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Occupational Silica Exposure for the Fuel Distributing Company on Hydraulic Fracturing Locations

Caleb Moore  
*Montana Tech of the University of Montana*

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Occupational Silica Exposure for the Fuel Distributing Company on Hydraulic Fracturing Locations

by

Caleb Moore

A report submitted in partial fulfillment of the requirements for the degree of

Master of Science
Industrial Hygiene Distance Learning / Professional Track

MONTANA TECH OF THE UNIVERSITY OF MONTANA
2015
Abstract

This report investigates the potential exposure to respirable crystalline silica experienced by fuel distributing employees on hydraulic fracturing locations. Hydraulic fracturing is an oil and gas technique used to develop shale formations all across the United States of America. This is done by injecting large volumes of water, sand, and treatment chemicals under high pressure into oil wells within the shale formation. This well stimulation is possible due to the high pressure of the fluid, which creates and opens cracks and fissures in the formation. The sand contained inside the fluid flows into these opened fissures and becomes wedged, holding the fissures open after the fluid pressure has been removed. The National Institute for Occupational Safety and Health (NIOSH) and Occupational Safety and Health Administration (OSHA) have issued warnings of the hazard created by using sand containing crystalline silica. They have reported that 99% of hydraulic fracturing locations have the possibility of being exposed to this hazard. In 2003 NIOSH collected 111 samples at 11 sites in five states evaluating respirable crystalline silica during hydraulic fracturing operations. Only two of the 111 samples were performed on fuel distributing employees on location. The evaluations of these employees showed that fuel distributing employees received an average of dose of 57% compared to the 8 hour time weighted permissible exposure limit and 114% of a 12 hour extended work shift exposure limit set by OSHA. This study is to be used to determine compliance with the OSHA existing PEL, the proposed PEL changes and ACGIH TLV. This study collected 10 breathing zone samples from fuel distributing employees on hydraulic fracturing locations on five sites in two states. This report focuses on the shale formation development in Oklahoma and Kansas. Four of the sites were located in Oklahoma and one in Kansas. The results from each sample showed that the exposure does not exceed the exposure limits using the current OSHA PEL limit but was over exposed under the proposed PEL and ACGIH’s TLV. These assessments are adjusted to the occupation exposure limit for extended work shifts typical of the fuel company. It is necessary for the company to provide a safe work environment free of known hazards, and limiting the hazards within the exposure limits set by the national government. With new limits and the research that documents old standards do not adequately protected employees, the company should provide safeguards for its employees.

Keywords:
Silica, Hydraulic, Fracturing, Fuel
Dedication

This research is dedicated to my wife, my mother who I will always miss, and my father. Without them I would have never had the courage to pursue my dreams.
Acknowledgements

I would like to express my very great appreciation to Dane Rombaugh and Bill Woolsey for their efforts to fund this project. I would also like to thank the following organizations for enabling me to visit and collect data at their worksites.

- Pilot Thomas Logistics
- Baker Hughes
- Basic Energy Services
- Archer Pressure Pumping
- Chesapeake Energy
- SandRidge Energy
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## Glossary of Terms

<table>
<thead>
<tr>
<th><strong>Term</strong></th>
<th><strong>Definition</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydraulic Fracturing</td>
<td>The forcing of fissures in subterranean rocks by introducing water, sand, and water treatment chemicals at high pressure especially to extract oil or gas.</td>
</tr>
<tr>
<td>Sand Storage Unit</td>
<td>Specific equipment consisting of multiple compartment storage system used to store and transfer proppant.</td>
</tr>
<tr>
<td>Hot Fueling</td>
<td>Fueling equipment while equipment is under pressure.</td>
</tr>
<tr>
<td>Casing</td>
<td>Steel pipe.</td>
</tr>
<tr>
<td>Respirable Crystalline Silica</td>
<td>That portion of airborne crystalline silica that is capable of entering the gas-exchange regions of the lungs if inhaled; by convention, a particle-size-selective fraction of the total airborne dust; includes particles with aerodynamic diameters less than approximately 10µm and has a 50% deposition efficiency for particles with an aerodynamic diameter of approximately 4µm.</td>
</tr>
</tbody>
</table>
1. Introduction

1.1. Background of Hydraulic Fracturing

The United States of America contains large quantities of oil and gas. In some areas these fluids have a poor flow rate to the surface due to a low permeability of the shale, tight sand, and coal bed methane formations. (U.S. Environmental Protection Agency, 2000) Hydraulic fracturing (Frac) stimulates preexisting wells drilled into these formations, allowing them to produce more oil and gas. Within the past decade the combination of hydraulic fracturing and horizontal drilling has allowed an incredible ability to extract oil and gas from shale deposits across the country and brought large scale natural gas drilling all across America.

Approximately 435,000 workers were employed in the U.S. oil and gas extraction industry in 2010, nearly half employed by well servicing companies, including companies that conduct hydraulic fracturing. (U.S. Department of Labor, Bureau of Labor Statistics)

The process of hydraulic fracturing, occurs after drilling and casing has been inserted into the drilled hole. The casing is perforated in specific points along geological zones that contain the oil and gas. This perforation allows the company performing the hydraulic fracturing to inject fluid and sand into these zones. The pressure created down the hole exceeds the absorption rate of the fluid causing fractures along the target zone. Once the fracturing has been done, pressure from the equipment on the surface stops and fluids begin to flow back to the surface. To stop the fractures from closing up companies mix the fluid with sand call proppants. These proppants become wedged between the formation fractures causing them to remain open after pressure from the surface equipment stops. These proppants are housed inside the sand storage unit. The proppant is then discharged from various compartments through multiple gates onto a hydraulically driven belt conveyor that delivers proppant directly into the receiving hopper of the
blender. The blender combines water, chemicals, and proppants together and agitates them together before being injected underground.

1.2. Fuel Distribution Company Functions on Hydraulic Fracturing Locations

Each piece of equipment on a hydraulic fracturing location is powered by diesel fuel. This extends from the pump unit to the light plant, each piece of equipment uses the fuel at different rates, and so operating companies subcontract the work to fuel to other companies. These fuel distribution companies serve as a single source for fueling solutions on location.

Employees working for the fuel company usually are located on the hydraulic fracturing pad for the entire duration of the job. Fuel distributing employees usually are located in different locations than those employees working for the hydraulic fracturing company. Each job location is unique unto itself; however placement of the equipment is fairly common, as shown in figure 1.

Figure 1 General Hydraulic Fracturing Equipment Layout (BC Oil & Gas Commission)

Two fuel distributing trucks are parked on each side near the hydraulic fracturing pump units. These fuel trucks are placed across from each other to better serve the hydraulic fracturing
company by allowing the fuel distributing employee access to each piece of equipment and mitigate the hazard of constantly moving a large vehicle on location. During a typical 12 hour shift the employees are not fueling the entire time, but more along the lines of 15 minutes every hour. This 15 minute span is where the risk of silica exposure happens. The other 45 minutes of the hour fuel employees spend their time away from the equipment usually inside a pickup truck or SUV parked along the edge of location.

1.3. Exposure to Crystalline Silica During Hydraulic Fracturing

The proppants creates aerosol of crystal known as silica. This aerosol is created by handling and the process of transferring the sand. The aerosol consists of particulate matter in the respirable function, and when inhaled in the lungs can lead to silicosis.

According to the U.S. Central of Disease Control (CDC) no effective specific treatment for silicosis is available (Ki Moon Bang, et al., 2015). Approximately 2 million U.S. workers remain potentially exposed to respirable crystalline silica (OSHA, 2013). New technical jobs like hydraulic fracturing continue to emerge that have the possibility of overexposure to crystalline silica.

In 1999, a council of State and Territorial Epidemiologists made silicosis a nationally notable condition. Because the current permissible exposure limits for respirable crystalline silica do not adequately protect workers, OSHA has proposed changes to lower the permissible exposure limit. (Ki Moon Bang, et al., 2015). Also, NIOSH released a report in 2002 reporting that 100% of all oil and gas extraction have the potential to be exposed to respirable crystalline silica (NIOSH, 2002). The conclusions of NIOSH and OSHA are that that respirable crystalline silica is a potential hazard and employees must be protected from being over exposed.
2. Problem Statement

The National Institute of Occupational Safety and Health (NIOSH) released a report in 2013 lacking data for fuel distributing companies. Researchers at NIOSH collected 111 samples of personal breathing zones on fracturing locations, and only two samples were from fuel distributing personnel (Esswein, et al., 2013). At any time during the hydraulic fracturing operations multiple companies are on location performing different tasks, at different locations on the worksite for different lengths of time. It might only be the fracturing company employees who are being exposed to the hazard, however with only the sample pool of two samples certainty of capturing the worst case is lacking. The NIOSH 2013 study is the only specific research done to evaluate if a fuel distributing company employees are being over exposed to the silica hazard. While fuel distributing employees are on the worksite during the entire hydraulic fracturing process, their exposure to crystalline silica has not been thoroughly evaluated. The object of this study was to evaluate the fuel distributing workers’ exposure to crystalline silica.

3. Occupational Exposure Limits for Crystalline Silica

3.1. OSHA Permissible Exposure Limit

OSHA’s permissible exposure limit for respirable crystalline silica is determined by the proportion of silica in the dust sample and determined by the formula (Code of Federal Regulations Title 29, 1910.1000, 2003);

\[
\text{Equation 1: OSHA Respirable Crystalline Silica PEL} \quad \frac{10 \text{ mg/m}^3}{\% \text{ quartz} + 2}
\]
3.2. ACGIH TLV

ACGIH has set their threshold limit value (TLV) for respirable quartz and cristobalite silica at 0.025 mg/m³. This guideline was developed by a consensus standard bodies which involves canvassing the opinion, views and positions of all interested parties and acceptable by these parties. This TLV are based solely on health factors and no consideration is given to economic or technical feasibility. Opinions are established by committees that review existing published and peer-reviewed literate in various scientific disciplines, and has formulated a limit value on respirable silica on these premises (ACGIH, 2015).

3.3. OSHA Proposed PEL

OSHA currently enforces a crystalline silica permissible exposure limit for the general industry that was enacted over 40 years ago in 1971. And with extensive scientific evidence, does not adequately protect worker health (OSHA, 2013). The new PEL and action level, proposed September 12, 2013 in the Federal Register would limit respirable crystalline silica to 0.05 mg/m³ and 0.025 mg/m³ respectively. The proposed rule is expected to prevent thousands of death caused by silicosis, lung cancer, kidney disease and other respiratory diseases. This proposed rule brings protection into the 21st century.

4. Literature Review

4.1. Silica-Related Disease

According to NIOSH hydraulic fracturing sand can contain up to 99% silica, and breathing silica can cause silicosis. Silicosis is a lung disease caused when tissue of the lung in contact with silica becomes inflamed and scars. (NIOSH, 1986) This reduces the total volume of respirable air in the lungs, reducing oxygen uptake in the body. Chronic and acute silica
exposure has also been linked to other diseases, such as chronic obstructive pulmonary disease (COPD), kidney disease, autoimmune disorders, tuberculosis, and lung cancer. (NIOSH, 2002)

Chronic silicosis can result from long-term exposure to low amounts of silica dust. Years of chronic alveolar inflammation and scaring provoked by respirable silica exposure may be asymptomatic or it may present with dyspnea and cough with sputum production. This disease also features breathlessness and may resemble COPD. Acute silicosis can result from short-term exposure to very large amounts of silica. When exposed to large volumes the lungs become inflamed and fill with fluid. This short-term exposure causes severe shortness of breath low blood oxygen levels, severe dyspnea, cough, fever, and weight loss.

4.2. Silica Toxicology

From an occupational health point of view, silica dust size is classified into three primary categories, respirable, inhalable, and total. Respirable dust refers to particles small enough to penetrate the noise and upper respiratory system and deep into the alveoli. Particles that penetrate that deep are generally beyond the body’s natural clearing mechanisms of cilia and mucous and are more likely to be retained. For a particle to reach the alveoli the size its aerodynamic diameter usually is smaller than 5\( \mu m \) (U.S. Bureau of Mines, 1987).

<table>
<thead>
<tr>
<th>Aerodynamic Diameter (( \mu m ))</th>
<th>Percent Passing Selector</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0</td>
<td>90</td>
</tr>
<tr>
<td>2.5</td>
<td>75</td>
</tr>
<tr>
<td>3.5</td>
<td>50</td>
</tr>
<tr>
<td>5.0</td>
<td>25</td>
</tr>
<tr>
<td>10.0</td>
<td>0</td>
</tr>
</tbody>
</table>
Inhalable dust is described as the size fraction of dust which enters the body, but is trapped in the nose, throat, and upper respiratory tract. Particles that are trapped in these areas are removed from the body by the mucociliary escalator. The median aerodynamic diameter of inhalable dust is about 10\(\mu m\). Total dust includes all airborne particles without regard of their size or composition. Respirable sized silica is of great concern and is a toxic health hazard.

Silica inhalation causes fibrogenesis or pulmonary fibrosis, but the mechanism by which silica produces this is not well understood (Churg A, 1997). This medical issue is a respiratory disease characterized by excessive accumulation of extracellular matrix, and remodeling of the lung architecture (Nevins W Todd, 2012). Current evidence suggests that the evolution of accumulation of extracellular matrix creates a sequence of events comprised of respirable sized silica particles being deposited widely over the alveolar surface of the lungs. This aggregates the macrophages around the area, as they attempt to metabolize the silica particle (Heppleston, 1984). The inability of the macrophage to remove the particle in turn progresses the accumulation of more fibroblasts in the location. The fibroblast creates a formation of collagen around the particle to in the attempt to limit the foreign particle from further damaging the alveolar membrane.

4.3. NIOSH Report on Occupational Exposures during Hydraulic Fracturing

On July 1\textsuperscript{st} 2013 the NIOSH released a report focusing on worker exposure to respirable crystalline silica during hydraulic fracturing. Eleven locations were included in the study including southwest Texas, Pennsylvania, Arkansas, Colorado, and North Dakota. Fifteen job titles were sampled, one being fuel distribution employees. Two samples were taken for the fueling job title. However one sample was used to compare it against the OSHA PEL. This one sample showed the fuel employee was exposed to 57\% of the PEL. (Esswein, et al., 2013)
sample results were adjusted for the usual 12 hour shift, the exposure severity would be 50% greater than what was listed and described.

4.4. Texas Commission of Environmental Quality

Texas is the only air agency in the US that has established a cancer-based health benchmark for ambient air exposures to crystalline silica. They established an air concentration of 0.27 $\mu g/m^3$ for 4 microgram size particles in the air as being the level of exposure corresponding to a lifetime cancer risk of one-in-one-hundred thousand. They have set this benchmark for inclusion of emission control requirements to ensure that public health is protected (TCEQ, 2009).

5. Research Design and Methods

5.1. Equipment

Sampling equipment includes 37mm polyvinyl chloride filter (PVC) with 5.0µm pore size supported with backup pad in a two-piece filter holder held together by tape or cellulose shrink band. Also sampling pumps with flexible connecting tubing capable of the 2.5L/min flow rate, aluminum cyclone, and a rotameter.

Lab equipment includes a 25mm in diameter silver membrane filter with 0.45µm pore size. An X-ray powder diffractometer equipped with copper target x-ray tube, graphite monochromator, and scintillation detector. Reference specimen for data normalization, this may be mica, Arkansas stone, or other stable standards. Filter preparation is done with a low temperature radio frequency plasma asher. Analytical balance done with magnetic stirrer with thermally insulated top, ultrasonic bath or probe, volumetric pipettes and flasks; Pyrex crucibles with covers, 40mL wide-mouth centrifuge tubes, desiccators regent bottles with ground glass
stoppers, drying oven, and polyethylene wash bottles. Finally an explosion resistant hot plate, 0.3 to 1mm thick Teflon sheet is used.

5.2. **NIOSH 7500 Sampling Method**

Sampling was done following the NIOSH 7500 sampling method. Starting with calibration, each personal sampling pump is attached to a representative sampler inline and calibrated to 2.5L/min with a rotameter. The calibrated sampling pump was attached to the employee using a hip belt, with the flexible connection tubing placed across the back and over the shoulder. The PVC filter and aluminum cyclone was clipped to the collar of the employee. The employee was instructed to not allow the sampler assembly to be inverted at any time when in use. Turning the cyclone to anything other than a vertical orientation may deposit oversized material from the cyclone body onto the filter. The employee was allowed to perform their regular duties without disturbance for an 8 hour time period. Once sampling was complete the equipment was gathered and a post calibration was collected on each personal sampling pump.

5.3. **NIOSH 7500 Analyst Method**

The analyst is a critical part of this analytical procedure (Pergamon Press, 1961). A high level of analyst expertise is required to optimize instrument parameters and correct for matrix interferences either during the sample preparation phase or the data analysis and interpretation phase (Hurst, 1997). The analyst should have some training (university or short course) in mineralogy or crystallography in order to have a background in crystal structure, diffraction patterns and mineral transformation. Therefore all analyst reports are to be done by the AIHA accredited lab, Galson Laboratories Inc. at 6601 Kirkville Road, East Syracuse, NY 13057.
5.4. Exposure Assessment Method

Exposure assessment was conducted for five days at five different locations, four being located in Oklahoma and one in Kansas. Two samples at each location were collected on different fuel distributing personnel. At each location personal air samples was explained to the operating company on site and the fuel distributing company employees. All 8 hour samples were collected using the sampling pump with flexible connecting tubing calibrated at 2.5 L/min, aluminum cyclone, and 37mm polyvinyl chlorides filter.

6. Results

The five locations evaluated in this study encompassed the states of Oklahoma and Kansas. Four of the locations were located in Oklahoma and ranged from south to north on the west side of the state. The single location in Kansas was located on the south central part of the state. Each of the locations were similar in terms of geography and climate. The exposure assessment occurred during multiple fracturing stages and typically three stages were completed during the assessment. All locations used silica sand as the proppant; however, usage figures were not available.

Sample results from the laboratory showed that neither cristobalite nor tridymite was detected in any sample. Only quartz mineral was detected. Samples detection ranged from below levels of detection to 100% quartz. Of the 10 samples shown in figure 2, seven of the samples were not able to collect a sufficient amount of respirable silica to be detected. The other three samples averaged 43% silica detected in the respirable dust collected.
Table 2 lists the sample concentrations and their comparison with OSHA’s current PEL, OSHA’s proposed PEL, and the ACGIH’s TLV for a full shift exposure. Comparing the severity level against the current regulations show that no employee exceeded the exposure limit, but one sample did exceed the action limit at 76% PEL. But comparing the results to the proposed PEL and TLV shows that employees who are exposed to quantifiable levels of respirable silica are exceeding those exposure limits. Laboratory samples returned an analytical error of ±14.3% based on a 95% confidence interval. This uncertainty applies to the media, technology and standard operating procedure reference in this report and does not account for the uncertainty associated with the sampling process that was done.
<table>
<thead>
<tr>
<th>ID #</th>
<th>Concentration (mg/m³)</th>
<th>Sample Period (minutes)</th>
<th>8hr TWA</th>
<th>Calculated OSHA PEL</th>
<th>RF</th>
<th>Current OSHA Severity Level</th>
<th>Proposed OSHA Severity Level</th>
<th>ACGIH TLV Severity Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.049</td>
<td>416</td>
<td>0.042</td>
<td>5</td>
<td>0.5</td>
<td>2%</td>
<td>2%</td>
<td>3%</td>
</tr>
<tr>
<td>2</td>
<td>0.048</td>
<td>417</td>
<td>0.042</td>
<td>5</td>
<td>0.5</td>
<td>2%</td>
<td>2%</td>
<td>3%</td>
</tr>
<tr>
<td>3</td>
<td>0.043</td>
<td>480</td>
<td>0.043</td>
<td>5</td>
<td>0.5</td>
<td>2%</td>
<td>2%</td>
<td>3%</td>
</tr>
<tr>
<td>4</td>
<td>0.068</td>
<td>480</td>
<td>0.068</td>
<td>5</td>
<td>0.5</td>
<td>3%</td>
<td>3%</td>
<td>5%</td>
</tr>
<tr>
<td>5</td>
<td>0.038</td>
<td>468</td>
<td>0.037</td>
<td>0.098</td>
<td>0.5</td>
<td>76%</td>
<td>148%</td>
<td>296%</td>
</tr>
<tr>
<td>6</td>
<td>0.039</td>
<td>468</td>
<td>0.038</td>
<td>5</td>
<td>0.5</td>
<td>2%</td>
<td>2%</td>
<td>3%</td>
</tr>
<tr>
<td>7</td>
<td>0.064</td>
<td>462</td>
<td>0.062</td>
<td>5</td>
<td>0.5</td>
<td>2%</td>
<td>2%</td>
<td>4%</td>
</tr>
<tr>
<td>8</td>
<td>0.043</td>
<td>462</td>
<td>0.041</td>
<td>5</td>
<td>0.5</td>
<td>2%</td>
<td>2%</td>
<td>3%</td>
</tr>
<tr>
<td>9</td>
<td>0.059</td>
<td>463</td>
<td>0.057</td>
<td>0.45</td>
<td>0.5</td>
<td>25%</td>
<td>228%</td>
<td>455%</td>
</tr>
<tr>
<td>10</td>
<td>0.071</td>
<td>463</td>
<td>0.068</td>
<td>0.84</td>
<td>0.5</td>
<td>16%</td>
<td>274%</td>
<td>548%</td>
</tr>
</tbody>
</table>

Figure 3 Upper and Lower Severity Level Compared to Current PEL, Proposed PEL and TLV
6.1. Brief and Scala Model

Regulatory exposure limits are based on an eight-hour work day. The effects of exposure for 12 hours shifts become critical because it not only increase exposure time during the work day but also reduces the recovery period. The Brief and Scala model was introduced to provide an easy method for reducing the exposure limits for extended work shifts beyond 8 hours.

\[
Reduction\ Factor = (8 \times hours\ worked\ in\ shift) \times \frac{(24 - hours\ worked\ in\ shift)}{16}
\]

Equation 2: Brief and Scala Model

Using the Brief and Scala model shown in Table 1 for a 12 hour shift, the reduction factor of the PEL was reduced by half, increasing the overall severity of the exposure.

6.2. Standard Analytical Error

Results from the lab associated with the samples were within established control limits. This gave an accuracy of ±14.3% and is based on a 95% confidence interval. The estimated uncertainty applies to the media, technology and standard operating procedure of the lab analysis referenced in this report. This does not account for the uncertainty associated with the sampling process which also followed standard operating procedure determined by the NIOSH 7500 method referenced above.
6.3. Calculating the Severity Level

Severity level is the comparison of sample results and comparing it to the calculated, proposed or in ACGIH’s position agreed upon exposure limits with a reduction factor taken into account. The following equation was used to calculate the severity of exposure compared to the three limits.

\[
\text{Severity Level} = \frac{\text{Sample Results}}{(\text{Exposure limit})(\text{Reduction Factor})}
\]

Equation 3: Calculation of severity levels

7. Discussion, Conclusions, Recommendations for Further Research

Dust is visibly present during hydraulic fracturing, especially during active operations. Fuel distributing employees work both in closed environment and near the dust producing sand storage units. These employees working near the sand equipment spend just a few minutes fueling each piece of equipment on location. The rest of the time employees were typically in an enclosed cab of a vehicle away from the hydraulic fracturing equipment. This equipment does not typically have high-efficiency particulate filtration or positive pressurization. None the less because of the separation from the hazard, the overall exposure to respirable silica is diminished. Comparing to the exposure limits of the current and proposed PEL and TLV, employees were shown to be below the exposure limit with the current PEL with one employee exceeding the action level, and exceeded the proposed PEL and TLV.

Although engineering controls for crystalline silica are well established in other industries, control limits for silica dust on hydraulic fracturing sites are only now emerging due to the recent focus of this hazard and the results of studies like this one. Respirator protection is suggested with the understanding that the current exposure limit set by OHSA may not
adequately protect the employee. And when comparing the severity levels of samples that had quantifiable levels of silica was over the exposure limits and is required by federal regulations that the employer takes action to protect its employees. Additional controls should be evaluated; however the implementation of engineering and administrative controls and economic feasibility of other engineering controls is beyond this report.
References Cited (or Bibliography)


Occupational Safety and Health Administration (OSHA), Department of Labor. (2013). *Occupational exposure to respirable crystalline silica; proposed rule*.


### Appendix A: Results

Table 3 Respirable Dust and Crystalline Silica: Quartz, Cristobalite, Tridymite

<table>
<thead>
<tr>
<th>ID #</th>
<th>Analyte</th>
<th>Air Vol (L)</th>
<th>mg</th>
<th>%</th>
<th>Concentration (mg/m³)</th>
<th>OSHA PEL (mg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Dust</td>
<td>1023.36</td>
<td>&lt;0.050</td>
<td>&lt;0.049</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quartz</td>
<td>1023.36</td>
<td>&lt;0.005</td>
<td>ND</td>
<td>&lt;0.0049</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Dust</td>
<td>1050.78</td>
<td>&lt;0.050</td>
<td>&lt;0.048</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quartz</td>
<td>1050.78</td>
<td>&lt;0.005</td>
<td>ND</td>
<td>&lt;0.0048</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Dust</td>
<td>1199.8</td>
<td>0.051</td>
<td>0.043</td>
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ND = Not Detectable
Appendix B: Raw Data

Mr. Caleb Moore
Pilot Thomas Logistics
621 N. Morgan Rd
Oklahoma City, OK 73127

March 17, 2015

DOH ELAP #11626  Account# 29081  Login# L340957
AIHA-LAP #100324

Dear Mr. Moore:

Enclosed are the analytical results for the samples received by our laboratory on March 10, 2015. All test results meet the quality control requirements of AIHA-LAP and NELAC unless otherwise stated in this report. All samples on the chain of custody were received in good condition unless otherwise noted.

Results in this report are based on the sampling data provided by the client and refer only to the samples as they were received at the laboratory. Unless otherwise requested, all samples will be discarded 14 days from the date of this report, with the exception of IOMs, which will be cleaned and disposed of after seven calendar days.

Current Scopes of Accreditation can be viewed at www.gaisonlabs.com in the accreditations section under the "about Galson" tab.

Please contact Bridgett Honeycutt at (888) 432-5227, if you would like any additional information regarding this report.

Thank you for using Galson Laboratories.

Sincerely,

Mary G. Unangst
Laboratory Director

Enclosure(s)
### Laboratory Analysis Report

**Client:** Pilot Thomas Logistics  
**Site:** N5  
**6601 Kirkville Road**  
**East Syracuse, NY 13057**  
**FAX:** (315) 437-0571  
**www.galsonlabs.com**  
**Date Sampled:** 02-MAR-15 - 06-MAR-15  
**Account No.:** 29081  
**Date Received:** 10-MAR-15  
**Login No.:** L340557  
**Date Analyzed:** 11-MAR-15 - 12-MAR-15  
**Report ID:** 970106

## Respirable Dust and Crystalline Silica: Quartz, Cristobalite, Tridymite

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**Comments:** Please see attached lab footnote report for any applicable footnotes.

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**Level of quantitation:** Dust 0.050mg Q1:0.080mg Q10:0.080mg T1:0.020mg  
**Submitted:** HNS/SRA  
**Analytical Method:** IODS/5600/7500/IODS, IRIS 12-142; SavXRF  
**OSHA PEL:** 0.15  
**Collection Media:** PVC SW 37mm  
**Supervisor:** HRS/CRI  
**QC by:** IUE  
**< Less Than** mg = Milligrams  
**mg/m³ = Milligrams Per Cubic Meter**  
**< Greater Than** ug = Micrograms  
**l = Liters**  
**mg/m³ = Milligrams Per Cubic Meter**  
**ppm = Parts Per Million**  
**ppm/m³ = Parts Per Million Per Cubic Meter**

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Page 2 of 9  
Report Reference: Generated:17-MAR-15 16:03
LABORATORY ANALYSIS REPORT

6601 Kirkville Road
East Syracuse, NY 13057
(315) 632-8227
www.galsonlabs.com

Client: Pilot Thomas Logistics
Site: NS

Date Sampled: 02-MAR-15 - 06-MAR-15
Date Received: 10-MAR-15
Date Analyzed: 11-MAR-15 - 12-MAR-15
Report ID: 873105

Account No.: 29081
Login No.: L340957

Respirable Dust and Crystalline Silica: Quartz, Cristobalite, Tridymite

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COMMENTS: Please see attached lab footnote report for any applicable footnotes.

Level of quantitation: Dust 0.050mg Q:0.0050mg C:0.0050mg T:0.020mg
Analytical Method: mod. NIOSH 0600/7500/mod. OSHA ID-1427 Grav./XRD Approved: CRI/CNR
OSHA PEL: see 1910.1000 (Table 2-8) Date: 17-MAR-15 NYS DOH #: 11626
Collection Media: PVC FW 50cm Supervisor: MNS/SFR QC by: TJB

< -Less Than  mg -Milligrams  m3 -Cubic Meters  kg -Kilograms
> -Greater Than ug -Micrograms  l -Liters  NS -Not Specified
NA -Not Applicable  ND -Not Detected  ppm -Parts per Million
mppcf -Million Particles per Cubic Foot
LABORATORY ANALYSIS REPORT

Client: Pilot Thomas Logistics
Site: NS

6601 Kirkville Road
East Syracuse, NY 13057
(315) 422-5227
FAX: (315) 457-0571
www.galsonlabs.com

Date Sampled: 02-MAR-15 - 06-MAR-15  Account No.: 29081
Date Received: 10-MAR-15  Login No.: L340987
Date Analyzed: 11-MAR-15 - 12-MAR-15
Report ID: 873105

Respirable Dust and Crystalline Silica: Quartz, Cristobalite, Tridymite

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COMMENTS: Please see attached lab footnote report for any applicable footnotes.

Level of quantitation: Dust 0.050mg Q1:0.0050mg Q1:0.0050mg T:0.020mg  Submitted: MNS/SBR
Analytical Method: mod. NIOSH 6060/7800/mod. OSHA ID-142; Grav/XRD Approved: CRI/CNR
OSHA PEL: see 1910.1000 | (Table 2-3) Date: 17-MAR-15  NYS DOH #: 11626
Collection Media: PVC P5 37mm  Supervisor: KBF/CRI  QC by: TJB

< -Less Than mg -Milligrams  m3 -Cubic Meters  kg -Kilograms
> -Greater Than  ug -Micrograms l -Liters  NS -Not Specified
NA -Not Applicable  ND -Not Detected  ppm -Parts per Million
mppcf -Million Particles per Cubic Foot

LABORATORY FOOTNOTE REPORT

Client Name: Pilot Thomas Logistics
Site:

5000 Kirkville Road
East Syracuse, NY 13057
Date Sampled: 02-MAR-15 - 06-MAR-15
Fax: (315) 655-0572
Date Received: 10-MAR-15
www.galsonlabs.com
Date Analyzed: 11-MAR-15 - 12-MAR-15
Login No.: L840657
Account No.: 20961

Unless otherwise noted below, all quality control results associated with the samples were within established control limits or did not impact reported results.

Unblended results are carried through the calculations that yield the final result and the final result is rounded to the number of significant figures appropriate to the accuracy of the analytical method. Please note that results appearing in the columns preceding the final results columns may have been rounded in order to fit the report format, and therefore, if carried through the calculations, may not yield an identical final result to that one reported.

The stated LOQs for each analyte represent the demonstrated LOQ concentrations prior to correction for detection efficiency (if applicable).

Unless otherwise noted below, reported results have not been blank corrected for any field blank or method blank.

L840657 (Report ID: 971016):
Dust analytical accuracy is within +/- 0.02 mg (95% confidence interval, or 94%). The estimated uncertainty applies to the media, technology, and NIO-x referenced in this report and does not account for any uncertainty associated with the sampling process.

L840657-5.7 (Report ID: 971020):
Cassette reading was unreported when received for analysis. Effect on sample is unknown.

L840657 (Report ID: 971016):
LOQs: 0.007-Bohr-0.09; 0.007-Bohr-0.09; in-calibrate(10); in-and-wash(q)21; in-and-wash(11); in-and-wash(23)
Ve perform a qualitative primary and secondary confirmation on all quartz results greater than 0.02 mg. Secondary angle bracket indicates confirmation is not possible below 0.02 mg.

L840657-5 (Report ID: 971016):
ERL is based on maximum possible percent Quartz.

Accuracy and mean recovery data presented below is based on a 95% confidence interval (94%).
The estimated uncertainty applies to the media, technology, and NIO-x referenced in this report and does not account for the uncertainty associated with the sampling process.

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< -Less Than mg -Milligrams m3 -Cubic Meters kg -Kilograms
> -Greater Than mg -Micrograms l -Liters lb -Pounds
NA -Not Applicable ND -Not Detected ppm -Parts per Million

Page 5 of 9 Report Reference 1 Generated:17-MAR-15 16:03
Client Acct No.: 29081
Report To: Mr. Caleb Moore
Company Name: Pilot Thomas Logistics
Address 1: 521 N. Morgan Rd
City, State Zip: Oklahoma City, OK 73137
Phone No.: 405-488-5445
Call No: 
Email: "caleb.moore@pilotthomas.com"

Invoice To: Mr. Caleb Moore
Company Name: Pilot Thomas Logistics
Address 1: 521 N. Morgan Rd
City, State Zip: Oklahoma City, OK 73137
Phone No.: 405-488-5445
Email: "caleb.moore@pilotthomas.com"
Comments:

Samples submitted using the FreePumpLoan™ Program
Samples submitted using the FreeSamplingBadges™ Program

Sampled By: Caleb Moore

Date Sampled: 3/36/2015
Collection Medium: 5pc 37mm PW PVC
Sample Volume: 1023.36
Analysis Requested: Silica, crystalline quartz, cristobalite, a tridymite (with respirable dust)

Date Sampled: 3/36/2015
Collection Medium: 5pc 37mm PW PVC
Sample Volume: 1050.78
Analysis Requested: Silica, crystalline quartz, cristobalite, a tridymite (with respirable dust)

Date Sampled: 3/36/2015
Collection Medium: 5pc 37mm PW PVC
Sample Volume: 1199.8
Analysis Requested: Silica, crystalline quartz, cristobalite, a tridymite (with respirable dust)

Comments:

Print Name / Signature: Caleb Moore
Date: 3/3/2015
Time: 4:15 PM

Print Name / Signature: M. Kom
Date: 3/3/2015
Time: 10:30 AM

Samples received after 3pm will be considered as next day's business.
<table>
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<th>Collection Medium</th>
<th>Sample Volume</th>
<th>Sample Area</th>
<th>Libras Minutes</th>
<th>Analysis Requested</th>
<th>Method Reference</th>
<th>Hazardous Chromium Process (e.g., welding, plating, painting, etc.)</th>
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<td>3pc 37mm PM PVC</td>
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<td>mod. NIOSH 0609/7500/mod. OSHA ID-142</td>
<td>Grav./XRD</td>
</tr>
</tbody>
</table>
This should NOT be used as a Chain of Custody

Field Pump Data Sheet

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Sample Media</th>
<th>Pump Number</th>
<th>Rotameter Number</th>
<th>Pre-Sample Flow Rate (LPM)</th>
<th>Time On</th>
<th>Time Off</th>
<th>Duration</th>
<th>Post-Sample Flow Rate (LPM)</th>
<th>Average of Pre- and Post-Sample Flow Rates</th>
<th>Adjusted TRUE Flow Rate (see sample *)</th>
<th>TRUE Flow Rate (in liters)</th>
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<tbody>
<tr>
<td>Baker-Yukon 01</td>
<td>PVC</td>
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<td>2.5</td>
<td>2.53</td>
<td>117.39</td>
</tr>
</tbody>
</table>

1. Flow Rate as indicated on Rotameter
2. Or use results on Page 1, 3rd column
3. SAMPLE: If the Pre-Sample Flow Rate was 2.00 LPM, and the Post-Sample Flow Rate was 2.1 LPM and the Rotameter's Correction Formula was "Y = 0.92 X + 0.142"

(CALCULATE as such: 2.00 + 2.1 divided by 2. Plug THAT figure (2.08) into the formula as "X". Our times were: 2.08 X - 0.005

The result (in this case): 2.0486 Liters per minute.
AIHA Laboratory Accreditation Programs, LLC

acknowledges that

SGS Galson Laboratories, Inc.
6801 Kirkville Road, East Syracuse, NY 13057
Laboratory ID: 100324

along with all premises from which key activities are performed, as listed above, has fulfilled the requirements of the AIHA Laboratory Accreditation Programs (AIHA-LAP), LLC accreditation to the ISO/IEC 17025:2005 international standard, General Requirements for the Competence of Testing and Calibration Laboratories in the following:

LABORATORY ACCREDITATION PROGRAMS

✓ INDUSTRIAL HYGIENE
✓ ENVIRONMENTAL LEAD
✓ ENVIRONMENTAL MICROBIOLOGY
☐ FOOD
☐ UNIQUE SCOPES

Accreditation Expires: 10/01/2016
Accreditation Expires: 10/01/2016
Accreditation Expires: 10/01/2016
Accreditation Expires:
Accreditation Expires:

Specific Field(s) of Testing (i.e. Method(s)) within each Accreditation Program for which the above named laboratory maintains accreditation is outlined on the attached Scope of Accreditation. Continued accreditation is contingent upon successful on-going compliance with ISO/IEC 17025:2005 and AIHA-LAP, LLC requirements. This certificate is not valid without the attached Scope of Accreditation. Please review the AIHA-LAP, LLC website (www.aihaaccreditedlabs.org) for the most current Scope.

Gerald Schultz, CHT
Chairperson, Analytical Accreditation Board

Cheryl A. Morton, MEd
Managing Director, AIHA Laboratory Accreditation Programs, LLC

Revision 14: 03/26/2014

Date Issued: 04/09/2015