Silica Sampling, Lab Analysis, and the New OSHA Rule (Proposed)

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Silica/Asbestos Lab Director
EMSL Analytical Inc.
Overview

- What is Silica?
- Health and Safety Concerns
- Types of Samples
- How to Sample?
- Laboratory Sample Analysis
- Understanding the Lab Report
- Current Silica Standards
- OSHA Silica E-Tool
- Other Silica Standards/Guidelines
- Proposed New OSHA Silica Rule
What is Silica?

- Crystalline silica is present in many materials and its use is widespread
  - Silicon Dioxide (SiO$_2$)-Chemical compound
  - 15% of Earth’s Crust
  - Sand, Granite, and Other “Hard Rocks”

- Crystalline Silica (OSHA regulated)
  - Quartz (most common)-Concrete for example
  - Cristobalite, Tridymite (Much less common) - Volcanic rock
  - All Silica forms have diagnostic X-ray diffraction patterns
What is Silica?

From OSHA....

“Respirable crystalline silica – very small particles at least 100 times smaller than ordinary sand you might encounter on beaches and playgrounds – is created during work operations involving stone, rock, concrete, brick, block, mortar, and industrial sand. Exposures to respirable crystalline silica can occur when cutting, sawing, grinding, drilling, and crushing these materials. These exposures are common in brick, concrete, and pottery manufacturing operations, as well as during operations using industrial sand products, such as in foundries, sand blasting, and hydraulic fracturing (fracking) operations in the oil and gas industry.”
What is Silica?

- Abrasive blasting/crushing
- Drilling rock and concrete
- Masonry and concrete work
- Mining/tunneling
- Cement and asphalt pavement manufacturing
- Jack-hammering
- Brick and concrete block cutting
- Fiber-cement siding work
- Fracking Operations
What is Silica?
What is Silica?
What is Silica?
Health and Safety Concerns

- Silicosis - Irreversible Lung Disease
- Tuberculosis
- Heart Disease
- Chronic Obstructive-Pulmonary Disease (COPD)
- Lung Cancer – Human Carcinogen
  (International Agency for Research on Cancer)
Types of Samples

- Air Sampling
  - Total
  - Respirable (Most Common)
- Bulk Materials
- Settled Dust
- Surface Wipes/Microvac Cassettes
- Water
How to Air Sample

What do we need?

- Preweighed 5um 37mm PVC Cassette
- Cyclone (Respirable Silica)
- Cyclone Calibrator-Adapter or Calibration-Jar
- Low Flow Sampling Pump (1-4 LPM)
- Field Rotameter
- Primary Calibrator (optional)
How to Air Sample

- Preweighed 5um 37mm PVC Cassette

- Do not use a regular MCE, PVC, PCM, TEM cassettes
  - OSHA has a % Silica component for the current PEL calculation
  - Future OSHA Sampling will not require preweight
How to Air Sample

- **Cyclone (Respirable Fraction)**
  - SKC
  - Higgens Dewell
  - Dorr Oliver

- 4-µm 50% cut-point at a 2.5 L/min flow rate - SKC
- 4-µm 50% cut-point at a 2.2 L/min flow rate - Higgens Dewell
- 4-µm 50% cut-point at a 1.7 L/min flow rate - Dorr Oliver
- Specified flow rate - based on dust collection sample curves
How to Air Sample

10mm Nylon Cyclone Collection Efficiency Curve Comparison at 1.7 lpm

Mirrors how our lungs capture respirable dust

Source: Internal Zefon performance tests with all 4 cyclones under identical conditions.
How to Air Sample

Respirable Silica Sampling Train
How to Air Sample

- **Cyclone Calibration**
  - SKC
  - Dorr Oliver
Other Types of Silica Samples

- **Bulk Sample/Settled Dust**
  - Categorization/Hazard Identification - % Silica
  - Analysis Interferences

- **Surface (Wipe)/Dust(Microvac) Samples**
  - Silica presence - Qualitative
  - Contamination amounts - Quantitative
  - Can be reported as mg/area sampled, % Silica

- **Water**
  - Silica presence/contamination levels (mg/L)
Laboratory Sample Analysis

- NIOSH Method 7500 Silica Crystalline, by X-Ray Diffraction (XRD) - (filter redeposition)
  - Quartz, Cristobalite, Tridymite

- Gravimetric Phase (Current OSHA Component)
  - Stabilize filters in controlled environmental chamber or room
  - 20 °C ± 1 °C and 50% ± 5% RH
  - Weigh Filters - Postweight (resp. or total dust)
Laboratory Sample Analysis

- Controlled Environmental Chamber
Laboratory Sample Analysis

- Gravimetric Scale (5 Digit)
Laboratory Sample Analysis

- Gravimetric Weighing
- Electrostatic charge removal
Laboratory Sample Analysis

- Redeposition Phase
  - Dissolve filter in Tetrahydrofuran (THF) and sonicate
  - Re-filter onto a 0.45u silver membrane filter
  - Dry the filter
  - Place and attach to XRD sample holder
Laboratory Sample Analysis

Filtering/Sonication System
Laboratory Sample Analysis

Redeposition Phase
Laboratory Sample Analysis

- Other types of Silica Samples
  - Mill/Sieve (bulks)
  - Sonicate and Filter (Bulk/wipes/dust)
  - Waters (Direct Prep)
  - Specialized prep- Phosphoric Acid/Sample Ashing

Silica prepped solutions
Laboratory Sample Analysis

XRD Units
Laboratory Sample Analysis

XRD - Each sample filter is subjected to an X-Ray Scan
Laboratory Sample Analysis

XRD Analysis Chart - Fingerprint
Laboratory Sample Analysis

XRD Analysis- Finding the Silica

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Peak (2-Theta Degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Primary</td>
</tr>
<tr>
<td>Quartz</td>
<td>26.66</td>
</tr>
<tr>
<td>Cristobalite</td>
<td>21.93</td>
</tr>
<tr>
<td>Tridymite</td>
<td>21.62</td>
</tr>
<tr>
<td>Silver</td>
<td>38.12</td>
</tr>
</tbody>
</table>
Laboratory Sample Analysis

- "Overloaded" Sample - >2 mg Dust
  - Dust thickness on final filter can mask Silica
  - Silica is under-reported from the X-Rays

- Special Preps
  - Mineral Interferences - Calcite, Feldspar, others
    - Mask peaks (lower data)
    - Create similar peaks (increase data)
  - Ash sample
  - HCL/Phosphoric Acid treatment
  - Bulk/settled dust sample helps in this aspect
Laboratory Sample Reporting

- Mass of each Silica Phase - ug or mg
- Mass of Respirable or Total Dust
- Interferences - Note Secondary and Tertiary Peaks
- LODs (Air samples/final filter)
  - 5ug Quartz (Primary Peak) - 20ug (other peaks)
  - 20ug Cristobalite
  - 20ug Tridymite
- Air Samples
  - Silica and Dust Concentrations
- Bulk/Dust Samples
  - % Silica - reporting limit varies depend on solution loading - Typically 0.2% Q and 0.8% Cr/Tr
## Understanding the Lab Report

### Test Report: Silica, Crystalline Analysis of Air Samples Performed by X-Ray Diffraction
Via NIOSH Method 7500 (Modified), Issue 4, 3/15/2003

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Collected Date</th>
<th>Location</th>
<th>Volume</th>
<th>Respirable Dust (mg)</th>
<th>Analytical Sensitivity (mg/m³)</th>
<th>Weight (mg)</th>
<th>Conc. (mg/m³)</th>
<th>% Silica</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td></td>
<td>FIELD BLANK</td>
<td>N/A</td>
<td>&lt;0.050 N/A</td>
<td>α-Quartz: N/A &lt;0.005</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>041131819-0001</td>
<td>11/15/2011</td>
<td>393.66</td>
<td>0.187</td>
<td>0.475</td>
<td>Cristobalite: N/A &lt;0.020</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>041131819-0002</td>
<td>11/16/2011</td>
<td>263.76</td>
<td>0.146</td>
<td>0.554</td>
<td>Tridymite: N/A &lt;0.020</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comment: Field Blank submitted with sample set. Results are not blank corrected.

1. **Gravimetric Data-Current OSHA**
2. **Silica Data- Current and Future OSHA**
## Understanding the Lab Report

**QC Batch ID: 04Q111219-001**

<table>
<thead>
<tr>
<th>Location</th>
<th>Collected Date</th>
<th>Volume (L)</th>
<th>Respirable Dust (mg)</th>
<th>Analytical Sensitivity (mg/m³)</th>
<th>Weight (mg)</th>
<th>Conc. (mg/m³)</th>
<th>% Silica</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duplicate 02</td>
<td>11/16/2011</td>
<td>263.76</td>
<td>0.146</td>
<td>α-Quartz: 0.019</td>
<td>0.047</td>
<td>0.178</td>
<td>32.2</td>
</tr>
<tr>
<td>041131819-0003</td>
<td></td>
<td></td>
<td></td>
<td>Cristobalite: &lt;0.020</td>
<td>&lt;0.076</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Tridymite: 0.076</td>
<td>&lt;0.020</td>
<td>N/A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N/A</td>
<td>N/A</td>
<td>α-Quartz: N/A</td>
<td>&lt;0.005</td>
<td>N/A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N/A</td>
<td>Cristobalite: N/A</td>
<td>&lt;0.020</td>
<td>N/A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N/A</td>
<td>Tridymite: N/A</td>
<td>&lt;0.020</td>
<td>N/A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Method Blank**

<table>
<thead>
<tr>
<th>Location</th>
<th>Analytical Sensitivity (mg/m³)</th>
<th>Weight (mg)</th>
<th>Conc. (mg/m³)</th>
<th>% Silica</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/A</td>
<td>α-Quartz: 0.257</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>N/A</td>
<td>Cristobalite: 0.004</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>N/A</td>
<td>Tridymite: 0.024</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>

**Reference Standards**

- α-Quartz (0.250 mg)
- α-Quartz (0.005 mg)
- Cristobalite (0.020 mg)

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1. **QC Duplicate**
2. **Lab Blank**
3. **Reference Standards**
Understanding the Lab Report

Silica, Crystalline Analysis of Bulk Material
Performed X-Ray Diffraction (XRD) Method Modified OSHA ID-142 &
Modified NIOSH Method 7500, Issue 3, 1/15/98

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Sample Description</th>
<th>% α-Quartz</th>
<th>% Cristobalite</th>
<th>% Tridymite</th>
</tr>
</thead>
<tbody>
<tr>
<td>041200036-0001</td>
<td>BULK SAMPLE</td>
<td>42.9</td>
<td>&lt;0.8</td>
<td>&lt;0.8</td>
</tr>
</tbody>
</table>

Notes:
1. Reporting limit for Quartz = 0.2%
2. Reporting limit for Cristobalite and Tridymite = 0.8%

% Silica Content- Not a full indicator of health and safety
Current Silica Standards

- **OSHA 29 CFR 1910.1000 Table Z-3**
  - “Sliding or Variable” PEL-Air Sample General Industry and Maritime/Construction- Same Calculation
    - **Respirable Silica**
      \[
      \frac{10}{\text{[\% quartz + (\% cristobalite \times 2) + (\% tridymite \times 2) + 2]}}
      \]
    - **Total Silica**
      \[
      \frac{30}{\text{[\% quartz + (\% cristobalite \times 2) + (\% tridymite \times 2) + 2]}}
      \]

- **Multiple TWA samples (A,B)**
  - Time Weighted average of the silica %s
    Many calculations can be involved
Current Silica Standards

➢ OSHA- PEL Examples
   ❑ No Silica present in air sample
     ✓ Respirable Dust PEL = 5 mg/m$^3$
     ✓ Total Dust PEL = 15 mg/m$^3$
     ✓ These are the OSHA Dust PELS-Respirable/Total

➢ Silica present in air sample
   ❑ Respirable Quartz 10%
     ▪ PEL = 10/(10+2) = 0.833 mg/m$^3$
   ❑ Respirable Quartz 10%, Cristobalite 3%
     ▪ PEL = 10/(10+(2x3)+2) = 0.556 mg/m$^3$
Current Silica Standards

What does this all mean?

- The OSHA Silica PEL is compared to the Respirable or Total Dust TWA. Severity Factor >1 = Exceedance

Examples

- Silica PEL = 0.833 mg/m$^3$
- Respirable Dust TWA = 0.517 mg/m$^3$
- Does not exceed- Severity Factor = $0.517/0.833 = 0.62$

- Silica PEL = 0.556 mg/m$^3$
- Respirable Dust TWA = 0.718 mg/m$^3$
- Does exceed- Severity Factor = $0.718/0.556 = 1.3$
# Understanding the Lab Report

## Test Report: Silica, Crystalline Analysis of Air Samples Performed by X-Ray Diffraction

Via NIOSH Method 7500 (Modified), Issue 4, 3/15/2003

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<th>Weight (mg)</th>
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<th>% Silica</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>N/A</td>
<td>FIELD BLANK</td>
<td>N/A</td>
<td>&lt;0.050</td>
<td>N/A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>041131819-0001</td>
<td>01</td>
<td>11/15/2011</td>
<td>393.66</td>
<td>0.187</td>
<td>0.013</td>
<td>0.043</td>
<td>0.109</td>
<td>23.0</td>
</tr>
<tr>
<td>041131819-0002</td>
<td>01</td>
<td>11/16/2011</td>
<td>263.76</td>
<td>0.146</td>
<td>0.019</td>
<td>0.046</td>
<td>0.174</td>
<td>31.5</td>
</tr>
</tbody>
</table>

Field Blank submitted with sample set. Results are not blank corrected.

1. **Gravimetric Data**
2. **Silica Data**
OSHA E-Tool For Silica


Disease of the lungs caused by silica inhalation

Each year 300 people die from a disease called silicosis.

Are you or your workers among the 2 million exposed to silica each year?

This Advisor will help you comply with the OSHA standard on respirable crystalline silica by guiding you through the following steps:

1. Determine if Silica exposure is present in your workplace
2. Obtain a measurement of Silica concentration
3. Determine if there is more Silica than OSHA allows
4. Take adequate measures of protection

By evaluating your workplace for potential silica hazards and then taking appropriate actions, employers and employees will be able to avoid:
OSHA E-Tool For Silica


Comparing Your Exposure to OSHA's Limit

There is not one crystalline silica exposure limit for all cases. Rather, the limit is derived from a calculation that takes into account the percentage of quartz, cristobalite, tridymite, and respirable dust specific to your particular work-site.

To determine the limit and compare it to the actual amount, you can:

Follow a written example to make the calculations yourself

or

Let the Advisor Genius do the calculations for you
OSHA E-Tool For Silica


The following information is only available on your computer. No information is sent to the government. Items marked as optional are not necessary for the calculation and may be left blank at your discretion.

Employer: [optional]
Employee: [optional]
Sampling Date: [optional]
Comments: [optional]

If the laboratory provided a sampling and analytical error value, enter it here: 0.3 (if the laboratory did not provide value you may want to use an estimated value of 0.3.)

Can the material collected be classified as cool dust? ○ Yes ○ No

For each sample, enter the requested information. You may enter information for up to 10 samples collected for this employee during a single work shift. If left blank, percentage values will be evaluated as zero (0%). Any sample with a sample time of zero (0) will not be included in the calculation.

When you are finished entering data, click the calculate button below. Use the report button to generate a report which you can print.

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>Sample Time (min)</th>
<th>Sampling Rate (L/min)</th>
<th>Respirable Weight (mg)</th>
<th>Quartz Cristobalite Tridymite</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>1.7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
OSHA E-Tool For Silica


Calculate the Time Weighted Average based on the sampling period

- Calculate the Time Weighted Average based on the sampling period (minutes).
- Calculate the Time Weighted Average based on a full work shift (8 hours).

Calculate | Clear Values | Report

PEL (mg/m³)  Exposure (mg/m³)  Severity (Exposure/PEL)  SAE*  LCL**  UCL***

* Sampling and Analytical Error
** Lower Control Limit
*** Upper Control Limit
OSHA E-Tool For Silica


Calculate the Time Weighted Average based on a full work shift (8 hours).

<table>
<thead>
<tr>
<th>PEL (mg/m³)</th>
<th>Exposure (mg/m³)</th>
<th>Severity (Exposure/PEL)</th>
<th>SAE*</th>
<th>LCL**</th>
<th>UCL***</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.714</td>
<td>1.14</td>
<td>1.6</td>
<td>0.3</td>
<td>1.3</td>
<td>1.9</td>
</tr>
</tbody>
</table>

* Sampling and Analytical Error
** Lower Control Limit
*** Upper Control Limit

A severity greater than 1 means that you are over the Permissible Exposure Limit (PEL). You must take appropriate actions to reduce your exposure.
Other Silica Standards/Guidelines

- OSHA- Bulk (labeling )
  - 0.1% or greater Silica content

- NIOSH REL
  - 0.050 mg/m$^3$ Respirable Silica

- ACGIH TLVs
  - 0.025 mg/m$^3$ Respirable Silica

- None of the air limits incorporate Silica %
- Lower limits than current OSHA standards
- Not specific to type of Silica
Other Silica Standards/Guidelines

- NY DOL DOSH Public Employee Safety & Health

  ✓ The Public Employee Safety and Health Bureau (PESH), created in 1980, enforces safety and health standards promulgated under the United States Occupational Safety and Health Act (OSHA) and several state standards.
The PESH Act created this unit to give occupational safety and health protection to all public sector employees. Public sector employers include:

- State
- County
- Town
- Village governments
- Public Authorities
- School Districts
- Paid and Volunteer Fire Departments
Other Silica Standards/Guidelines

- **PESH Respirable Silica Limits**
  - **Through 1992**
    - Transitional Limits: OSHA PEL Tbl. Z-3 = Current Federal OSHA Limits
  - **Since 1992 (20+years!)**
    - 0.100 mg/m\(^3\) Respirable Quartz
    - 0.050 mg/m\(^3\) Respirable Cristobalite
    - 0.050 mg/m\(^3\) Respirable Tridymite

- None of the current air limits use Silica %
- Lower limits than current OSHA standards
Proposed New OSHA Silica Standard

www.osha.gov/silica

- OSHA PELS are approx. 40 years old and not as stringent as NIOSH/ACGIH guidelines
- Need for a more comprehensive Silica standard and updated exposure limits
- Estimated 2 million US workers are exposed to crystalline silica annually
- The proposed rule is expected to save nearly 700 lives and prevent 1,600 new cases of silicosis per year and to provide average net benefits of $2.8 to $4.7 billion annually over the next 60 years
Proposed New OSHA Silica Standard

www.osha.gov/silica

- Designed similar to Asbestos and Lead Standards in format and content

- OSHA 1910.1053 Respirable Crystalline Silica

- New OSHA Silica PEL (Eight hour TWA)
  - 0.050 mg/m³

- New OSHA Silica Action Level (Eight hour TWA)
  - 0.025 mg/m³
## Proposed New OSHA Silica Standard

www.osha.gov/silica

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Via NIOSH Method 7500 (Modified), Issue 4, 3/15/2003

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<th>Location</th>
<th>Volume (mg)</th>
<th>Respirable Dust (mg/m³)</th>
<th>Analytical Sensitivity (mg/m³)</th>
<th>Weight (mg)</th>
<th>Sum Concentration (mg/m³)</th>
<th>% Silica</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td></td>
<td>FIELD BLANK</td>
<td>N/A</td>
<td>&lt;0.050</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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</tr>
<tr>
<td>041131819-0001</td>
<td>11/15/2011</td>
<td></td>
<td>393.66</td>
<td>0.187</td>
<td>0.475</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>041131819-0002</td>
<td>11/16/2011</td>
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<td>263.76</td>
<td>0.46</td>
<td>0.54</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comment: Field Blank submitted with sample set. Results are not blank corrected.

### Notes:

1. **Gravimetric Data- NOT USED**
2. **Silica Data**
   
   Sum concentrations (use 0 for <)
   
   Watch for low sample volumes
Proposed New OSHA Silica Standard

www.osha.gov/silica

- Sections for
  - Exposure assessment
  - Employee notification
  - Regulated areas
  - Written access control plan
  - Compliance methods
  - Respiratory protection program
  - Recordkeeping
  - Encourages engineering controls and good work practices
  - Table 1- Exposure Control Methods for Construction Operations
Proposed New OSHA Silica Standard

www.osha.gov/silica

<table>
<thead>
<tr>
<th>Operation</th>
<th>Engineering and work practice control methods</th>
<th>Required air-purifying respirator (minimum assigned protection factor)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Using Stationary Masonry Saws</td>
<td>Use saw equipped with integrated water delivery system Note: Additional specifications: • Change water frequently to avoid silt build-up in water. • Prevent wet slurry from accumulating and drying. • Operate equipment such that no visible dust is emitted from the process • When working indoors, provide sufficient ventilation to prevent build-up of visible airborne dust. • Ensure saw blade is not excessively worn.</td>
<td>None</td>
</tr>
</tbody>
</table>

≤ 4 hr/day | > 4 hr/day |
Proposed New OSHA Silica Standard

Exposure Control Methods to Reduce Silica Dust

1. Water-Based Controls
   ✓ First choice and most effective

2. Dust Collection Controls
   ✓ Second choice but not always practical

3. Control Booth
   ✓ Third choice and process limited

4. Respirators can be a necessary choice to compliment or replace other controls
   ✓ Full slate of requirements for a respirator program
Proposed New OSHA Silica Standard

Exposure Monitoring

- Initial for demonstrating compliance
- Assessment of results - Over Silica PEL
  - Implementation of engineering controls, administrative controls, and/or respiratory protection
  - Medical Surveillance
  - Reassessment
- Assessment of results - Over Silica Action Level under PEL
  - Periodic re-sampling and reassessment
  - Communication to monitored staff
Proposed New OSHA Silica Standard

Impact

- Hazard assessments
- Evaluation of work procedures and controls
- Implementation of engineering and process controls
- Training of workers
- Airborne silica exposure monitoring
  - Use of ISO 10725/AIHA Accredited Laboratories
- Increased use of consultants
  - “Expert” individuals
Proposed New OSHA Silica Standard

Future timeline

- Written comments regarding OSHA's proposed silica rule can be submitted until January 27, 2014
  - Online, Fax, and Mail options available
- Public hearings are scheduled to begin on March 18, 2014 at the Department of Labor's Frances Perkins Building in Washington, DC - Several weeks
- Current AIHA forecast is by end of 2014.
- Possible alternative exposure limits/rewrites/lawsuits
- All information is available at www.osha.gov/silica/
Questions?

Stephen Siegel, CIH
EMSL Analytical, Inc.
Phone: 856-303-2555
ssiegel@emsl.com