
Understanding Silica Exposure Risks and Controls



for Wellsite Completions Crews

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The National Institute for Occupational Safety and Health (NIOSH) is conducting research to identify possible workplace exposures in oil and gas extraction. This article describes results and conclusions of wellsite measurements for respirable crystalline silica associated with the use of silica sand—the primary proppant used in hydraulic fracturing. To learn more about frac sand see *Well Servicing, January/February 2012, Where Does Frac Sand Come From?*

It is important that supervisors and employees understand that silica sand may contain up to 99 percent crystalline silica and depending on the concentration and duration of exposure, breathing fine dusts containing respirable crystalline silica can pose an occupational health hazard. Inhalation of respirable crystalline silica is associated with silicosis and lung cancer. For more information visit the OSHA-NIOSH Hazard Alert on the web and the NIOSH Science Blog.

The study

NIOSH partnered with operators and service companies to evaluate worker exposures to respirable silica at 11 completion sites in five states (CO, TX, ND, AR and PA). The majority of work involved slick water completions with a variety of silica sand (20/40, 40/70 and 100 mesh) and in some cases resin coated and ceramic proppant. Samples were collected in different weather conditions, altitudes and geographic locations. Workers who participated wore sampling equipment designed to collect full shift (typically 12 hours) personal breathing zone (PBZ) samples. Samples were analyzed by an American Industrial Hygiene Association accredited laboratory. Samples were analyzed first by weight for respirable dust and then by X-ray diffraction for crystalline silica. Quartz, a type of crystalline silica, was the only mineral detected above the limit of quantitation.

PBZ sample results were compared to occupational exposure limits (OELs) for respirable silica exposures. The Occupational Safety and Health Administration (OSHA)

permissible exposure limit (PEL) is not a fixed value like hydrogen sulfide (H₂S) or carbon monoxide, it is calculated for each sample based on the percentage of silica present in the dust sample using the formula: $10\text{mg}/\text{m}^3 \div (\% \text{silica} + 2)$. As an example, if the percentage of silica is 100 percent, the PEL is 0.098 milligrams of silica per cubic meter of air (mg/m³). The NIOSH recommended exposure limit (REL) for respirable silica is a fixed value (0.05 mg/m³) and the American Conference of

Government Industrial Hygienist's Threshold Limit Value (TLV) for respirable silica is fixed at 0.025 mg/m³. Each of these exposure limits is a time-weighted average (TWA) for a work day.

Results

Employees who worked around sand movers (74% of the samples were above the PEL), transfer belts (83% of the samples were above the PEL) and blenders (50% of the samples were above the PEL) during sand moving and transfer

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Figure 1 - Eight Primary Points of Dust Release or Generation from Completions Equipment or Workplace Operations

operations—especially during hot loading—were more at risk for silica exposures than employees who worked farther from sand moving operations or who were upwind.

However, silica exposures exceeding the OELs were documented for sand coordinators who primarily worked upwind and not in the immediate area of sand movers (exposures likely due to dust generated from wellsite traffic) or who worked downwind from sand moving operations (e.g., water tank operators). Employees in data vans were protected because doors on the data van were always kept closed. However, chemical truck operators and blender operators working in cabs were sometimes overexposed to silica despite spending most of the day inside their trucks or cabs (which did not have fine particulate filtration or tight-sealing doors).

Sources of silica dust generation

Based on workplace observations NIOSH researchers identified eight (8) primary points of dust release or generation from completions equipment or workplace operations (Figure 1).

Controls for reduction/elimination of silica exposures

NIOSH working together with industry partners and the National STEPS Network, Respirable Crystalline Silica Focus Group (a volunteer organization comprising E&P operators, industry trade associations, completions companies, OSHA, and individual occupational safety and health experts), has identified controls that can be implemented immediately. Some controls are simple; some are more complex. The following controls are listed in order of increasing complexity, costs and time to develop, as well as from the primary point sources of silica generation.

- Train employees on the hazards of silica exposures, locations of silica dust generation and the types of controls that are used to prevent exposures (see sidebar). Instruct employees to remove silica dust from hands, face, clothing and personal protective equipment (PPE) prior to leaving the wellsite



1.



2.



3.



4.



5.



6.



7.



8.

1. Dust ejected from thief hatches on top of the sand movers during refilling operations.
2. Dust ejected and pulsed through side fill ports on the sand movers during refilling operations.
3. Dust generated by on-site truck vehicle traffic including sand trucks and crew trucks, the release of air brakes on sand trucks and by winds.
4. Dust released from the transfer belt under the sand movers.
5. Dust created as sand drops into, or is agitated in the blender hopper and on transfer belts.
6. Dust released from operations of transfer belts between the sand mover and the blender.
7. Dust released from the top of the dragon's tail on sand movers.
8. Dust deposited on and released from worker's coveralls.

and provide cleaning instruction for contaminated PPE including clothing. If silica cannot be removed from clothing instruct employees to change into clean clothes at the end of their work shift.

- Train sand truck delivery drivers to use lower air pressures (10 p.s.i. or less) when off-loading sand into sandmovers.

- Keep thief hatches on top of sandmovers closed as much as possible, especially when filling.

- Ensure that unused fill ports on sandmovers are capped. Capping unused fill ports eliminates silica dust release during filling. If the caps are missing, stuffing the opening with a rag can help reduce dust generation.

- Limit the number of workers, and the time spent in areas where dust and silica levels may be elevated; consider ways to perform dusty operations remotely.

- Minimize the drop height between the dragon tail and T-belts and blender hoppers. Limiting the

distance that sand falls through the air can help reduce dust.

- Employ dust controls at the wellsite.

- When engineering and work practices controls do not control workplace exposures below OEL's, employers must provide respirators for workers. Whenever respirators are used, the employer must have a respiratory protection program that meets the requirements of OSHA's Respiratory Protection Standard (29 CFR 1910.134). This program must include proper respirator selection, fit testing, medical evaluations and training in worksite-specific hazards. Half-face respirators are not likely to be completely protective; use of respirators that offer more protection (e.g., a full-facepiece respirator, which will protect workers at silica levels up to 50 times the PEL) are likely to be needed in the absence of effective engineering controls. Full-face powered air-purifying respirators (PAPR) provide more

protection than half-face air-purifying respirators. In general, workers find PAPRs to be more comfortable.

Practices that involve equipment changes/modifications:

- Use passive enclosures on machinery where silica dust can be released. Installation of plastic or heavy cloth stilling or staging curtains around the bottom sides of the sand movers can limit dusts released from belt operation. Hard-sided enclosures can also be added along and at the ends of the dragon tail and along sand transfer belts.

- Install appropriate ventilation engineering controls (on-board filtration, aftermarket baghouses) that effectively contain release of respirable silica dust from sand movers.

- Investigate and install alternative ways to transfer proppant including slurry systems, use of screw augers instead of belts on sand movers and non-pneumatic

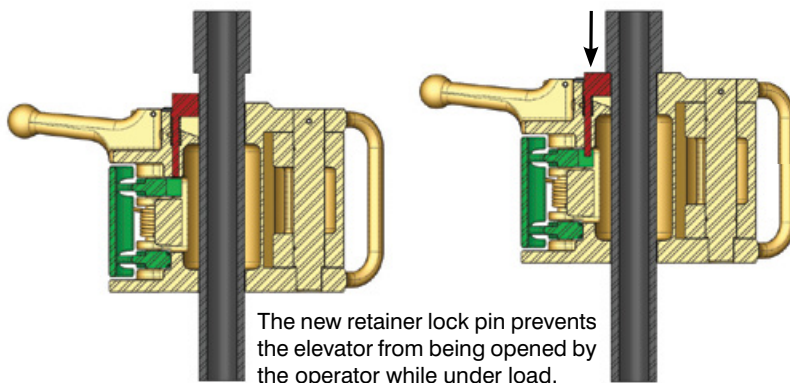
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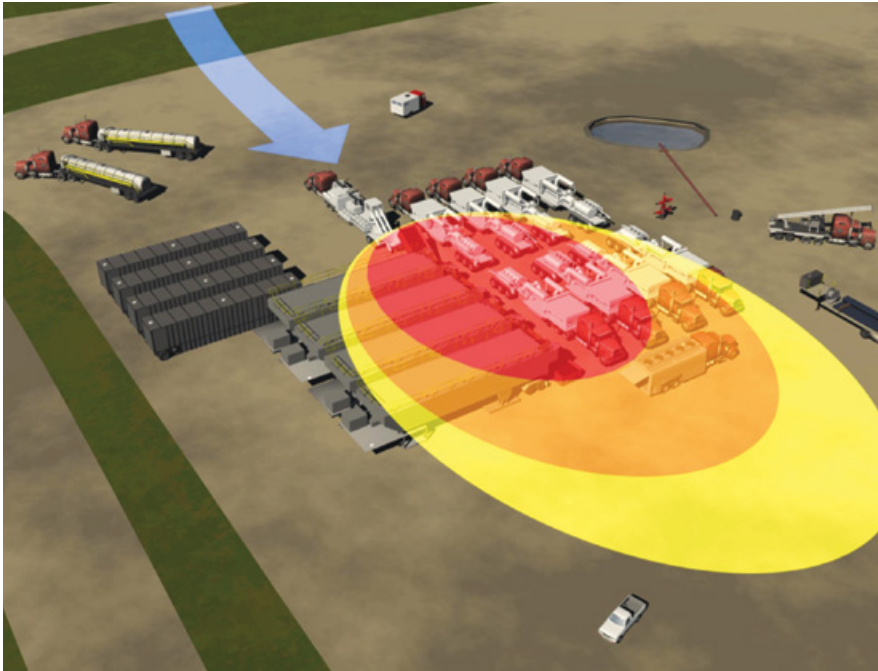
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Figure 2 - Effect of Wind (Blue Arrow) and the Potential for Windborne Movement of Crystalline Silica during Sand Handling and Transfer During Completions



Until dust controls are in place on sand movers, T-belts or sand delivery trucks, workers within the red zone should be adequately protected with proper use of a full-face respirator and P-100 cartridges (assigned protection factor = 50). Workers within the orange zone should be adequately protected by proper use of a half-mask, elastomeric facepiece respirator (P-100 cartridges) or N-95 or greater (e.g., P-100) filtering facepiece respirator (both respirators have assigned protection factors of 10). Unprotected workers should avoid the area within the yellow oval or be in that area only when wearing properly fitted, N-95 (or greater) respiratory protection.

transfer systems such as gravity-assist silos.

Summary

Exposure to respirable crystalline silica is an occupational health hazard for completions crews. Sand mover and blender operators appear to be at greatest risk for exposures but other crew members have exposure risks as well.

Until a variety of engineering controls can be developed and implemented, employers and employees should:

- Restrict access to areas with potential exposure to respirable silica to workers trained to recognize and avoid silica hazards and post signs warning of the silica hazard (**Figure 2**).

- Conduct personal breathing zone sampling for silica. Workers should participate in all air monitoring or training programs offered by the employer.

- Where respirators are required, workers must wear respirators approved for protection against crystalline silica-containing dust

with an assigned protection factor based on the risks determined.

- Clean contaminated work clothing using clothes cleaning booths or change into clean clothing before leaving the worksite.

- Do not eat, drink or use tobacco products in areas where there is dust containing crystalline silica. 🧢

NIOSH is looking for additional E&P industry partners to work with us to evaluate worker exposures to chemical hazards and develop controls as needed, any of the authors can be contacted for more information.

Communicate the Risk



Provide warnings to worker when there is potential for breathing crystalline silica. Use signage to limit entry to areas with the potential silica hazards or notify when respirators must be worn.

Resources

- OSHA has an InfoSheet for completion workers that addresses potential exposures to respirable silica during hydraulic fracturing http://www.osha.gov/dts/infosheets/silica_hydraulicfracturing.html.

- For information on silica hazards and ways employers can protect workers and workers can protect themselves OSHA and NIOSH have jointly prepared "A Guide to Working Safely with Silica. If it's Silica, It's Not Just Dust" <http://www.cdc.gov/niosh/pdfs/silicax.pdf>.

- NIOSH published Best Practices for Dust Control in Metal/Nonmetal Mining (NIOSH Informational Circular 9521) which discusses dust control in underground mining operations. <http://www.cdc.gov/niosh/mining/UserFiles/works/pdfs/2010-132.pdf>.

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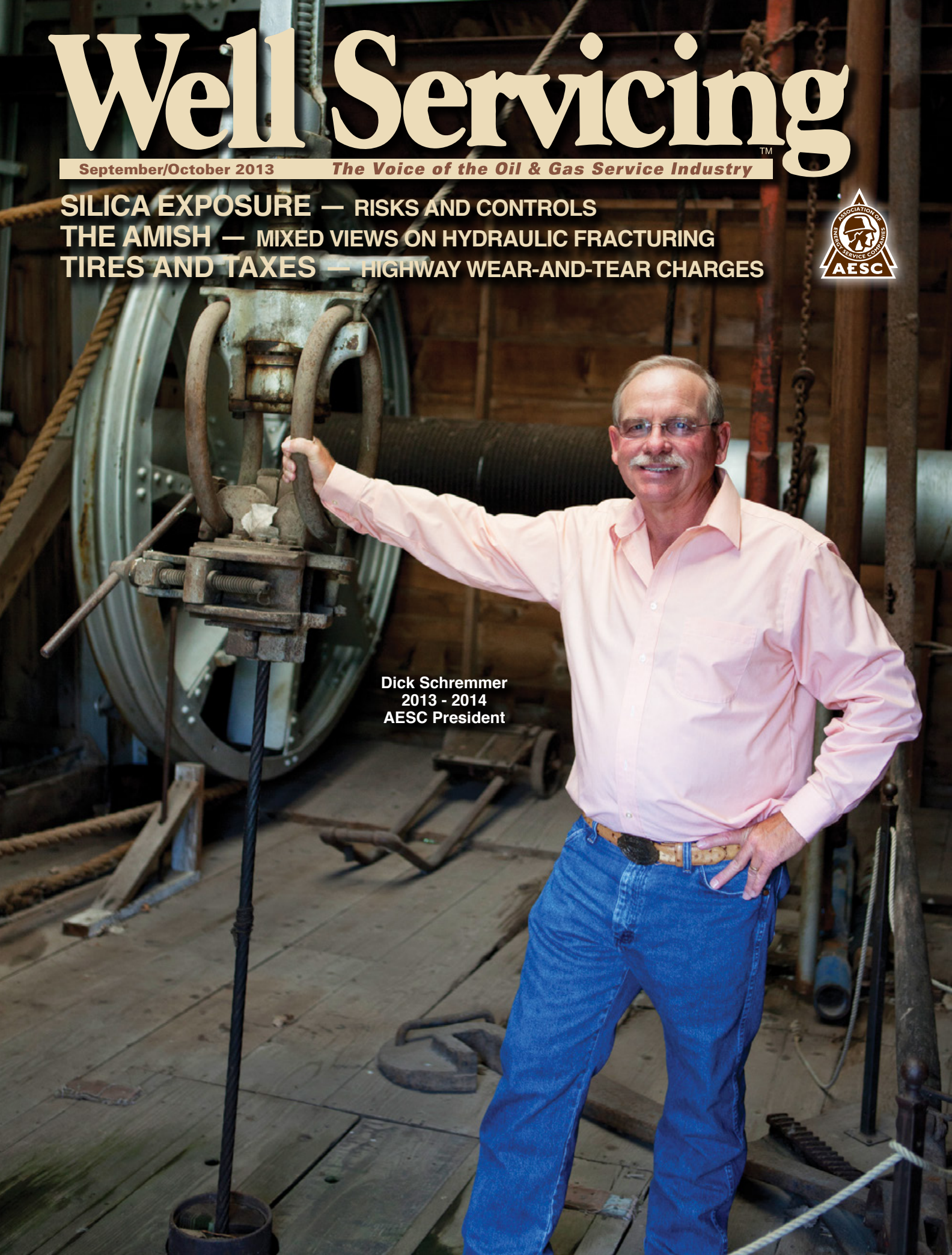
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OFFICIAL PUBLICATION OF
THE ASSOCIATION OF ENERGY
SERVICE COMPANIES

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Foreign Subscriptions: Canada and Mexico \$100/year, all other non-U.S. addresses \$200/year.

CHANGE OF ADDRESS: Please send copy of mailing label with new address to *Well Servicing*, 14531 FM 529, Suite 250, Houston, Texas 77095

Official publication of the Association of Energy Service Companies. Editorial, business and advertising offices: 14531 FM 529, Suite 250, Houston, Texas 77095; (713) 781-0758 or (800) 692-0771; Fax (713) 781-7542

Well Servicing (USPS 537-670) (ISSN 0043-2393) is published bimonthly by Workover/Well Servicing Publications, Inc., 14531 FM 529, Suite 250, Houston, Texas 77095. A wholly owned subsidiary of the Association of Energy Service Companies. Periodicals postage paid at Houston, Texas 77201.

POSTMASTER: Send address changes to *Well Servicing*, 14531 FM 529, Suite 250 Houston, Texas 77095



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