HHE Health Hazard® Evaluation Program

Evaluation of Silica Exposures During Drywall Sanding

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Availability of Report

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Introduction

Request

Management from a drywall finishing company requested a health hazard evaluation concerning employee exposure to respirable crystalline silica during drywall-sanding activities. Crystalline silica is a common mineral in construction materials. When it becomes airborne in dust, it can harm the lungs.

Workplace

The drywall finishing company performs work in different locations depending on the contract. For this health hazard evaluation, we visited a hospital construction site. The employees we evaluated hung drywall board and prepared it for painting. Part of this process involved applying thin layers of joint compound to the boards (skim coat) and then sanding it smooth once the compound dried. The amount and frequency of sanding depended on the scope of the project. For this project, the sanding took 8 hours, which was the length of a full shift. Sanding activities occurred about once every 4 days at this site.

The crew consisted of three employees. Two employees sanded by hand using sandpaper and sanding foam blocks. One employee operated a power drywall sander attached to a vacuum equipped with a high efficiency particulate air (HEPA) filter. The employee who used the power sander was responsible for emptying the vacuum contents and replacing the vacuum bag. All employees belonged to a union.

All employees working at the site were required to wear hard hats, safety glasses, and steel-toed boots. Some areas/tasks also required hearing protection. Based on previous exposure monitoring results, the employer did not require their employees to wear respirators during sanding activities. During our visit, one employee voluntarily wore a filtering facepiece respirator.

To learn more about the workplace, go to Section A in the Supporting Technical Information

Our Approach

We conducted an initial walkthrough of the work site in February 2023 and returned in April 2023. During our return visit, we did the following activities:

- Observed work processes and work practices.
- Collected air samples for respirable crystalline silica and respirable dust.
- Collected bulk samples of sanding dust and wet joint compound to determine their silica content.
- Conducted semi-structured interviews with employees to discuss personal protective equipment use during current work processes and whether they have health or safety concerns.

To learn more about our methods, go to Section B in the Supporting Technical Information

Our Key Findings

One employee was overexposed to respirable crystalline silica

- The Occupational Safety and Health Administration (OSHA) has limits of how much respirable crystalline silica is allowed in the air. One concentration was over what OSHA allows.
- Three respirable crystalline silica concentrations that we found were over the OSHA "action level." When exposure levels reach or go over their action level, employers are required to take steps to protect employees.

Work practices may have added to more exposures

- Employees sanded the tops of walls and ceilings while other employees were sanding directly below.
- We saw the vacuum being used without a disposable bag, which can put more dust into the air when the vacuum is emptied.
- Dust clouds were visible in the air when employees emptied the vacuum.
- Employees shook dust off their clothes at the end of their shift into the air around them and others.
- Employees who voluntarily wore respirators were not wearing them correctly.

None of the employees interviewed reported health or safety concerns

- Employees did not report any symptoms they associated with their work activities.

To learn more about our results, go to Section B in the Supporting Technical Information

Our Recommendations

The Occupational Safety and Health Act requires employers to provide a safe workplace.

Potential Benefits of Improving Workplace Health and Safety:

- ↑ Improved worker health and well-being
- ↑ Better workplace morale
- ↑ Easier employee recruiting and retention
- ↑ Enhanced image and reputation
- ↑ Superior products, processes, and services
- ↑ Increased overall cost savings

The recommendations below are based on the findings of our evaluation. For each recommendation, we list a series of actions you can take to address the issue at your workplace. The actions at the beginning of each list are preferable to the ones listed later. The list order is based on a well-accepted approach called the "hierarchy of controls." The hierarchy of controls groups actions by their likely effectiveness in reducing or removing hazards. In most cases, the preferred approach is to eliminate hazardous materials or processes and install engineering controls to reduce exposure or shield employees. Until such controls are in place, or if they are not effective or practical, administrative measures and personal protective equipment might be needed. Read more about the hierarchy of controls at https://www.cdc.gov/niosh/topics/hierarchy/.

We encourage the company to use a health and safety committee to discuss our recommendations and develop an action plan. Both employee representatives and management representatives should be included on the committee. Helpful guidance can be found in *Recommended Practices for Safety and Health Programs* at https://www.osha.gov/shpguidelines/index.html.

Recommendation 1: Keep employees' exposures to respirable crystalline silica below the OSHA exposure limits

Why? Some levels we measured were above OSHA's allowable exposure limits. Exposure can happen by breathing dust in the air that contains silica.

Breathing in crystalline silica dust particles at work has been associated with lung diseases, such as silicosis, lung cancer, and other airway problems. These exposures have also been linked to kidney and autoimmune diseases. An autoimmune disease is when a person's body attacks its own cells as if those cells were an outside virus or bacteria.

The results of our evaluation indicated that, according to the OSHA respirable crystalline silica standard for construction, action needs to be taken to reduce employees' exposures to respirable crystalline silica to below OSHA's permissible exposure limits. Employers must comply with the OSHA respirable crystalline silica standard for construction, 29 CFR 1926.1153: https://www.osha.gov/laws-regs/regulations/standardnumber/1926/1926.1153.

How? At your workplace, we recommend these specific actions:

Change work practices so that employees do not sand above other employees.

- When possible, have employees pole sand rather than hand sand to increase the distance between the employee's breathing zone and the task. See Figure 1.

Figure 1. A finisher is standing on scaffolding (right) and hand sanding while another finisher (in front of the scaffolding) is hand sanding below (red arrow). Photo by NIOSH.

Use a vacuum with a HEPA filter to clean dusty clothing.

- Consider providing employees with disposable coveralls to reduce the potential for carrying contaminants home.

Create clear guidelines for employees to operate and maintain the vacuum.

- Look closely at all parts of the vacuum, including filters, disposable bag, power cord, and vacuum hose, at the start and end of each shift. Replace any broken or damaged parts right away. Report any issues to your foreman.
- Tell employees not to use the vacuum without a bag.
- Follow the guidelines offered by the vacuum's manufacturer for vacuum operation, maintenance, and filter replacement.
- Remove and replace the vacuum cleaner bags at the end of the shift and as needed throughout the day. Develop a schedule for changing the bags based on experience (such as the number of rooms or hours used). Replace the bags more often to reduce the chances of having the bag tear and the vacuum canister fill with dust.
    - By changing the bags more often, the bag should catch and hold more dust. Changing the bags more often could also help the HEPA filters last longer.
- Make sure there are enough vacuum bags available at all times. The bag should be replaced when the vacuum begins to not work as well.
- Properly maintaining the vacuum will help to reduce possible exposures to dust. If you find that you are filling and changing vacuum bags several times during a shift, consider purchasing a larger capacity vacuum cleaner.

- Ensure employees wear the correct respiratory protection while they inspect the vacuum and remove and replace the vacuum bags. This will reduce possible exposure to silica.

Improve the existing respiratory protection program.

- Based on the results of this evaluation, employees are required to wear respirators until additional sampling shows their exposures are below the OSHA permissible exposure limit.
- Write a program noting worksite-specific tasks that require respirator use. Also, name a capable person to run the program. OSHA lays out all the requirements for your written program. This includes annual fit testing, documented training, and medical clearance, among other things. Find that information here: https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.134AppC.
- OSHA has developed a *Small Entity Compliance Guide for the Respiratory Protection Standard* that you might find useful when developing your respiratory protection program: https://www.osha.gov/sites/default/files/publications/3384small-entity-for-respiratory-protection-standard-rev.pdf.
- Consider contacting the OSHA consultation program for assistance with developing your respiratory protection program: https://www.osha.gov/dcsp/smallbusiness/consult.html.
- Ensure that employees have access to respirators and are trained on their use in a language that the worker will understand.

Educate employees on the health effects of silica exposure. Tell them what workplace tasks can expose them to silica and how they can limit that exposure.

Review the OSHA *Small Entity Compliance Guide for the Respirable Crystalline Silica Standard for Construction.*

- This OSHA document can be found here: https://www.osha.gov/sites/default/files/publications/OSHA3902.pdf.
- OSHA also offers free on-site safety and health consultation services for small businesses: https://www.osha.gov/consultation.

Recommendation 2: Continue to conduct exposure monitoring at regular times

Why? One day of sampling on a small number of people may not fully represent exposures during these job tasks. However, it is concerning that all three samples were higher than the OSHA action level.

Further sampling on days where employees are doing skim-coat sanding may be needed to make sure that work sites comply with the OSHA silica standard. More respirable crystalline silica may be in the dust in work sites that are different than the one we sampled in this evaluation. Other work sites may have different conditions that could affect exposure levels. For example, these can be work sites where there is more sanding than normal or where there is less air moving through the building.

How? At your workplace, we recommend these specific actions:

Do additional personal air sampling for respirable dust and silica.

- Multiple days of sampling at different work sites will offer more information about possible respirable dust exposures.
    - Further sampling efforts may show that certain work-site conditions lead to higher or lower exposures. These work sites may need to use different ways to protect workers by reducing their silica exposure. This is particularly important in work activities that can be highly variable from day-to-day.

Assess exposures again when there is a change in the how the work is done, who does it, or what equipment is used.

- Any changes at work may lead to changes in exposures. If exposures increase, the controls used might need to be updated to stay effective at lowering exposures to acceptable levels.

Recommendation 3: Address other health and safety issues we identified during our evaluation

Why? A workplace can have multiple health hazards that cause worker illness or injury. Similar to the ones identified above, these hazards can potentially cause serious health symptoms, lower morale and quality of life for your employees, and possibly increased costs to your business. We saw the following potential issues at your workplace:

- We observed multiple nonemployees walking through the work area where drywall sanding was taking place.
- Employees held portable work lights on their shoulders while standing on scaffolding and sanding.

- Employees did not always wear safety glasses properly while sanding. The safety glasses often became dirty and fogged up, so employees were not able to see the areas they were sanding.
- During our initial walkthrough, we observed an employee using a powered man-lift without a harness.
- Food and drink were observed in the work area.

Although they were not the focus of our evaluation, these hazards could cause harm to your workers' health and safety and should be addressed.

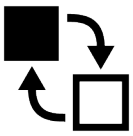
How? At your workplace, we recommend these specific actions:

Consider keeping nonemployees out of work areas where drywall sanding is taking place.

- When possible, use signs, cones, or tape to block off the work area to lessen the risks of exposure for other contractors on the job site. Make sure any cones or tape do not create tripping hazards that make it difficult for workers to move in their work area.

Provide head lamps to employees. Ask them not to hold portable work lights on their shoulders while working.

- Head lamps give direct light on where the employee is working. Employees could lose their balance while working if they were holding the lights while sanding. Losing balance while working could result in falls or injuries. Additionally, holding the lamp with one hand while sanding could result in musculoskeletal issues or pain.



Explore other personal protective equipment and procedures.

- If combining safety glasses, respirator, and hard hat is uncomfortable for some employees, look at other options. For example, different types of loose-fitting powered air purifying respirators can combine a hard hat and an industry-safe face shield.
- Providing antifog wipes or spray for safety glasses may be a short-term measure to take now, while looking at other protective equipment combinations. Drywall sanding requires close inspection of the work surface to ensure a high-quality finish, presenting challenges to using eye and face protection.

Ensure employees use a harness when they are operating the powered man-lift.

Do not eat or drink in the work area.

Supporting Technical Information

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Section A: Workplace Information

Workplace

The work took place on a hospital construction site. Sanding occurred approximately once every 4 days. The crew was made up of three drywall finishers.

Employee Information

- All three finishers participated in the evaluation.
- All employees belonged to a union.
- During our visit, the crew worked a single shift that was about 8 hours long. The length of the shift could change depending on the scope and stage of the project. On the day of our evaluation, the sanding took about 8 hours.

Process Description

In interior finishing, drywall installers fitted gypsum boards to wall studs or ceiling joists and secured them in place with screws. The joints between the drywall boards were taped, and a joint compound was applied to fill the joints and fix any defects in the drywall board. For this project, the walls were skim coated; a thin layer of joint compound was applied to the entire surface of the drywall to create a smooth finish for painting. During our evaluation, drywall finishers used dry-sanding techniques. One employee used a power sander, and two employees sanded the drywall by hand. First, the surfaces are sanded with a power sander. The power sander allows a large area of drywall to be sanded quickly but cannot get into corners or small spaces. These surfaces are sanded by hand.

In hand sanding, the drywall finishers sanded the drywall with a sanding sponge to create a uniform surface. For ceiling-level sanding, the finishers either stood on stilts or on a scaffold to reach the areas that needed to be sanded.

In power sanding, a drywall finisher operated an electric motor-driven sander with a disk head that spins. The power sander was attached to a dust-extraction vacuum cleaner equipped with high efficiency particulate air (HEPA) filters and disposable fleece filter bags.

Section B: Methods, Results, and Discussion

Methods: Observations of Work Processes, Practices, and Conditions

We evaluated the following during our site visit:

- Work processes
- Personal protective equipment (PPE) use
- Workplace conditions

Results: Observations of Work Processes, Practices, and Conditions

- We observed that employees sanded for their entire workday.
- The finishers worked in a team of three. One employee sanded the walls with a power sander. This was followed by two employees who hand sanded. Employees were either standing on stilts, on the floor, or on rolling scaffolds while sanding.
- A power sander was connected to a vacuum cleaner with a vacuum hose. The vacuum cleaner started automatically when the sander was switched on. The vacuum was equipped with a HEPA filter. When the vacuum was full, the operator emptied it.
- On the day of our visit, the vacuum was emptied once towards the end of the finishers' shift. The vacuum was emptied into a communal dumpster located outside of the immediate work area. There was no bag in the vacuum cleaner. The employee opened the vacuum, dumped the debris into the dumpster, and reassembled the vacuum. Emptying the vacuum generated a dust plume. The employee did not wear respiratory protection while emptying the vacuum.
- All sanding activities generated visible amounts of dust.
- The company had previously determined that respirators were not necessary for sanding activities. However, employees could wear respirators if they desired. One employee wore an N95® filtering facepiece respirator on a voluntary basis. This employee did not have their respirator straps positioned correctly.
- We observed nonemployees walking through the work area where drywall sanding took place.
- The finishers used lights to help them see the texture of the walls they sanded. We observed finishers using site lights on tripods and portable work lights. We observed one employee standing on a scaffold, balancing a portable work light on their shoulder with one hand and sanding with the other.
- All employees wore safety glasses, hard hats, long pants, high visibility shirts, and boots. We observed one employee wearing their safety glasses on the tip of their nose. The safety glasses would often become foggy or covered in sanding dust, which made the finisher's job more difficult as they relied heavily on seeing the surface they are sanding.

- During our initial walkthrough, we observed an employee using a powered man-lift without a harness.
- Food and drink were observed in the work area.

Methods: Exposure Assessment

Air Sampling

We collected air samples for respirable crystalline silica (RCS) from the breathing zone of three employees in April 2023. We used three-piece, 37-millimeter diameter cassettes with 5-micrometer (µm) pore size polyvinyl chloride filters. We used a Mesa Labs Model GK 2.69 high flow personal sampling cyclone at a flow rate of 4.2 liters per minute.

- We analyzed each sample for respirable dust and RCS using the NIOSH Methods 0600 and 7500 with a tetrahydrofuran preparation [NIOSH 2023].
- We changed cassettes approximately every 2 hours to avoid overloading.
- We calculated 8-hour time-weighted average (8-hr TWA) exposure concentrations for respirable dust and RCS. The calculated 8-hr TWA accounts for the remainder of the workday when employees were not performing tasks generating dust and assumes there is zero exposure to respirable dust or RCS.

Bulk Samples

We collected bulk samples of sanding dust and wet joint compound during the sampling day. The bulk samples of sanding dust were collected from multiple locations in the work area. Samples were collected to determine the silica concentration in the substrate that was being sanded and identify anything that may interfere with the analyses of the air samples. Samples were prepared and analyzed following NIOSH Method 7500 [NIOSH 2023].

Results: Exposure Assessment

Air Sampling

The 8-hr TWA concentrations for RCS ranged from 28 to 87 micrograms per cubic meter of air (µg/m^3). All three 8-hr TWA concentrations for RCS were above the Occupational Safety and Health Administration (OSHA) action level (AL) of 25 µg/m^3. One sample was higher than the OSHA permissible exposure limit (PEL) of 50 µg/m^3. The RCS exposure of the employee using the power sander was less than the exposures of the employees who were hand sanding.

The 8-hr TWA concentrations for respirable dust ranged from 1,000 to 2,700 µg/m^3. Two samples were greater than 50% of both the OSHA and American Conference of Governmental Industrial Hygienists (ACGIH®) occupational exposure limits (OELs). No respirable dust samples were higher than the OSHA PEL of 5,000 µg/m^3 or the ACGIH threshold limit value (TLV®) of 3,000 µg/m^3.

Bulk Samples

We collected two bulk dust samples of settled dust from different rooms and one bulk sample of wet joint compound. We took these bulk samples from the scaffolding that a sander was standing on and from a sink drain stub in a bathroom.

The bulk samples contained between 1.2% and 4.3% quartz (Table B1).

Table B1. Percent quartz detected in bulk samples

Sample location	% Quartz*
Dust collected from scaffolding	4.0
Dust collected from sink drain stub in bathroom	1.2
Wet joint compound	4.3

* The limit of quantification was 0.83%

Methods: Semi-Structured Interviews With Employees

We invited all three finishers to participate in semi-structured interviews. Interviews covered basic demographics, work history and practices, health and safety concerns, PPE use, training, and possible work-related health effects.

Results: Semi-Structured Interviews With Employees

Confidential Medical Interviews

All three finishers participated in the semi-structured interviews. All were male with an age range of 21 to 47 years. The range of job tenure was 7 months to 6 years. All three employees work 40 hours per week with 1 day per week of sanding. Sanding was reported to take place over 5 to 8 hours in the workday with typically two employees hand sanding and one employee running the power sander. The workers did not rotate these tasks.

Of the three employees interviewed, all reported wearing PPE when sanding. All wore safety glasses, gloves, steel toe shoes, and a hard hat. One employee reported wearing an unfitted N95® filtering facepiece respirator. Two of three employees reported having verbal training on the proper maintenance and use of PPE. Two of three employees also reported receiving general safety training in the form of weekly toolbox talks.

None of the three employees' interviews revealed health or safety concerns. None reported symptoms they think are related to their current work activities.

Discussion

RCS has been recognized as a carcinogen, and steps should be taken to protect employees from potential exposures [IARC 1997; NIOSH 2002]. One personal air sample we collected for RCS was above the OSHA PEL. In general, the PEL is the highest level of exposure that an employee may be exposed without incurring the risk of adverse health effects. By law, employers are required to keep employee exposures below the PEL. All three personal air samples we collected for RCS were above the OSHA AL. Employee exposures higher than the AL initiate certain required activities, such as exposure

monitoring and medical surveillance. Respirable dust exposures were within occupational exposure limits.

The results of our evaluation indicate that, according to the OSHA RCS standard for construction, action needs to be taken to reduce employees' exposures to RCS below OSHA's PEL. The OSHA silica standard requires these actions from employers:

- Keep employee exposures below the PEL of 50 μg/m^3, averaged over an 8-hour day.
- Use a combination of dust controls and safer work practices to protect employees from silica exposures above the PEL.
- Provide respirators to workers when dust controls and safer work practices cannot limit exposures to the PEL.

To comply with OSHA's RCS standard for construction, employers are also required to establish and implement a written exposure control plan that identifies tasks that involve exposure and methods used to protect workers. These include procedures to restrict access to work areas where high exposures may occur; designate a competent person to implement the written exposure control plan; restrict housekeeping practices that expose employees to silica where effective, safe alternatives are available; offer medical exams every 3 years for employees who are required by the standard to wear a respirator for 30 or more days per year; train employees on the health effects of silica exposure, workplace tasks that can expose them to silica, and ways to limit exposure; and keep records of employees' RCS exposure and medical exams [OSHA 2017].

According to the OSHA RCS standard, where the most recent exposure monitoring indicates that employee exposures are above the PEL, the employer shall repeat such monitoring within 3 months of the most recent monitoring. If the most recent exposure monitoring indicates that employee exposures are at or above the AL but at or below the PEL, the employer needs to repeat such exposure monitoring within 6 months of the most recent monitoring. Additionally, the OSHA RCS standard for construction states that the employer needs to reassess exposures whenever a change in the production, process, control equipment, personnel, or work practices may reasonably be expected to result in new or additional exposures at or above the AL, or when the employer has any reason to believe that new or additional exposures at or above the AL have occurred.

We observed respirators being worn incorrectly. Training employees about proper donning, doffing, and care for respirators can help increase awareness about potential dust and RCS exposures. Based on the results of this evaluation, employees are required to wear respirators until additional sampling shows their exposures are below the OSHA PEL. Where respiratory protection is required, OSHA states that employees must train workers on how to do the following: use respirators correctly; be aware of when respirators are necessary; know what kind of respirator is necessary; understand the limitations of respirators; put on, adjust, wear, and take off respirators; and maintain respirators properly [OSHA 2006, 2023].

OSHA requires the use of NIOSH Approved® respirators. OSHA also requires that medical evaluation, fit testing, and training be provided before use [OSHA 2006, 2023]. Allowing employees to wear respirators improperly could lead to these employees wearing their respirators improperly in the future

if respirator use becomes a requirement. When respirator use is not required, the employer must ensure that all employees who voluntarily use a respirator are provided with certain basic information on proper respirator use. If filtering facepieces are the only respirator being worn voluntarily, the employer is only required to provide employees with a copy of Appendix D of OSHA's respiratory protection standard, 1910.134. If other types of respirators are worn voluntarily (e.g., elastomeric), the employer must also make provisions for medical evaluations, as well as for cleaning, storage, and maintenance of respirators. For more information refer to the OSHA Small Entity Compliance Guide for the Respiratory Protection Standard [OSHA 2011].

The RCS exposure of the employee using the power sander was less than the exposures of the employees who were hand sanding. The vacuum attached to the power sander appeared to work well, but we discovered issues related to its use and maintenance. On the day of our sampling visit, we observed that the vacuum did not have a disposable bag in it, so the employee emptied the vacuum contents into a communal dumpster located outside the immediate work area. Emptying the vacuum in this manner generated a plume of dust, which could have contributed to the employee's exposures to RCS and respirable dust. If the communal dumpster was moved to different work areas at the site, nonemployees could potentially be exposed to RCS. We also observed nonemployees walking through the work area where drywall sanding took place. Therefore, we recommend improving practices related to vacuum care and maintenance and consider restricting nonemployee access to work areas where drywall sanding is occurring.

We did not evaluate the cleanup stages of this process. The finishers sanded until the end of their shift, and no cleanup activities took place on the day of our evaluation. Certain steps in the cleanup process could generate additional exposure to RCS and respirable dust. For example, avoid using compressed air or dry sweeping to clean up settled dust, as this could resuspend dust into the air and increase employees' overall exposures to RCS and respirable dust.

Limitations

This evaluation is subject to several limitations. Industrial hygiene sampling can only document exposures and conditions in the locations evaluated and on the day that the evaluation occurred. These results may not be representative of conditions during other days due to the nature of the work or change in season. Additionally, the small size and homogenous nature of the population sampled limit the generalizability of our evaluation results.

Conclusions

Our air sampling found that one employee was overexposed to RCS, and all three employees were exposed to RCS at levels above OSHA's AL. Employees' exposures to RCS may be reduced by improving vacuum care and maintenance and modifying work practices so that employees do not sand above each other. Reassess exposures whenever a change in the production process, control equipment, personnel, or work practices may reasonably be expected to result in new or additional exposures and/or to see if any controls you implement are effective in reducing exposures. Because employees are required to wear respirators until additional sampling shows their exposures are below the OSHA PEL,

the existing respiratory protection program needs to be strengthened and brought into compliance with the OSHA standard.

Attribution Statement

N95 and NIOSH Approved are certification marks of the U.S. Department of Health and Human Services (HHS) registered in the United States and several international jurisdictions.

Section C: Occupational Exposure Limits

NIOSH investigators refer to mandatory (legally enforceable) and recommended OELs for chemical, physical, and biological agents when evaluating workplace hazards. OELs have been developed by federal agencies and safety and health organizations to prevent adverse health effects from workplace exposures. Generally, OELs suggest levels of exposure that most employees may be exposed to for up to 10 hours per day, 40 hours per week, for a working lifetime, without experiencing adverse health effects.

However, not all employees will be protected if their exposures are maintained below these levels. Some may have adverse health effects because of individual susceptibility, a preexisting medical condition, or a hypersensitivity (allergy). In addition, some hazardous substances act in combination with other exposures, with the general environment, or with medications or personal habits of the employee to produce adverse health effects. Most OELs address airborne exposures, but some substances can be absorbed directly through the skin and mucous membranes.

Most OELs are expressed as a TWA exposure. A TWA refers to the average exposure during a normal 8- to 10-hour workday. Some chemical substances and physical agents have recommended short-term exposure limits (STEL) or ceiling values. Unless otherwise noted, the STEL is a 15-minute TWA exposure. It should not be exceeded at any time during a workday. The ceiling limit should not be exceeded at any time.

In the United States, OELs have been established by federal agencies, professional organizations, state and local governments, and other entities. Some OELs are legally enforceable limits; others are recommendations.

- OSHA, an agency of the U.S. Department of Labor, publishes PELs [29 CFR 1910 for general industry; 29 CFR 1926 for construction industry; and 29 CFR 1917 for maritime industry]. These legal limits are enforceable in workplaces covered under the Occupational Safety and Health Act of 1970.
- NIOSH recommended exposure limits (RELs) are recommendations based on a critical review of the scientific and technical information and the adequacy of methods to identify and control the hazard. NIOSH RELs are published in the *NIOSH Pocket Guide to Chemical Hazards* [NIOSH 2007]. NIOSH also recommends risk management practices (e.g., engineering controls, safe work practices, employee education/training, PPE, and exposure and medical monitoring) to minimize the risk of exposure and adverse health effects.
- Another set of OELs commonly used and cited in the United States includes the TLVs, which are recommended by ACGIH. The ACGIH TLVs are developed by committee members of this professional organization from a review of the published, peer-reviewed literature. TLVs are not consensus standards. They are considered voluntary exposure guidelines for use by industrial hygienists and others trained in this discipline "to assist in the control of health hazards" [ACGIH 2023].

Outside the United States, OELs have been established by various agencies and organizations and include legal and recommended limits. The Institut für Arbeitsschutz der Deutschen Gesetzlichen Unfallversicherung (Institute for Occupational Safety and Health of the German Social Accident Insurance) maintains a database of international OELs from European Union member states, Canada (Québec), Japan, Switzerland, and the United States. The database, available at https://www.dguv.de/ifa/gestis/gestis-stoffdatenbank/index-2.jsp, contains international limits for more than 2,000 hazardous substances and is updated periodically.

OSHA (Public Law 91-596) requires an employer to furnish employees a place of employment free from recognized hazards that cause or are likely to cause death or serious physical harm. This is true in the absence of a specific OEL. It also is important to keep in mind that OELs may not reflect current health-based information.

When multiple OELs exist for a substance or agent, NIOSH investigators generally encourage employers to use the lowest OEL when making risk assessment and risk management decisions.

Respirable Crystalline Silica

Silica, or silicon dioxide, occurs in a crystalline or noncrystalline (amorphous) form. In crystalline silica, the silicon dioxide molecules are oriented in a fixed pattern versus the random arrangement of the amorphous form. The more common crystalline forms in workplace environments are quartz and cristobalite, and to a lesser extent, tridymite. Occupational exposures to RCS (quartz and cristobalite) have been associated with silicosis, lung cancer, pulmonary tuberculosis disease and other airway diseases, kidney disease, and autoimmune disorders.

Silicosis is an irreversible but preventable fibrotic disease of the lung caused by the deposition of fine crystalline silica particles in the lungs. Silicosis is caused by the inhalation and deposition of crystalline silica particles that are 10 μm or less in diameter. Particles 10 μm and smaller are considered respirable particles and have the potential to reach the lower portions of the human lung (alveolar region). Although particle sizes 10 μm and smaller are considered respirable, some of these particles can be deposited before they reach the alveolar region [Hinds 1999].

Symptoms of silicosis usually develop insidiously, with cough, shortness of breath, chest pain, weakness, wheezing, and nonspecific chest illnesses. Silicosis usually occurs after years of exposure (chronic) but may appear in a shorter period of time (acute) if exposure concentrations are very high. Acute silicosis is typically associated with a history of high exposures from tasks that produce small particles of airborne dust with a high silica content [NIOSH 1986]. Even though the carcinogenicity of crystalline silica in humans has been strongly debated in the scientific community, the International Agency for Research on Cancer (IARC) in 1996 concluded that there was "sufficient evidence in humans for the carcinogenicity of inhaled crystalline silica in the form of quartz or cristobalite from occupational sources" [IARC 1997]. Several other serious diseases from occupational exposure to crystalline silica include lung cancer and noncancerous disorders such as immunologic disorders and autoimmune diseases, rheumatoid arthritis, renal diseases, and increased risk of developing tuberculosis disease after exposure to the infectious agent [NIOSH 2002].

When proper practices are not followed or controls are not maintained, RCS exposures can exceed the OSHA PEL, NIOSH REL, or the ACGIH TLV. The OSHA PEL and NIOSH REL for RCS are both 50 μg/m^3 [NIOSH 2007; OSHA 2016]. The ACGIH TLV for quartz is 25 μg/m^3 as an 8-hour TWA [ACGIH 2023]. The OSHA AL for RCS is 25 μg/m^3 [OSHA 2016].

Section D: References

Discussion

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