Managing chemical hazards

Silica on hydraulic fracturing sites – sources of exposure

PROCESS DOCUMENT GS 407

BACKGROUND

This document is part of the Silica Exposure Control Plan (ECP) template. The template provides general silica information. Please refer to Guidance Sheets GS 408 and GS 409 to understand controls and conduct a hazard assessment on hydraulic fracturing sites.

Hydraulic fracturing involves the use of water, proppant, chemicals and pressure to fracture the formation and hold it open so petroleum resources may be extracted.

One of the most common proppants is sand. Sand typically contains 30-100 percent quartz silica, one of the most abundant minerals on the planet. In addition to sand, some ceramic proppants are used that contain other forms of silica such as cristobalite.

Elevated respirable crystalline silica exposures associated with hydraulic fracturing – herein referred to as fracking – are a serious emerging concern, because silica can cause serious lung disease. The amount of sand used in fracking operations has changed in recent years. Current operations use significantly more sand than earlier ones did. The amount of proppant moved down hole in any given work shift has increased from a few tonnes to as much as a 1,000 tonnes. In addition, advances in the ability to measure silica and more scientific evidence of the toxicity of silica have resulted in a reduction of the silica exposure level by several times.

Silica exposure levels on frack sites vary widely in concentration from <0.0125 to 10.0 mg/m^3 compared to the respirable quartz 12-hour occupational exposure limit of 0.0125 mg/m^3 as identified by NIOSH[3] and Alberta Jobs, Skills, Training and Labour[4,5]. Sources of these exposures and a variety of exposure factors exist that differentiate one situation from another.

SOURCES OF SILICA EXPOSURE ON FRACK SITES

A variety of sources of exposure can exist on a fracking site. They may include the following, which are listed from highest to lowest airborne concentration:

- Thief and vent hatches during loading of proppant, either by way of conveyor belts or pneumatic conveyance (use of air)
- Any uncovered fill nozzles on vertical or horizontal sand storage
- Hopper
- Handling of bulk silica frack dust (powder), such as from local exhaust ventilation engineering controls or in air filters
- Conveyor junction points
- Sand tent loading and un-loading
- Top of blend truck auger
- Truck end-dump or bottom-dump locations
- Contaminated coveralls
- Soil, rock and clay ground cover

SPECIFIC FACTORS OF EXPOSURE

In addition to the general determinates of exposure discussed in the Silica ECP, please see the following additional determinates and information provided specific to fracking.

Quantity in use: For workers in close proximity to silica sources the more sand moved down hole in a 12-hour period the more elevated the silica levels will be. For example, the “ball drop” method minimizes the downtime between frack stages. Thus, more proppant is moved down hole in a 12-hour period when compared to the “plug and perforate” technique.

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<u>Relative dustiness</u>: Not all sands are created equal: Mesh size and ceramic proppant all impact dust levels. In addition, the use of sand with reduced fines (smaller diameter particles that are more likely to become airborne) will reduce the exposures. However, it is also important to remember that it does not eliminate the risk, because of the dust that is generated when the sand is moved. Dust suppressants may be used to reduce the silica dust generated from moving the sand.

Sand comes in different sizes with small sand grains having a higher mesh size. Higher mesh size sand typically generates more dust. For example, 100 mesh sand may generate several times more dust than 40/70 mesh sand. Therefore, the higher mesh number of sand that is used the more elevated the exposures may be. Often higher mesh sands are used at the front end of the frack followed by lower mesh sand (larger sand) for the majority of the sand in that stage. In general, as the ratio of 100 mesh to 40/70 mesh increases, so do the exposures.

Ceramic proppant is manmade, contains less silica, and may be less dusty. As a result, silica exposures associated with ceramic proppant are generally significantly less. Ceramic proppant is used based on formation requirements, is significantly more expensive than frack sand and is not as widely available.

Bulk silica frack dust (powder) is the collected or settled airborne silica dust such as in filter socks affixed to pneumatic air hoses or thief hatches. This material is extremely dusty and may result in very elevated exposures.

<u>Energy</u>: The more energy that is incorporated into the sand, the more dust that is created at junction and drop points. Wide and deep conveyor belts moving slower can deliver the same volume of sand as a flat and narrow belt moving several times faster.

Sand can be stored onsite using horizontal or vertical containers. Horizontal storage containers are equipped with a conveyor while vertical storage containers are typically gravity feed either directly into the hopper or onto a conveyor. Offsite sand storage could be a sand tent or building with conveyors and augers.

Proppant can be moved to the work site in a variety of ways, such as:

- the use of end dump trucks on very small fracks
- the use of bottom dump trucks that drop the sand into augers or conveyors to move it into site sand storage
- pneumatic conveyance

Pneumatic conveyance is one of the most visible – and significantly elevated – silica frack dust sources. As the sand moves through the metal pipes and hoses, friction creates new fractures in the sand. The pneumatic air now contains silica dust and in the absence of engineering controls, this dust is released from the sand storage equipment into the air of the work site. When pneumatic in-loading is conducted on an on-going basis while pumping is occurring, referred to as “Hot Loading”, additional risk is created because of increased personnel in the area and duration of exposure. Depending on the type of sand storage equipment, site layout, and prevailing winds, adjacent workers may be at risk from exposure.

As a result, the use of PPE controls alone for adjacent workers can be very challenging and often not effective. Therefore, a variety of controls are required to reduce silica dust at the source; examples include engineering controls and administrative controls. These, and other controls, are discussed in Guidance Sheet GS 408. For work sites with lower tonnages, exceeding the full-shift exposure level and associated full-face respirator protection factor is unlikely. However, it is important to recognize that exceeding other exposure limits, like the 30-minute derived TWA (3 X full-shift TWA) and associated respirator protection factor, is very likely. This is due to the high energy involved at the sources. This is particularly true for those personnel in close proximity to the silica dust sources such as within 1 meter.

SOURCES OF EXPOSURE

☐ Thief hatches

☐ Uncovered fill nozzles

☐ Hopper

☐ Handling filters or uncontained bulk silica frack dust (powder)

☐ Conveyor junctions

☐ Blender auger

☐ Sand storage (tents)

☐ Ground cover

FACTORS OF EXPOSURE

☐ Energy

☐ Relative Dustiness

☐ Quantity in use

☐ Percentage silica

☐ Proximity

☐ Time

☐ Ventilation

Further Reading and References

1. Enform’s Silica Exposure Control Plan
2. Enform’s Silica Information website: Enform.ca
3. Esswein EJ, Breitenstein M, Snawder J, Kiefer M, Sieber WK. Occupational exposure to respirable crystalline silica during hydraulic fracturing. J Occup Environ Hyg 2013;10:347–56.
4. Radnoff D, Todor M, Beach J. Exposure to Crystalline Silica at Alberta Work Sites: Review of Controls. J Occup Environ Hyg 2015: 12,6:393-403
5. Radnoff D, Todor M, Beach J. Occupational Exposure to Crystalline Silica at Alberta Work Sites. J Occup Environ Hyg 2014: 11, 9:557-570