in more detail below (DOL/OSHA, 2014):

Exposure Assessment: In the event of an exposure assessment, employers must notify each affected employee no more than 5 working days after completion, either in writing or posted results. If the results of the assessment indicate an exposure above the PEL, the written notification must contain corrective actions.

Written Access Control/ Regulated Area Plan: This plan must be established by the employer and contain information regarding areas where respirable crystalline silica exposures are, or expected to be, in excess of the PEL and how these areas will be regulated and marked from the rest of the workplace. A competent person must be listed who can designate these areas. There must be provisions to minimize the number of workers exposed in these areas. The plan must also include provisions for protective clothing or means to remove excessive dust from contaminated clothing. The employer must review the effectiveness of this plan annually and revise as necessary.

Respiratory Protection: A respiratory protection program must be written and implemented in accordance with 29 CFR 1910.134. As part of this program, medical evaluation records must be obtained. A physician or other licensed health care professional must review conditions in which the employee will use a respirator, and administer a fit test. Written information regarding medical evaluations, fit testing, and the respirator program must be established and retained by the employer.

Medical Surveillance: Employers must provide employees an initial medical examination within 30 days of assignment unless the employee received an examination within the last 3 years. The medical evaluation must consist of a medical and work history, a physical examination with emphasis on the respiratory system, a chest X-ray, pulmonary function test, latent tuberculosis infection test, and any other tests required by the physician or licensed health care professional. Periodic medical examinations must be conducted every 3 years. These medical examinations must be provided at no cost to the employee.

Hazard Communication: Communication of respirable crystalline silica hazards to employees must follow the current Hazard Communication Standard - 29 CFR 1910.1200. Safety data sheets and labels must be readily available to employees.

Recordkeeping: Employers must maintain accurate records of all employee exposure measurements results and be made available to employees. Medical records shall be preserved and maintained for the duration of employment plus 30 years. The exposure records shall be in accordance with the recordkeeping standard - 29 CFR 1910.1020.

These ancillary provisions will accompany the reduced PEL in OSHA's proposed silica rule. By complying with both the provisions and PEL, OSHA believes the construction industry will benefit by reducing both silica related illnesses and fatalities.

2.3 Cost – Benefit Analysis

Many agencies have questioned if the proposed silica rule is feasible, both economically and technologically. After the rule is enacted, OSHA estimates the rule would cost employers of all industries $637 million annually for the first ten years. Over five hundred and eleven ($511.2) million of the total industry cost will affect the construction industry. A workplace with more than 20 workers would cost roughly $1,250 annually, and $550 for companies with fewer than 20 employees. OSHA estimated the benefits from preventing silicosis and other respiratory diseases would generate net benefits of up to $4.6 billion annually. These benefits greatly outweigh the cost of preventing exposure; however, some believe OSHA grossly underestimated the proposed rule's cost to employers (Maurer, 2013). It has been ruled that cost-benefit analysis may not be a basis for setting OSHA health standards (DOL/OSHA, 2014).

OSHA developed quantitative estimates of the cost of compliance which were then compared with industry revenues and profits to determine the potential economic impacts (DOL/OSHA, 2014). Below indicates how OSHA estimated the cost of many ancillary provisions of the proposed silica rule, as described by the Construction Industry Safety Coalition (CISC) (Construction Industry Safety Coalition, 2014):

Engineering Controls: OSHA estimated the cost for engineering controls by first identifying control measures to reduce exposure below the PEL, then deriving the cost for a single worker to utilize these controls. This cost was then multiplied by the number of workers likely to be overexposed according to the proposed PEL with the absence of said controls. In order to estimate the number of workers overexposed to the proposed PEL, OSHA developed an estimate of 652,000 full-time equivalents (FTEs) by task and industry. It was then determined how many at-risk workers will yield from specific tasks and industries.

Providing Respirators and Establishing a Respirator Program: OSHA estimated a respirator unit cost and reduced that number by 50 percent to reflect assumptions that only half of all workers will have shift lengths longer than 4 hours. The amount of workers exposed to levels of silica above the PEL was estimated and multiplied by the respirator unit cost. The need for workers to wear respirators was based on the requirements of Table 1.

Exposure Assessment: OSHA estimated the unit cost for an exposure assessment by industry and company size. The number of workers exposed to silica above the Action Level of 25 µg/m3 was multiplied by the unit cost of an exposure assessment to derive the total cost.

Medical Surveillance: OSHA estimated the cost for both establishing a medical surveillance program, as well as conducting periodic worker medical surveillance. The number of workers expected by be exposed above the Action Level or those who have not had a medical examination in two or more years are adjusted to account for employee turnover. This number was then multiplied by the medical surveillance unit cost estimates.

Training: OSHA estimated the cost for training and adjusted that number to account for employers already training workers on silica. This cost is then multiplied by all estimated 1.8 million at-risk workers.

The following table compares OSHA's cost estimate to that of the Construction Industry Safety Coalition's, one of the agencies who believe OSHA grossly underestimated the cost of the proposed standard on the construction industry.

Table I: Estimated Compliance Costs for the Construction Industry (Millions of dollars per year) (Construction Industry Safety Coalition, 2014)

	OSHA Estimate	CISC Estimate
Engineering Controls	242.6	1,124.0
Program Costs	268.6	1,045.4
Total	511.2	2,169.4

Others have raised concerns about the technological feasibility of the proposed standard in construction. One concern being the "no visible dust" from OSHA's table 'Exposure Control Methods for Selected Construction Operations.' This may not be a reality in a construction environment. Dust is rarely completely eliminated with the use of wet methods or other engineering controls, and if one work crew is creating nuisance dust next to a silica-generating activity, it may be difficult to decipher if there truly is "no visible dust" (Maurer, 2013). While it may be difficult for some employers to comply with the new standard, OSHA believes the proposed rule is economically and technologically feasible in the construction industry (DOL/OSHA, 2014).

2.4 Timeline of Ruling

The dangers of silica exposure have been understood for more than 100 years, yet there is still no specific standard on this health hazard. OSHA first listed silica as a priority for rulemaking in 1995 and was listed on OSHA's regulatory agenda in 1997; however, the draft silica standard did not get very far. In 2011, OSHA pushed a draft of a proposed silica standard to the Small Business Regulatory Fairness Enforcement Act (SBREFA) for review. In 2013, the Office of Management and Budget (OMB) continued to review the proposed standard and were urged to take prompt action to expedite the rulemaking process by Democrats in both the House and Senate. In July 2013, silica was again listed on OSHA's regulatory agenda, and a month later OSHA announced the proposed rule (The Center for Construction Resource and Training). On August 23, 2013, OSHA's proposed rulemaking for respirable crystalline silica was published in the Federal Register. OSHA extended the public comments period for the proposed standard to April 2014 (Occupational Safety & Health Administration, g).

The proposed rule will become effective 60 days following when the final rule is released. OSHA will begin enforcing the standard as early as 180 days after the effective date. One year succeeding the final ruling, adequate engineering controls will be required and lab requirements will be required within two years of the enacted rule (DOL/OSHA, 2014).

Research Design and Methods

3. Purpose of Personal Exposure Monitoring

The Occupational Safety and Health Administration's proposed silica standard, if approved, will lower the permissible exposure limit (PEL) from 250 mppcf/ (%SiO_2 + 5) to 50 µg/m^3 (0.05 mg/m^3) with an action level of 25 µg/m^3 (0.025 mg/m^3). OSHA has stated this amendment is technologically feasible in almost all cases with the use of engineering controls and personal protective equipment. In the proposed standard, construction employers may follow the control methods OSHA identifies for different silica generating activities in place of sampling. Personal exposure monitoring was conducted on three different operations listed on OSHA's table 'Exposure Control Methods for Selected Construction Activities.' The purpose of the exposure monitoring was to determine the effectiveness of engineering controls and if the controls OSHA listed are sufficient in reducing the worker's exposure below the proposed PEL.

3.1 Methods

Personal breathing zone sampling for respirable crystalline silica was performed on ten workers performing three different construction activities that could potentially generate silica dust. The activities monitored were:

- Using stationary masonry saws;
- Using hand operated grinders; and
- Using portable walk-behind saws.

A form of engineering control (as defined in Table III of Appendix A) was used during each operation. In addition, these controls were supplemented with personal protective equipment. Each activity was monitored for varying lengths of time, dependent on the activity duration, ranging from 118 minutes to 438 minutes.

GilAir5 personal air sampling pumps with Zefon nylon cyclones were used to conduct the respirable dust sampling. Each pump was equipped with a 37 mm open faced cassette fitted with a 5 µm pore size poly vinyl chloride filter. A list of equipment used for sampling can be found in Table II.

Table II: Sampling Equipment Used During Exposure Monitoring

Equipment Type	Serial Number
GilAir5 Personal Air Pump Sampler	20140602023
GilAir5 Personal Air Pump Sampler	20140602022
EMS Rotameter	194588-00
Zefon Nylon Cyclone (2)	N/A
Cyclone Holder (2)	N/A
Tygon Tubing	N/A
Zefon 2 Liter Cyclone Calibration Jar	ZA0085

The sampling pumps were calibrated pre- and post-sample to 1.7 L/min using a rotameter, which is a secondary standard for calibration, shown in Figure 1. A cassette, used for calibration only, was connected to the nylon cyclone and placed in a calibration jar to record the readings. All samples were within range after post calibration to be viable.

Figure 1: Sampling pump calibration

Ten samples were collected in total in the workers' breathing zone. Three samples were taken during activities using a walk-behind concrete saw, three samples were taken using a hand-held grinder, and four samples were taken during the use of a stationary masonry saw. All ten samples were sent to an AIHA accredited laboratory and were analyzed by X-ray diffraction (XRD) using NIOSH method 0600 for respirable dust and NIOSH method 7500 modified & OSHA ID-142 for crystalline silica (National Institute of Occupational Safety and Health, 2003).

A sampling and worker task log from the silica sampling conducted for this research is provided in Appendix B.

3.2 Results

Results of the personal breathing zone sampling are presented in Table VI provided in Appendix C. Each sample was analyzed for respirable dust, alpha quartz, cristobalite, and tridymite by XRD. With the use of dust control methods, most of the concentrations for dust, alpha quartz, cristobalite, and tridymite were below the current and proposed permissible exposure limit for respirable silica of .05 mg/m^3. Results are presented as sample weighted concentrations (Table VI) and 8 hour time weighted average (TWA) concentrations (Table VII), provided in Appendices C and D, respectively. The 8 hour TWA concentrations were adjusted using the equation below:

Shift adjusted sample = Sample duration concentration x (duration of sample / 480 minutes)

It should be noted that the concentration in the analysis results is reported in mg/m^3 rather than $\mu g/m^3$. The proposed silica permissible exposure limit converted to milligrams from micrograms is .05 mg/m^3.

The analysis results, shown in Figure 2, determined two workers were exposed to a hazardous environment containing respirable crystalline silica dust. One worker using a wet cut masonry saw was exposed to 0.19 mg/m^3 of alpha quartz silica over 5.61 hours. The other worker, who was chipping and grinding concrete, was exposed to .36 mg/m^3 of alpha quartz silica dust over 2.5 hours. In both cases, OSHA's control methods were followed by the use of water to suppress the dust. When wet cutting CMU block and the duration is over 4 hours, OSHA would require an air-purifying respirator with an assigned protection factor of 10 to supplement the engineering controls. When grinding concrete for less than 4 hours, OSHA would not require the use of a respirator to supplement water used to control the dust. No other workers were exposed to hazardous environments over the proposed silica permissible exposure limit.

These two worker's exposures were compared to the current OSHA PEL for construction using the equation below.

PEL, quartz = 250 mppcf / % SiO_2 + 5

where %SiO_2 is the percent of quartz in the sample.

Table III: Exposures Compared to Current PEL

Sample ID	% Quartz	Current PEL	Proposed PEL	Sample Concentration
9036	8.3	1.80 mg/m^3	0.05 mg/m^3	0.36 mg/m^3
9035	12	1.47 mg/m^3	0.05 mg/m^3	0.19 mg/m^3

The PEL, quartz was then converted from mppcf to mg/m^3 using the conversion factor of 1 mppcf is equal to 0.1 mg/m^3.

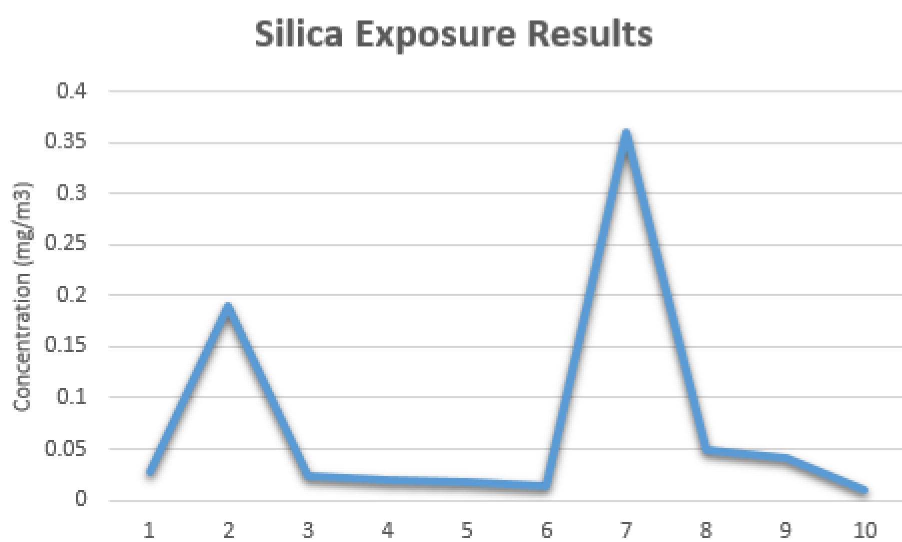

Figure 2: Silica Exposure Results Graph

There may be other factors that contributed to the concentrations in the results as well. For activities that were performed outdoors, wind may have been a factor by pushing the dust away from the workers breathing zone. This could lower the exposure greatly, but may also expose other workers downwind of the operation. Workers not performing the task were not considered in this research. Water used as dust suppression can vary in the amount of hazardous dust it can control depending on the source of output. When using a walk behind concrete saw with water being sprayed on the cut as the engineering control, visible dust appeared to remain near the blade and far away from the workers breathing zone.

OSHA states in the table titled ‘Exposure Control Methods for Selected Construction Activities’ for numerous activities that there may be “no visible dust.” During the activities using a walk behind saw and hand held grinder, there were times where small amounts of dust were visible near the point of contact; however, the employees were not overexposed to respirable crystalline silica or respirable dust during the duration of the activity. There may be a different exposure resulting from visible dust if the activity continued for a longer period of time.

Conclusion

OSHA's proposed silica standard is long overdue. The current permissible exposure limit for respirable crystalline silica is an outdated particle counting equation which does not adequately protect workers. The proposed silica standard will significantly reduce the permissible exposure limit and also create ease when comparing exposures to this limit.

Personal exposure monitoring was conducted to determine if OSHA's controls listed in the table titled 'Exposure Control Methods for Selected Construction Activities' were sufficient in protecting eighty percent of exposures below the permissible exposure limit. Based on the results of this monitoring, eight of ten workers were exposed to environments below the proposed limit. However, following OSHA's table, the workers with higher exposures would be required to supplement engineering controls with air-purifying respirators which would provide adequate protection from the hazardous dust. Two samples (twenty percent) revealed concentrations that were above the proposed PEL with the sole use of engineering controls. It is possible that OSHA's proposed PEL is feasible with the use of engineering controls, however, PPE may also be needed. Further research, including more sampling, should be conducted to determine 8-hour shift exposures and the feasibility of controls with these durations in the construction industry.

The health effects resulting from silica exposure cannot be reversed, but they can be prevented. The proposed standard is expected to save hundreds of lives and prevent thousands of illnesses every year. This standard is currently still in the review process and the final version of the silica standard may vary from what is written prior to the regulation being released.

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Appendix A

Table IV: Exposure Control Methods for Selected Construction Operations (Occupational Safety & Health Administration, e)

Operation	Engineering and Work Practice Control Methods	Required Air-Purifying Respirator (Minimum Assigned Protection Factor)	
		≤ 4 hr/day	> 4 hr/day
Using Stationary Masonry Saws	Use saw equipped with integrated water delivery system. NOTE: Additional specification: Change water frequently to avoid silt build-up in water. • Prevent wet slurry from accumulating and drying. • When working indoors, provide sufficient ventilation to prevent build-up of visible airborne dust. • Ensure saw blade is not excessively worn.	None	Half-Mask (10)
Using Hand-Operated Grinders	Use water-fed grinder that continuously feeds water to the cutting surface.	None	Half-Mask (10)
	OR		
	Use grinder equipped with commercially available shroud and dust collection system, operated and maintained to minimize dust emissions. Collector must be equipped with a HEPA filter and must operate a 25 cubic feet per minute (cfm) or greater airflow per inch of blade diameter. NOTE: Additional specifications (wherever applicable): • Prevent wet slurry from accumulating and drying. • Operate equipment such that no visible dust is emitted from the process. • When working indoors, provide sufficient ventilation to prevent build-up of visible airborne dust.	Half-Mask (10)	Half-Mask (10)

Tuck pointing	Use grinder equipped with commercially available shroud and dust collection system. Grinder must be operated flush against the working surface and work must be performed against the natural rotation of the blade (i.e., mortar debris must be directed into the exhaust). Use vacuums that provide at least 80 cfm airflow through the shroud and include filters at least 99 percent efficient. NOTE: Additional specifications: • Operate equipment such that no visible dust is emitted from the process. • When working in enclosed spaces, provide sufficient ventilation to prevent build-up of visible airborne dust.	Powered air-purifying respirator (PAPR) with loose-fitting helmet or negative pressure full facepiece (25)	Powered air-purifying respirator (PAPR) with loose-fitting helmet or negative pressure full facepiece (25)
Using Jackhammers or Other Impact Drillers	Apply a continuous stream or spray of water at the point of impact. OR Use tool-mounted shroud and HEPA-filtered dust collection system. NOTE: Additional specifications: • Operate equipment such that no visible dust is emitted from the process. • When working indoors, provide sufficient ventilation to prevent build-up of visible airborne dust.	None None	Half-Mask (10) Half-Mask (10)
Using Rotary hammers or Drills (except overhead)	Use drill equipped with hood or cowl and HEPA-filtered dust collector. Eliminate blowing or dry sweeping drilling debris from working surface. NOTE: Additional specifications: • Operate equipment such that no visible dust is emitted from the process. • When working indoors, provide sufficient ventilation to prevent build-up of visible airborne dust. • Use dust collector in accordance with manufacturer specifications.	None	None

Operating Vehicle-Mounted Drilling Rigs for Rock	Use dust collection system around drill bit and provide a low-flow water spray to wet the dust discharged from the dust collector. NOTE: Additional specifications: • Operate equipment such that no visible dust is emitted from the process. • Half-mask respirator is to be used when working under the shroud. • Use dust collector in accordance with manufacturer specifications. For equipment operator working within an enclosed cab having the following characteristics: • Cab is air conditioned and positive pressure is maintained. • Incoming air is filtered through a pre-filter and HEPA filter. • Cab is maintained as free as practicable from settled dust. • Door seals and closing mechanisms are working properly.	None None	None None
Operating Vehicle-Mounted Drilling Rigs for Concrete	Use dust collection system around drill bit and provide a low-flow water spray to wet the dust discharged from the dust collector. NOTE: Additional specifications: • Use smooth dusts and maintain duct transport velocity at 4,000 feet per minute. • Provide duct clean-out points. • Install pressure gauges across dust collection filters. • Activate LEV before drilling begins and deactivate after drill bit stops rotating. • Operate equipment such that no visible dust is emitted from the process. • Use dust collector in accordance with the manufacturer specifications. For equipment operator working within an enclosed cab having the following characteristics:	None	Half-Mask (10)

	• Cab is air conditioned and positive pressure is maintained. • Incoming air is filtered through a pre-filter and HEPA filter. • Cab is maintained as free as practicable from settled dust. • Door seals and closing mechanisms are working properly.		
Milling	For drivable milling machines: Use water-fed system that delivers water continuously at the cut point to suppress dust. NOTE: Additional specifications: • Operate equipment such that no visible dust is emitted from the drum box and conveyor areas.	None	Half-Mask (10)
	For walk-behind milling tools: Use water-fed equipment that continuously feeds water to the cutting surface.	None	Half-Mask (10)
	OR Use tool equipped with commercially available shroud and dust collection system. Collector must be equipped with a HEPA filter and must operate at an adequate airflow to minimize airborne visible dust. NOTE: Additional specifications: • Use dust collector in accordance with manufacturer specifications including airflow rate.	None	Half-Mask (10)
Using Handheld Masonry Saws	Use water-fed system that delivers water continuously at the cut point.		
	Used outdoors.	None	Half-Mask (10)
	Used indoors or within partially sheltered area.	None	Half-Mask (10)
	OR		

	Use saw equipped with local exhaust dust collection system. Used outdoors. Used indoors or within partially sheltered area. NOTE: Additional specifications: • Prevent wet slurry from accumulating and drying. • Operate equipment such that no visible dust is emitted from the process. • When working indoors, provide sufficient ventilation to prevent build-up of visible airborne dust. • Use dust collector in accordance with manufacturer specifications.	 Half-Mask (10) Full Facepiece (50)	 Half-Mask (10) Full Facepiece (50)
Using Portable Walk-Behind or Drivable Masonry Saws	Use water-fed system that delivers water continuously at the cut point. Used outdoors. Used indoors or within partially sheltered area. NOTE: Additional specifications: • Prevent wet slurry from accumulating and drying. • Operate equipment such that no visible dust is emitted from the process. • When working indoors, provide sufficient ventilation to prevent build-up of visible airborne dust.	 None Half-Mask (10)	 None Half-Mask (10)
Rock Crushing	Use wet methods or dust suppressants. OR Use local exhaust ventilation systems at feed hoppers and along conveyor belts. NOTE: Additional specifications: • Operate equipment such that no visible dust is emitted from the process.	Half-Mask (10) Half-Mask (10)	Half-Mask (10) Half-Mask (10)

	For equipment operator working within an enclosed cab having the following characteristics: • Cab is air conditioned and positive pressure is maintained. • Incoming air is filtered through a prefilter and HEPA filter. • Cab is maintained as free as practicable from settled dust • Door seals and closing mechanisms are working properly.	None	None
Drywall finishing (with silica-containing material)	Use pole sander or hand sander equipped with a dust collector in accordance with manufacturer specifications OR Use met methods to smooth or sand the drywall seam.	None None	None None
Use of Heavy Equipment During Earthmoving	Operate equipment from within an enclosed cab having the following characteristics: • Cab is air conditioned and positive pressure is maintained. • Incoming air is filtered through a pre-filter and HEPA filter. • Cab is maintained as free as practicable from settles dust. • Door seals and closing mechanisms are working properly.	None	None

Appendix B

Table V: Silica Sampling and Worker Task Log

	Sample ID	Job Title	Task Description	Sample Start Time/ Date	Sample End Time/ Date	Sample Duration (minutes)	Comments	Respirator Worn
1	9043	Masonry Foreman	Wet cut CMU block	3/10/2015 10:27 am	3/10/2015 2:50 pm	263	Wet cut Norton Clipper stationary masonry saw. 14” diamond blade. Water changed daily. Indoors.	N95 dust mask
2	9035	Masonry Foreman	Wet cut CMU block	3/18/2015 7:37 am	3/18/2015 1:00 pm	337	Wet cut Husqavarna stationary masonry saw. 14” diamond blade. Water changed daily. Indoors/ partially enclosed area.	None
3	9041	Mason	Wet cut CMU block	3/11/2015 10:16 am	3/11/2015 2:37 pm	261	Wet cut Norton Clipper stationary masonry saw. 14” diamond blade. Water changed daily. Outdoors.	None
4	9039	Mason	Wet cut CMU block	3/12/2015 7:16 am	3/12/2015 12:35 pm	314	Wet cut Norton Clipper stationary masonry saw. 14” diamond blade. Water changed daily. Indoors.	None
5	9037	Concrete Finisher	Grinding concrete ceiling	3/12/2015 11:14 am	3/12/2015 2:03 pm	168	Grinder connected to HILTI VC 40-u for dust collection. Most dust	None

							occurs when cleaning filter of vacuum. Indoors.	
6	9040	Laborer	Grinding concrete columns	3/11/2015 7:41 am	3/11/2015 2:59 pm	438	4” diamond blade hand held grinder connected to a Rigid vacuum. No HEPA filter. Indoors.	N95 dust mask
7	9036	Concrete Finisher	Cut, chip, and grind concrete slab	3/23/2015 2:14 am	3/23/2015 4:44 pm	150	Cut slab with STIHL TS 420 chop saw (1 hr), chipped out remaining area D25313 DeWalt hammer drill (1 hr), grinded area with Milwaukee 4.5” hand held grinder. Water sprayed continuously with Chapin industrial concrete sprayer. Indoors.	N95 dust mask
8	9044	Concrete Finisher	Wet cut concrete slab	3/17/2015 7:01 am	3/17/2015 8:59 am	118	Husqavarna Soff-cut 150 walk behind saw. Water sprayed continuously on cut with Chapin industrial concrete sprayer. Indoors/ partially enclosed area.	None

9	9042	Concrete Finisher	Wet cut concrete slab	3/18/2015 8:39 am	3/18/2015 10:59 am	140	Husqavarna Soff-cut 150 walk behind saw. Water sprayed continuously on cut with Chapin industrial concrete sprayer. Indoors/ partially enclosed area.	None
10	9045	Concrete Finisher	Wet cut concrete slab	3/20/2015 7:54 am	3/20/2015 11:57 am	243	Husqavarna Soff-cut 150 walk behind saw. Water sprayed continuously on cut with Chapin industrial concrete sprayer. Outdoors.	N95 dust mask

Appendix C

Table VI: Silica Sampling Results (Sample TWA)

Sample Number	Task Description	Air Volume (m^3)	Analyte	CONCENTRATION mg/m^3
9043	Wet cut CMU block	0.3672	Dust	1.8
			Alpha Quartz	<0.027
			Cristobalite	<0.022
			Tridymite	<0.022
9035	Wet cut CMU block	0.573	Dust	1.6
			Alpha Quartz	0.19
			Cristobalite	<0.018
			Tridymite	<0.018
9041	Wet cut CMU block	0.4437	Dust	0.33
			Alpha Quartz	<0.023
			Cristobalite	<0.023
			Tridymite	<0.023
9039	Wet cut CMU block	0.5338	Dust	1.2
			Alpha Quartz	<0.019
			Cristobalite	<0.019
			Tridymite	<0.019
9037	Grinding concrete ceiling	0.2856	Dust	<0.18
			Alpha Quartz	<0.035
			Cristobalite	<0.035
			Tridymite	<0.035

9040	Grinding concrete columns	0.7446	Dust	2.2
			Alpha Quartz	<0.013
			Cristobalite	<0.013
			Tridymite	<0.013
9036	Cut, chip, and grind concrete slab	0.255	Dust	4.3
			Alpha Quartz	0.36
			Cristobalite	<0.040
			Tridymite	<0.040
9044	Wet cut concrete slab	0.201	Dust	<0.25
			Alpha Quartz	<0.050
			Cristobalite	<0.050
			Tridymite	<0.050
9042	Wet cut concrete slab	0.238	Dust	0.35
			Alpha Quartz	<0.042
			Cristobalite	<0.042
			Tridymite	<0.042
9045	Wet cut concrete slab	0.413	Dust	0.15
			Alpha Quartz	<0.024
			Cristobalite	<0.024
			Tridymite	<0.024

Appendix D

Table VII: Shift Adjusted Concentrations

Sample Number	Task Description	SAMPLE CONCENTRATION mg/m^3	ADJUSTED SHIFT CONCENTRATION mg/m^3
9043	Wet cut CMU block	0.027	0.012
9035	Wet cut CMU block	0.190	0.133
9041	Wet cut CMU block	0.023	0.013
9039	Wet cut CMU block	0.027	0.012
9037	Grind concrete	0.018	0.006
9040	Grind concrete	0.013	0.012
9036	Cut, chip, grind concrete	0.360	0.113
9044	Wet cut concrete slab	0.050	0.012
9042	Wet cut concrete slab	0.042	0.012
9045	Wet cut concrete slab	0.010	0.005