National Institute for Occupational Safety and Health

NIOSH

Comments to OSHA

Comments of the National Institute for Occupational Safety and Health on the Occupational Safety and Health Administration (OSHA) proposed rule (PR) on *Occupational Exposure to Respirable Crystalline Silica*

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The National Institute for Occupational Safety and Health (NIOSH) has reviewed the Occupational Safety and Health Administration (OSHA) proposed rule (PR) on *Occupational Exposure to Respirable Crystalline Silica* published in the *Federal Register* (FR) on September 12, 2013 [78 FR 56274]. Occupational exposures to respirable crystalline silica are associated with the development of silicosis, lung cancer, pulmonary tuberculosis (TB), and airways diseases. These exposures may also be related to the development of autoimmune disorders, chronic renal disease, and other adverse health effects. The adverse health effects of exposure to respirable crystalline silica are well-known, long lasting, and preventable. In 1974, NIOSH published "Criteria for a Recommended Standard: Occupational Exposure to Crystalline Silica" recommending that the exposure limit be reduced to 50 micrograms per cubic meter ($\mu g/m^3$), the level proposed in the PR [NIOSH 1975]. The current proposal by OSHA of a comprehensive respirable crystalline silica standard, including the proposed permissible exposure level (PEL) of 50 $\mu g/m^3$, is consistent with the NIOSH recommended exposure limit (REL). This standard is measurable by techniques that are valid, reproducible, attainable with existing technologies, and available to industry and government agencies. NIOSH supports the OSHA proposal, and offers the following comments on the A) OSHA questions; B) other parts of the preamble text; C) regulatory text. Mention of any company or product does not constitute endorsement by NIOSH.

A. Comments on OSHA Questions in the preamble

I. Issues

NIOSH provides the following responses to questions in the PR.

Health Effects

2. *Using currently available epidemiologic and experimental studies, OSHA has made a preliminary determination that respirable crystalline silica presents risks of lung cancer, silicosis, and non-malignant respiratory disease (NMRD) as well as autoimmune and renal disease risks to exposed workers. Is this determination correct? Are there additional studies or other data OSHA should consider in evaluating any of these adverse health risks? If so, submit the studies (or citations) and other data and include your reasons for finding them germane to determining adverse health effects of exposure to crystalline silica.*

NIOSH recommends adding the recent studies by Liu et al. [2013] and Chen et al. [2012]. The former has important information about the quantitative relationship between silica exposure and lung cancer and the latter suggests a potential role for silica exposure in risk for cardiovascular disease. Lung cancer risk is reviewed in a recent report by Steenland and Ward [2013].

Risk Assessment

3. *OSHA has relied upon risk models using cumulative respirable crystalline silica exposure to estimate the lifetime risk of death from occupational lung cancer, silicosis, and NMRD among*

exposed workers. Additionally, OSHA has estimated the lifetime risk of silicosis morbidity among exposed workers. Is cumulative exposure the correct metric for exposure for each of these models? If not, what exposure measure should be used?

Cumulative exposure is a standard and appropriate metric for irreversible effects that occur soon after the actual exposure experience. For lung cancer and non-malignant respiratory disease mortality (NMRD) mortality, a cumulative exposure (lagged for cancer) is fully justified [Checkoway et al. 2004], although there is evidence of attenuation at higher exposures [Stayner et al. 2003]. The NIOSH risk assessments for NMRD mortality and silicosis incidence [Park et al. 2002] were restricted to observation at lower cumulative exposures for that reason. For silicosis, silica exposures at different intervals in the past make different contributions to the silicosis incidence rate [Park and Chen 2013], but for silicosis risk assessment purposes, cumulative exposure is a reasonable and practical choice.

4. Some of the literature OSHA reviewed indicated that the risk of contracting accelerated silicosis and lung cancer may be non-linear at very high exposures and may be described by an exposure dose rate health effect model. OSHA used the more conservative model of cumulative exposure that is more protective to the worker. Are there additional data to support or rebut any of these models used by OSHA? Are there other models that OSHA should consider for estimating lung cancer, silicosis, or NMRD risk? If so, describe the models and the rationale for their use.

Because low-dose behavior is what drives a risk assessment, the high-dose exposure-response is not relevant for regulatory considerations provided the selected models accommodate it. The possibly nonlinear effects at very high silica levels leading to acute and rapidly fatal silicosis would be entirely outside the range of permissible, regulated exposures.

6. Steenland et al. (2001a) pooled data from 10 cohort studies to conduct an analysis of lung cancer mortality among silica-exposed workers. Can you provide quantitative lung cancer risk estimates from other data sources? Have or will the data you submit be peer-reviewed? OSHA is particularly interested in quantitative risk analyses that can be conducted using the industrial sand worker studies by McDonald, Hughes, and Rando (2001) and the pooled center-based case-control study conducted by Cassidy et al. (2007).

Regarding data from other sources, Cassidy et al. did not report fits of models using a continuous exposure metric, although a linear exposure-response estimate could be derived from their findings. To our knowledge, there are no other sources than those considered in detail in the OSHA document.

7. OSHA has made a preliminary determination that the available data are not sufficient or suitable for quantitative analysis of the risk of autoimmune disease, stomach cancer, and other cancer and non-cancer health effects. Do you have, or are you aware of, studies, data, and rationale that would be suitable for a quantitative risk assessment for these adverse health effects? Submit the studies (or citations), data, and rationale.

NIOSH is not aware of additional studies or data. If such data were available for risk assessment purposes, it is unlikely that they would justify a PEL above the currently proposed PEL.

Technological and Economic Feasibility of the Proposed PEL

9. *What are the job categories in which employees are potentially exposed to respirable crystalline silica in your company or industry? For each job category, provide a brief description of the operation and describe the job activities that may lead to respirable crystalline silica exposure. How many employees are exposed, or have the potential for exposure, to respirable crystalline silica in each job category in your company or industry? What are the frequency, duration, and levels of exposures to respirable crystalline silica in each job category in your company or industry? Where responders are able to provide exposure data, OSHA requests that, where available, exposure data be personal samples with clear descriptions of the length of the sample, analytical method, and controls in place. Exposure data that provide information concerning the controls in place are more valuable than exposure data without such information.*

NIOSH recently conducted multiple site visits to on-shore oil and gas extraction well sites to investigate and characterize potential occupational chemical exposures in this industry. Exposures to respirable crystalline silica during hydraulic fracturing operations are one focus of this research. The collected data will facilitate implementation of controls to decrease hazards associated with these exposures and prevent injuries and illnesses to workers in that industry.

Esswein et al. [2013] recently published the results of an 11-site, 5-state NIOSH study of oil and gas industry workers exposed to respirable crystalline silica during the hydraulic fracturing process. To our knowledge, this is the only comprehensive evaluation of respirable crystalline silica in this industry and encompasses 15 job categories during hydraulic fracturing. NIOSH suggests that OSHA include Esswein et al. [2013] in Appendix A (Hydraulic fracturing) of the OSHA Preliminary Economic Assessment.

Sand containing crystalline silica (quartz) is used as a proppant to hold open the fissures created by hydraulic pressure during hydraulic fracturing operations. Each stage of the process requires hundreds of thousands of pounds of quartz-containing sand; four to five million pounds may be needed for all zones of a well. Workers may be exposed to respirable crystalline silica dust from offloading sand from transport trucks and mechanical handling of sand during hydraulic fracturing.

To characterize these exposures, NIOSH collected 111 voluntary personal breathing zone samples for respirable silica at hydraulic fracturing sites in multiple states. Workers sampled included 15 job titles that comprised most members of a hydraulic fracturing crew. These job titles included blender operator, chemical truck operator, fueler, hydration unit operator, mechanic, data van operator, pump truck operator, quality control technician, roving operator, sand coordinator, sand truck driver, sandmover operator, T-belt operator, water tank operator, and wireline operator (detailed descriptions of each job are available from NIOSH). The job activities of many workers involved offloading sand from the sand delivery trucks to a sand holding/transport vehicle (i.e., a "sand mover"). Sand movers supply sand to blender trucks via a motor-driven belt assembly near sand mover operator stations. The use of multiple sand movers and transfers to a T-belt to convey the sand between the sand movers and the blender truck is increasingly common. The sand remains dry until it enters the wet section of the blender before being pumped through a manifold, connection piping, and into the wellbore. During this sand-moving process, uncontrolled silica can become airborne and present an inhalation hazard for workers in the immediate area.

At each of the 11 sites NIOSH collected full-shift personal breathing zone samples for particulates and silica using personal sampling pumps connected to pre-weighed, 5 micrometer polyvinyl chloride (PVC) filters in three-piece, 37-millimeter polystyrene cassettes. The respirable fractions of dust were captured using BGI model GK2.69 cyclones. All samples were analyzed at an accredited laboratory according to the NIOSH Manual of Analytical Methods (NMAM) Method 0600 for gravimetric analysis of respirable particulates and NMAM Method 7500, X-ray diffraction (XRD) analysis for crystalline silica. Many full-shift samples exceeded occupational health criteria (e.g., the OSHA PEL, the NIOSH REL, and the American Conference of Governmental Industrial Hygienists (ACGIH®) Threshold Limit Value (TLV®) by ten or more times the occupational health criteria, in some cases. Workers with jobs near sand handling equipment were over-exposed most often. Job titles with the highest geometric mean silica exposures included T-belt operators (0.327 mg/m^3) and sand mover operators (0.259 mg/m^3). Workers with lower geometric mean silica exposures included blender operators (0.091 mg/m^3) and hydration unit operators (0.072 mg/m^3). Workers with the lowest geometric mean silica exposures included sand coordinators (0.054 mg/m^3) and water tank operators (0.048 mg/m^3). Overall, 51.4% of all samples collected in the study were above the OSHA PEL [Esswein et al. 2013].

Workers at those sites used personal protective equipment (PPE) including filtering-facepiece respirators, half-face elastomeric respirators, full face air-purifying respirators (APRs) with P-100 cartridges, and combination acid gas/P-100 cartridges. However, NIOSH determined that PPE use was ineffective because most workers wearing respirators had visible facial hair that was in contact with the sealing surface of the respirator, did not understand how to properly wear or store the respirators, and did not participate in a formal respiratory protection program.

NIOSH observed ineffective efforts to use engineering controls at some sites. Cotton (muslin) cloth sacks were attached to the ends of fill ports on sand movers, possibly to contain or capture dust ejected from the fill ports during bin filling. NIOSH determined the sacks to be ineffective; the bags were torn or degraded and visible dust was emitted during bin filling. Similarly, muslin bags atop thief hatch covers were not effective because dust was observed leaking from the bags during operation.

15. OSHA requests the following information regarding engineering and work practice controls to control exposure to crystalline silica in your workplace or industry:

...e. Describe additional engineering and work practice controls that could be implemented in each operation where exposure levels are currently above the proposed PEL to further reduce exposure levels.

NIOSH suggests the following engineering and work practice controls for eight primary points of crystalline silica-containing dust release or generation observed during site visits of hydraulic fracturing operations [Esswein et al. 2013]:

1) Exposure point: Dust ejected from thief hatches on top of sand movers during refilling operations
   Control: Retrofit technology such as the NIOSH mini-baghouse assembly, local exhaust ventilation such as stand-alone portable baghouse units which connect to the thief hatches on sand movers.
2) Exposure point: Dust ejected and pulsed through side fill ports on the sand movers during refilling operations
   Control: Assure that caps are on all fill ports on each side of the sand mover.
3) Exposure point: Dust generated by on-site truck vehicle traffic including sand trucks and crew trucks, the release of air brakes on sand trucks, and wind
   Control: Use commercially available dust suppression agents (not well brines) and apply to lease roads, around the well pad; slow truck traffic to reduce dust generation.
4) Exposure point: Dust released from the transfer belt under the sand movers
   Control: Attach clear plastic stilling/staging curtains around the lower perimeter of the sand movers.
5) Exposure point: Dust created as sand drops into, or is agitated in the blender hopper and on transfer belts
   Control: Use misting at the blender.
6) Exposure point: Dust released from operations of transfer belts between the sand mover and the blender
   Control: Use shrouding around the T-belt, modify the T-belt to sit lower in the T-belt frame assembly.
7) Exposure point: Dust released from the top of the dragon tail on sand movers
   Control: Minimize the drop distance of the sand from the dragon tail to the blender or T-belt and use enclosures on the dragon tail, using skirting and shrouding at the end of the dragon tail.
8) Exposure point: Dust released from worker's clothing can affect workers around sand moving equipment (sand-mover and blender truck operators), in cabs, crew rooms, break areas, trailers, and other areas, and when protective (fire retardant) clothing is doffed due to accumulated silica dust being released in the air. NIOSH confirmed visually that dust was released, resulting in re-suspension of silica particles and risks for inhalation exposures to workers in the area.
   Control: Clothes cleaning technology developed by NIOSH that is described in the responses to OSHA questions 51 and 66.

Provisions of the Standards—Scope

30. *OSHA's Advisory Committee on Construction Safety and Health (ACCSH) has historically advised the Agency to take into consideration the unique nature of construction work environments by either setting separate standards or making accommodations for the differences in work environments in construction as compared to general industry. ASTM, for example, has separate silica standards of practice for general industry and construction, E 1132-06 and*

E 2625-09, respectively. To account for differences in the workplace environments for these different sectors, OSHA has proposed separate standards for general industry/maritime and construction. Is this approach necessary and appropriate? What other approaches, if any, should the Agency consider? Provide a rationale for your response.

NIOSH agrees with the Advisory Committee on Construction Safety and Health (ACCSH) recommendation and strongly supports the proposal of a separate silica standard for construction. Unlike other industries, where production conditions are relatively similar day to day, construction conditions change as the building project progresses. Work is more temporary in nature and workplaces are shared by multiple employers and trades. OSHA has a record of successfully tailoring standards for construction with other health hazards such as asbestos, lead, and hexavalent chromium. NIOSH endorses this approach for silica as necessary and appropriate.

33. *Should OSHA limit coverage of the rule to materials that contain a threshold concentration (e.g., 1%) of crystalline silica? For example, OSHA's Asbestos standard defines "asbestos-containing material" as any material containing more than 1% asbestos, for consistency with EPA regulations. OSHA has not proposed a comparable limitation to the definition of respirable crystalline silica. Is this approach appropriate? Provide the rationale for your position.*

NIOSH does not support limiting coverage of the rule to materials that contain a threshold concentration (e.g., 1%) of crystalline silica. Achievable Limits of Detection (LOD) and Limits of Quantitation (LOQ) of crystalline silica are unknown because inter-laboratory "round robin" studies to determine these limits have not been conducted. In addition, there are no available reference materials at this level against which accuracy can be assessed. It is very likely that the LOD and LOQ vary according to other materials in the bulk composition and the capabilities of the detection system. The OSHA Hazard Communication Standard has a requirement for listing the silica content of bulk materials above 0.1%, implying that quantitative measurements can be made at this level. However, in response to an inquiry concerning interpretation (February 11, 1991 - Label requirements for crystalline silica), OSHA stated: "*While OSHA does not take bulk samples of products to analyze for respirable crystalline silica, our Analytical Laboratory has confirmed that there is no validated method to perform such an analysis.*" [https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=INTERPRETATIONS&p_id=20191].

Verma et al. [2002] evaluated a method for bulk analysis between 1% and 75% and concluded that it could be used to determine to 1% in routine analyses but was ineffective below 1%. A more recent method evaluation [Martin et al. 2012] suggests that it may be very difficult to go much below 1%, even using XRD with Rietveld refinement (LOQ = 0.76%). Thus, any reported measurements below 1% are open to doubt.

More recent studies have been published (Radnoff and Kutz [2013], Meeker et al. [2005, 2006]); however, it is not possible to conclude whether materials with less than 1% silica can contribute to exposures greater than the action level in the absence of other silica sources. Several important issues should be considered: 1) a valid analytical method for bulk silica analyses below 1% is not available and advertised analyses below this level should be suspect; 2) users of products containing <1% silica may not be aware that the silica content of other materials in the process can contribute to overall exposure; and 3) materials containing less than 1% silica can be handled in ways that generate respirable crystalline silica in significant concentrations if respirable particles containing silica are more likely than others to become airborne. Although NIOSH has done no studies to determine whether this occurs with silica, it is well-known that bulk materials containing less than 1% asbestos can liberate fibers in sufficient concentration to be hazardous.

Matrix effects, particularly in XRD but also in infrared air sample analysis methods, interfere with the accurate or reliable determination of silica at less than 1% of the sample, regardless of on-filter sample load. The current PEL (NIOSH does not have a REL) for Particles Not Otherwise Regulated, Respirable (PNOR-RF) of 5 mg/m^3 could include the proposed PEL of 50 μg/m^3 respirable crystalline silica (i.e., 1%) and this would be just measurable in a filter sample due to the matrix effects. Therefore, it would be possible to determine that the proposed PEL for respirable crystalline silica had been exceeded in samples marginally below the PEL for PNOR-RF, but it would not be possible to determine whether or not the proposed action level for respirable crystalline silica (0.025 mg/m^3) had been exceeded. In order to ensure respirable crystalline silica concentrations were maintained below the action level given this limitation on sample analysis, employers would not want to exceed a concentration of 2.5 mg/m^3 for PNOR-RF.

Provisions of the Standards—Definitions

35. *Competent person. OSHA has proposed limited duties for a competent person relating to establishment of an access control plan. The Agency did not propose specific requirements for training of a competent person. Is this approach appropriate? Should OSHA include a competent person provision? If so, should the Agency add to, modify, or delete any of the duties of a competent person as described in the proposed standard? Provide the basis for your recommendations.*

General comment

NIOSH strongly supports the inclusion of silica-competent person provisions in the construction silica standard. Competent persons play a crucial role in construction safety and health practice [AIHA 2013]. Construction has numerous small employers, and some cannot support a full-time safety and health employee. However, small employers can arrange hazard-specific training or skills development for personnel such as site supervisors. Pairing these safety and health capabilities with employer authorization to evaluate and control hazards on the job can help ensure employee protection on small employer worksites.

The use of competent persons is accepted well in the construction industry. For example, it is included in many American National Standards Institute (ANSI) Construction and Demolition Operations A10 standards, which are developed by construction stakeholders for the industry. Competent persons are integrated into the OSHA General Safety and Health Provisions for Construction (1926.20) which call for *"...frequent and regular inspections of the job sites, materials, and equipment to be made by competent persons designated by the employers."* NIOSH and its state partners routinely include recommendations addressing the need for, and role of, competent persons in construction investigation reports conducted under our Fatality Assessment and Control Evaluation (FACE) program (see http://www.cdc.gov/niosh/face/).

Silica goals developed under the auspices of the National Occupational Research Agenda (NORA) by construction stakeholders mentioned the need for awareness and training materials about silica exposures, resulting illnesses, and exposure control solutions and model practices for groups such as site safety and competent persons [NORA 2008].

Training requirements

NIOSH supports including specific training requirements for silica-competent persons. OSHA required competency training for the construction asbestos standard [1926.1101(0) (4)]. NIOSH recommends a similar approach in the current proposal to specify needed competencies and ensure that the competent person provisions are effective.

OSHA could consider allowing appropriate experience to qualify (e.g., learning by apprenticing to a trained silica-competent person.) For example, ANSI A10.38 (Basic elements of an employer's program to provide a safe and healthful work environment) defines a competent person as: *"One who, as a result of specific education, training,* ***and/or experience,*** *is capable of identifying existing and predictable hazards in the surroundings of working conditions that are unsanitary, hazardous or dangerous to employees, and who has the authorization and responsibility to take prompt corrective measures to eliminate them"* (emphasis added) [ASSE 2013].

NIOSH suggests that OSHA provide a list of specific silica competencies and capabilities in the standard or an appendix. This information would provide an important framework for the development of competent person training materials and the meaningful evaluation of experience by employers.

Scope of duties

NIOSH recommends including explicit silica-competent person duties such as: 1) help determine whether silica is present prior to start of a project; 2) assess the potential for planned tasks and tools to create silica overexposures; 3) implement needed controls, practices, and personal protective equipment as needed; 4) perform regular checks for Table 1 and other tasks to assure that required engineering controls are used, are functioning properly, and are maintained in proper operating condition; 5) perform regular checks to assure that required personal protective equipment is used, functioning properly, and maintained in proper operating condition; 6) assure that appropriate hygiene steps are taken to prevent taking silica dust home on clothing; and 7) work with qualified persons to assess the adequacy and relevance of any exposure monitoring required by the standard. The duties also might include specific daily checks for cases where sandblasting is performed.

OSHA requested comments on whether the agency should add to, modify, or delete any of the "limited duties" of a competent person to establish an access control plan as described in the proposed standard. NIOSH recommends expanding these duties in a manner consistent with other OSHA standards. Safety standards such as Cranes and Derricks, Excavation, Fall Protection, Scaffolding, and Steel Erection include multiple competent person duties involving visual inspections, evaluation of precautionary measures, supervision, training, and stopping of unsafe work when changes are needed. Construction health standards such as asbestos, lead, and cadmium also rely on expanded competent person duties such as a) identification of existing and potential hazards; b) methods for controlling hazards; c) ensuring that engineering controls are functioning properly; and d) ensuring that employees are using proper work practices [OSHA 1926.1101(o)(3)(i); 1926.62 (e)(2)(iii);1926.1127(b)]. These important and relevant duties allow confidence that efforts by small employers to comply with the standard will produce the intended results.

The need for expanding the duties of the silica-competent person is especially important when employers plan to rely on Table 1 because it is less likely that an industrial hygienist will visit the project to evaluate the job, collect air samples, or check the effectiveness of controls. Effectiveness deteriorates when controls or personal protective equipment (PPE) are not maintained; this performance degradation may not be obvious to workers using the devices. NIOSH emphasized the importance of maintaining dust control systems in good working order in Alerts for sandblasting and construction [NIOSH 1992, 1996]. NIOSH recommends that OSHA add language to ensure that competent persons perform daily checks on controls and respirators used for abrasive blasting because of extremely high respirable silica levels that can be generated by this operation.

The NIOSH [2009a] Workplace Solutions publication titled "Control of Hazardous Dust When Grinding Concrete" provides several recommendations reinforcing the importance of checking on controls, such as:

- Shake the hose as needed to loosen the settled dust and prevent the hose from clogging.
- If dust is escaping, turn off the unit and clean or change the filter as recommended by the manufacturer. Sometimes the build-up on the filter can be dislodged by simply moving or shaking the cleaner, or turning the motor off and on a few times. Build-up on the filters slows down the air flow through the system and reduces dust capture.
- Change vacuum cleaner bags before they leak.

PEL and Action Level

39. OSHA has proposed a single PEL for respirable crystalline silica (quartz, cristobalite, and tridymite). Is a single PEL appropriate, or should the Agency maintain separate PELs for the different forms of respirable crystalline silica? Provide the rationale for your position.

OSHA's preliminary conclusion that respirable cristobalite and quartz have similar health risks is supported by the NIOSH health effects review cited by OSHA [NIOSH 2002], and a single PEL for these two substances is appropriate. Tridymite is extremely rare in workplaces, so a separate PEL probably cannot be supported by epidemiologic evidence and may not be warranted for this material.

Exposure Assessment

43. OSHA is proposing to allow employers to initially assess employee exposures using air monitoring or objective data. Has OSHA defined "objective data" sufficiently for an employer to know what data may be used? If not, submit an alternative definition. Is it appropriate to allow employers to use objective data to perform exposure assessments? Explain why or why not.

This question is important because of dynamic conditions inherent in construction. Various construction-related factors can impact exposure levels including the type of task, tool, and controls, other nearby dust sources, the open or enclosed nature of the task location, and maintenance of equipment and controls. Even tool consumables can affect exposure–for example, a diamond tip saw will cut more quickly than an abrasive wheel saw, which affects exposures [HSE 2010].

NIOSH notes the wording used for the current "objective data" definition proposed by OSHA is general and may not be defined sufficiently for employers to know what data may be used. The language mentions exposure "*...associated with a particular product or material, or a specific process, operation, or activity*" and that "*The data must reflect workplace conditions closely resembling the processes, types of material, control methods, work practices, and environmental conditions in the employer's current operations.*" The language used also varies with closely related sections. For example, section (d)(4) calls for additional sampling when 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 action level.*" Types of materials and environmental conditions are not mentioned in this section. Section (j)(2)(i) on objective data recordkeeping provides a list of required data elements that includes: D) a description of the process, operation, activity and how the data support the assessment, and E) other data relevant to the process, operation, activity, material, or employee. However, controls and environmental conditions are not explicitly mentioned in this section.

At least two studies examined the collection of objective exposure-related data during exposure assessment. Flanagan et al. [2006] compiled and evaluated construction silica exposure data from 13 private, research, and regulatory groups. An effort was made to collect as much detail as possible about task, tool, and environmental and control conditions. Considerable data gaps existed. For example, 17.4% of the measurements did not include the construction task, 26.2% did not mention the type of tool being used, 74.6% did not mention if there were other nearby dust sources, and 61.9% did not mention if the work task environment was open or enclosed. Sauvé et al. [2013] assembled a database of construction silica exposures from 115 sources of data published between 1987 and 2009. These investigators reported that the percentage of measurements with unreported descriptions for these determinants—construction sector (e.g. residential, road building), project type, workspace, use of ventilation and control methods—ranged from 15% to 31%. Type of tool in use was absent for 29% of measurements and type of material being worked on was absent for 25%.

These studies suggest that the collection of important exposure determinant information is not routine or consistent. Thus, the objective data definitions would benefit greatly from additional specificity and examples. This information could be provided in the standard itself or an appendix. Collecting additional information on relevant exposure determinants during sampling is not burdensome and results in higher quality data that can be used with a higher degree of confidence to predict future exposures. Collecting information on exposure determinants provides an added benefit for employers; where overexposures are found, this information helps employers and competent persons address likely causes and conditions.

NIOSH suggests that OSHA consider previous guidance on this topic created for the OSHA Lead in Construction standard. OSHA Instruction CPL 2-2.58 includes caveats to help employers and professionals understand this term. For example, it states "*This means that all factors which could significantly affect variation between historic and current conditions must be identified and assessed by the employer as part of the initial determination*" and "*If the state of such variable factors was not noted at the time the historic work data was collected, then it is unknown whether the data would reflect current exposures, and the data may not be substituted for initial monitoring*" [OSHA 1993].

In summary, NIOSH recommends that OSHA add specificity to the current definitions and requirements. Useful terms to add are "task", "tool", "presence of other dust sources", and "open or enclosed nature of work area.." NIOSH offers the following definition:

Objective data means existing information that can be used to reasonably infer employee exposures about a current or future task. The tasks being compared must have similar exposure factors such as work operation, materials used, tools, work practices, production conditions, control methods, and environmental conditions (such as presence of other dust sources and open or enclosed nature of work area). Existing information can include air monitoring data from previous employer or industry surveys, or calculations based on the composition or chemical and physical properties of a substance. Information with partial or missing exposure factor information cannot be used.

46. OSHA is proposing specific requirements for laboratories that perform analyses of respirable crystalline silica samples. The rationale is to improve the precision in individual laboratories and reduce the variability of results between laboratories, so that sampling results will be more reliable. Are these proposed requirements appropriate? Will the laboratory requirements add necessary reliability and reduce inter-lab variability, or might they be overly proscriptive? Provide the basis for your response.

NIOSH agrees with OSHA that additional laboratory requirements are needed to increase reliability and reduce inter-laboratory variability. NIOSH has conveyed recommendations to laboratories in publications [Eller et al. 1999] and through the American Industrial Hygiene Association (AIHA) laboratory quality programs. However, NIOSH notes that without on-site audits by laboratory accreditation services, a user of laboratory services cannot be assured that these requirements are performed in all cases. Therefore, NIOSH supports the proposed accreditation requirement of 29 CFR 1910.1053 (d)5(ii)A (page 56487). NIOSH is aware that laboratory accreditation alone does not ensure good analyses, and recommends that providers of proficiency test materials make samples closer to loadings expected at the proposed PEL and action level using current samplers operating near a 2 liter per minute flow-rate.

47. Has OSHA correctly described the accuracy and precision of existing methods of sampling and analysis for respirable crystalline silica at the proposed action level and PEL? Can worker exposures be accurately measured at the proposed action level and PEL? Explain the basis for your response, and provide any data that you believe are relevant.

NIOSH suggests that OSHA consider recent publications on cyclone performance such as Lee et al. [2010, 2012]. Lee et al. [2010] found that a more optimal flow of 4.4 liters per minute (L/min) for the GK2.69 (BGI, Inc.) cyclone met the International Organization for Standardization/European Standardization Committee (ISO/CEN) respirable convention. The Lee et al. findings were confirmed by Stacey et al. [2014], although the latter study found that the bias at the manufacturer's recommended flow-rate of 4.2 L/min met the ISO/CEN requirements for cyclone performance. The results of those two studies do not imply that the optimal flow-rate for the GK2.69 is uncertain; either 4.4 L/min or 4.2 L/min can be used to meet the ISO convention within acceptable limits. Other studies have investigated the role of sampling pump pulsation on cyclone performance and established criteria for acceptability [Lee et al. 2013a,b]. Results from these and other recent studies support the proposed rule's description of the accuracy and precision of existing methods for respirable crystalline silica sampling and analysis at the proposed action level and PEL [Lee et al. 2010, 2012; Coggins et al. 2013; Stacey et al. 2013]. However, sampling and analysis of silica at an action level and PEL below the proposed levels would be difficult to achieve without samplers with higher flow-rates than proposed. In addition, higher flow-rate sampling may require large, heavy cyclones and personal sampling pumps that workers may resist wearing [Coggins et al. 2013]. Cyclones operating at or slightly above 4 L/min offer a current compromise between the need for larger sample volumes and wearing burdensome equipment. Studies of sampler performance [Lee et al. 2010, 2012] are simple to perform in a laboratory. Comparison of high flow-rate and low flow-rate samplers in the field requires large numbers of samples with quantifiable silica loadings [Carballo Menéndez et al. 2013] and these have been difficult to achieve with lower flow-rate samples in many studies performed by NIOSH. However, data from different sites are being accumulated by NIOSH and a merged set of side-by-side samples suitable for estimating field equivalency will be made available.

Investigations of accuracy of sampling for airborne particles determined that large proportions of particles passing through the sampler opening can deposit in the sampler other than on the filter. This loss has been documented specifically for quartz in proficiency test and field samples using Dorr-Oliver 10-mm nylon cyclones for sample collection [Dobson et al. 2005]. Published guidance from NIOSH authors recommends that internal non-filter deposits form part of the sample and should be incorporated in the analysis [Ashley and Harper 2013]. Although respirable gravimetric sampling is discussed, the recommendations do not specifically address silica sampling issues. OSHA collects silica field samples using OSHA gravimetric Method PV2121 for PNOR-RF (polyvinyl chloride (PVC) filters with aluminum cones). Their laboratory procedure is to wipe the inside of the aluminum capsule with the filter prior to digestion for all samples; however, this step is not included in text of their Method ID-142. NIOSH recommends that OSHA update Method ID-142 to include the use of the PVC filter with aluminum cone and the procedure for wiping the internal surface of the cone. Other laboratories often do not receive samples collected on the PVC filter plus aluminum cone assembly; typically, only a filter is used inside the cassette. Many, but not all, laboratories wipe particles from the internal surfaces of the cassette and include the wipe material in the analysis. NIOSH is currently reviewing the NIOSH Manual of Analytical Methods for silica sampling and analysis with a view to specifically including this or a similar procedure. NIOSH will also evaluate currently available PVC versions of an internal capsule bonded to a filter, which could be ashed by muffle furnace or low-temperature plasma asher to reduce the need for a manual wipe procedure. The use of static-dissipative cassettes to minimize electrostatic attraction of particles to the cassette walls is an alternative NIOSH recommendation if an internal capsule is not used. NIOSH is currently researching potential bias from not wiping the internal surfaces of static-dissipative cassettes. The need for incorporating non-filter deposits in cyclones other than the Dorr-Oliver 10-mm nylon cyclone has not yet been established. In NIOSH tests of the GK2.69 cyclone, static-dissipative cassettes were used.

Regulated Areas and Access Control

49. Where exposures exceed the PEL, OSHA has proposed to provide employers with the option of either establishing a regulated area or establishing a written access control plan. For which types of work operations would employers be likely to establish a written access control plan? Will employees be protected by these options? Provide the basis for your position and include supporting information.

Based on the information available to us, NIOSH does not have any overall preference between the regulated area option or the written access control plan option. Regarding the protection offered by these options, NIOSH believes it would be helpful to specify that silica-competent persons regularly check to ensure that regulated areas and/or written access control plans are maintained properly (see response to question 35).

NIOSH strongly supports the need to protect construction bystanders from exposures via these options. Different construction trades often work adjacent to one another in shared spaces. Area sampling studies of exposures adjacent to the work involving silica suggest that overexposure conditions can occur. Two examples are quoted from the report "Preventing Silicosis and Deaths in Construction Workers" [NIOSH 1996]:

> **Bridge Demolition Case, May 1992**
> "At the demolition site of a small bridge, handheld drills and a concrete saw were used to weaken the structure. The commercial-type saw consisted of a steel diamond-tipped blade in a large portable circular-saw housing. The saw used water to prevent wear of the blade. Respiratory protection was not used by any of the workers present. For a worker using a handheld drill, a 45-minute personal air sample indicated a respirable quartz concentration of 0.78 mg/m^3. For a concrete saw operator, a 45-minute personal air sample indicated a respirable quartz concentration of 1.64 mg/m^3. Area air samples indicated concentrations of 0.0, 0.65, 1.96, and 2.15 mg/m^3 respirable quartz."
>
> **Multistory Building Renovation Case, August 1992**
> "During renovation of a high-rise office building (Figure 2), a plumber cut the concrete floor on each of the 16 floors to install rest room floor drains. He wore a disposable particulate respirator and used a floor-stand fan to direct dust out the window. A 350-minute personal air sample indicated a respirable quartz concentration of 14.2 mg/m^3. Area air samples indicated 3.2, 3.36, and 4.1 mg/m^3 respirable quartz. Other workers in the area (such as elevator mechanics) were exposed without respiratory protection."

Site and task-specific factors will determine whether bystanders working for the same employer or bystanders from other employers will experience exposures over the action level. Factors to consider include the number of workers involved in dust-creating tasks, the ability to reduce dust at the source using local exhaust ventilation, and the ability to use scheduling to minimize the presence of bystander trades.

51. OSHA is proposing limited requirements for protective clothing in the silica rule. Is this appropriate? Are you aware of any situations where more or different protective clothing would be needed for silica exposures? If so, what type of protective clothing and equipment should be required? Are there additional provisions related to protective clothing that should be incorporated into this rule that will enhance worker protection? Provide the rational and data that support your conclusions.

Questions 51 and 66 address the importance of worker clothing cleanliness.

NIOSH recommends that the NIOSH-designed and -tested clothes cleaning booth technology be listed as a possible option when dealing with contaminated work clothing.

The clothes cleaning booth system is an effective technique to clean dust-laden work clothing periodically during the workday to minimize workers' exposure to respirable silica dust and other contaminants.

Past studies have shown a significant increase in workers' respirable dust exposure from contaminated work clothing [Cecala and Thimons 1986] and NIOSH developed a clothes cleaning booth system that workers can use to minimize this exposure. The system uses a compressed air nozzle manifold to blow dust and contaminants from a worker's clothing in an enclosed booth [Cecala et al. 2007, 2008]. The cleaning booth safely captures the dust and contaminants from the worker's clothing and removes them to prevent further exposure of the worker, co-workers, or work environment. The units are now in use in many different industries around the world.

Because the clothes cleaning system uses compressed air to clean workers' clothing, the system was designed to comply with the current OSHA 29 CFR 1926.302(b)(4) which states: "*Compressed air shall not be used for cleaning purposes except where reduced to less than 30 p.s.i. and then only with effective chip guarding and personal protective equipment which meets the requirements of Subpart E of this part. The 30 p.s.i. requirement does not apply for concrete form, mill scale and similar cleaning purposes.*" (https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10690).

The clothes cleaning system is regulated to 30 pounds per square inch (psi) by a tamper-proof regulator. In addition, an in-line strainer captures any metal flakes or scaling blown towards an individual from the compressor or compressed air lines. This technology has been in use since 2001 without any reported cases of injury or harm from the system.

NIOSH supports efforts to minimize worker exposure to respirable dust liberated from their clothing. However, NIOSH does not recommend limiting the use of the clothes cleaning system only to those times when gross contamination of clothing occurs. NIOSH has not evaluated the frequency of using the clothes cleaning system; however, periodic use throughout the work day could help minimize dust exposure. Effective cleaning of contaminated clothing can be accomplished in less than one minute with the clothes cleaning system without contaminating the worker, co-workers, or the work environment.

52. In OSHA's cadmium standard (29 CFR 1910.1027(f)(1)(ii),(iii), and (iv)), the Agency established separate engineering control air limits (SECALs) for certain processes in selected industries. SECALs were established where compliance with the PEL by means of engineering and work practice controls was infeasible. For these industries, a SECAL was established at the lowest feasible level that could be achieved by engineering and work practice controls. The PEL was set at a lower level, and could be achieved by any allowable combination of controls, including respiratory protection. In OSHA's chromium (VI) standard (29 CFR 1910.1026), an exception similar to SECALs was made for painting airplanes and airplane parts. Should OSHA follow this approach for respirable crystalline silica in any industries or processes? If so, in what industries or processes, and at what exposure levels, should the SECALs be established? Provide the basis for your position and include supporting information.

NIOSH does not support the use of separate engineering control air limits (SECALS) in a new silica standard because the requirement to meet the PEL for these specific processes should be maintained.

Methods of Compliance

53. The proposed standards do not contain a requirement for a written exposure control program. The two ASTM standards for general industry and construction (E 1132-06, section 4.2.6, and E 2626-09, section 4.2.5) state that, where overexposures are persistent (such as in regulated areas or abrasive blasting operations), a written exposure control plan shall establish engineering and administrative controls to bring the area into compliance, if feasible. In addition, the proposed regulatory language developed by the Building and Construction Trades Department, AFL-CIO contains provisions for a written program. The ASTM standards recommend that, where there are regulated areas with persistent exposures or tasks, tools, or operations that tend to cause respirable crystalline silica exposure, the employer will conduct a formal analysis and implement a written control plan (an abatement plan) on how to bring the process into compliance. If that is not feasible, the employer is to indicate the respiratory protection and other protective procedures that will be used to protect employee(s) permanently or until compliance will be achieved. Should OSHA require employers to develop and implement a written exposure control plan and, if so, what should be required to be in the plans?

NIOSH suggests that a written plan would greatly improve reliability of the protection provided. The plan does not need to be complex or burdensome. It can be based on the common Job Hazard Analysis [OSHA 2002] approach used by construction safety and health professionals to address safety hazards.

Written plans help ensure accountability and consistency in the face of changing conditions, materials, tools, tasks, and personnel. For example, they can help silica-competent persons consider factors such as enclosed spaces and regulated areas when evaluating exposure potential. Silica-competent persons can use the written plans to explain expected silica exposures and controls to affected employees. They provide a simple mechanism to ensure that maintenance checks are performed and Table 1 conditions are maintained.

54. Table 1 in the proposed construction standard specifies engineering and work practice controls and respiratory protection for selected construction operations, and exempts employers who implement these controls from exposure assessment requirements. Is this approach appropriate? Are there other operations that should be included, or listed operations that should not be included? Are the specified control measures effective? Should any other changes be made in Table 1? How should OSHA update Table 1 in the future to account for development of new technologies? Provide data and information to support your position.

Response to 54, first question:

Fully implementing the exposure control methods described in Table 1 would not automatically ensure compliance with the proposed PEL. The employer must be careful to select equipment that is designed to fully comply with the intent of the requirements specified in Table 1. In addition, the engineering controls described in Table 1 are only effective when the employer ensures they are properly maintained and trains employees in their correct use. Periodic exposure monitoring would ensure that the employers who fully implement the exposure control methods in Table 1 meet the proposed PEL and that their equipment selection, maintenance practices, and employee training are effective. HSE [2012b] reviewed 36 publications on the effectiveness of tool-mounted dust controls (both vacuum and water) for use in construction and noted that effective dust control depended upon design of the hood or enclosure, user training and work practices, water or air flow rate, the type of vacuum used, and the work environment (indoor exposures tended to be higher due to the effect of dilution when the work occurred outside).

Response to 54, second, third, and fourth questions:

Are there other operations that should be included, or listed operations that should not be included? Are the specified control measures effective? Should any other changes be made in Table 1?

Based on a NIOSH laboratory evaluation and four field studies, NIOSH suggests that the operation of cutting fiber-cement boards (siding and trim) using handheld circular saws be included in Table 1. Those saws are equipped with polycrystalline diamond blades designed for cutting fiber-cement board [NIOSH 2014]. The use of water as a dust suppressant is incompatible with fiber-cement board as wet-cutting will damage the product:

Operation	Engineering and work practice control methods	Required air-purifying respirator (minimum assigned protection factor)	
		≤ 4 hr/day	> 4 hr/day
Using Handheld circular saws cutting fiber-cement boards (siding and trim)	Use circular saws equipped with shroud and dust collection system that can be connected to an external dust collector or shop vacuum Note: Additional	None............................	None.

	specifications: • Use outdoors • Use dust collector or shop vacuum with the saw in accordance with manufacturer specifications • Ensure dust collector or shop vacuum is maintained according to manufacturer recommendations • Ensure dust collector or shop vacuum is inspected daily for defects and that filters are changed according to manufacturer recommendations to prevent restricted air flow • Use polycrystalline diamond blade • Ensure saw blade is not excessively worn		

Fiber-cement boards can contain as much as 50% crystalline silica. Excessive exposures to respirable crystalline silica can occur when cutting this material without any engineering control measure [Lofgren et al. 2004; NIOSH 2013a].

The use of fiber-cement siding in construction and renovation is growing rapidly. From 1991 to 2010, the annual market share of fiber-cement siding in the United States climbed from 1% to 13% [US Census Bureau 2013]. In contrast, the market share of wood siding in residential construction decreased from 38% to 8% [US Census Bureau 2013]. The durability and appearance of fiber-cement siding, which simulates wood without the maintenance problems associated with wood siding, is appealing and provides a competitive advantage over other building materials [Bousquin 2009]. As the use (and sawing) of fiber-cement siding increases, the number of workers exposed to respirable crystalline silica-containing dust is expected to increase.

NIOSH conducted a laboratory study on the generation rate and engineering control of dust from cutting fiber-cement siding. Several handheld circular saws with dust-reduction designs were tested. The saws have a built-in shroud or dust collection container covering the saw blade and connecting to an exhaust port; the air flow from the running blade collects a large amount of the dust and directs it to the exhaust port. The study found that connecting a dust-collecting circular saw to a dust collector can remove 80%-90% of the dust from cutting fiber-cement siding, even at a low flow-rate of about 0.014 cubic meters per second (m^3/s) (30 cubic feet per minute (cfm)). This result suggests that connecting a dust-collecting circular saw to a regular shop vacuum with built-in air filters that normally runs at a higher flow-rate than 0.014 m^3/s (30 cfm), can be a simple and low-cost engineering control for the dust generated from cutting fiber-cement siding [NIOSH 2014].

An in-depth NIOSH field survey [NIOSH 2014] found that all the sampled workers' 8-hr time-weighted average (TWA) exposures to respirable crystalline silica ranged from 0.003 mg/m^3 to 0.018 mg/m^3, considerably lower than the NIOSH REL of 0.05 mg/m^3 (the proposed OSHA PEL) and the ACGIH® TLV® of 0.025 mg/m^3. These results indicated that the engineering control measure was effective in reducing the workers' exposures to concentrations below the NIOSH REL and ACGIH® TLV® for respirable crystalline silica.

The row in Table 1 for hand-held masonry saws (page 56498) does not specify a water flow-rate. NIOSH suggests that OSHA specify a water flow-rate that results in exposures below the proposed PEL when coupled with their respirator use requirement. The Health and Safety Executive of the United Kingdom (HSE) [2013] recommends a flow-rate of 0.5 L/min for hand-held masonry saws plus the use of respirators with an assigned protection factor of 20, "even when your water suppression equipment is working effectively." Thorpe et al. [1999] demonstrated that water applied at a rate of 0.5 L/min produced optimal dust reduction and that additional water use did not result in lower dust emissions. A NIOSH study found that a water flow-rate of 1.4 L/min reduced quartz exposures by 90% when cutting concrete block [NIOSH 2007]. However, those substantial reductions resulted in quartz exposures of 22–48 times the proposed PEL (1.1 to 2.4 mg/m^3) during 10 minutes of block cutting using the water-spray control. Based on the HSE recommendation and the results of Thorpe et al. [1999], which showed that additional water use did not result in further dust reduction, NIOSH recommends a minimum water flow-rate of 0.5 L/min for hand-held abrasive cutters (i.e., cut-off machines, cut-off saws, chop-saws, etc.).

Table 1 should include a row on the use of manual or powered splitters as an alternative to using saws to cut pavers and brick. HSE [2008a] reported that using a manual or hydraulic block splitter eliminates the risks associated with dust produced when using a saw. In addition, job planning can minimize the number of cuts required and the associated risk of dust exposure from saw cutting [Interpave 2007].

Although the HSE report [HSE 2008a] did not include any exposure data, a NIOSH [2006] study of a splitter used for concrete roofing tiles reported nearly a 100-fold reduction in respirable dust concentrations during the use of a Hytile tile cutter (a type of manual splitter) compared to masonry saws. The authors reported average respirable dust (relative) exposures of 0.08 mg/m^3 to 0.014 mg/m^3 with the Hytile cutter compared to 2.5 mg/m^3 using the Bosch saw and 6.5 mg/m^3 for the gas-powered Partner saw. These limited data suggest that periodic monitoring would not be required if a splitter was used. Worksafe BC [2009] recommends the use of an N95 single-use respirator when cutting or splitting pavers or blocks with a hand-powered splitter. In the absence of any additional exposure data, NIOSH suggests that OSHA adopt the Worksafe BC respiratory protection recommendation for this task and add this row to Table 1:

Operation	Engineering and work practice control methods	Required air-purifying respirator (minimum assigned protection factor)	
		≤ 4 hr/day	> 4 hr/day
Cut, shape or break bricks, concrete block, stone, and pavers.	Using mechanical, pneumatic or hydraulic splitter	Half-Mask (10)	Half-Mask (10)

NIOSH recommends that OSHA include drivable milling machines equipped with local exhaust ventilation plus water-spray dust suppression in Table 1 of the PR. Since 2003, NIOSH has been involved in the Silica/Milling Machines Partnership, a collaborative effort by labor, industry, and government to reduce respirable crystalline silica exposure during asphalt pavement milling in highway construction. The Partnership is coordinated by the National Asphalt Pavement Association (NAPA) and includes all U.S. and foreign heavy construction-equipment manufacturers that currently sell pavement-milling machines to the U.S. market. The goal of the partnership is to develop and implement engineering controls on all new half-lane and larger drivable milling machines to reduce silica exposures.

NIOSH and the Silica/Milling Machines Partnership recently evaluated successful controls that used both local exhaust ventilation and water-spray to control silica dust on drivable milling machines. Forty-two full-shift personal breathing zone samples (21 days with 2 workers per day) were collected; all were below the NIOSH REL (i.e., the proposed OSHA PEL) for respirable crystalline silica for workers using drivable milling machines equipped with local exhaust ventilation plus water-spray dust suppression [NIOSH 2013b,c]. Use of the controls resulted in worker silica exposures below the NIOSH REL (the proposed PEL) during all shifts, including several shifts longer than 11 hours, indicating that workers would not need to wear respirators to keep full-shift worker silica exposures below 50 $\mu g/m^3$ for drivable milling machines equipped with local exhaust ventilation and water-spray dust controls. The local exhaust ventilation and water-spray dust controls were integrated into the design of new (current model) drivable milling machines and evaluated by NIOSH through the Silica/Milling Machines Partnership [NIOSH 2013b,c]. NIOSH researchers have not evaluated whether older models of drivable milling machines could be retrofitted with the same combination of local exhaust ventilation and water-spray controls that were successful on current models of drivable milling machines. Several manufacturers have questioned whether local exhaust ventilation-based retrofit dust controls would be technically feasible on older machines. NIOSH is not aware of any formal evaluation of retrofitting older machines with the same local exhaust ventilation controls tested by NIOSH.

Response to 54, fifth question:

How should OSHA update Table 1 in the future to account for development of new technologies?

Regarding updating Table 1, NIOSH believes this is an important question. The standard hopefully will encourage technological innovation by tool and equipment manufacturers. For example, tool manufacturers might incorporate controls into other types of construction equipment or improve existing controls so that respirators would no longer be required for a given Table 1 task. A clear path for testing, review, and subsequent listing in Table 1 would benefit construction employers, especially small business employers and employees. OSHA could develop a database of control technology studies to supplement the controls listed in Table 1, rather than initiating a new rulemaking process. To ensure data quality, the database should include only studies published in a peer-reviewed journal or issued as a peer-reviewed report by a government agency or other recognized authoritative source.

55. OSHA requests comments on the degree of specificity used for the engineering and work practice controls for tasks identified in Table 1, including maintenance requirements. Should OSHA require an evaluation or inspection checklist for controls? If so, how frequently should evaluations or inspections be conducted? Provide any examples of such checklists, along with information regarding their frequency of use and effectiveness.

NIOSH recommends that OSHA require an evaluation of the engineering controls. Controls should be evaluated each day before use to determine if they are performing as designed and that workers using the controls possess the training and materials to ensure proper operation. In an evaluation of silica exposures associated with concrete surface preparation with hand grinders and tool-mounted local exhaust ventilation, NIOSH [2001] reported that a worker continued to use a vacuum cleaner without a bag after exhausting an entire supply of bags. The same worker later used a vacuum cleaner without its paper filter because it had a tendency to clog. In an evaluation of water-spray controls for jackhammers, NIOSH [2004] noted that when a spray nozzle on one jackhammer became clogged, it was replaced with a lower flow nozzle, which resulted in diminished dust suppression. The lower flow (about 250 milliliters of water per minute (mL/min)) nozzle reduced quartz and dust exposures by 39% and 43% when compared to no control, while the proper water-spray attachment used by a second worker (approximately 300 mL/min) resulted in a 77% reduction in quartz exposure and dust exposure reductions of 71% to 77%.

Inspection checklists help ensure that the control is functioning as designed and that the worker has the necessary supplies to do the job. If the tool manufacturer does not provide a checklist for maintaining the dust control, one could be developed by the employer in cooperation with the tool manufacturer. The HSE provides simple guidance documents for workers potentially exposed to silica in construction. For example, the document for workers scabbling concrete [HSE 2011a] includes this simple employee checklist:

- ☐ Are you sure how to use all dust controls?
- ☐ Check your RPE [*respiratory protective equipment*] works properly every time you use it.
- ☐ Is the dust extraction or water suppression working?
- ☐ Look for signs of leaks, wear and damage every day.
- ☐ If you find any problems, tell your supervisor. Don't just carry on working.
- ☐ Make suggestions to improve the effectiveness of dust control.
- ☐ Co-operate with health surveillance.
- ☐ Use, maintain and store your protective equipment in`accordance with instructions.

- ☐ Use skin creams provided as instructed.

That checklist is part of a three-page document that also includes the following guidance for the employer regarding equipment use and maintenance:

- ✓ Check that there is adequate water for dust suppression and confirm that dust extraction and water suppression are working before starting work.
- ✓ Make sure that workers check that their RPE works properly every time they put it on.
- ✓ Minerals and silica-containing dusts are very abrasive. Plan regular maintenance.
- ✓ Follow instructions in maintenance manuals – keep equipment in effective and efficient working order.
- ✓ If the dust control is faulty, stop work until it is repaired.
- ✓ Daily, look for signs of damage. Make repairs.
- ✓ At least once a week, check that the dust extraction or water suppression works properly.
- ✓ You need to keep all controls in good working order. See sheet G406 for advice on engineering controls.
- ✓ You need to know the manufacturer's performance specifications to know if the equipment is working properly.
- ✓ Keep this information in your testing log-book.
- ✓ Get a competent ventilation engineer to examine any dust extraction thoroughly and test its performance at least once every 14 months. See the HSE publication HSG54 – see 'Further information.'
- ✓ Examine and test RPE thoroughly at least once every three months.
- ✓ Keep records of all examinations and tests for at least five years.
- ✓ Review records – failure patterns show where preventive maintenance is needed.
- ✓ Carry out air sampling to check that all controls are working well. See sheet G409.

Other topics in the three-page document include a description of the hazard, site access control, equipment selection, personal protective equipment, health surveillance, site cleaning, and worker training.

A practice used in the Vermont granite industry for controlling silicosis also is relevant to the OSHA PR [Hosey et al. 1957]. Beginning in 1940, a table of hood static pressure versus airflow for hoods commonly used in that industry was printed on a card that also indicated the desired location for the static pressure reading. Only a pocket vacuum gauge and the card were necessary to evaluate the exhaust ventilation system. Member companies of the Barre Granite Manufacturers Association reportedly conducted monthly air flow measurements as part of a program "promoting better maintenance and use of the exhaust ventilation systems."

Ensuring that a control is working properly is not a complex task. The water flow-rate through a spray nozzle can be determined with a measuring cup or other container of known volume, such as a 0.5 litre (L) water bottle or 8-ounce foam beverage cup, and a wristwatch with a second hand.

Air flow-rates are more difficult to measure, but the task and necessary instrumentation are not overly complex. Determining the air flow through a tool equipped with an exhaust shroud is based on determining a coefficient of entry for the hood, and then using the relationship between air flow and hood static pressure (equation 1, below) to measure the air flow on the job site. This method was the basis of the 1940s checklist used in the Vermont granite industry and was used recently by Meeker et al. [2009] in a study of engineering controls for masonry cutting and tuckpointing tools.

$$Q = 4005(C_e)(A_d)\sqrt{SP_h} \qquad (1)$$

Q is the airflow rate through the hood in cubic feet per minute (cfm). C_e is the coefficient of entry of the hood. A_d is the cross-sectional area of the duct at the static tap (e.g., on the exhaust outlet of the shroud), and SP_h is the hood static pressure as measured at the tap in inches of water gauge.

56. In the proposed construction standard, when employees perform an operation listed in Table 1 and the employer fully implements the engineering controls, work practices, and respiratory protection described in Table 1 for that operation, the employer is not required to assess the exposure of the employees performing such operations. However, the employer must still ensure compliance with the proposed PEL for that operation. OSHA seeks comment on whether employers fully complying with Table 1 for an operation should still need to comply with the proposed PEL for that operation. Instead, should OSHA treat compliance with Table 1 as automatically meeting the requirements of the proposed PEL?

NIOSH endorses OSHA efforts to develop the Table 1 approach, via section f(2), to provide small- and medium-sized contractors with simpler compliance alternatives for specific operations.

NIOSH encourages OSHA to explore ways to make the Table 1 approach effective, both for this and future construction health standards.

As stated in the response to question 54, fully implementing the exposure control methods described in Table 1 does not automatically ensure compliance with the proposed PEL. The employer must carefully select equipment that fully complies with the intent of the requirements specified in Table 1. Employers need to ensure that a tool manufacturer's implementation of a specified control method is effective in controlling exposures. For example, Table 1 specifies the use of an integrated water delivery system with a masonry-cutting saw. However, if water is not delivered properly to the cutting interface, exposures may not be adequately controlled. A variety of construction condition variables can influence exposures. Compliance with the PEL ensures that employers who fully implement the exposure control methods in Table 1 properly select and maintain the engineering controls and train employees effectively in the use of the control technology.

Longstanding industrial hygiene practice—used in every OSHA health standard including the current proposal—requires periodic assessment when exposure levels are expected to exceed an action level set below the PEL. Periodic assessments provide important confirmation that controls and work practices are effective. The action level provides a high degree of confidence that a high percentage of actual daily exposures are below the standard [NIOSH 1975].

It is important to know what type of periodic assessment options are needed to provide similar levels of confidence when using Table 1. All Table 1 engineering and work practice control recommendations derive from published research reports showing control effectiveness in representative lab and field studies. However, many construction variables can influence exposures, and no single research report can evaluate the effectiveness of controls in all problematic exposure conditions such as use in enclosed areas or use in an unmaintained condition.

Shepherd and Woskie [2013] found that the experience level of the worker and whether the cutting occurred indoors or outdoors significantly affected predicted exposures. In a study of the use of hand-held masonry saws, Thorpe et al. [1999] reported that exposure reductions were influenced by a worker's technique and posture during cutting, as well as wind speed and direction. Middaugh et al. [2012] reported a 20% difference from the results obtained by Thorpe et al. [1999] for similar hand-held masonry saws with different water application designs. NIOSH is not aware of other published studies of the use of water with hand-held masonry saws.

Generally, controls are not systematically tested for worst case conditions. There is an expectation that there will be an ongoing assurance plan involving a qualified person such as an industrial hygienist to provide guidance about conditions and assess the effectiveness of controls in use. When assessment reveals higher than expected exposure levels, feedback can be provided to modify and improve techniques and procedures. This assures that users do not continue to use controls in sub-optimal ways that create unrecognized overexposures.

Shepherd and Woskie [2013] noted this about Table 1 in their recent study of dust controls for hand-held masonry saws (emphasis added):

> *"In 2003, OSHA submitted a proposed draft standard for exposure to respirable crystalline silica (RCS) in construction that includes a table of suggested engineering controls to reduce exposure. Using these controls under the described circumstances together with recommended respiratory protective equipment would allow the contractor to avoid measurement of RCS exposures. This is a new regulatory approach, also found in the hexavalent chromium OSHA standard and is likely to be welcome in construction.* ***However, it is important to recognize that there are many variables that may contribute to exposure levels in the construction setting and that these exposure controls may not operate the same way in all circumstances."***

The HSE of the United Kingdom (UK) approaches silica control in construction in a manner similar to that proposed in Table 1, using the Control of Substances Hazardous to Health (COSHH) regulation [HSE 2012a]. A series of 12 documents describes controls for several construction tasks with potential exposure to respirable crystalline silica. For example, the document on cut-off saws for concrete describes the engineering and work practices and respiratory protection required to control silica exposure and comply with the COSHH regulations [HSE 2011b]. The approach allows for exposure monitoring to: 1) ensure that exposure controls are adequate; 2) determine if improvements are needed; and 3) confirm that new controls are adequate [HSE 2011b,c].

At least one UK study [HSE 2009] evaluated construction sites at random to evaluate silica "Control Competency" and "RPE (Respiratory Protective Equipment) Competency" and to assess exposures [HSE 2009]. Eight UK sites were scored for competency from low to high using this scale:

0 Evidence of unacceptable levels of overexposure brought about through manifest failures to recognize hazard and risk coupled with a failure to provide any form of controls.

1 Evidence of unacceptable levels of overexposure brought about through failures to recognize hazard and risk and take appropriate steps to control.

2 Evidence of overexposure. Some understanding of hazard and risk and some controls in place but not receptive to need to improve.

3 Occasional overexposure. Reasonable awareness of hazard and risk and desire to improve.

4 Adoption of good control practice consistent with risk. Reasonable awareness of hazard and risk and knowledge to implement effective strategies.

5 Exemplary control consistent with risk.

Of the 8 sites evaluated for control competency, 3 achieved a "good control" rating of 4, one achieved an "occasional overexposure" rating of 3 and the remaining 4 achieved "evidence of overexposure" ratings of 2 [HSE 2009]. Governmental control guidance materials were available to contractors. The findings suggest that some contractors will benefit from feedback and coaching to optimize use of controls.

Requirements for periodic assessment are especially important under the current proposal because it does not include an explicit role for silica-competent persons to perform periodic qualitative checks of control effectiveness. NIOSH comments in response to question 35 mentioned that the standard would be strengthened by clarifying and expanding the scope of silica-competent person duties to include performing regular checks to assure that required engineering controls are used, functioning properly, and maintained in proper operating condition.

All Table 1 tasks would benefit from periodic monitoring to provide valuable confidence about the effectiveness of controls and provide feedback to employers and workers to optimize control use.

To develop requirements for periodic assessment, NIOSH suggests that OSHA consider grouping the Table 1 activities into categories to help prioritize periodic assessment requirements. For example:

Group 1: Hand-held tools (e.g., hand-held grinders, tuckpointing grinders, portable masonry saws)

Group 2: Stationary tools (e.g., stationary masonry saws)

Group 3: Portable walk-behind tools (e.g., walk-behind masonry saws)

Group 4: Motorized equipment (e.g., milling, rock crushing, drilling rigs)

Group 1 tools and controls represent the highest priority for periodic assessment requirements because existing studies suggest that:

1) Dust created by hand-held tools is generally closest to the worker's breathing zone;

2) Hand-held tools are subject to the most variation from worker techniques and postures [Shepherd and Woskie [2013]; Thorpe et al. [1999]].

3) Exposures from hand-held tools are often in the upper range of known silica exposures.

In the absence of mandating regular exposure assessment for groups 2 through 4, OSHA might consider a reduced schedule of periodic assessment or develop other options. OSHA might allow reliance on built-in monitoring systems, such as pressure gauges or flow meters, to assess the performance of engineering controls. Such systems would be used with standardized maintenance procedures provided by equipment manufacturers. For example, the European standard EN 60335-2-69:2009 governing the use of dust extractors and vacuum cleaners for the collection of hazardous dusts recommends that vacuum cleaners have a low-flow warning when the velocity in the largest diameter hose falls below 20 meters per second, or about 3900 feet per minute (equivalent to an exhaust volume of about 80 cfm in a 2-inch diameter vacuum cleaner hose) [HSE 2012b]. Collingwood and Heitbrink [2007] recommended 80 cfm as the minimum flow-rate for effective dust control in tuckpointing, a construction task associated with extremely high silica exposures when controls are not used. The OSHA lead standard [1910.1025(e)(4)(ii)] mandates "*controls to monitor the concentration of lead in the return air and to bypass the recirculation system automatically if it fails are installed, operating, and maintained.*" A similar approach could mandate the use of alarms of the type required by EN 60335-2-69:2009 for silica dust controls in construction, coupled with periodic controls system testing and maintenance as mandated in the lead standard. Lastly, regarding the concept of using categories, the Ontario Ministry of Labor also used categories of silica work tasks—essentially low, medium, or high exposure—to classify and tailor precautions and procedures in their 2004 "Guideline for Silica on Construction Projects" [OML 2011].

In summary, conventional industrial hygiene practice requires periodic exposure monitoring where exposures may exceed an action level. For Table 1, the current proposal provides neither checks by a silica-competent person nor periodic exposure assessment checks by a qualified person. NIOSH is concerned that this does not provide a sufficient level of confidence that exposures are adequately controlled. NIOSH recommends that some form of periodic assessment be required. NIOSH recognizes and supports OSHA efforts to provide meaningful options for small- and medium-sized employers. We encourage OSHA to further explore approaches that make use of Table 1 groupings, silica-competent person activities, built-in devices, periodic exposure assessment scheduling variations, and other ideas to preserve options while providing confidence that daily exposures are below the proposed PEL.

57. Are the descriptions of the operations (specific task or tool descriptions) and control technologies in Table 1 clear and precise enough so that employers and workers will know what controls they should be using for the listed operations? Identify the specific operation you are addressing and whether your assessment is based on your anecdotal experience or research. For each operation, are the data and other supporting information sufficient to predict the range of expected exposures under the controlled conditions? Identify operations, if any, where you believe the data are not sufficient. Provide the reasoning and data that support your position.

Additional information or specifications about controls in Table 1 would help employers select and purchase tools to comply with the proposed standard. A preferred approach would require the tool manufacturer or employer to demonstrate state-of-the-art effectiveness of the control through objective tool testing data. That approach is used in Germany today [TRGS 2010] where, "...machines and devices which are approved with respect to dust emissions are used it may be assumed that the emission rate is in accordance with the state of the art applying at the time the approval test was conducted." An alternative approach would specify hoods, air and water flow-rates, and other design or performance specifications demonstrated to be effective in controlling silica dust in construction. This approach would restrict controls to those available at the time the standard is promulgated which could stifle innovation.

NIOSH is concerned that the distinction between other impact drills and rotary hammers or drills is not defined clearly for the employer and worker. OSHA could eliminate this potential confusion by re-labelling the first of the two rows "Using Jackhammers, Pavement Breakers and Similar Tools (Except Mounted Breakers)." In addition, the published studies available on use of wet grinders do not support the respiratory protection recommendations in Table 1.

Studies by Akbar-Khanzadeh et al. [2007, 2010] suggest that wet grinding in the absence of general exhaust ventilation can result in exposures to silica in excess of the proposed PEL for operations of four hours or less duration. In the 2007 study, the best result was an exposure of 1.08 mg/m^3 respirable crystalline silica. If that exposure continued for four hours, the 8-hr TWA exposure would be 0.54 mg/m^3, more than 10 times the proposed PEL [Akbar-Khanzadeh et al. 2007]. If the exposure continued for eight hours, the 8-hr TWA exposure would be more than 20 times the proposed PEL. Based upon those results, the respiratory protection guidance for "Use water-fed grinder that continuously feeds water to the cutting surface" in Table 1 must be changed accordingly from "none" for "$\leq$ 4 hr/day" and "Half-Mask (10)" for "> 4 hr/day" to "Powered air-purifying respirator (PAPR) with loose-fitting helmet or negative pressure full facepiece (25)" in both columns.

Linch [2002] reported quartz exposures to a grinder and helper smoothing concrete walls of a large building using an angle-grinder equipped with a 4-inch (in) diameter diamond-impregnated steel disc. The helper used a compression sprayer (pump sprayer) to apply tap water to the concrete surface in front of the grinder. The grinder's personal breathing zone quartz exposure was 0.02 mg/m^3 in a 342-minute sample. Respirable quartz was not detected in the helper's 225-minute sample. The minimum detectable concentration was 0.026 mg/m^3, based on a 225-minute sample at 1.7 L/min and a limit of detection of 0.01 mg of quartz per sample. The actual grinding time was estimated to be 270 minutes.

Akbar-Khanzadeh et al. [2007] performed a laboratory study to evaluate the effectiveness of a grinder with a continuous water flow system to reduce respirable crystalline silica exposure. An angle grinder equipped with a 7-in diameter grinding disc was used with a water flow of 3 L/min to grind the horizontal surface of a 12 by 20-in concrete slab placed upon two saw horses. The study was conducted in a room equipped with a general ventilation system capable of providing 40 air changes per hour. Wet grinding without general ventilation resulted in time-weighted average silica exposures from 1.08–1.84 mg/m^3 in three samples (average time 93.3 minutes). Wet grinding with the general ventilation in use produced time-weighted average silica exposures from 0.331–0.929 mg/m^3 in four samples (average time 85.6 minutes), a 97% reduction from uncontrolled grinding.

Akbar-Khanzadeh et al. [2010] performed a second laboratory study of dust controls for concrete grinding using three different-sized angle grinders modified for wet grinding by the researchers. The grinders were used in combination with four different diameter wheels as follows: a 4.5-in grinder with a 4-in or 4.5-in grinding cup; a 6-in grinder with a 5-in grinding cup; and a 7-in grinder with a 7-in grinding cup. Concrete slabs measuring approximately 17 by 21 by 4-in were placed on a table. Grinding was conducted with the slab laid flat (horizontal grinding) and nearly vertical (to simulate wall grinding). The study was conducted in a room equipped with general exhaust ventilation capable of 62 air changes per hour. The authors reported mean respirable crystalline silica concentrations of 0.96 mg/m^3 for 17 samples with the 4- to 5-in grinding cups and 8.83 mg/m^3 for 8 samples with the 7-in grinding cup with no general exhaust ventilation. With the general exhaust ventilation in operation, the mean silica concentrations were 0.27 (14 samples) and 2.08 mg/m^3 (7 samples) for the 4- to 5-in grinding cups and the 7-in grinding cup, respectively.

58. In one specific example from Table 1, OSHA has proposed the option of using a wet method for hand-operated grinders, with respirators required only for operations lasting four hours or more. Please comment and provide OSHA with additional information regarding wet grinding and the adequacy of this control strategy. OSHA is also seeking additional information on the second option (commercially available shrouds and dust collection systems) to confirm that this control strategy (including the use of half-mask respirators) will reduce workers' exposure to or below the PEL.

A. Wet grinding

NIOSH suggests that OSHA reconsider requiring respirators only when wet grinders are used for four hours or more. The results reported by Akbar-Khanzadeh et al. in 2007 and 2010 studies suggest that wet grinding in the absence of general exhaust ventilation can result in exposures to silica in excess of the proposed PEL for operations of four hours or less in duration [Akbar-Khanzadeh et al. 2007, 2010]. In the 2007 study, the best result achieved was 1.08 mg/m^3 of respirable crystalline silica. If that exposure continued for four hours, the 8-hr TWA exposure would be 0.54 mg/m^3, more than 10 times the proposed PEL [Akbar-Khanzadeh et al. 2007].

Linch [2002] reported quartz exposures to a grinder and helper smoothing concrete walls of a large building using an angle-grinder equipped with a 4-in diameter diamond-impregnated steel disc. The helper used a compression sprayer (pump sprayer) to apply tap water to the concrete surface in front of the grinder. The grinder's personal breathing zone quartz exposure was 0.02 mg/m^3 in a 342-minute sample. Respirable quartz was not detected in the helper's 225-minute sample. The minimum detectable concentration was 0.026 mg/m^3, based on a 225-minute sample at 1.7 L/min and a limit of detection of 0.01 mg of quartz per sample. The actual grinding time was estimated to be 270 minutes.

Akbar-Khanzadeh et al. [2007] performed a laboratory study to evaluate the effectiveness of a grinder with a continuous water flow system to reduce respirable crystalline silica exposure. An angle grinder equipped with a 7-in diameter grinding disc was used with a water flow of 3 L/min to grind the horizontal surface of a 12 by 20-in concrete slab placed upon two saw horses. The study was conducted in a room equipped with a general ventilation system capable of providing 40 air changes per hour. Wet grinding without general ventilation resulted in time-weighted average silica exposures from 1.08–1.84 mg/m^3 in three samples (average time 93.3 minutes). Wet grinding with the general ventilation in use produced time-weighted average silica exposures from 0.331–0.929 mg/m^3 in four samples (average time 85.6-minutes), a 97% reduction from uncontrolled grinding.

Akbar-Khanzadeh et al. [2010] performed a second laboratory study of dust controls for concrete grinding using three different-sized angle grinders modified for wet grinding by the researchers. The grinders were used in combination with four different diameter wheels as follows: a 4.5-in grinder with a 4-in or 4.5-in grinding cup; a 6-in grinder with a 5-in grinding cup; and a 7-in grinder with a 7-in grinding cup. Concrete slabs, that measured approximately 17 by 21 by 4-in were placed on a table. Grinding was conducted with the slab laid flat (horizontal grinding) and nearly vertical (to simulate wall grinding). The study was conducted in a room equipped with general exhaust ventilation capable of 62 air changes per hour. The authors reported mean respirable crystalline silica concentrations of 0.96 mg/m^3 for 17 samples with the 4- to 5-in grinding cups and 8.83 mg/m^3 for 8 samples with the 7-in grinding cup with no general exhaust ventilation. With the general exhaust ventilation in operation, the mean silica concentrations were 0.27 (14 samples) and 2.08 mg/m^3 (7 samples) for the 4- to 5-in grinding cups and the 7-in grinding cup, respectively.

B. Grinding with tool-mounted local-exhaust ventilation

The results of field investigations and laboratory studies of grinders equipped with local exhaust ventilation show that, in many cases, this control strategy, combined with the use of half-mask respirators, will reduce workers' exposure to or below the OSHA PEL. However, effective dust control depends on proper selection of the shroud and vacuum cleaner, the size of the grinder, worker training, and equipment maintenance. It is especially important to select and maintain a vacuum cleaner capable of sustaining an adequate air flow-rate for the duration of the task and with a capacity to contain the captured dust. Heitbrink and Santalla-Elias [2009] recommended using cyclones as the first stage of filtration for vacuum cleaners used as dust collectors for tasks that generate large volumes of dust, like concrete grinding. They noted that cyclones can prevent the accumulated waste material from clogging vacuum cleaner filters and reducing air flow. NIOSH [2001] reported that a worker continued to use a vacuum cleaner without a bag after exhausting an entire supply of bags. The worker continued using the vacuum cleaner until it was unusable, and later used a vacuum cleaner without its paper filter because of its tendency to clog frequently. The volume of dust captured during concrete grinding required changing vacuum cleaner bags about every 35 minutes [NIOSH 2001]. NIOSH [2008a, 2009a] recommends the use of a vacuum cleaner that uses a pre-filter or cyclone to increase the length of service of the HEPA filter and maintain adequate air flow for grinding tasks.

Hallin [1983] evaluated seven grinder-hood-dust collector triplets for grinding concrete walls in a room built for that purpose. Sampling periods ranged from 37 to 63 minutes. The grinder-hood-dust collector triplet that produced the lowest silica exposure was a Bahco SK2-72 grinder-Bahco hood-Dustcontrol DC3000 dust collector. That combination resulted in a respirable quartz exposure of 0.15 mg/m^3 in a 60-minute sample. If that operation was performed for an 8-hour shift, the exposure would be three times the proposed PEL. The grinder operator would be required to utilize respiratory protection. The remaining grinder-hood-duct collector triplets in Hallin's study produced respirable silica exposures from 0.16 mg/m^3 to 3.5 mg/m^3. Hallin concluded that grinding for extended periods of time would require the use of respiratory protection.

NIOSH [2001] reported the results of grinding concrete walls in a parking structure construction site over three days. On the first day, the concrete finisher used a 4.5-in grinder, Pearl Abrasive medium PW cup wheel, Pearl Abrasive Vacu-Guard™ shroud. They were initially paired with a WAP model SQ 10-gallon vacuum cleaner, replaced with a Pullman Holt model 102 drum-top vacuum. The cement finisher's 8-hr TWA respirable quartz exposure was 0.16 mg/m^3. On the second day, again using a 4.5-in grinder, Vacu-Guard™ shroud, and Pullman-Holt vacuum cleaner, the cement finisher's 8-hr TWA respirable quartz exposure was 0.21 mg/m^3. On the third day of sampling, a 4.5-in grinder, Vacu-Guard™ shroud, and WAP vacuum cleaner were used. The cement finisher's 8-hr TWA respirable quartz exposure was 0.14 mg/m^3. Measurements over these three days indicate that the exposures exceeded the proposed PEL by about 3 to 4 times, necessitating the use of respiratory protection.

Linch [2002] studied a 4-in angle grinder and shroud with three different vacuum cleaners. The first combination, 4-in grinder, shroud, and SawTec Micro mini-vac, resulted in a respirable quartz exposure to the grinder operator less than the limit of detection. The minimum detectable concentration was 0.05 mg/m^3, based on a 127-minute sample at 1.7 L/min and a limit of detection of 0.01 mg of quartz per sample. Actual grinding time was estimated to be 77 minutes. The second combination, 4-in grinder, cut-shroud (to allow grinding in corners) and SawTec Maxi-Vac, resulted in the grinder operator's respirable quartz exposure of 0.13 mg/m^3 in a 150-minute sample, or an 8-hr TWA of 0.04 mg/m^3, if no further exposure occurred. The actual grinding time was estimated to be 96 minutes. The third combination tested was a 4-in grinder, shroud, and WAP canister vacuum cleaner. Respirable quartz was not detected in the grinder operator's 117-minute sample. The minimum detectable concentration was 0.05 mg/m^3, based on a 117-minute sample at 1.7 L/min and a limit of detection of 0.01 mg of quartz per sample. The actual grinding time was estimated to be 100 minutes. These results show that two of the three grinder-shroud-vacuum combinations tested resulted in actual TWA silica exposures at or below the proposed PEL, the third combination resulted in exposure for the sampled period that would extrapolate to over 2.5 times the proposed PEL for a full shift. Respiratory protection would be required to protect the concrete grinder operator.

Akbar-Khanzadeh and Brillhart [2002] conducted a field study of concrete grinding with and without local exhaust ventilation. Workers used 4.5-in angle grinders to grind concrete surfaces in a variety of construction sites, including parking garages, hotels, and research buildings. The local exhaust ventilation systems had a hood surrounding the grinding wheel, hose, and vacuum source. Task-based exposure monitoring found that the mean respirable crystalline silica exposure while grinding with local exhaust ventilation was 0.38 mg/m^3 for 15 shifts. When the authors used the task-based data to calculate 8-hr TWA exposures, 7 of the 15 respirable crystalline silica exposures were less than 0.05 mg/m^3 and 8 were from 1 to 4 times the proposed PEL. These results indicate that respiratory protection would be required for more than half of these tasks for workers grinding concrete using tools equipped with local exhaust ventilation.

Croteau et al. [2002] evaluated concrete surface grinding at a brick and cement mason apprentice training facility. Two cement mason apprentices with at least four weeks of experience and training in the use of grinders participated in the study, which examined 2 local exhaust ventilation flow-rates, 30 and 70 cubic feet per minute, and no local exhaust ventilation. A Flex (Porter Cable) LD 1509 FR electric grinder and Dimas 5.3-in diamond cup wheel were used to grind the surface and top of a concrete wall and chamfer the edges. The wall was inside a 5267-cubic foot tent equipped with a 3925-cubic feet per minute exhaust fan. Suction for the tool-mounted local exhaust ventilation was provided by a Dust Control 3700c vacuum cleaner with a 24-cm diameter cyclone. The geometric mean respirable quartz concentration measured during five 15-minute work sessions at the higher local exhaust ventilation flow-rate was 1.7 mg/m^3, or 34 times the proposed PEL if the task had continued for eight hours.

Echt and Sieber [2002] reported a case study of concrete wall grinding during parking garage construction. Full-shift personal breathing zone samples were collected for five days. Sampling periods ranged from 265 to 340 minutes. The worker used a Metabo model W7-115 Quick grinder on days one through four and a Bosch model 1347A grinder on day five. A Pearl Abrasive Vacu-Guard™ shroud, connected to a Dust Control DC 2700 C vacuum cleaner was used on all five days. Eight-hr TWA respirable quartz exposures ranged from 0.036 mg/m^3 to 0.13 mg/m^3, or from 0.72 to 2.6 times the proposed OSHA PEL. These results exceeded the proposed PEL on four of the five sampling days.

Croteau et al. [2004] conducted a field study of the use of concrete grinders with and without local exhaust ventilation. Cement masons used three different grinder-shroud configurations at six large building sites. Two grinders were used; a Flex LD 1509 FR and a Metabo WE 9-125 Quick were each used with a Pferd EDP 61508 4.5-in grinding wheel. Three shrouds were utilized in the study—a Flex shroud, a SawTec shroud, and a SawTec cut shroud. A Dust Control 2700C vacuum cleaner provided suction for the local exhaust ventilation. The results of 27 paired control-on/control-off samples were collected, 22 during wall grinding, 3 while grinding walls and columns, and 2 during ceiling and wall grinding. The geometric mean respirable quartz concentration reported for all samples with local exhaust ventilation was 0.034 mg/m^3. For the Flex shroud and whole SawTec shroud, the geometric mean respirable quartz concentration was 0.03 mg/m^3. With the cut shroud, it was 0.04 mg/m^3. However, the authors reported that 26% of the samples exceeded 0.05 mg/m^3 (i.e., the proposed OSHA PEL), and recommended that respiratory protection with an assigned protection factor of at least five be used by workers grinding concrete with tool-mounted local exhaust ventilation.

Kluger et al. [2006] conducted a laboratory study of several tools, including concrete grinders. Tests were performed in a test room with no ventilation provided during the test (doors and windows closed, ventilation shut off), representing a worst-case scenario. Grinders tested were equipped with diamond cup wheels 5-, 6-, and 7-in in diameter. If the grinding speed was adjustable, the tools were always used at their highest rotational rate. Ten concrete sidewalk slabs 40 centimeters (cm) by 60 cm by 5 cm were arranged on an A-frame support to provide a working surface of 2.4 square meters. Each test duration was about an hour. The dust collected in the vacuum cleaner was weighed before and after sampling to determine how much dust was captured. Fifteen different grinder-vacuum cleaner combinations were evaluated, including 12 that were available commercially at that time. Three trials were carried out for each combination. Eighty-seven percent of the silica samples (both area and personal) were below the detection limits of 0.02 mg/m^3 for personal breathing zone samples and 0.04 mg/m^3 for area samples.

Akbar-Khanzadeh et al. [2007, 2010] performed two laboratory studies of concrete grinding. In the first study, grinding was performed with a Hilti model DG150 6-in grinder and Hilti model VCD 50 L vacuum cleaner. The tool was used to grind the horizontal surface of a 12 by 20-in concrete slab placed on two saw horses. The study was conducted in a room equipped with a general ventilation system capable of providing 40 air changes per hour. The authors reported a mean TWA respirable silica dust concentration of 0.15 mg/m^3 (geometric mean 0.13 mg/m^3) for 3 samples. In the second study, three angle grinders (4.5-, 6- and 7-in) and a 5-in concrete grinder were evaluated using three different vacuum cleaners. The angle grinders were fitted with a durable urethane shroud. Concrete slabs that measured approximately 17 by 21 by 4-in were placed on a table. Grinding was conducted with the slab laid flat (horizontal grinding) and nearly vertical (to simulate wall grinding). The study was conducted in a room equipped with general exhaust ventilation capable of 62 air changes per hour. With the general exhaust ventilation off, the 4.5- and 5-in grinders produced mean task-based respirable crystalline silica exposures of 0.17 mg/m^3 when used with two of the vacuum cleaners. A shop vacuum used with those grinders resulted in a mean task-based respirable crystalline silica exposure of 0.92 mg/m^3. The 7-in grinder produced higher mean respirable crystalline silica exposures–0.54 mg/m^3 with two of the vacuums and 1.9 mg/m^3 with the shop vacuum cleaner. The larger grinders produced more dust. The percent reduction in measured exposure compared to uncontrolled grinding decreased for larger grinders paired with larger wheels.

59. For impact drilling operations lasting four hours or less, OSHA is proposing in Table 1 to allow workers to use water delivery systems without the use of respiratory protection, as the Agency believes that this dust suppression method alone will provide consistent, sufficient protection. Is this control strategy appropriate? Please provide the basis for your position and any supporting evidence or additional information that addresses the appropriateness of this control strategy.

NIOSH suggests that the distinction between rotary hammers and drills and impact hammers be clarified so employers can determine which row in Table 1 applies to the tool their employee is using. For example, the Power Tool Institute [2007] notes that "hammer drills and rotary hammers use impacting action in combination with rotation of the specially designed 'percussion bit' to drill holes in masonry materials." The reader of Table 1 might have difficulty determining which of the two consecutive rows, "Using Jackhammers and Other Impact Drillers" and "Using Rotary Hammers or Drills (except overhead)" would apply to their operation since a rotary hammer or drill is technically an impact driller. OSHA could eliminate this potential confusion by re-labelling the first of the two rows "Using Jackhammers, Pavement Breakers and Similar Tools (Except Mounted Breakers)." Perhaps OSHA can work with appropriate tool manufacturer trade associations to clarify the definitions in Table 1.

This control strategy is only appropriate to maintain exposures at or below the proposed OSHA PEL of 50 $\mu g/m^3$, 8-hr TWA if the water-spray system delivers a sufficient flow. A NIOSH in-depth survey of jackhammers used with water-spray controls demonstrated that water applied using a solid cone nozzle at a flow-rate of 300 mL/min resulted in a 69% to 71% reduction in respirable dust exposure and a 77% reduction in quartz exposure [NIOSH 2004]. However, a water flow-rate of 250 mL/min resulted in a 42% to 43% reduction in respirable dust exposure and a 39% reduction in silica exposure.

The NIOSH [2004] field study found that a water-spray flow-rate of 300 mL/min would permit a worker to use the jackhammer for up to 4 hours and 45 minutes in an eight-hour shift without exceeding the proposed PEL. Based on that result, NIOSH recommends that Table 1 specify a minimum water-spray flow-rate of 300 mL/min.

An earlier NIOSH study [Echt et al. 2003], where silica dust was not measured due to short sampling times, found that 350 mL/min reduced respirable dust exposures by 72% on filter samples and 90% in direct-reading measurements compared to no control. A water spray flow-rate of 300 mL/min produced a 71% respirable dust reduction on filter samples and a 69% reduction in direct-reading measurements compared to no control [NIOSH 2004]. NIOSH [2008b] recommended 350 mL/min as the water spray flow-rate based on the higher reduction in real-time respirable dust exposures.

Zalk [2000] evaluated the reduction in respirable crystalline silica exposures associated with using a jackhammer equipped with two water-spray nozzles. The jackhammer was tested indoors and outside. The sampling time and water flow-rate were not reported. Two employees were sampled; their average respirable crystalline silica exposures were <0.045 mg/m^3 and 0.085 mg/m^3 outdoors and 0.065 mg/m^3 and <0.030 mg/m^3 inside a temporary structure built for the evaluation.

Brouwer et al. [2004] investigated the effectiveness of water spray for jackhammer dust control, sampling three workers breaking concrete slabs indoors, utilizing a 9-kilogram (kg) Wacker EHB7 electric jackhammer. The quartz content of the slab was reported as 16% by weight. The authors measured respirable silica and dust exposures four times (twice with dust control, twice without). The dust control consisted of two hollow-cone spray nozzles that supplied 0.085 L/min water each (total water flow 0.17 L/min). For the six samples collected with the water spray in use (the average sample time was 35 minutes), respirable quartz exposures ranged from 0.02 mg/m^3 to 0.36 mg/m^3, with an average of 0.17 mg/m^3. In the worst case under the conditions tested, work could continue for 67 minutes before exceeding the proposed PEL. This example demonstrates the importance of water flow-rate in determining the extent of the exposure reduction.

The same study [Brouwer et al. 2004] also evaluated the use of water to suppress dust while removing wall and floor tile in a bathroom using a 4.8-kg Hitachi electric jackhammer equipped with a single water-spray nozzle (0.19 L/min flow-rate). The respirable quartz results for two samples collected during wall tile removal (average sampling time of 60 minutes) were 0.21 mg/m^3 and 0.26 mg/m^3. During floor tile removal, the results for two respirable quartz samples (60-minute average sampling time) were 0.04 mg/m^3 and 0.67 mg/m^3. The tile scrap was reported to contain 14% quartz by weight, while the slab beneath the floor tile was 15% quartz by weight. This study illustrates the range of exposures that might be encountered when the same control is used. The range in control effectiveness should be taken into account when dictating the length of time a control can be used without respiratory protection before the proposed PEL is exceeded.

Scharf published a series of five papers on using water to suppress sandstone dust during jackhammering tasks. In a report of one study [Scharf 1973], the author described the results of respirable dust sampling while using a water-drip attachment made of perforated coiled steel tubing (4 coils of 11 standard wire gauge black steel pipe with 6 equally-spaced 3/32-in diameter holes) positioned 2-in above the impact point of the jackhammer during trenching in sandstone with a high free silica content. Scharf reported a maximum allowable concentration (MAC) of 5.7 million particles per cubic foot. This result means the dust contained 15.5% quartz using the general industry PEL formula and OSHA-recommended conversion factor of 10 millions of particles per cubic foot (mppcf) equals 1 mg/m^3. Scharf recommended a flow-rate of 0.5 gallons per minute to achieve optimum dust control of 50% of the MAC while using the coiled attachment to dispense water near the point of impact. If the sandstone dust was 15.5% quartz, with a MAC of 0.57 mg/m^3, a 50% reduction means that the control achieved a silica exposure of approximately 0.04 mg/m^3, less than the proposed PEL.

61. OSHA has specified a control strategy for concrete drilling in Table 1 that includes use of a dust collection system as well as a low-flow water spray. Please provide to OSHA any data that you have that describes the efficacy of these controls. Is the control strategy in Table 1 adequate? Please provide the basis for your position and any supporting evidence or additional information regarding the adequacy of this control strategy.

In Table 1, page 56498, OSHA describes a concrete drilling task "*Operating Vehicle-Mounted Drilling Rigs for Concrete.*" It appears that when OSHA drafted Table 1, much of the engineering control information in this row was copied from the previous row "*Operating Vehicle-Mounted Drilling Rigs for Rock.*"

NIOSH believes that the guidance to "*provide a low-flow water spray to wet the dust discharged from the dust collector*" should not apply to concrete drilling rigs. Both manufacturers of dowel drills offer dust controls that include close-capture hoods that surround the drill at the face of the concrete, flexible duct, a dust collector (which includes a filter), and a receptacle for the collected dust. Adding water at any point in this control would add weight to the concrete dust and potentially cause it to solidify, clogging the dust control. Both dowel drill manufacturers offer dust controls that utilize water to suppress dust at its source, but, those controls are not used in combination with a dust collection system [NIOSH 2011a,b,c,d, 2012a, 2013d].

The recommendations (page 56498) to "*Use smooth ducts and maintain duct transport velocity at 4,000 feet per minute; provide duct clean-out points; install pressure gauges across dust collection filters*" are based on good ventilation control design practices. However, in field studies of concrete drills on construction sites, NIOSH did not encounter any dowel drills with all of those features, so their effectiveness was not documented.

The recommendations (page 56498) "*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,*" and "*door seals and closing mechanisms are working properly*" would only apply to those dowel drills that are mounted on backhoe, trackhoe, skid-steer loader, or other construction vehicle with an enclosed cab.

Dowel drilling machines (also known as gang drills or dowel drills) are used to drill horizontal holes in concrete pavement. Steel dowels transfer loads between adjacent concrete pavement slabs [Park et al. 2008]. They are typically used in "transverse joints in rigid airport and highway pavement to transfer shear from a heavily loaded slab to an adjacent less heavily loaded slab" [Bush and Mannava 2000]. Typical dowel drilling machines have one or more drills held parallel in a frame that aligns the drills and controls wandering [FHWA 2006]. The dowel drilling machine may be self-propelled or boom-mounted, and may ride on the slab or on the grade [FHWA 2006]. After drilling to a typical depth of 23 cm (9 inches (in)) the anchoring material is placed, and the dowel is installed. The diameter of the hole is determined by the dowel diameter and whether cement-based grout or an epoxy compound is used to anchor the dowels [FHWA 2006]. Compressed air may be used to clean the hole prior to placing the anchoring material.

Dowel drilling is required during runway construction by the Federal Aviation Administration (FAA), using either rotary-type core drills or rotary-type percussion drills [FAA 2009]. Contractors reportedly do not use core drills for this task.

Valiante et al. [2004] reported that dowel drilling respirable crystalline silica exposures ranged from 0.05 mg/m^3 to 0.16 mg/m^3, 8-hr TWA. A NIOSH study of exposures during dowel drilling in concrete pavement repair reported 8-hr TWA quartz exposures for operators and laborers using boom-mounted 3-gang dowel drilling machines [Linch 2002]. The operators were in the cabs of backhoes operating the booms, while the laborers positioned and operated the drills. The operators' 8-hr TWA exposures ranged from less than the minimally detectable concentration of 0.029 mg/m^3 to 0.11 mg/m^3, with a geometric mean respirable crystalline silica exposure of 0.037 mg/m^3 for 8 samples. The highest result was 2.2 times the proposed PEL of 0.05 mg/m^3. The laborers' 8-hr TWA respirable crystalline silica exposures ranged from 0.12 mg/m^3 to 1.3 mg/m^3 (2.4–26 times the proposed PEL), with a geometric mean of 0.24 mg/m^3 (4.8 times the proposed PEL) for 8 samples. An enclosed cab, as described in Table 1, would certainly have reduced the exposures of the backhoe operators in that study.

Dust controls for small pneumatic rock drills used in mining were first reported in the 1930s [Harrington and Davenport 1937]. One, the Kadco dust control system (Kadco stands for Kelley-Atwell development company; the patent for the device was issued to George S. Kelley), used a hood to surround the drill steel and control the dust at the point of generation, where it was conveyed to a filter through "rubber hose or pipe" [Harrington and Davenport 1937]. Another, the Drill-Vac, reduced dust counts (area samples collected 2 to 4 feet from the drill, due to the technology of the day) from 790 mppcf to 0.612 mppcf (79 to 0.06 mg/m^3, using the OSHA conversion factor) while the dust control was used with a rock drill at a quarry [Harrington and Davenport 1937].

Hatch et al. [1933] evaluated the Kadco dust control system in the Ingersoll-Rand experimental limestone mine in New Jersey. They found that in a horizontal drilling position, the average respirable dust count was 7 mppcf (0.7 mg/m^3). An air flow-rate of 0.094 m^3/sec through the hood was found to reduce the driller's breathing zone dust exposures to less than 10 mppcf (1 mg/m^3) in horizontal and down drilling.

Hatch et al. [1932] also tested the Kadco dust control system during outdoor rock drilling in "medium-hard" Manhattan Schist at the site of the Metropolitan Life Insurance Company building in Manhattan. The company was a collaborator in a series of silicosis-prevention studies. They found that an air flow-rate of 0.028 m^3/sec reduced operator exposures below 5 mppcf (0.5 mg/m^3). The authors also provided the static pressure required for that air flow-rate based upon the length of 5 cm diameter flexible hose. It ranged from 0.87 kilopascals (kPa) for a 7.6 meter (m) hose to 3.5 kPa for a 30 m hose.

Cooper et al. [2012] reported on a custom-made vacuum attachment used with a rock drill when drilling concrete to place steel bars for seismic reinforcement. This experimental device utilized a shroud that surrounded the steel and a vacuum cleaner with a flow-rate of 0.054 m^3/sec and 20.9 kPa static head (lift). The device reduced the operator's mean respirable silica exposure by 94%, from 0.68 to 0.04 mg/m^3.

NIOSH studies by Echt et al. [NIOSH 2011a,b] conducted laboratory evaluations of dowel drills at two sites. A total of 90 respirable dust samples were collected at both sites. The dust collection system on both drills consisted of hoods surrounding the bits at the concrete surface, a length of flexible duct hose, and a pneumatically-powered dust collector and air cleaner. Comparing dust levels from both sites combined with the controls "off" versus "on" showed that dust levels were dramatically reduced by the control measures. Overall, there was a highly significant average decrease of over 50 mg/m^3 in dust levels after the control devices were implemented. When stratified by site, very similar results were obtained with geometric mean (GM) dust levels decreasing significantly at both sites after controls were implemented ($p<0.0001$). The results showed that, overall, the emissions without the dust control in use were 14 times greater than when the control was in use (i.e., the dust control reduced emissions by 93%). The exhaust air flow-rate measured at the two sites, 0.018 m^3/sec, was one-third to one-fifth of the flow-rates measured by Cooper et al. [2012] and recommended by Hatch et al. [1933]. This rate may result in settling and plugged ducts in actual use, although the vibration of the drill and repeated flexing of the duct when the drill array is raised and lowered may minimize settling.

NIOSH et al. [2011c,d; 2012a] also performed field studies to evaluate dowel drills used in airport runway construction. Three sites were visited, including two sites where dust controls were used and one with no dust control in use. The TWA respirable dust results from the two sites where controls were used were compared with data from sites where no control was in place, including the Linch [2002] data. Respirable dust data were analyzed because of the differences in the silica content of the concrete across sites, and because a laboratory error precluded obtaining silica exposure data from a site where dust controls were used. On average, the GM respirable dust concentration at sites where dust controls were used was one-fifth the level at sites where no dust controls were used. While the difference was not statistically significant (p=0.12), this was likely due to the small sample size and resultant low experimental power rather than an absence of effect. The probability of a difference of the means, 0.88, approaches 90% significance.

NIOSH has also studied the difference in the extent of reductions seen in the lab compared with those seen in the field and whether it was due to the design of the control or to its use and maintenance or operator training. NIOSH [2013d] performed a site visit to a training center with a new drill transported from the factory. A representative of a drill manufacturer instructed apprentice trainers in the use and maintenance of the drill prior to air sampling. The dust control performed well under the conditions of the test, controlling silica exposures to levels below the proposed PEL during drilling. The initial duct velocity with a clean filter in the dust collector was sufficient to prevent settling, but gradually fell below the recommended value to prevent dust from settling in the duct. In this site visit, the practice of raising the drill between each hole may have prevented the dust from settling in the duct. A slightly higher flow-rate would prevent settling without regard to the position of the drill.

63. OSHA has not proposed to prohibit the use of crystalline silica as an abrasive blasting agent. Abrasive blasting, similar to other operations that involve respirable crystalline silica exposures, must follow the hierarchy of controls, which means, if feasible, that substitution, engineering, or administrative controls or a combination of these controls must be used to minimize or eliminate the exposure hazard. Is this approach appropriate? Provide the basis for your position and any supporting evidence.

Because of the high silicosis risk for sandblasters and the difficulty in controlling exposures, the use of crystalline silica for blast cleaning operations was prohibited in Great Britain in 1950 (Factories Act 1949) and other European countries in 1966 [NIOSH 1992]. In 1974, NIOSH recommended that silica sand (or other substances containing more than 1% free silica) be prohibited as abrasive blasting material and that less hazardous materials be used in blasting operations [NIOSH 1974]. In 1992, NIOSH published "Preventing Silicosis and Deaths from Sandblasting" and in 2009, NIOSH published "Prevention of Silicosis Deaths"; both these publications recommended that silica be banned for this use and that less hazardous materials be used in blasting operations [NIOSH 1992, 2009b].

64. The technological feasibility study (PEA, Chapter 4) indicates that employers use substitutes for crystalline silica in a variety of operations. If you are aware of substitutes for crystalline silica that are currently being used in any operation not considered in the feasibility study, please provide to OSHA relevant information that contains data supporting the effectiveness, in reducing exposure to crystalline silica, of those substitutes. Provide any information you may have on the health hazards associated with exposure to these substitutes.

The Preliminary Economic Analysis and Initial Regulatory Flexibility Analysis (PEA) mentions exposures associated with curb cutting among the sources of silica exposure to landscape workers (PEA, page IV-219) and among masonry cutters using portable saws (PEA, page

IV-425). The HSE reported a case study where plastic curbs were used in place of concrete curbs to repair a highway overpass [HSE 2008b]. The case study notes that the employer considered using "smaller/precut/low silica concrete blocks, cutting blocks off site, or using water suppression when cutting." The plastic curb material was selected because it reduced loading on the highway overpass. In addition, substituting the plastic product eliminated the occupational respiratory hazard from silica dust (i.e., the product did not need to be cut) and reduced the risks from manual material handling because the plastic product was lighter.

66. The proposed rule prohibits the use of compressed air and dry brushing and sweeping for cleaning of surfaces and clothing in general industry, maritime, and construction and promotes the use of wet methods and HEPA-filter vacuuming as alternatives. Are there any circumstances in general industry, maritime, or construction work where dry sweeping is the only kind of sweeping that can be done? Have you done dry sweeping and, if so, what has been your experience with it? What methods have you used to minimize dust when dry sweeping? Can exposure levels be kept below the proposed PEL when dry sweeping is conducted? How? Provide exposure data for periods when you conducted dry sweeping. If silica respirable dust samples are not available, provide real time respirable dust or gravimetric respirable dust data. Is water available at most sites to wet down dust prior to sweeping? How effective is the use of water? Does the use of water cause other problems for the worksite? Are there other substitutes that are effective?

Regarding the use of compressed air and high efficiency particulate air (HEPA) filters for cleaning of clothing, we recommend the use of the clothes cleaning booth system as discussed in our response to question 51. NIOSH researchers evaluated the use of a HEPA filter vacuum for cleaning soiled clothes. Results indicated that HEPA vacuuming was not as effective in removing dust from soiled clothing and was substantially more time-consuming than the clothes cleaning booth technique [Cecala et al. 2007].

Regarding dry sweeping, previous U.S. Bureau of Mines research indicated that dry sweeping can increase the worker's respirable dust exposure and release dust into the work environment [USBM 1986]. NIOSH discourages dry sweeping as a cleaning technique and recommends alternatives to dry sweeping such as the use of water to wash down facilities, vacuum systems (portable or centralized), and floor sweeping compounds [NIOSH 2012b].

Medical Surveillance

General statement about medical surveillance

OSHA makes the following recommendations for medical surveillance (pages 56363–56364): Baseline: "*...the initial (baseline) medical examination would consist of (1) a medical and work history, (2) a physical examination with special emphasis on the respiratory system, (3) a chest X-ray that is interpreted according to guidelines of the International Labour Organization, (4) a pulmonary function test that meets certain criteria and is administered by spirometry technician with current certification from a NIOSH-approved spirometry course, (5) testing for latent tuberculosis (TB) infection, and (6) any other tests deemed appropriate by the physician or licensed health care professional (PLHCP).*" Periodic: "*...the periodic medical examination (every third year after the initial health screening) would consist of (1) a medical and work* *history review and update, (2) a physical examination with special emphasis on the respiratory system, (3) a chest X-ray that meets certain standards of the International Labour Organization, (4) a pulmonary function test that meets certain criteria and is administered by a spirometry technician with current certification from a NIOSH-approved spirometry course, (5) testing for latent TB infection, if recommended by the PLHCP, and (6) any other tests deemed appropriate by the PLHCP.*"

NIOSH agrees with the choice of tests and their proposed frequency. NIOSH also agrees with OSHA's assessment that there is not a strong rationale for providing temporary work removal in the regulation. Thus, in view of the lack of a statutory parallel to the Part 90 rights for transfer to a low-dust job offered to coal miners, NIOSH agrees with OSHA's approach to this matter.

77. Is exposure for 30 days at or above the PEL the appropriate number of days to trigger medical surveillance?

NIOSH suggests that because silica retention in the lung is prolonged and can cause progressive lung damage even after exposure ends, OSHA should consider requiring that medical monitoring (surveillance) of a silica-exposed worker continue while the worker is employed by the employer, even when the worker is no longer exposed above the OSHA PEL (or exposed less than the 30-day minimum). It might be reasonable to consider limiting continued monitoring (surveillance) only for those workers who have been monitored (surveilled) for some minimum number of years or who have had medical monitoring (surveillance) results (e.g., International Labour Organization (ILO) classification, spirometry test results, or any other Physician or Licensed Health Care Professionals (PLHCPs) assessment) indicative or suggestive of a silica-related health effect. The decision about whether or not to continue medical monitoring when an employee transfers to a job without silica exposure could be left to the discretion of the responsible PLHCP.

Given the long latency and chronic progressive nature of the non-malignant respiratory diseases caused by occupational exposure to respirable crystalline silica, it has been authoritatively recommended in a World Health Organization document that:

> "Ideally, health surveillance, particularly for workers exposed to silica dust, should be lifelong" [WHO 1996].

In a statement on medical surveillance focusing mainly on asbestos-exposed workers (and with clear applicability to silica-exposed workers), Harber [1996] noted that:

> "Surveillance efforts, particularly screening, should be focused in individuals at significantly elevated risk and provided at the most useful time in the person's life. Therefore, since many of the asbestos-related disorders (e.g., lung cancer, asbestosis) have relatively long latencies, screening efforts are best conducted well after exposure has begun (and often long after exposure has ceased). Hence, for many individuals, the best time to screen is twenty or more years after exposure has started (often after the individual has retired). Despite this logic, many governmental screening programs (such as OSHA) focus on current workers and largely ignore retirees, the group at the highest risk."

A 2010 guide from the National Industrial Sand Association (NISA) recommends that workers more than 35 years old with 0 to 8 years since first silica exposure should have a chest X-ray every 4 years, and those in this age group with more than 8 years of silica exposure should have a chest X-ray every 2 years. Thus, this recommendation is based on duration of exposure and does not place an outer limit on duration of surveillance (http://www.sand.org/Silica-Occupational-Health-Program, page 110).

Similarly, 2012 medical surveillance recommendations from Michigan State University do not place an outer limit on duration of periodic chest X-ray examinations of silica-exposed workers (http://www.oem.msu.edu/userfiles/SilicaScreenProtocol.pdf, page 2). It notes: "The frequency of chest x-rays should be every 5-10 years in the first 20 years of work unless the air levels are above the OSHA standard. For individuals who work in areas where the level of silica is above the OSHA air standard chest x-rays need to be done more frequently (every 1-3 years). If an individual does abrasive blasting with silica than [sic] an annual x-ray is recommended even in the first 20 years of work. The first chest x-ray should be done as a baseline before exposure begins. Any worker with 20 or more years of exposure, or x-ray evidence of silicosis should be given an x-ray annually." In this recommendation, frequency of surveillance is based on duration of exposure and this is not an outer limit on duration of surveillance.

79. OSHA is proposing to allow an ''equivalent diagnostic study'' in place of requirements to use a chest X-ray (posterior/anterior view; no less than 14 x 17 inches and no more than 16 x 17 inches at full inspiration; interpreted and classified according to the International Labour Organization (ILO) International Classification of Radiographs of Pneumoconioses by a NIOSH-certified ''B'' reader). Two other radiological test methods, computed tomography (CT) and high resolution computed tomography (HRCT), could be considered ''equivalent diagnostic studies'' under paragraph (h)(2)(iii) of the proposal. However, the benefits of CT or HRCT should be balanced with risks, including higher radiation doses. Also, standardized methods for interpreting and reporting results of CT or HRCT are not currently available. The Agency requests comment on whether CT and HRCT should be considered ''equivalent diagnostic studies'' under the rule. Provide a rationale and evidence to support your position.

The proposed OSHA silica standard should clarify that only a standard digital posteroanterior chest radiograph is equivalent to a traditional film chest radiograph (meeting the specifications presented in Question 79). Computed tomography (CT) typically has higher radiation dose and higher cost. In addition, CT is more sensitive than chest radiography and can more readily identify abnormalities suggesting possible lung cancer, most of which will be found to be "false positives." In addition to other potential adverse impacts on affected individuals (e.g., additional time, effort, expense, and worry), the additional clinical evaluations warranted to assess these "false positives" (e.g., additional radiologic imaging and in some cases, invasive biopsy) have their own health risks [Bach et al. 2012].

A major reason that CT or high resolution computed tomography (HRCT) is not an "equivalent diagnostic study" is that the ILO classification system applies only to posteroanterior views of the chest and does not extend to CT studies. CT and HRCT can be usefully viewed as complementary (not equivalent) to a standard or digital chest radiograph (e.g., to be obtained on a case-by-case basis and only at the discretion of a pulmonary or public health clinical specialist to whom a small minority of silica-exposed workers is expected to be referred under the provisions of the proposed standard).

Particularly in permitting digital chest radiographs, OSHA may wish to incorporate or adapt language from parts of a recent NIOSH regulation that apply to radiograph examinations for pneumoconiosis. (See https://www.federalregister.gov/articles/2012/09/13/2012-22253/specifications-for-medical-examinations-of-underground-coal-miners#h-25). The NIOSH regulation includes provisions describing requirements for radiograph systems, qualifications of the radiologic technologists, specifications for interpreting and classifying chest radiographs, and definitions, including the following:

> "*Chest radiograph* means a single posteroanterior radiographic projection or radiograph of the chest at full inspiration recorded on either film or digital radiography systems."

87. Some OSHA health standards include appendices that address topics such as the hazards associated with the regulated substance, health screening considerations, occupational disease questionnaires, and PLHCP obligations. In this proposed rule, OSHA has included a non-mandatory appendix to clarify the medical surveillance provisions of the rule. What would be the advantages and disadvantages of including such an appendix in the final rule? If you believe it should be included, comment on the appropriateness of the information included. What additional information, if any, should be included in the appendix?

Two responses:

1. NIOSH suggests this information be included in the final rule to make it easier for PLHCPs managing silica-exposed patients to find and access the information. In addition, medical schools and residency programs provide little instruction on what illnesses are related to occupational and environmental exposures [Schenk et al. 1996; Michas and Iacono 2008]. As such, including an appendix in the final rule that clarifies the medical surveillance provisions of the rule would be helpful for the many PLHCPs with little awareness of the illnesses related to silica exposure and how they should be evaluated and managed.

2. Page 56492, Appendix A, Section II Medical Surveillance, E. Radiography, fifth sentence: "*Medical imaging is currently in the process of transitioning from conventional film-based radiography to digital radiography systems. Until the ILO endorses the use of digital standards, conventional chest radiographs are needed for classification using the ILO system.*"

NIOSH recommends that Appendix A, if referenced, should note the most recent ILO policy on digital radiography. In 2011, ILO released a revised set of guidelines that endorsed the use of digital chest radiographs and provided a set of digital standards (ILO 2011-D) for the classification of pneumoconiosis. (The reference, ILO (2011), is on page 56480 of the preamble).

B. Comments on other parts of preamble text

VI. Summary of OSHA's Preliminary Quantitative Risk Assessment

-- Page 56313, column 3, description of Rice et al. [2001]: suggest adding the results of the best model fit and the risk estimates as in other descriptions in this section.

These comments pertain to the three-paragraph description "*d. Kuempel et al. (2001) Rat-Based Model for Human Lung Cancer*" that starts in the middle column of page 56314:

a) suggest the following two sentences be added to the end of paragraph 1 to provide a more accurate and complete description of results:

"Kuempel et al. [2001] included an evaluation of both linear and nonlinear (threshold) models, and they estimated the 95% lower confidence limit of the human-equivalent M_{crit} to be 0.005 mg/m^3. This value is similar to the no observed adverse effect levels (NOAELs) for silicosis estimated in human studies [Rice and Stayner 1995]."

b) paragraph 2, please replace this sentence:

"*Finally, they used these latter slope estimates in a life table program to estimate lung cancer risk associated with their "threshold" exposure of 0.036 mg/m3 and to the OSHA PEL and NIOSH REL.*"

with this one:

"Finally, they used these latter slope estimates in a life table program to estimate the lung cancer risks associated with working lifetime exposure to the human-equivalent average M_{crit} of 0.36 mg/m^3 (8-hr TWA) or to the OSHA PEL or NIOSH REL."

c) Column 3, line 9: "*Keumpel*" should be "Kuempel".

d) Column 3, line 14: suggest adding the following sentence to the end of the paragraph (after … "epidemiology studies."") for a more complete and accurate description of results:

"They also reported that workers exposed for a working lifetime at the current exposure limits have an estimated excess risk of developing lung cancer, whether these risk estimates were derived using models that assume a biological mechanism of direct genotoxicity (low-dose linear) or indirect genotoxicity (non-linear) acting, for example, through chronic pulmonary inflammation."

-- Page 56315, last paragraph in description of Miller et al. [2007] and Miller and MacCalman [2009] describes 0.055 mg/m^3 for 45 years as an average quartz exposure (column 3, top of the paragraph), while the bottom of the paragraph describes it as cumulative exposure (0.055 mg/m^3-years). Please check. (Note: Miller and MacCalman was published in 2010. The PR cites the 2009 e-pub).

-- Page 56320, Table VI-1, first line of "*Model parameters (standard error)*" column gives a value that seems incorrect (i.e., β=0.60 (0.015); probably should be 0.06 (0.015) or 0.6 (0.15). The "*Model*" column of the same table appears to have a floating entry halfway down ("*Log-linear*^{c}").

-- Page 56320, Table VI-2: would be helpful to include an estimate and discussion of total risk from all attributable diseases (i.e., lung cancer, non-malignant respiratory diseases, renal disease, silicosis incidence). At 0.025 mg/m^3 of respirable crystalline silica exposure, the estimate would be about 70/1,000 (7%) and about 140/1,000 (14%) at the proposed PEL of 0.05 mg/m^3.

VII. Significance of Risk

1. First column, first sentence, page 56324, suggested edit: *"The appearance of ILO category 2 or 3* ~~**background**~~ *profusion of small opacities has been shown to increase the risk of developing large opacities characteristic of PMF."*

Including the word "background" in this context could be confusing and inappropriate; suggest deleting it.

2. Middle of first column, page 56324, suggested edit: *"Although there is no national silicosis* ~~*disease*~~ morbidity *surveillance system in the U.S., a published analysis of state-based surveillance data from the time period 1987–1996 estimated that between 3,600–7,000 new cases of silicosis occurred in the U.S. each year (Rosenman et al., 2003)."*

The suggested edit is needed for clarification. There is a national silicosis mortality surveillance system in the U.S. and OSHA cites data from it in the preamble; however, this sentence refers to national silicosis morbidity surveillance.

3. Second sentence in middle column, page 56325, suggested edit: *"Silicosis is not a reversible condition and there is no specific treatment for the disease,* ***though silicosis-related airflow limitation is sometimes improved by*** ~~***other than***~~ *administration of drugs to alleviate* ***airways*** *inflammation and maintain open airways,* ~~***or***~~ ***and, in severe cases, low oxygen levels can be improved by*** *administration of* ***supplemental*** *oxygen therapy* ~~***in severe cases***~~*."*

The original wording implied that oxygen and airways treatments are treatments specific to silicosis. Rather, they are generic supportive treatments.

4. First full paragraph, first sentence, page 56336, suggested edit: *"One study of coal miners also permitted the agency to evaluate the risk of developing lung fibrosis consistent with an ILO category 2+* ~~***degree of***~~ *profusion of small opacities (Buchanan et al., 2003)."*

The words "*degree of*" context can be deleted; "*category 2+ profusion*" suffices. Note that this phrase occurs two more times in the paragraph.

VIII. Summary of the Preliminary Economic Analysis and Initial Regulatory Flexibility Analysis

Paragraph 2 in E.1.d. Medical Surveillance (page 56363) states "*…current certification…*"

NIOSH recommends replacing this text with "a current certificate" because NIOSH does not certify individual technicians. This clarification needs to be made in the remainder of the document.

XVI. Summary and Explanation of the Standards

Paragraph 21 in (h) Medical Surveillance (page 56470) states: "*The NIOSH-approved spirometry training is based upon procedures and interpretation standards developed by the ATS/ERS and European Respiratory Society and addresses topics such as instrument calibration, testing performance, data quality, and interpretation of results (NIOSH, 2011b).*"

NIOSH recommends removing "European Respiratory Society" because the acronym ATS/ERS includes the European Respiratory Society.

C. Comments on Regulatory Text

--Page 56488, lines 3-5, (d)5 *Method of sample analysis* (ii)B: suggested additional sentence in bold underline: "*Participates in round robin testing with at least two other independent laboratories at least every six months.* **Samples used in the round robin tests should be relevant to the loading range of samples collected from atmospheres with concentrations around the PEL and action level that are received by the laboratory.**" (See response to question 46 for further explanation).

--Page 56488, (d)5 *Method of sample analysis* (ii)E states: "*Characterizes the sample material by identifying polymorphs of respirable crystalline silica present...*". The proposed rule treats respirable crystalline silica polymorphs as having the same health risk and the distinction here may be to ensure that the analysis is performed correctly. However, NIOSH recommends that this requirement be clarified.

--Page 56488, (d)5 *Method of sample analysis* (ii)F(3) states: "*Optimizes methods and instruments to obtain a quantitative limit of detection that represents a value no higher than 25 percent of the PEL based on sample air volume.*"

Suggested edit: "*Optimizes analytical methods and instruments to obtain a quantitative limit of detection* **(Limit of Quantitation)** no higher than **10 µg/filter for quartz or 20 µg/filter for cristobalite**." This edit more fully separates the selection of sampling device from the requirements for analytical methods and instruments.

The term "quantitative limit of detection" is presumed to be the Limit of Quantitation (LOQ) used in analytical methods. A sample volume of 800 liters (L) is required to obtain a sample meeting the quartz LOQ of 10 µg/filter per OSHA Method ID-142 (revised December 1996) at 25% of the PEL (12.5 µg/m^3). The sampling time is 471 minutes (nearly 8 hours) when using a flow-rate of 1.7 L/min. Thus, when the Dorr-Oliver 10-mm nylon cyclone is used for less than 8 hours, it cannot provide a sample that meets this requirement—the statement as written in the proposed rule may be interpreted as a restriction on lower flow-rate cyclones, such as the Dorr-Oliver 10-mm nylon cyclone, to no less than 8-hour samples. The situation becomes more critical when considering the higher LOQ for cristobalite. (Note: An LOQ of 20 µg/filter for cristobalite is achievable, although it is listed as 30 µg/filter in OSHA Method ID-142). The Dorr-Oliver 10-mm nylon cyclone could not meet the proposed requirement because, for a full-shift sample, an air concentration of 50% of the PEL would be needed to provide a sample that could be quantified accurately at 20 µg/filter.

--Page 56489, (h) Medical surveillance, (1) General (i), suggested edit: "*The employer shall make medical surveillance available at no cost to the employee, and at a reasonable time and place, for each employee who* ~~*will*~~ **is or is expected in the coming year to** *be occupationally exposed to respirable crystalline silica above the PEL for 30 or more days per year.*"

The suggested edit provides clarification and also applies to the proposed standard for Part 1926. The response to question 77 has additional suggestions.

--Page 56489, (h) Medical surveillance (ii)(2)(i) *Initial examination*, suggested edit: "*A medical and work history, with emphasis on: ... history of tuberculosis* **and testing for tuberculosis**; *and smoking ...*"

The suggested edit provides clarification and also applies to the proposed standard for Part 1926.

--Page 56489, (h) Medical surveillance (2)(iii), suggested edit: "*A* ~~*chest X-ray*~~ **standard posterioanterior radiograph of the chest** ~~*(posterior/anterior view; no less than 14 x 17 inches and no more than 16 x 17 inches*~~ *at full inspiration* **(either a conventional film-based image [no less than 14 x 17 inches and no more than 16 x 17 inches] or a digital chest image**), ~~*interpreted and*~~ *classified according to the International Labour* ~~*Organization*~~ **Office** (ILO) International Classification of Radiographs of Pneumoconioses by a *NIOSH-certified* ~~"B" reader,~~ ***B Reader***~~*; or an equivalent diagnostic study*~~*;*

The suggested edits specify the nature of the "equivalent diagnostic study," to clarify that any "equivalent diagnostic study" must also be classified by a B Reader, and to more precisely specify the source of the ILO guidelines. (Note: Wherever they occur, "*'B' reader*" or the hyphenated form (e.g., "*B-reader*") should be replaced by "B Reader". (The NIOSH-preferred format does not place quote marks around the B and is not hyphenated). Similarly, "Organization" should be replaced by "Office" when spelling out "ILO" in the context of the ILO system for classifying radiographs of pneumoconiosis). This comment would also apply to the proposed standard for Part 1926.

--Page 56489, third column (comment also applies to the proposed standard for Part 1926): the proposed standard provides for testing lung function as *"(iv) A pulmonary function test to include forced vital capacity (FVC) and forced expiratory volume at one second (FEV_1) and FEV_1/FVC ratio, administered by a spirometry technician with current certification from a NIOSH-approved spirometry course.*" The limited text here and in Appendix A differs from the OSHA cotton dust standard (29 CFR 1910.1043) which provides details including that individual test results should be compared to predicted values and that a "*comparison shall be made between the current examination results and those of previous examinations and a determination made by the physician as to whether there has been a significant change.*" If those provisions were included in the silicosis standard, Appendix A could be revised to include details about:

1) prediction equations to use;

2) when and how to adjust results for workers of particular race/ethnicity for which prediction equations are unavailable;

3) how to compare test results to normative date to assess normality/abnormality of spirometry test results;

4) how to assess changing test results over time.

NIOSH investigators published normative spirometry values [Hankinson et al. 1999] and further information about spirometric reference values is available in the NIOSH [1995] coal mine dust criteria document (appendix G), Pellegrino et al. [2005], Townsend et al. [2011], and Wang and Petsonk [2004]. In addition, NIOSH provides software to evaluate longer-term longitudinal change in spirometry test results for individual workers at http://www.cdc.gov/niosh/topics/spirometry/spirola.html.

--Pages 56496–56499 "*Table 1 – Exposure Control Methods for Selected Construction Operations*", two responses:

1. (respirators) column 3 "*Required air-purifying respirator*"

Table 1 contains the following types of respirators in the respirator recommendations: "Half-mask" and "Full facepiece" and "Powered air-purifying respirator (PAPR) with loose-fitting helmet or negative pressure full facepiece." No other types of respirators are included in these recommendations. NIOSH does not use the following terminology that appears in Table 1: "Powered air-purifying respirator (PAPR) with loose-fitting helmet or negative pressure full facepiece." The term "negative pressure" is used only for non-powered air-purifying respirators. The terminology should be changed to "Powered air-purifying respirator (PAPR) with loose-fitting helmet or full facepiece."

"Half-mask" designation does not specify whether this category also includes filtering facepiece respirators. The OSHA respiratory protection standard 29 CFR 1910.134, Table 1: Assigned Protection Factors, specifies that the half-mask category includes filtering facepiece respirators and elastomeric half-mask respirators.

Table 1 does not appear to allow for the use of respirators designed for use at higher maximum use concentrations in place of the type recommended. This policy is present in the OSHA respiratory protection standard 29 CFR 1910.134 Table 1: Assigned Protection Factors, which includes the following footnote: "*Employers may select respirators assigned for use in higher workplace concentrations of a hazardous substance for use at lower concentrations of that substance, or when required respirator use is independent of concentration.*"

The respirator recommendations do not include the filter type that should be used (e.g., N95, P100). These filter types should be included in this table (see next paragraph for the respirator and filter types recommended by NIOSH), or section 1926.1053 (f) (2) page 56496 should be revised to include a reference to the OSHA respiratory protection standard 1910.134 for proper filter selection, because Table 1 does not include the type of filters to use with the respirator, and the employer needs to follow the guidance on respirator selection in 1910.134.

The NIOSH Pocket Guide to Chemical Hazards [NIOSH 2005] has a listing for respirable crystalline silica dust that includes respirator recommendations and the type of filter to use with the respirator. For respirable crystalline silica dust, NIOSH recommends the following types of respirators in the Pocket Guide:

- for concentrations not exceeding 10 times the REL, the NIOSH recommendation is any particulate respirator equipped with an N95, R95, or P95 filter (including N95, R95, and P95 filtering facepieces) except quarter-mask respirators. The following filters may also be used: N99, R99, P99, N100, R100, P100;

- for concentrations not exceeding 25 times the REL, NIOSH recommends using any powered air-purifying respirator (PAPR) with high-efficiency particulate (HE) filter(s) or a supplied-air respirator operated in continuous flow mode;

- for concentrations not exceeding 50 times the REL, NIOSH recommends using a full-facepiece respirator with N100, R100 or P100 filter, or any PAPR with a tight-fitting facepiece and HE filter;

- for concentrations not exceeding 25 mg/m^3, NIOSH recommends using any supplied-air respirator operated in the pressure-demand or other positive-pressure mode;

- for emergencies or planned entry into unknown concentrations or IDLH conditions, NIOSH recommends using a full-facepiece self-contained breathing apparatus (SCBA) operated in the pressure-demand or other positive-pressure mode or a full-facepiece supplied-air respirator operated in the pressure-demand or other positive-pressure mode with an auxiliary self-contained air supply for escape;

- for escape, NIOSH recommends using a full-facepiece respirator with N100, R100 or P100 filter or any appropriate escape-type SCBA.

If oil particles (e.g., lubricants, cutting fluids, glycerine, etc.) are present, use an R- or P-series filter. N-series filters cannot be used if oil particles are present. If oil particles are present and the filter is to be used for more than one work shift, use only a P-series filter.

In 2008, NIOSH published a policy statement "Respiratory Protection Recommendations for Airborne Exposures to Crystalline Silica" that recommended half-facepiece particulate respirators with N95 or better filters for protection against airborne exposures to crystalline silica at concentrations less than or equal to 0.5 mg/m^3 (ten times the NIOSH REL) [NIOSH 2008c]. This recommendation is consistent with the NIOSH Pocket Guide to Chemical Hazards.

2. The "*Engineering and work practice control methods*" presented in the rows "*Operating Vehicle-Mounted Drilling Rigs for Rock*", "*Operating Vehicle-Mounted Drilling Rigs for Concrete*", and "*Rock Crushing*" specify that "*Incoming air is filtered through a prefilter and HEPA filter.*"

NIOSH recommends: 1) using a mechanical filter media for machinery-mounted filtration and pressurization systems; this filter media becomes more efficient as it loads with dust and develops a filter cake [Cecala et al. 2012]; 2) the proposed rule specify that incoming air for an enclosed cab of mobile equipment be filtered through a prefilter and then either a Minimum Efficiency Reporting Value (MERV)-16 or HEPA filter [Cecala et al. 2013].

Recently-published NIOSH research found that a MERV-16, (as defined by the American Society of Heating, Refrigerating and Air-Conditioning Engineers) -quality filter media may be more advantageous than HEPA-quality intake filter on mobile equipment [Cecala et al. 2012, 2013]. A non-loaded MERV-16 media has greater than 95% filtering efficiency on particles in the respirable size range (i.e., 0.3–10 microns). As this filter media loads with dust, it becomes more efficient at removing particles from the intake airflow. It is common practice to use a HEPA-quality filter, which has an efficiency rating of 99.97% for particles greater than 0.3 microns in size. However, the HEPA filter is more costly and restrictive than the MERV-16 and places additional demands on the entire system, including the intake fan. A recent NIOSH laboratory study evaluated the performance of different MERV-rated filters and a HEPA filter on diesel particulate matter and found that the MERV-16-rated filter would be an effective alternative to the HEPA filter for enclosed cabs in mining applications [Noll et al. 2011]. The HEPA filter loads more quickly with dust and diesel contaminants, leading to a quicker reduction in system airflow and increased maintenance requirements. As a result, mandated use of a HEPA filter may not be a benefit for filtration and pressurization systems for enclosed cabs in mining.

--Appendix A, p. 56491, I. Recognition of Silica-Related Diseases, A--C (This comment would also apply to proposed Appendix A for Part 1926). OSHA lists the symptoms, physical exam findings, spirometry test results, and chest radiograph abnormalities separately for chronic silicosis and accelerated silicosis. However, a severe case of chronic silicosis can have the same symptoms and other clinical findings as a severe case of accelerated silicosis; the distinction is that the chronic case will take much longer to develop and progress because the exposures for the chronic case were generally lower. Accelerated silicosis and chronic silicosis are not different diseases pathologically. However, acute silicosis (with alveolar filling) is pathologically a distinct form of silicosis. OSHA could revise the chronic silicosis section by incorporating the content from the accelerated silicosis section relating to symptoms, physical exam findings, spirometry test results, and chest radiograph abnormalities. Then, the accelerated silicosis section could simply refer back to the chronic silicosis section for descriptions of symptoms, physical exam findings, spirometry test results, and chest radiograph abnormalities. The change would emphasize the shorter latency and more rapid progression of accelerated silicosis due to higher exposures.

OSHA states "*Accelerated silicosis occurs within 2–10 years,*"; clarification could be "*Accelerated silicosis occurs within* a few years, generally *2–10 years of exposure and results from* very *high levels of exposure to respirable crystalline silica.*" (A reasonable clinician may diagnose "accelerated silicosis" in a patient with rapidly progressive disease and no silicoproteinosis (alveolar filling) even with a latency of less than 2 years). Similarly, OSHA could modify its description of acute silicosis: "*Acute silicosis is a rare disease caused by inhalation of* ~~*very*~~ **extremely** *high levels of respirable crystalline silica particles. … Acute silicosis develops rapidly,* **often** *within a few* **weeks or** months ~~**to less than 2 years**~~ of exposure." A patient with a biopsy showing silicoproteinosis would reasonably be diagnosed as having "acute silicosis" even if the latency exceeded 2 years.

--Page 56491, first column (this comment would also apply to proposed Appendix A for Part 1926), suggested edit: "*4.* ~~*Chest X-ray*~~ **Digital or conventional film-based chest radiograph**—*classic findings are small, rounded opacities in the upper lung fields bilaterally. However, small* *irregular opacities and opacities in other lung areas can also occur. Rarely, ''eggshell calcifications'' are seen* **in the hilar and mediastinal lymph nodes**."

The suggested edit provides more precise information.

--Page 56491, C. Acute Silicosis (this comment would also apply to proposed Appendix A for Part 1926), suggested edit: "1. *Symptoms—sudden, progressive, and severe shortness of breath*, **sometimes accompanied by productive cough, hemoptysis, and pleuritic chest pain**. *Constitutional symptoms are frequently present and include weight loss, fatigue*, **and fever**~~*productive cough, hemoptysis, and pleuritic chest pain*~~.

Some symptoms listed as "constitutional" symptoms are not constitutional, and fever is an additional constitutional symptom in many acute silicosis cases.

--Page 56492, E. Radiography (this comment would also apply to proposed Appendix A for Part 1926), suggested edit: "*A* **digital or conventional film-based** *chest* ~~*roentgenogram,*~~ **radiograph** ~~*or an equivalent diagnostic study*~~ *must* be ~~performed~~ **done** *on the initial examination and every three years thereafter. ... An International Labor* ~~*Organization*~~**Office** *(ILO)* ~~*reading*~~ **classification** *must be performed by a NIOSH-certified* ~~*''B'' reader*~~ **B Reader**. *If the* ~~*B reading*~~ **classification** *indicates small opacities in a profusion of 1/0 or higher, the worker must be referred to a physician who is certified by* ~~*ABMS*~~ **the American Board of Internal Medicine (ABIM)** *in pulmonary* ~~*medicine*~~ **disease**. *Medical imaging* ~~*is currently in the process of*~~ **has been** *transitioning from conventional film-based radiography to digital radiography systems.* ~~*Until the*~~ *The use of digital* **images is now endorsed for** *ILO* **classification**~~*endorses standards, conventional chest radiographs are needed for classification using the ILO system*~~. *Current ILO* **and NIOSH** *guidance on radiography for pneumoconioses* ~~*and B reading*~~ *should be reviewed periodically on the ILO (www.ilo.org) or NIOSH (www.cdc.gov) Web sites.*

The suggested edit updates content and corrects format issues already noted. The American Board of Internal Medicine (ABIM), a member board of the American Board of Medical Specialties (ABMS), certifies specialists in pulmonary disease (not pulmonary medicine, although "pulmonary medicine" is often used to mean the same thing).

--Page 56492, middle of third column, suggested edit (this comment would also apply to proposed Appendix A for Part 1926): "*c. A statement that the employee should be examined by a physician who is certified by* ~~*ABMS*~~ **the American Board of Internal Medicine (ABIM)** *in pulmonary* ~~*medicine*~~ **disease**, *where such a referral is necessary. Referral to a pulmonary specialist is required for* ~~*a chest X-ray B reading*~~ **ILO classification** *indicating small opacities in a profusion of 1/0 or higher, or if referral to a pulmonary specialist is otherwise deemed appropriate.* ~~*A referral to the Public Health Department should not be disclosed to the employer. If necessary, a public health professional will contact the employer to discuss work-related conditions and/or to perform additional medical evaluations.*~~"

The suggested edit is intended to correct terminology issues already noted; the last two sentences appear to be misplaced because they relate to referral to a local public health department and not to a pulmonary disease specialist.

--Page 56492, middle of third column, suggested edit (this comment would also apply to proposed Appendix A for Part 1926): "*2. State Reporting Requirements. Health care providers should be aware that some States require them to report cases of silicosis to the State Department of Health or to the State Department of the Environment.* **In addition, most states require clinicians to report cases of active tuberculosis.**"

The suggested edit adds to Appendix A's Tuberculosis (TB) information.

--Page 56492, last paragraph, suggested edit (this comment would also apply to proposed Appendix A for Part 1926): "*B. Medical Specialists. The Silica standard requires that all workers with ~~chest X-ray~~ **~~B readings~~***<u>**digital or conventional film-based chest radiograph ILO classification**</u> *of 1/0 or higher be referred to* ***~~an American Board Certified Specialist in Pulmonary Disease~~*** <u>**a physician who is certified by the American Board of Internal Medicine (ABIM) in pulmonary disease**</u>."

The suggested edit addresses terminology issues noted above.

--Page 56493, first paragraph (this comment would apply also to proposed Appendix A for Part 1926): Appendix A should be consistent in guidance and recommendations about referral of latent TB cases to the local health department. The recommendation here that "*Clinicians* ***<u>should</u>*** *<u>refer latent and active</u> TB cases to their local Public Health Department*" contrasts with recommendations given near the bottom of page 56502 where a distinction is made between active and latent TB and referral to the local health department (emphasis added): "*Workers who develop <u>active pulmonary TB **should** be referred</u> to the local public health department. Workers who have evidence of <u>latent TB infection **may** be referred</u> to the local public health department ....*"

-- Pages 56501—56503, *Appendix A to §1926.1053—Medical Surveillance Guidelines (Non-Mandatory)*:

Suggested edits:

Section II, A.2.c: change "*History of TB infection and/or positive test for latent TB*" to "History of active TB infection and/or positive test for latent TB infection."

Section II, A.2.d: change "*...obstructive pulmonary disease...*" to "...chronic obstructive pulmonary disease..."

Section II, C: in the first sentence change "*latent or active tuberculosis*" to "latent or active tuberculosis infection." When referring to "active TB" or "latent TB", include the word "infection" (e.g., "active TB infection" and "latent TB infection").

Section III, A.1.a. and A.1.c.: change "*...Public Health Department*" to "State or local Public Health Department".

Section IIIC: change "*...local Public Health Department.*" to "State or local Public Health Department". A local health department does not exist in some areas of the United States.

The preceding two suggested edits would also apply to Page 56492, third column, end of first paragraph.

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