

# KEEPING UP with the Oil and Gas Rush

**NIOSH Seeks to Improve Worker Safety and Health in the U.S. Upstream Oil and Gas Industry**

BY ERIC ESSWEIN AND RYAN HILL

**U**nconventional oil and gas extraction—for example, directional drilling and hydraulic fracturing (also known as fracking) to extract oil and gas from deep shale formations—can rightly be regarded as a modern-day “oil and gas rush.” But while this rush has created hundreds of thousands of well-paying jobs, the drive to extract gas and oil has brought with it some important considerations regarding the safety and health of oil and gas extraction workers.

In 2004, 98 U.S. oil and gas extraction workers died on the job. The resulting fatality rate (31.9 deaths per 100,000 workers, according to the Bureau of Labor Statistics) was similar to the rate found in coal miners, twice that of construction workers and almost eight times that for all U.S. workers that year. When these data were released, the director of NIOSH charged a small group of NIOSH researchers with the task of investigating fatalities, and funded a small pilot project to examine fatal injuries to oil and gas extraction workers. NIOSH researchers collected and analyzed data, identified industry partners for collaboration, visited well sites, and met with health and safety professionals and workers to better understand oil and gas operations and associated hazards. The findings from these early investigations remain consistent: highway crashes and workers struck by objects were the two most frequent fatal events in the oil and gas extraction industry, resulting in almost half of all fatalities

(49.4 percent; see Table 1).

The next most frequent fatal events were explosions, workers caught or compressed by machinery, and falls from heights.

### Developing Partnerships

In 2005, NIOSH identified and invited influential safety and health professionals from industry, government, and academia to participate in a partnership program, the National Occupational Research Agenda (NORA) Oil and Gas Extraction Sector Council. The first meeting of this council occurred in July 2008. The primary objective of the first meeting was to formulate an outline of possible safety and health research topics. Over the course of the next three years, the council met, refined the safety and health research topics, and published a strategic plan outlining research priorities for both NIOSH and U.S. oil and gas extraction industry stakeholders. The work of the council continues in conducting research and developing products that will reduce injuries, illnesses and exposures among oil and gas extraction workers.

### Expanding Research

Since 2005, the NIOSH Oil and Gas Extraction Safety and Health Program has expanded to include additional researchers and new research projects. In 2007, NIOSH funded a project to conduct an “occupational ethnography,” a study of the unique work culture in the upstream oil and gas industry. NIOSH staff (and a contractor) traveled to dozens of well sites around the country interviewing workers about their safety and health concerns and priorities. Information and knowledge gathered during this study have been used to guide subsequent NIOSH research activities and to ensure the development of meaningful products that meet the needs of workers.

Additionally, NIOSH expanded its research portfolio to include other safety-related projects. These projects focused on the causes of, and methods to reduce, the most frequent fatal events in the industry. Research topics included motor vehicle fatalities, falls from height, and fires and explosion events. More recently, NIOSH began a project to describe safety and health issues among workers employed in the offshore oil and gas extraction industry.

### Industrial Hygiene Knowledge Gaps

Currently, a limited number of published studies (such as industrial hygiene exposure assessments) describe the scope and magnitude of occupational health risks for workers employed in the land-based oil and gas extraction industry, which includes well drilling, completions (hydraulic fracturing), and well servicing activities. (Hydraulic fracturing involves using hydraulic pressure to create and expand fractures in geologic formations to increase permeability and encourage the recovery of gas and oil inherent in the petroleum reservoir.) Based on the priorities identified in the NORA Oil and Gas Extraction Sector Council goals, NIOSH set out to address this lack of information by conducting research to better understand potential health risks associated with chemical exposures in oil and gas extraction. Contacts were made with oil and gas operators (companies who own or lease land for oil and gas extraction), and permission was obtained to visit active well sites in several states during different seasons to observe drilling, completions, and well servicing operations. The objectives of the site visits were to collect area air samples, meet and observe workers and supervisors, understand the nature of work performed, identify chemical (or mineral) products used or likely encountered, and review the use of personal protective equipment. Safety data sheets were reviewed for products used in drilling and completions.

Based on site observations and limited area air sampling, the NIOSH Field Effort to Assess Chemical Exposures in Oil and Gas Workers was initiated. Industrial hygiene exposure characterizations were conducted for chemical and mineral substances, including hydrocarbons (for example, benzene, toluene, xylenes, and ethyl benzene), diesel particulate (as elemental carbon) and respirable aerosols. The majority of the exposure assessment studies focused on worker exposures to respirable crystalline silica (alpha quartz) during hydraulic fracturing because quartz was identified as a possible exposure hazard with well-known toxicity and occupational exposure criteria.

Silica-containing sand is widely used as a proppant during hydraulic fracturing operations to hold open fissures and cracks in the petroleum-bearing formations. Millions of pounds of quartz sand are typically used during hydraulic fracturing. Respirable quartz-containing dusts are generated from handling and transporting sand through a variety of machinery commonly used during hydraulic fracturing operations.

Exposure assessments at 11 locations in five states over a 15-month period determined that PBZ concentrations of respirable crystalline silica regularly exceeded calculated OSHA PELs for respirable dust containing silica, the NIOSH REL (0.05 mg/m<sup>3</sup> as a TWA for respirable silica), and the ACGIH TLV (0.025 mg/m<sup>3</sup> as a TWA for respirable crystalline silica). In some cases PBZ

**Table 1.** The Most Frequent Fatal Events in the U.S. Oil and Gas Extraction Industry, 2003-2009

Injury Event	Fatalities	% Total
Highway crash	210	29.3
Struck by object	144	20.1
Explosion	57	8.0
Caught/compressed in machinery or tools	50	7.0
Fall to lower level	46	6.4
Fire	40	5.6
Electric current	36	5.0
Aircraft crash	25	3.5
Other	108	15.1
<b>Total</b>	<b>716</b>	<b>100.0</b>

concentrations exceeded the assigned protection factor of 10 for the types of respirators most commonly used by workers during hydraulic fracturing—air-purifying, elastomeric half-masks with P-100 cartridges or N-95 (or greater) filtering facepiece respirators. Workers operating sand movers and sand conveyers (also called transfers or “T-belts”) were determined to have the highest risks for exposures, but even workers who did not work in the immediate area where large amounts of sand are handled and transported had risks for silica exposures in excess of occupational exposure limits. Figure 2 describes six worker job titles and the geometric means of full-shift (12-hour) sampling for respirable crystalline silica.

Based on site observations, NIOSH researchers identified at least eight points of silica-containing dust release or generation from equipment used on site, the site itself, or the worker including:

- ejected from hatches on the top of sand moving equipment during sand refilling
- released from sand transport belts beneath sand moving machines
- created when sand is dropped from height when moved from one machine to another
- ejected from fill ports on sand moving machines during refilling operations

- released from transfer belts connecting sand movers and liquid blending trucks
- released at the end of a reciprocating sand belt on sand moving machines
- generated from site vehicle traffic, release of air brakes on trucks, and by wind
- from work clothing (for example, flame retardant coveralls) contaminated with crystalline silica

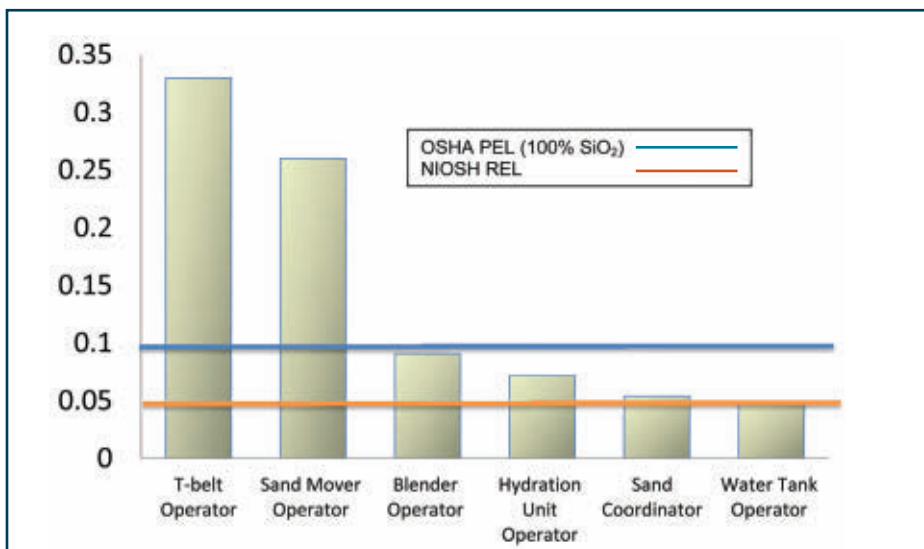
### Controls for Respirable Crystalline Silica

NIOSH communicated the research findings to industry and provided a variety of recommendations for controls, including engineering, administrative, work practice, and personal protective equipment (for example, proper use of respirators) to limit dust generation and the potential for exposures during hydraulic fracturing. Examples of controls include:

- substitute alternative (non-silica-containing) proppants when and where feasible
- use local exhaust ventilation for capture and collection of silica-containing dust
- use administrative controls; minimize numbers of workers in areas where silica dust is commonly present
- consider water misting when and where appropriate to minimize dust generation

- use passive enclosures (such as enclosures and shrouding) at identified points of dust generation
- minimize drop distances between ends of sand transfer belts and blender hoppers
- use dust control on roads and at the well pad to minimize secondary silica-containing dust generation
- ensure that end caps are on fill ports on sand movers during refilling operations
- consider methods to clean silica-containing dusts that contaminate workers’ clothing
- consider Prevention-through-Design dust control measures for future iterations of sand moving devices ([www.cdc.gov/niosh/topics/PtD](http://www.cdc.gov/niosh/topics/PtD))

One engineering control (developed in-house by NIOSH) is a “bolt-on” option to control dust emitted from the top hatches of sand moving machinery. This NIOSH mini-baghouse retrofit assembly consists of a base plate that seals to the rim of the hatch opening on sand movers (see Figure 2). A section of ductwork connects to a nine-foot length of suspended baghouse fabric. The design exploits pressurization generated during pneumatic filling of the sand into the sand mover; no additional power is needed. Instead of particulate-laden air being ejected from thief hatch openings, the baghouse fabric inflates and a dust cake forms on the inside of the fabric, which traps and contains fine particulates. When the bin is filled, the pneumatic pressure is reduced, the fabric slackens and the dust cake is shed and collapses back into the sand bin. The technology is patent-pending and in a pre-licensure status at the time this article was written. NIOSH mining safety and health engineers also developed a method to clean dust from soiled work clothing (<http://bit.ly/dustworkclothes>) that consists of a cleaning booth, compressed air reservoir, a spray manifold and an exhaust air system. Evaluation of the technology shows that the system is 10 times faster and removed 50 percent more dust from clothes than vacuuming or using compressed air (which is never recommended).



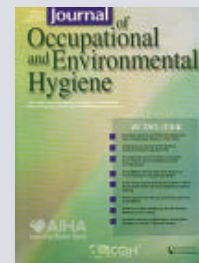
**Figure 1.** Geometric means (mg/m<sup>3</sup>) of PBZ samples for various job titles and relative comparisons to an OSHA PEL and the NIOSH REL for respirable crystalline silica.

### Research Dissemination

Based on the risks for silica exposures, NIOSH developed a Science Blog post (<http://bit.ly/nioshblogsilicafracking>) and OSHA and NIOSH published a joint Hazard Alert (<http://1.usa.gov/frackingalertweb>), both of which describe results and provide recommendations for controlling silica exposures during hydraulic fracturing. The National Service, Transmission, Exploration and Production (STEPS) Network quickly established the Respirable Crystalline Silica Focus Group to address the need for immediate, short-term and long-term control options to limit worker silica exposures. The STEPS Network is an all-volunteer organization comprising safety and health professionals in the oil and gas industry. OSHA and NIOSH also participate in the STEPS Network, which “promotes safety, health and environmental improvement in the exploration and production of oil and gas in U.S. onshore operations.” The STEPS Network communicated the hazard throughout the industry and quickly produced a guidance document, *Guidelines for Minimizing Silica Exposures in Hydraulic Fracturing* (<http://bit.ly/minimizingsilica>), which provides recommendations for immediate, short-term and long-term actions employers and employees can take to prevent silica exposures.

### JOEH Publishes New NIOSH Research on Silica Exposures in Fracking

The July issue of the *Journal of Occupational and Environmental Hygiene* will include new research from NIOSH on work crew exposures to respirable crystalline silica during hydraulic fracturing. The paper, authored by Eric J. Esswein, Michael Breitenstein, John Snawder, Max Kiefera, and W. Karl Sieber, is already available online. AIHA members can access the online version by signing in at [www.aiha.org](http://www.aiha.org) and clicking on the link to the Journal in the Member Center.



### Improving Safety and Health

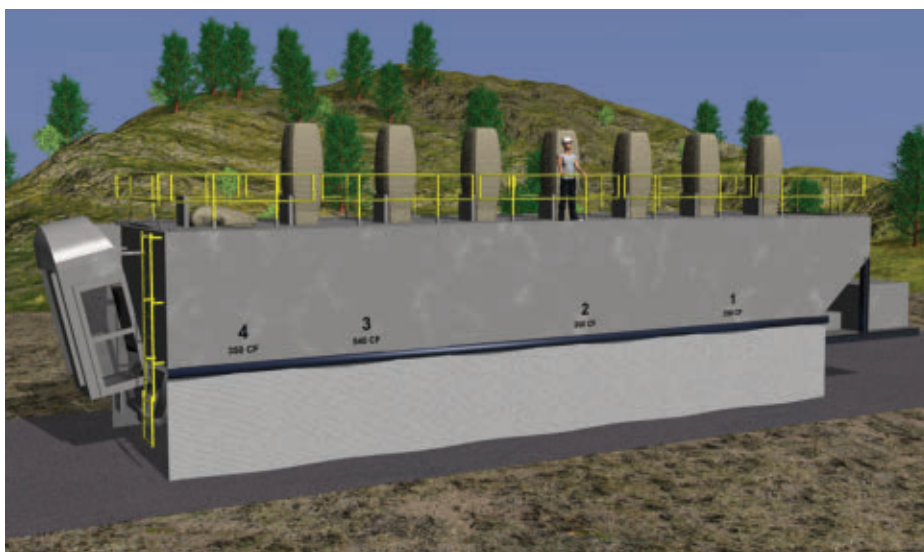
While risks for fatalities and the nature of occupational safety hazards are well documented for upstream workers, the scope and magnitude of chemical exposure health risks are not well described (or, at least are not published in the peer-reviewed literature). Exposure to respirable crystalline silica is an occupational health hazard for crews at hydraulic fracturing sites. Sand mover and T-belt operators appear to be at greatest risks for exposures, but other on-site crew members have risks for exposures as well. Additional exposure risks in oil and gas extraction include H<sub>2</sub>S, hydrocarbons (for example, benzene), diesel particulate matter, lead, acids, a variety of biocides, and naturally-occurring radioactive materials (NORM), which includes a variety of

terrestrial isotopes such as U, Th, Ra and radon daughters.

From a safety perspective, highway crashes and struck-by injuries, followed by explosions, workers caught or compressed in machinery, and falls from heights, are the most frequent fatal events in the oil and gas extraction industry. One overarching and consistent finding is that small companies (those with fewer than 20 employees) and workers with less than one year of experience with their current employer have the highest fatality rates and should be a focus for improved safety efforts.

Industrial hygienists and safety professionals can make needed and valuable contributions to the profession in the area of oil and gas extraction safety and health. However, these contributions need to balance a focus on the *soon and certain* hazards that, if uncontrolled, can cause acute injury or even death, with the need to anticipate, think, and understand the risks for the *long and latent*: chemicals (or minerals) that may cause disease years or decades after exposure. NIOSH will continue to focus on research needs, build collaborative relationships with industry partners to further research to prevent fatalities, injuries and exposures, and work to improve the overall health and safety for workers in this industry. 🌱

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**Figure 2.** Sand mover configured with a variety of controls to control silica dust emissions, including mini-baghouse retrofits (top) and enclosures and stilling curtains along bottom and side of sand moving belt.