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Worker Exposure to Silica during Countertop Manufacturing, Finishing, and Installation

The Occupational Safety and Health Administration (OSHA) and the National Institute for Occupational Safety and Health (NIOSH) have identified exposure to silica as a health hazard to workers involved in manufacturing, finishing, and installing natural and engineered stone countertop products. This exposure exists in fabrication shops and during on-site finishing/installation, as well as in the production or quarrying of the countertop material. The hazard can be mitigated in most countertop operations with dust control methods following the requirements of the OSHA silica standard.

Introduction

Crystalline silica occurs in nature mostly as the minerals quartz, cristobalite, and tridymite, and is found in granite, sandstone, quartzite, various other rocks, and sand. Workers who inhale very small dust particles containing respirable crystalline silica (RCS) are at risk for silicosis — **an incurable, progressively disabling, and potentially fatal lung disease**.

RCS is very small particles — typically 100 times smaller than ordinary sand — that can become trapped in lung tissue, causing inflammation and scarring and reducing the lungs' ability to take in oxygen. Symptoms of silicosis include shortness of breath, cough, and fatigue, and the timeline of developing silicosis symptoms depends on duration and intensity of RCS exposure. Exposure to RCS also puts workers at increased risk for lung cancer, chronic obstructive pulmonary disease (COPD), tuberculosis, and kidney disease, and is associated with development of autoimmune disorders and cardiovascular damage.

OSHA and NIOSH investigated U.S. worker exposure to RCS and the effectiveness of exposure control measures in the stone countertop industry following reports of engineered stone countertop workers in the United States and around the world developing silicosis.[1-9] In some cases, workers were operating with inadequate or no dust suppression; respiratory protection was also inadequate or not being used at all.[1,3,10,11] While the stone industry has worked to implement dust controls to protect workers,[12] studies and OSHA inspections indicate that exposure levels are not adequately controlled in some U.S. stone countertop manufacturing and fabrication worksites.[8,13] Employers can utilize the recommendations listed in this document to adequately control exposure levels.

Courtesy David L. Johnson & Margaret Phillips, University of Oklahoma Health Sciences Center

Dry-cutting stone, as pictured, generates dangerous crystalline silica dust that can become trapped in lung tissue and cause silicosis.

The Stone Countertop Industry

Stone countertop industry workers in shops and on job sites saw, grind, polish, and drill slabs of natural (marble and granite) and engineered (man-made, manufactured, artificial, or cultured) stone as part of manufacturing, finishing, and installing countertops. Whether working with natural or engineered stone, producing finished countertops involves similar tasks. Working with natural stone, however, involves different initial steps than working with engineered stone. Granite and other natural stones

are quarried and cut into large stone slabs. These slabs are further cut to countertop sizes at the quarries or at countertop fabrication shops. Making engineered stone slabs often involves mixing silica powder, resins, and pigments. Workers who quarry and cut natural stone and who manufacture engineered stone, as well as those involved in finishing and installing both natural and engineered stone countertops, are at risk of RCS exposure. In these industries, production operators (such as sawyers), inspectors (including quality control technicians), and staff who perform maintenance and housekeeping activities may be exposed to hazardous levels of RCS.

Why is RCS exposure a concern for workers in stone countertop manufacturing, finishing, and installation?

Stone countertops contain high amounts of the natural mineral silica

Depending on the type of stone, countertops may contain over 90% crystalline silica. The highest crystalline silica levels are associated with quartzite and with certain engineered stones. Crystalline silica can comprise up to 95% of the material in engineered stone, with resins, pigments, and adhesives making up the rest. Some engineered stones contain less than 50% crystalline silica in a polymer resin matrix, and some engineered stones containing recycled glass and pigments in a portland cement matrix have less than 0.2% crystalline silica. Calcium carbonate-based natural stones, including limestone and marble, contain little or no crystalline silica. In contrast, granite can contain up to 50% crystalline silica. The table below describes typical crystalline silica content of common natural and engineered stones. Note that crystalline silica content will vary among stone varieties, and the exact content can be determined by petrographic and X-ray diffraction analysis on each stone.

Stone	Typical Crystalline Silica Content (%)
Engineered stone	< 0.2 - 95
Quartzite	≥ 95
Quartzitic sandstone	≥ 90
Sandstone	≥ 60
Marble / Limestone	< 5
Granite	10 - 50
Slate	20-40
Soapstone	Varies

Sources: Characterization of Airborne Dust Generated from the Grinding of Natural and Engineered Stone Products, NIOSH report, October 2023; ASTM C616, *Standard Specification for Quartz-Based Dimension Stone;* American Geological Institute, *Dictionary of Geological Terms;* Worksafe Victoria, *Stonemasons: Preventing crystalline silica exposure*

Certain work tasks release crystalline silica dust into the air

Workers operating powered hand tools, such as saws, grinders, and high-speed polishers, have some of the highest RCS exposures in the countertop manufacturing, finishing, and installation industries. These exposures come from cutting, grinding, edging, and contouring stone, and may occur in shop environments as well as on job sites where finishing work is completed.

In the engineered stone industry, workers may also be exposed to RCS when opening bags of silica powder, moving or mixing bulk raw materials, cleaning and scraping mixers, changing filters on dust collectors, or cleaning dust collector bag houses.

Workers performing other tasks in areas close to where silica dust-generating operations occur may also be exposed.

What can be done at stone countertop worksites to protect workers from exposure to silica?

Employers with employees who manufacture, finish, or install countertops containing crystalline silica must comply with the applicable OSHA standard for respirable crystalline silica (general industry – 29 CFR 1910.1053; construction – 29 CFR 1926.1153). The silica standards include provisions for assessing worker exposures to RCS, a Permissible Exposure Limit (PEL) of 50 µg/m^3 as an 8-hour time-weighted average, controlling exposures, personal protective equipment, establishing a written exposure control plan, housekeeping, medical surveillance, training, and recordkeeping. The standards require employers to implement engineering and work practice controls to reduce exposures to the PEL or below, and to ensure workers use respirators where exposures remain above the PEL. Some requirements vary between general industry and construction. Additional guidance can be found on OSHA's Safety and Health Topics page on Crystalline Silica.

A combination of protective measures, such as engineering and administrative controls, personal protective equipment, and worker training, is needed to ensure workers are not overexposed to RCS during stone countertop manufacturing, finishing, and installation.

Worker Exposure Assessment

An assessment of worker exposures, required under OSHA's silica standards, will help identify where exposures occur, assess control effectiveness, prevent overexposures, and provide information to employees

performing the work as well as medical providers conducting exams. An exposure assessment can include collecting airborne RCS samples for tasks that expose workers to RCS. Employers should consult with a trained occupational safety and health professional, such as a certified industrial hygienist, to assess exposures; small businesses may contact OSHA's free On-site Consultation Program for assistance.

If the exposure assessment indicates worker exposures are above OSHA's PEL, the OSHA silica standards require employers to take action to reduce worker exposures to the PEL or below. If levels are above OSHA's Action Level (AL) of 25 µg/m^3 as an 8-hour time-weighted average, employers must conduct further exposure monitoring as well as, in some cases, provide medical surveillance.

OSHA Permissible Exposure Limit (PEL)

The OSHA PEL for respirable crystalline silica is 50 µg/m^3 as an 8-hour time-weighted average.

OSHA Action Level

The OSHA Action Level for respirable crystalline silica is 25 µg/m^3 as an 8-hour time-weighted average.

Control exposures by following the hierarchy of controls and safe work practices

Controlling exposures to occupational hazards is the fundamental method of protecting workers. The hierarchy of controls outlines the following methods to reduce exposures, from most to least effective: elimination, substitution, engineering controls, administrative controls, and personal protective equipment. Elimination, substitution, and engineering controls are the most effective methods because they reduce risks without requiring much action from workers. Administrative controls and personal protective equipment can also help lower exposure to hazards, but they work best when combined with the more effective methods. Below are practical examples of how to control worker exposure to RCS during countertop manufacturing, finishing, and installation.

Elimination and substitution — remove the hazard or use a safer alternative

- Verify the crystalline silica content in the stone products under consideration for fabrication by consulting the safety data sheets for the products. When possible, choose products with little (substitution) or no (elimination) crystalline silica.[21, 22] Evaluate whether the potential alternative stone products can mitigate employees' exposure to RCS without posing a greater or new hazard to employees.

Engineering controls — prevent or reduce workers' contact with hazards

- Use air monitoring to identify and isolate high exposure tasks associated with countertop fabrication operations. Isolation can be provided by dust control booths[19] or enclosures with local exhaust ventilation (LEV).[22]
- Avoid dry operations (e.g., dry cutting, grinding, sweeping) and use of compressed air. Replace dry grinders with wet-edge milling machines or stone routers.
- Improve design of the fabrication process to use remote-controlled tools with water-spraying systems (e.g., large bridge or gantry-like saws, waterjet cutting machines, computer numerical control machines) as much as possible.
- Modify handheld angle grinders and polishers to deliver water from multiple locations and/or augment them with additional water wetting methods to ensure effective wetting[20] at the point of contact with the stone.
- Install LEV systems at fixed locations to capture dust near its point of origin. System designs should account for the dimensions of the operation area to provide sufficient airflow velocity[22] to capture dust without interfering with the water used to control dust.[18] LEV systems with air filtration and recirculation capability can also provide dilutional ventilation to reduce RCS concentration in the surrounding area.
- Use a combination of both water and LEV controls, if necessary.
- Enhance general ventilation of indoor spaces by replacing dusty indoor air with clean air from outdoors or from recirculating air filtration systems. The effectiveness of this type of ventilation varies depending on the size of the indoor space and the available capacity of the general ventilation.

Administrative controls — establish work practices that reduce exposure to hazards

- Train workers to effectively use LEV (e.g., always positioning themselves upstream of the dust source, adjusting the operation area to maximize proximity inside or near the LEV's hooded enclosure).[22]

- Develop a system or schedule to evaluate the effectiveness of engineering controls and equipment to ensure that they are functioning properly; maintain and operate water-treatment, housekeeping (e.g., wet floor scrubber), and ventilation equipment (including air filter replacement) in accordance with manufacturers' instructions.
- Train workers to raise awareness of the general risk of RCS exposure and exposure control measures implemented at the workplace.
- Use wet sweeping or wet floor scrubbers to keep the floor clean, which will help avoid dust getting back into the air after it has settled on the floor. Do not dry sweep or use compressed air to clean floors and work surfaces.
- Ensure the quality of water used in the fabrication process. Whenever feasible, use tap water for handheld tools and limit recycled water for use in remotely operated machines only. When recycled water is used, it should first be treated to remove solid particles and other harmful residuals.
- When using wet method dust suppression controls, adjust water flow as necessary to control dust, following manufacturers' recommendations for water flow rates.
- Pre-wash stone slabs prior to cutting or in between cuts.
- Provide HEPA-filtered vacuums for cleaning worker clothes, and provide water for hand, face, and hair cleaning in high exposure areas, such as where cutting, grinding, or polishing work generates silica dust.

Administrative controls — Installation in commercial and residential spaces

- Do as much work as possible under controlled shop conditions instead of at an installation site. Use laser measurement to increase dimension accuracy and use mock models and templates to ensure installation processes can be done without the need for onsite finishing tasks for the stone countertop.
- Perform work outdoors and use water to suppress dust in situations where onsite finishing tasks cannot be avoided.

Personal protective equipment — Respirators

When engineering and administrative controls alone cannot reduce RCS exposures to OSHA's PEL or below, the OSHA silica standards require respirators to be used to protect employee health. Whenever respirators are required, the employer must have a respiratory protection program that meets the requirements of OSHA's Respiratory Protection standard (29 CFR 1910.134). This program must include proper respirator selection, fit testing, medical evaluations, and training. Any respirator used must be stored in a non-dusty environment and kept clean or washed (if applicable) so that wearers are not exposed to additional RCS.

If respirators are provided, use at least a NIOSH Approved® N95® respirator. If the RCS level is more than 10 times the OSHA PEL, a half-face respirator is not protective enough and a respirator that offers a greater level of protection, such as a full-facepiece elastomeric respirator that will protect workers at RCS levels up to 50 times the PEL, must be used. Powered air-purifying respirators (PAPR) also provide more protection than half-face air-purifying respirators. In general, workers find PAPRs to be more comfortable than negative pressure respirators, including tight-fitting elastomeric varieties.

For more information, visit OSHA's Safety and Health Topics page on Respiratory Protection, OSHA's eTool on respiratory protection, and NIOSH's Workplace Safety & Health Topics page on Respirators.

The workers shown above are wearing a NIOSH-approved N95 filtering facepiece respirator (left), a full facepiece elastomeric respirator (center), and a loose-fitting powered air-purifying respirator (PAPR) (right).

Medical surveillance for workers who are exposed to silica

Under OSHA's silica standards, employers are required to make medical exams available to: (1) all employees exposed to RCS at or above the OSHA AL for 30 or more days a year in general industry; and (2) all employees required under the RCS construction standard to wear a respirator for 30 or more days a year. The initial exam must be completed within 30 days of assignment, and then periodic exams conducted per the applicable standard. The medical exam must include:

- A medical and work history;
- A physical exam with emphasis on the respiratory system;
- A chest X-ray, evaluated by a qualified professional;
- A pulmonary function test;
- Testing for latent tuberculosis infection (initial exam only); and
- Any other tests deemed appropriate by the physician or other licensed health care professional providing the exam.

Although not required by OSHA's silica standards, chest high-resolution computed tomography without contrast is more sensitive than chest X-ray in detecting silicosis and should be considered for follow-up evaluation of individuals suspected to have silicosis.[25,26] Low-dose chest computed tomography could also be considered for screening of workers in settings where a case of silicosis has been identified.

Silicosis is a reportable condition in many states. Per state requirements, cases should be reported to state or local health departments to assist in identification of outbreaks and targeting of prevention efforts.

Standards and Directives

Several OSHA standards and directives cover operations that may expose workers to silica, including:

- Hazard Communication (29 CFR 1910.1200)
- Respirable Crystalline Silica (29 CFR 1910.1053, 29 CFR 1926.1153)
- Respiratory Protection (29 CFR 1910.134)

Directive CPL 03-00-023, *National Emphasis Program – Respirable Crystalline Silica,* has detailed information on silica hazards, guidelines for air sampling, and other compliance information.

Directive CPL 02-02-080, Inspection Procedures for the Respirable Crystalline Silica Standards, has inspection procedures and enforcement policies.

The Natural Stone Institute technical module, "Silicosis – An Industry Guide to Awareness and Prevention", offers tips on controlling silica exposures in stone cutting operations. It is available to workers and employers on the Institute's Silica Resources web site.

Findings on Worker Exposures to Silica

Data from OSHA and NIOSH provide estimates of countertop industry worker exposure to RCS. When engineering and administrative controls as described above are used properly, they are generally effective in reducing worker exposures below the OSHA PEL, and in some instances, to levels below the OSHA AL. Respiratory protection may still be necessary to protect workers in some cases, however.

In many shops, practices may involve dry cutting, grinding, polishing, and other work that releases silica dust into the air. In a study of 47 shops in Oklahoma, 74% reported using dry methods all or most of the time in at least one step of their work, and only 9% reported using dust collection systems.[10] During inspections of 106 engineered stone fabrication facilities in 2019-2020 by Cal/OSHA, 26% of employees reported sometimes using dry methods.[11] Approximately one quarter of breathing zone samples for RCS taken by OSHA exceeded the OSHA PEL during calendar year 2022 in workplaces that work with natural and engineered stone slabs.[23] The data summarized below provides additional information on worker exposures to RCS and illustrates how the implementation of proper controls can help protect workers from overexposures.

Countertop Finishers in Washington State

Nineteen air samples were taken in granite countertop shops where fabrication and finishing workers were using dry methods without engineering controls such as LEV.[14] These samples showed exposures to RCS concentrations between <40 and 770 µg/m^3. Shops using dry methods switched to wet methods, resulting in a dramatic reduction in worker exposure to RCS. Eighteen samples from workers using wet methods showed RCS concentrations between <20 and 100 µg/m^3. In one shop where the workers were sampled using bridge saws and angle grinders, the mean RCS concentration dropped by 440 µg/m^3 after switching to new and retrofitted water-fed tools.

Cutting Stone Blocks and Slabs

In 2015, OSHA reviewed the results of exposure samples for sawyers from 10 OSHA Special Emphasis Program inspection reports and one NIOSH report. Among 22 instances in which sawyers used wet methods—

often a water feed to the saw—to reduce dust, full-shift median exposure was 54 µg/m^3, with mean exposure of 61 µg/m^3 and a range of 15-134 µg/m^3. Twelve results (55%) exceeded 50 µg/m^3, and four results (18%) exceeded 100 µg/m^3.

Where a water feed to a saw alone was not sufficient, spraying the stone before cutting it or between multiple cuts can further reduce exposures. In one operation where workers used wet sawing, they were still exposed to full-shift RCS concentrations of 70-110 µg/m^3. Spraying the stone before cutting resulted in exposures below 50 µg/m^3. The addition of LEV in the shop further reduced exposures to 15-32 µg/m^3.

Exposure Varies by Stone Type

OSHA collected air samples as part of inspections at several granite and marble shops. In the marble shop, two finishers dry grinding green marble with very low silica content (1.8% quartz) without the use of engineering controls, such as water sprays or LEV, were exposed to RCS levels of 39 and 45 µg/m^3. In the granite shop, which also did not use engineering controls, RCS exposures were considerably higher, ranging from 89 to 460 µg/m^3. In a separate study, NIOSH collected short-term task-based samples from shops finishing both natural and engineered stone countertops using a traditional wetting method of water sprays as the only exposure control in most cases.[15-17] NIOSH made the following observations from the collective data in a recent publication:[24]

- Workers using handheld grinders had average RCS exposures of 238 µg/m^3 when working exclusively with high silica-content engineered stones and 148 µg/m^3 when working with both natural and engineered stones.
- Workers using handheld polishers had average RCS exposures of 69 µg/m^3 when working exclusively with high silica-content engineered stones and 37 µg/m^3 when working with both natural and engineered stones.

A recent NIOSH laboratory study found that the generation of RCS from grinding is strongly related to the silica content in the stones.[21]

- Engineered stone with <0.2% crystalline silica generated an undetectable level of RCS,
- Engineered stone with <50% crystalline silica generated RCS at a similar level as granite, and
- Engineered stones with >70% crystalline silica from various manufacturers generated the highest amounts of RCS.

Exposure Varies by Finishing Task and Control Measure

A NIOSH Health Hazard Evaluation[15] evaluated workers' full-shift RCS exposures while conducting different finishing tasks at a shop finishing both natural and engineered stone countertops. The study found that workers using hand-held grinders with diamond cup wheels and a traditional water spray wetting method had the highest exposures to RCS (all the full-shift samples had exposure above 50 µg/m^3, with an average exposure of 121 µg/m^3). All other workers operating machines remotely or using hand-held polishers with water sprays as the only exposure control had full-shift exposures below 50 µg/m^3.

A follow-up study[20] by NIOSH employing short-term task-based sampling found that adding a sheet-wetting method, which involves supplying water to the stone surface with a water hose, in addition to the traditional water spray wetting method, helped ensure consistent and effective wetting at the point of operation. The combined control measures led to reduced exposures, with an average of 33 µg/m^3 for workers who used hand-held grinders and worked with both natural and engineered stone.

A worker uses an angle grinder with a diamond grinding cup wheel to finish a stone countertop. Combining "sheet-wetting" with a water spray nozzle helps reduce RCS exposure during grinding. Photo by NIOSH.

A comprehensive NIOSH study[22] evaluated three different configurations of exposure control measures, including LEV provided by multiple dust extractors, at the same worksite, for workers using hand-held grinders and polishers. When used in addition to existing wet methods, designating dust extractors for the grinding task and training workers to properly position themselves and their workbenches when using the dust extractor led to effective exposure control. The workers' exposures under this configuration of exposure control measures were below or near the OSHA PEL when the

stones they worked with included engineered stones containing high silica content, but their exposures were all below the OSHA AL when mostly working with the new engineered stones containing less than 50% silica.

How Can OSHA and NIOSH Help?

OSHA has compliance assistance specialists throughout the nation who can provide information to employers and workers about OSHA standards, short educational programs on specific hazards, worker rights and employer responsibilities, and information on additional compliance assistance resources. Contact your local OSHA office for more information by visiting the OSHA Offices by State websitethe OSHA Offices by State website.

OSHA's On-site Consultation Program offers no-cost and confidential occupational safety and health services for small businesses, with priority given to high hazard worksites. Consultants from state agencies or universities work with employers to identify and correct workplace hazards. On-site consultation services are separate from enforcement. To locate the nearest OSHA Consultation office, visit OSHA's free On-site Consultation Program or call 1-800-321-OSHA (6742).

OSHA has a Safety and Health Topics Page for Crystalline Silica that includes additional information about crystalline silica.

NIOSH Health Hazard Evaluation Program: Employees, employee representatives, or employers can ask NIOSH to conduct Health Hazard Evaluations (HHEs) at their workplace. For more information about the HHE program, visit NIOSH's website on Health Hazard Evaluations or contact 513-841-4382.

NIOSH recommendations for preventing silicosis can be found on the Silica topic webpage, which includes a link to a NIOSH page on exposure assessment. The NIOSH Engineering Controls Program provides additional resources on engineering interventions that can eliminate hazards or make work safer.

Workers' Rights

Workers have the right to:

- Working conditions that do not pose a risk of serious harm.
- Receive information and training (in a language and vocabulary the worker understands) about workplace hazards, methods to prevent them, and the OSHA standards that apply to their workplace.
- Review records of work-related injuries and illnesses.
- File a complaint asking OSHA to inspect their workplace if they believe there is a serious hazard or that their employer is not following OSHA's rules. OSHA will keep all identities confidential.
- Exercise their rights under the law without retaliation, including reporting an injury or raising health and safety concerns with their employer or OSHA. If a worker has been retaliated against for using their rights, they must file a complaint with OSHA as soon as possible, but no later than 30 days.

For additional information on Workers' Rights, Employer Responsibilities, and other services OSHA offers, visit www.osha.gov.

Contact OSHA

For questions or to get information or advice, to report an emergency, to report a fatality or catastrophe, to order publications, to file a confidential complaint, or to request OSHA's free on-site consultation service, contact your nearest OSHA office, visit www.osha.gov, or call OSHA at 1-800-321-OSHA (6742).

Many states operate their own occupational safety and health programs approved by OSHA. States enforce similar standards that may have different or additional requirements. A list of state plans is available at OSHA's State Plans website.

Contact NIOSH

For questions or to get more information about occupational safety and health topics, or to order publications, visit the NIOSH website, call 1-800-CDC-INFO (1-800-232-4636), TTY 1-888-232-6348, or email cdcinfo@cdc.gov.

[1] Martínez C, Prieto A, García L, Quero A, González S, Casan P. Silicosis: a disease with an active present. Arch Bronconeumol. 2010;46(2):97-100. doi:10.1016/j.arbres.2009.07.008

[2] García Vadillo C, Gómez JS, Morillo JR. Silicosis in quartz conglomerate workers. *Arch Bronconeumol*. 2011;47(1):53. doi:10.1016/j.arbres.2010.09.005

[3] Kramer MR, Blanc PD, Fireman E, et al. Artificial stone silicosis [corrected]: disease resurgence among artificial stone workers [published correction appears in Chest. 2012 Oct;142(4):1080]. *Chest*. 2012;142(2):419-424. doi:10.1378/chest.11-1321

[4] Friedman GK, Harrison R, Bojes H, Worthington K, Filios M; Centers for Disease Control and Prevention (CDC). Notes from the field: silicosis in a countertop fabricator - Texas, 2014. *MMWR Morb Mortal Wkly Rep*. 2015;64(5):129-130.

[5] Hoy RF, Baird T, Hammerschlag G, et al. Artificial stone-associated silicosis: a rapidly emerging occupational lung disease. *Occup Environ Med*. 2018;75(1):3-5. doi:10.1136/oemed-2017-104428

[6] Rose C, Heinzerling A, Patel K, et al. Severe Silicosis in Engineered Stone Fabrication Workers - California, Colorado, Texas, and Washington, 2017-2019. *MMWR Morb Mortal Wkly Rep*. 2019;68(38):813-818. Published 2019 Sep 27. doi:10.15585/mmwr.mm6838a1

[7] Wu N, Xue C, Yu S, Ye Q. Artificial stone-associated silicosis in China: A prospective comparison with natural stone-associated silicosis. *Respirology*. 2020;25(5):518-524. doi:10.1111/resp.13744

[8] Tustin AW, Kundu-Orwa S, Lodwick J, Cannon DL, McCarthy RB. An outbreak of work-related asthma and silicosis at a US countertop manufacturing and fabrication facility. *Am J Ind Med*. 2022;65(1):12-19. doi:10.1002/ajim.23304

[9] Fazio JC, Gandhi SA, Flattery J, et al. Silicosis Among Immigrant Engineered Stone (Quartz) Countertop Fabrication Workers in California. *JAMA Intern Med*. 2023;183(9):991-998. doi:10.1001/jamainternmed.2023.3295

[10] Phillips ML, Johnson AC. Prevalence of dry methods in granite countertop fabrication in Oklahoma. *J Occup Environ Hyg*. 2012;9(7):437-442. doi:10.1080/15459624.2012.684549

[11] Spiegel A, Cummings KJ, Flattery J, Harrison R, Heinzerling A. Self-reported silica exposures and workplace protections among engineered stone fabrication workers in California. *Am J Ind Med*. 2022;65(12):1022-1024. doi:10.1002/ajim.23432

[12] Natural Stone Institute. *Silicosis: An Industry Guide to Awareness and Prevention*. Natural Stone Institute; 2020

[13] Phillips ML, Johnson DL, Johnson AC. Determinants of respirable silica exposure in stone countertop fabrication: a preliminary study. *J Occup Environ Hyg*. 2013;10(7):368-373. doi:10.1080/15459624.2013.789706

[14] Simcox NJ, Lofgren D, Leons J, Camp J. Silica exposure during granite countertop fabrication. *Appl Occup Environ Hyg*. 1999;14(9):577-582. doi:10.1080/104732299302350

[15] NIOSH. *Health Hazard Evaluation Report: Evaluation of Crystalline Silica Exposure during Fabrication of Natural and Engineered Stone Countertops*. Zwack L, Victory K, Brueck S, Qi C. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, HHE 2014-0215-3250; 2016

[16] NIOSH. *Engineering Control of Silica Dust from Stone Countertop Fabrication and Installation*. Qi C, Echt A. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, EPHB 375-11a; 2016

[17] NIOSH. *Engineering Control of Silica Dust from Stone Countertop Fabrication and Installation*. Qi C, Lo L. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, EPHB 375-12a; 2016

[18] Johnson DL, Phillips ML, Qi C, Van AT, Hawley DA. Experimental Evaluation of Respirable Dust and Crystalline Silica Controls During Simulated Performance of Stone Countertop Fabrication Tasks With Powered Hand Tools. *Ann Work Expo Health*. 2017;61(6):711-723. doi:10.1093/annweh/wxx040

[19] NIOSH. *Field Evaluation of a Mobile Dust Control Booth for Stone Countertop Grinding*. Qi C, Echt A. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, EPHB Report No. 2020-DFSE-165; 2019

[20] NIOSH. *Engineering Control of Silica Dust from Stone Countertop Fabrication and Installation – Evaluation of Wetting Methods for Grinding*. Qi C, Echt A. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, EPHB Report No. 2021-DFSE-710; 2021

[21] NIOSH. *Characterization of Airborne Dust Generated from the Grinding of Natural and Engineered Stone Products*. Thompson D, Qi C. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, EPHB Report NO. 2023-DFSE-1489; 2023

[22] NIOSH. *Investigation of Ventilation Engineering Controls for Stone Countertop Fabrication*. Qi C. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, EPHB Report NO. 2024-DFSE-1618; 2024

[23] Hodgson MJ, Smith PA. Workers at Risk of Silicosis-Ongoing Overexposure and Lack of Medical Surveillance. *JAMA Intern Med*. 2024;184(2):224-225. doi:10.1001/jamainternmed.2023.6632

[24] Qi C, Thompson D, Brogan U. Protecting Stone Workers - Reducing Exposure to Respirable Crystalline Silica during Stone Countertop Fabrication. *American Industrial Hygiene Association. The Synergist.* 2024 Oct; https://synergist.aiha.org/202410-protecting-stone-workers

[25] Hoy RF, Jones C, Newbigin K, et al. Chest x-ray has low sensitivity to detect silicosis in artificial stone benchtop industry workers. *Respirology*. 2024;29(9):785-794. doi:10.1111/resp.14755

[26] Hoy RF, Dimitriadis C, Abramson M, et al. Prevalence and risk factors for silicosis among a large cohort of stone benchtop industry workers. *Occup Environ Med*. 2023;80(8):439-446. doi:10.1136/oemed-2023-108892

DHHS (NIOSH) Publication Number 2026-101 | OSHA (DTSEM) - HA-3768-2026