Leading Edge Asbestos & Silica Analysis

“Setting the Standard in Best Practice”

Annual Joint Breakfast Meeting
NY AIHA/ASSE/SENY
(February 24, 2015)
Today’s Presentation

• Topics of Interest
  – A toxicological overview of asbestos and LA
  – NYS DOH ELAP Guidance requirements
  – Overview of SOF-V Methods 055.1 and 198.8
  – Future applications of LAB.055.1
  – A toxicological overview of silica polymorphs
  – Review of current OSHA PEL derivation processes’
  – Description of sampling methods and XRD analysis
  – Silica reporting schemes and analytical details
  – Performance comparison of 3 preparation techniques
<table>
<thead>
<tr>
<th><strong>RJ Lee Group – Asbestos Expertise</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Richard J. Lee, Ph.D.</strong> – For more than 30 years, Dr. Lee has been involved with the development of asbestos and vermiculite analysis methods. Early on, he participated in pioneering analytical methods for asbestos analysis including the drafting of the Yamate method and the EPA AHERA analytical method, which was based on RJ Lee Group’s internal asbestos analysis methods. He was a member of the HEI peer-review panel to assess the significance of asbestos in public buildings, and helped author the resulting landmark report.</td>
</tr>
<tr>
<td><strong>Matthew Sanchez, Ph.D.</strong> – Dr. Sanchez has been involved in the characterization of Libby vermiculite and associated amphiboles for the last decade. Along with Dr. Lee, he was active in method development for identification and quantification of vermiculite and asbestos in soil, air, and water as well as in characterizing vermiculite for the W. R. Grace &amp; Company.</td>
</tr>
<tr>
<td><strong>Drew R. Van Orden</strong> – Mr. Van Orden is a Registered Professional Engineer with over 20 years of experience in developing asbestos analytical methods, analyzing asbestos-containing materials (ACM), and conducting studies to measure potential asbestos release from ACM. He has participated in many national evaluations of ambient asbestos concentrations, directed a study of earthquake effects on airborne asbestos concentrations, and participated in EPA investigations into airborne asbestos concentrations in public buildings.</td>
</tr>
<tr>
<td><strong>Donald Ewert</strong> – With 3 decades of experience providing consulting, industrial hygiene, litigation support and engineering services to those individuals impacted by asbestos, Mr. Ewert is a recognized expert in asbestos management, control and analysis. Not only was he responsible for drafting the first Operations and Management document utilized by EPA during creation of the 1985 Purple Book, he also shepherded the first EPA and NBS/NIST mobile laboratory through accreditation so that PLM services could be provided on-site rather than from a distant laboratory. Don has also served as expert witness in a range of property, tort and injury cases involving exposure to asbestos.</td>
</tr>
</tbody>
</table>
Cutting Edge Technology

RJLG utilizes innovative technology for unprecedented materials characterization abilities.
RJ Lee Group - Materials Sciences

- Microscopy
  - Optical Microscopes
  - Scanning electron microscopes
  - Transmission electron microscopes
  - High resolution electron microscopes
  - Computer-controlled microscopy
- Surface Analysis: ESCA/XPS
- X-ray Diffraction
- X-ray Fluorescence
- Fourier Transform Infrared Spectroscopy
- Raman Imaging & Spectroscopy
- Analytical Chemistry
  - ICP-ES and ICP-MS
  - AA and IC
  - GC-MS, GC-FID, GC-ECD
  - DSC / TGA

Thermo K-Alpha XPS
Asbestos – A Summary Refresher

Asbestos

- Occurs naturally in rock and soil, including the regulated forms of chrysotile, amosite, crocidolite, tremolite, and anthophyllite asbestiform minerals.

- All asbestos minerals have demonstrated an ability to produce cancer in animals as well as humans. In fact, asbestos is one of only a few known carcinogens regulated by USOSHA.

- Asbestos use in the United States is limited as a result of laws passed in the 70’s and 80’s while it remains actively produced and used in other portions of the world.

AIHA Webinar - Wednesday, May 7, 2014

“Miracle Mineral”
Risk Assessment
New Information and New Models Are Transforming Asbestos Risk Assessment

By Andrey Korchevskiy, James Rasmuson, and Eric Rasmuson
Asbestos – Two Distinct Mineral Groups

Serpentine Fibers – Represented by chrysotile

• Cleared quickly from the human lung
• Low in iron concentration
• Distinct morphology
• Airborne fibers are often agglomerated

Amphibole Fibers – Represented by amosite, crocidolite, tremolite, and anthophyllite, Actinolite, Winchite and Richterite

• Biopersistent – exceptionally long half-life
• Moderately high iron concentration
• Straight fiber bundles capability of defoliation
• Airborne fibers don’t agglomerate
# Model Comparison – Excess Cancer Cases/Million

(0.1 f/cc, 45 years starting at 18)

<table>
<thead>
<tr>
<th></th>
<th>Chrysotile</th>
<th>Amosite</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. EPA</td>
<td>3146 (0.31%)</td>
<td>3146 (0.31%)</td>
</tr>
<tr>
<td>Berman, Crump</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(2008b)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PCME</td>
<td>719 (0.07%)</td>
<td>22020 (2.2%)</td>
</tr>
<tr>
<td>Long, thin</td>
<td>1404 (0.14%)</td>
<td>82790 (8.3%)</td>
</tr>
<tr>
<td>fibers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long, all width</td>
<td>831 (0.08%)</td>
<td>44869 (4.4%)</td>
</tr>
<tr>
<td>fibers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hodgson, Darnton</td>
<td>213 (0.02%)</td>
<td>7005 (0.7%)</td>
</tr>
</tbody>
</table>
## Cancer Experience by Mineral Group

<table>
<thead>
<tr>
<th>Wittenoom, Australia</th>
<th>Quebec, Canada</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predominant crocidolite exposure.</td>
<td>Predominant chrysotile exposure.</td>
</tr>
<tr>
<td>Average cumulative exposure 23 f/cc-years</td>
<td>Average cumulative exposure 600 f/cc-years</td>
</tr>
<tr>
<td>Cohort of 5173 men</td>
<td>Cohort of 9780 men</td>
</tr>
<tr>
<td>165 cases of mesothelioma</td>
<td>38 cases of mesothelioma</td>
</tr>
</tbody>
</table>


Asbestos Use and Permissible Exposure Limits - US, 1900-2007

http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5815a3.htm
NATIONAL PROGRAMMES FOR ELIMINATION OF ASBESTOS RELATED DISEASES: REVIEW AND ASSESSMENT

Trends of asbestos use and asbestos-related diseases in Finland

Long-term trends of asbestos exposure and mesothelioma deaths in UK
Regulated Asbestos - The EPA and OSHA definitions of 'asbestos' both include the six commercial forms of asbestos minerals: chrysotile, amosite, crocidolite, tremolite, anthophyllite, and actinolite (40 CFR 763 and 29 CFR 1910.1001). All states, including New York regulate asbestos by the same standard.

According to the US EPA, materials containing greater than 1 percent (>1%) asbestos are regulated as asbestos containing materials (ACM) while OSHA regulates exposure at all levels of asbestos above the Limit of Detection (LOD).
Non-Regulated Amphibole Asbestos (Winchite/Richterite) LAB.055.1 reports these amphiboles when the morphological characteristics of the minerals are consistent with asbestos. However, the values are not used in determining whether a material is ACM.

While winchite and richterite amphiboles are non-regulated forms of asbestos, they exhibit some of the same characteristics as regulated asbestos. As a result, they are often misreported as tremolite or actinolite asbestos because of the fact that their characteristics are consistent with these asbestiform minerals.
Vermiculite is a hydrous, silicate mineral that is classified as a phyllosilicate and that expands greatly when heated. Exfoliation occurs when the mineral is heated sufficiently, and the effect is routinely produced in commercial furnaces.

The vermiculite mined at Libby contains amphibole asbestos, with a characteristic composition including tremolite, actinolite, richterite, and winchite; this material is referred to as Libby Amphiboles (LA). The raw vermiculite ore was estimated to contain up to 26% LA as it was mined. For most of the mine’s operation, Libby asbestos was considered a by-product of little value and was not used commercially. The mined vermiculite ore was processed to remove unwanted materials and then sorted into various grades or sizes of vermiculite that were then shipped to sites across the nation for expansion (exfoliation) or use as a raw material in manufactured products. Samples of the various grades of unexpanded vermiculite shipped from the Libby mine contained 0.3%–7% fibrous tremolite-actinolite (by mass).
Winchite – 84%
Richterite – 11%
Tremolite – 6%

Fibrous asbestiform winchite/richterite collected near Libby, Montana seen in hand sample (left) and scanning electron micrograph (right).

Relationships between magnesium, calcium, and sodium content of the three amphibole minerals found in LA: tremolite, winchite, and richterite. All three names have been assigned to various amphibole samples from former vermiculite mining and milling sites near Libby, Montana.
Vermiculite & SOF-V Mineralogy by PLM

PLM photos of amphibole asbestos between the sheets from heavy liquid sink fraction in 1.630 RI oil.
Introduction to NYS DOH ELAP Guidance
Spray-On Fireproofing containing Vermiculite (SOF-V)

SOF-V is defined as a material containing vermiculite, intended to act as a fire-retardant coating when applied to building structures via spraying equipment as opposed to a manually applied (trowel) material. SOF-V can be in the form of Thermal Systems Insulation (TSI), surfacing material, or other presumed ACM (PACM). No matter the form, it is a miscellaneous suspect ACM as specified in 12 NYCRR Part 56 which include, but are not limited to, existing or new surfacing material, plaster, pipe lagging, and spray-on fireproofing.

New York State DOH guidance FAQ #10 states that wherever SOF-V is calculated to be greater than 10% vermiculite containing, the material may be evaluated to evaluate the asbestos content of the material; provided however, that any test results using this method must be reported with the following conspicuous disclaimer: "This method does not remove vermiculite and may underestimate the level of asbestos present in a sample containing greater than 10% vermiculite.”

New York State DOH interpretation of vermiculite-related guidance does not prohibit the use or application of vermiculite materials, but instead applies during renovation and/or demolishing of structures when the origin of the vermiculite material is unknown.

RJ Lee Group notifies RJ Lee Group that validation for LAB.055.1 has met the conditions set forth in 10NYCRR 55-2.5 and is fully certified for SOF-V testing.

New York State DOH announces the imminent availability of two new NYS DOH ELAP-approved methods for the detection and quantitation of asbestos content in spray-on fireproofing that contains vermiculite (SOF-V). These methods become known as RJ Lee Group Method LAB.055.1 and NY ELAP Method 198.8.

New York State DOH introduction of vermiculite related guidance does not prohibit the use or application of vermiculite materials, but instead applies during renovation and/or demolishing of structures when the origin of the vermiculite material is unknown.

New York State DOH guidance FAQ #10 recommends that with no approved analytical methodology to reliably confirm vermiculite as non-asbestos containing, it is always best to assume that vermiculite is contaminated with asbestos and proceed accordingly.
1. **Introduction.** This is the method for the analysis of asbestos in Spray-On Fireproofing Containing Vermiculite (SOF-V) by Polarized-Light Microscopy (PLM).

Thus:

\[
\text{Total Asbestos in original sample} = 0.8050\% + 0.6498\%
\]

\[
= 1.4548\%
\]

9.4. **Rounding Rules.** The percentage of asbestos must be rounded off to two significant digits. Results ending in 5 or greater are rounded up. Results ending in 0 to 4 are rounded down. For example, a total asbestos result of 1.05\% is rounded to 1.1\%. A total asbestos result of 1.01\% is rounded to 1.0\%.
LAB.055.1 – Item 198.8
SOF-V Analysis
Process Description
SOF-V Process Overview

Level 1 Chrysotile Analysis
- Acid Digestion
- Ashing
- PLM Analysis

Level 2 Amphibole Analysis
- Ashing
- Acid/Base Digestion
- PLM & SEM Analysis

Level 1 Chrysotile Analysis
- Ashing
- Water Digestion
- PLM Analysis

Level 2 Amphibole Analysis
- Heavy Liquid Centrifugation
- PLM Analysis
Sample Preparation & Preliminary Analysis

055.1 samples undergo cone & quartering to assure homogeneity

198.8 samples undergo homogenization using mortar and pestle

055.1 and 198.8 sub-samples are analyzed for vermiculite content

Plane Polarized Light 1.550 RI oil

Cross Polarized Light 1.550 RI oil
198.8 samples are ashed in a muffle furnace for 10 hours.

198.8 samples undergo acid treatment and separation of free vermiculite.

055.1 samples are transferred to dilution vials for chemical digestion.

055.1 digestion residue undergoes filtration.

055.1 digestion residues undergo ashing.
Level 1 Sample Analysis - Chrysotile

055.1 filtered digestion residues undergo L1 analysis

198.8 filtered sink residues undergo L1 analysis

PLM photos of Level I treated sample showing chrysotile and thin vermiculite in 1.550 RI oil.
198.8 sink residues are dispersed into two centrifuge tubes containing density-adjusted heavy liquid 2.75 g/cc and placed into the centrifuge.

198.8 undergoes repeated centrifugation with float material removed at each step.

055.1 Level 2 samples undergo ashing followed by aggressive digestion to remove all interferences.
Level 2 Sample Analysis - Amphiboles

198.8 filtered sink fraction at 35x magnification showing abundant sheet structures

PLM photos of 198.8 amphibole asbestos from heavy liquid sink fraction in 1.630 RI oil.

055.1 PLM images of analysis residues

055.1 filter sectioning for PLM and SEM analysis

055.1 SEM images and EDS analysis of residues

Winchite Amphibole

Winchite/Richterite
Method LAB.055.1

SOF-V Sample

Visual/Microscopic Examination

Separate Layering (As Required)

Validate Vermiculite Content

Parallel Treatment Process

Analyze by 198.1 Equivalent

No

Level I Treatment

Chrysotile Analysis

Acid Treatment to Remove Soluble Groups

Ash to Remove Combustibles

Chrysotile Analysis (PLM Only)

Yes

Level II Treatment

Amphibole Analysis

Ash to Remove Combustibles

Acid Treatment to Remove Soluble Groups

Amphibole Analysis (PLM & SEM)

Cone & Quarter Sample Material
“Item 198.8 incorporates a sequential approach to the identification and quantitation of asbestos without differentiation Libby Amphibole species”

Item 198.8 Sequential Analysis Process

- Microscopic exam to check for vermiculite
- Subsampling & crushing
- Ashing to remove organics / cellulose
- Acid / Water treatment to dissolve carbonate & gypsum
- PLM analysis for chrysotile
- Heavy liquid centrifugation for amphibole asbestos
- PLM analysis for amphibole asbestos
- If chrysotile % is >1%, then process complete
LAB.055.1

Scanning Electron Microscopy
To identify amphibole mineral species a portion of the Level II filter residue is analyzed by SEM / EDS.

EDS identification is then used to discriminate amosite, crocidolite, anthophyllite, tremolite and actinolite asbestos species.

Observed amphibole particles similar to tremolite-actinolite, but with the additional elements Na or Na-K suggest origin from the vermiculite mine near Libby, Montana. These non-regulated amphiboles are normally identified as winchite richterite.
Amosite

Fe$_2^+$Si$_8$O$_{22}$(OH)$_2$

Crocidolite

Na$_2$(Fe$_{2.3}$Fe$_{3.2}$)Si$_8$O$_{22}$(OH)$_2$

Actinolite

Ca$_2$Fe$_{2.5}$Si$_8$O$_{22}$(OH)$_2$

Anthophylite

Mg$_7$Si$_8$O$_{22}$(OH)$_2$

Tremolite

Ca$_2$Mg$_5$Si$_8$O$_{22}$(OH)$_2$

Winchite/Richterite

Winchite: (NaCa)Mg$_4$(Al,Fe$_{3.4}$)Si$_8$O$_{22}$(OH)$_2$
Richterite: Na(NaCa)Mg$_5$Si$_8$O$_{22}$(OH)$_2$
### SOF-V Analysis Method Comparison
(Typical SOF-V Analysis Results)

<table>
<thead>
<tr>
<th>Sample ID’s</th>
<th>Both Methods Chrysotile</th>
<th>ELAP 198.8 Amphibole</th>
<th>LAB.055.1 Amphibole</th>
</tr>
</thead>
<tbody>
<tr>
<td>FP-01B &amp; 10302918</td>
<td>N/D</td>
<td>Trace (Amphibole)</td>
<td>0.02% (Wi/Ri)</td>
</tr>
<tr>
<td>FP-02B &amp; 10302919</td>
<td>N/D</td>
<td>Trace (Amphibole)</td>
<td>0.03% (Wi/Ri)</td>
</tr>
<tr>
<td>FP-03B &amp; 10302920</td>
<td>N/D</td>
<td>Trace (Amphibole)</td>
<td>0.02% (Wi/Ri)</td>
</tr>
<tr>
<td>FP-04B &amp; 10302921</td>
<td>N/D</td>
<td>Trace (Amphibole)</td>
<td>0.02% (Wi/Ri)</td>
</tr>
<tr>
<td>FP-05B &amp; 10302922</td>
<td>N/D</td>
<td>Trace (Amphibole)</td>
<td>0.06% (Wi/Ri)</td>
</tr>
<tr>
<td>FP-06B &amp; 10302923</td>
<td>N/D</td>
<td>Trace (Amphibole)</td>
<td>0.02% (Wi/Ri)</td>
</tr>
<tr>
<td>FP-07B &amp; 10302924</td>
<td>N/D</td>
<td>N/D</td>
<td>0.02% (Wi/Ri)</td>
</tr>
<tr>
<td>FP-08B &amp; 10302925</td>
<td>N/D</td>
<td>Trace (Amphibole)</td>
<td>0.02% (Wi/Ri)</td>
</tr>
<tr>
<td>FP-09B &amp; 10302926</td>
<td>N/D</td>
<td>Trace (Amphibole)</td>
<td>0.02% (Wi/Ri)</td>
</tr>
</tbody>
</table>
### Comparative Analysis Results

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Amphibole (%)</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>10302417 – Unground</td>
<td>0.17 (Wi/Ri)</td>
<td>LAB.055.1 – PLM / SEM Analysis</td>
</tr>
<tr>
<td>10302418 – Unground</td>
<td>0.36 (Wi/Ri)</td>
<td></td>
</tr>
<tr>
<td>10302419 – Unground</td>
<td>0.45 (Wi/Ri)</td>
<td></td>
</tr>
<tr>
<td>10302417 – Ground</td>
<td>0.23 (Wi/Ri)</td>
<td></td>
</tr>
<tr>
<td>10302418 – Ground</td>
<td>0.22 (Wi/Ri)</td>
<td></td>
</tr>
<tr>
<td>10302419 – Ground</td>
<td>0.46 (Wi/Ri)</td>
<td></td>
</tr>
<tr>
<td>10302420 – Mortar &amp; Pestle</td>
<td>0.08 – Amphibole</td>
<td>ELAP 198.8 - PLM Analysis Only</td>
</tr>
<tr>
<td>10302421 – Mortar &amp; Pestle</td>
<td>0.03 – Amphibole</td>
<td></td>
</tr>
<tr>
<td>10302422 – Mortar &amp; Pestle</td>
<td>&lt;0.03 – Amphibole</td>
<td></td>
</tr>
</tbody>
</table>
## SOF-V Method Comparison

<table>
<thead>
<tr>
<th>Method Detail</th>
<th>LAB.055.1</th>
<th>ELAP 198.8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vermiculite-Amphibole Separation Method (Preparation Technique)</td>
<td>Chemical</td>
<td>Physical</td>
</tr>
<tr>
<td>Microscopy Method</td>
<td>SEM / PLM</td>
<td>PLM Only</td>
</tr>
<tr>
<td>Differentiation of Amphibole Species</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Analysis Pricing</td>
<td>18 Hour Process - $200</td>
<td>15-20 Hour Process - $200</td>
</tr>
<tr>
<td>Number of Sample Contact and Transfer Processes</td>
<td>&lt;5</td>
<td>&gt;10</td>
</tr>
<tr>
<td>Round Robin Equivalency with Expanded Libby Vermiculite</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>OSHA and NESHAPS Exemptions Where Material Contains Only Wi/Ri Asbestiform Species</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>
USOSHA Interpretation - ACM with $\leq 1\%$ Asbestos

1926.1101(k)(5)(ii)
An employer or owner may demonstrate that PACM does not contain more than 1 percent asbestos by the following:

1926.1101(k)(5)(ii)(A)
Having a completed inspection conducted pursuant to the requirements of AHERA (40 CFR Part 763, Subpart E) which demonstrates that the material is not ACM; or

1926.1101(k)(5)(ii)(B)
Performing tests of the material containing PACM which demonstrate that no ACM is present in the material. Such tests shall include analysis of bulk samples collected in the manner described in 40 CFR 763.86. Analysis of samples shall be performed by persons or laboratories with proficiency demonstrated by current successful participation in a nationally recognized testing program such as the National Voluntary Laboratory Accreditation Program (NVLAP) or the National Institute for Standards and Technology (NIST) or the Round Robin for bulk samples administered by the American Industrial Hygiene Association (AIHA) or an equivalent nationally-recognized round robin testing program.
USOSHA Interpretation - ACM with ≤1% Asbestos

November 24, 2003

Question 1: Are the OSHA letters dated April 17, 1997; August 7, 1998; and August 13, 1999 correct? They all say that items that do not contain >1% asbestos are covered to at least some extent by the Construction Asbestos Standard.

Reply: Yes, those letters are correct although some requirements of the Construction Asbestos Standard, 29 CFR 1926.1101 were not addressed. 29 CFR 1926.1101 would apply even if neither asbestos permissible exposure limit (PEL) is exceeded. The standard contains numerous work practice requirements and prohibitions which apply, regardless of the exposure levels. However, only two of the requirements and three of the prohibitions must be observed in the case of work activities involving installed construction materials that do not contain >1% asbestos.
USOSHA Interpretation - ACM with ≤1% Asbestos

A Conversation with Daniel Crane
Lead Physical Scientist at US Department of Labor; Salt Lake City

On the Issue of OSHA Regulations and the Disturbance of ACM with Reported Amphibole Asbestos Content of <1%

January 29, 2015 11:06 AM
Dan, is OSHA still regulating Asbestos Containing Material down to trace levels, as per the 5 Letters of Interpretation available on-line?

January 29, 2015 2:24 PM
The quick answer is that ACM is defined as containing asbestos in amounts greater than 1%. **We regulate asbestos at any level.** If there is more than 1%, then the requirements specified in Class I, II, III, or IV kick in (Construction standard). If asbestos is present at amounts less than 1%, there are still parts of the regulations that apply and the letters of interpretation lay them out fairly well.
January 29, 2015 2:38 PM
Thank you Dan! **Does that mean that we should request the labs to report anything over the Limit of Detection, not just <1% to meet OSHA’s standards?**

January 29, 2015 4:02 PM
Some laboratories are under the impression that 1% is a detection limit. **It is not.** We have seen operations where there has been more than 100 times the PEL from materials having less than 1% when handled inappropriately. **The problem is that there are folks who treat a result less than 1% as a “home free” card to abate without any controls whatsoever.** An employer must always provide a workplace with an exposure below the PEL.

I do not have anything regulatory to offer in terms of what a lab must report. Clearly, to meet the employers test to rebut the presence of ACM in PACM, a lab has to be able to quantitate down to 1%. The regulations do require that labs are accredited.
The RJ Lee Group Method LAB.055.1:

- Provides sound data on vermiculite materials because of the chemical removal of vermiculite interferences from the analysis.
- Level I PLM accurately quantifies Chrysotile content while Level II SEM/EDS precisely ID’s regulated and non-regulated amphiboles.
- Reliably determines whether a product is truly ACM at the new and more stringent NY DOH limit of 1.0% as well as existing international standards down to 0%.
- Accurately quantifies all amphibole asbestos down to 0.01%.
- Represents one of the only analysis methods capable of exempting owners and contractors from OSHA regulation for materials containing unregulated asbestos types.
SOF-V Method Comparison

RJ Lee Group LAB.055.1

- Proprietary to RJ Lee Group
- Dissolves the Vermiculite (Heat/Acid Digestion)
- Polarized Light and Scanning Electron Microscopy
- Non-Regulated Amphiboles Reported but **not** included in ACM Percentage

NYS DOH - ELAP 198.8

- Available to all New York ELAP Laboratories
- Physical Separates the Vermiculite (Heavy Liquids)
- Polarized Light Microscopy
- Non-Regulated Amphiboles Included in Reporting of ACM Percentage
RJ Lee Group Method LAB.055.1 vs. NYS ELAP Item 198.8:

- 198.8 uses only Polarized Light Microscopy (PLM) for analysis. 055.1 utilizes not only PLM, but also Scanning Electron Microscopy (SEM) and Energy Dispersive X-ray Spectroscopy (EDS) to discriminate between regulated and non-regulated amphibole asbestos species (Libby Amphiboles = 84% Winchite + 10% Richterite + 6% Tremolite).

- Because 055.1 chemically dissolves the sample as opposed to 198.8 which physically separates asbestos from the vermiculite using density adjusted liquids and excludes analysis of any materials floating on the surface, potential for error is significantly reduced:
  - False negatives don’t occur due to asbestos floating off from the sample.
  - False positives don’t occur due to misidentification of asbestiform minerals.
NIOSH 7500

Silica Sampling & Exposure Assessments
What is Silica?

- Family of materials consisting of silicon dioxide ($\text{SiO}_2$)
  - crystalline or amorphous material
- Crystalline –
  - a solid formed by a repeating framework of atoms in 3D, which have fixed distances between them

Regulated Crystalline Silica Polymorphs

Quartz  Cristobalite  Tridymite
Exposure to Crystalline Silica

• Rock – an aggregate of minerals
  – Igneous – granite, other felsic igneous rocks
  – Sedimentary – sandstone, shale, carbonates
  – Metamorphic – schist, gneiss, quartzite, etc.

• Many industries exposed
  – Mining
  – Construction
  – Railroads

• Delayed health effects:
  – Silicosis
  – Lung cancer
  – Chronic obstructive pulmonary disease (COPD)
  – Kidney disease
Permissible Exposure Limits for Silica

OSHA regulates silica exposure using the permissible exposure limit (PEL), which is the maximum amount of airborne dust an employee may be exposed to during a full work shift.

The PEL is dependent on the amount of crystalline silica that is present in the dust. The equation for this calculation is given below. For the most part, OSHA is more concerned with the respirable fraction of the sample because it is more hazardous; however, both respirable and total dust equations are shown. The following parameters are necessary to calculate the PEL and the exposure level. % crystalline silica in the air samples (if the laboratory reports the silica concentrations in units of mass convert the mass to percent - e.g., \( \frac{\text{sample weight (mg)}}{\text{dust weight (mg)}} \times 100\% \)): % quartz, % cristobalite, % tridymite

- Total weight of the dust collected in the air samples in milligrams
- Total volume of air sampled for each sample in cubic meters (1000 liters = 1 cubic meter)
- Total sampling time for each air sample in minutes

\[
\text{PEL (respirable fraction)} = 10 \div \left[ \% \text{ quartz} + (\% \text{ cristobalite} \times 2) + (\% \text{ tridymite} \times 2) + 2 \right]
\]

\[
\text{PEL (total dust)} = 30 \div \left[ \% \text{ quartz} + (\% \text{ cristobalite} \times 2) + (\% \text{ tridymite} \times 2) + 2 \right]
\]

The total dust sample is normally taken using the same sampling technique described previously, but without a cyclone. Exposure = \( \frac{[(\text{mg/m}^3(1) \times \text{time}(1)) + (\text{mg/m}^3(2) \times \text{time}(2)) + \ldots + (\text{mg/m}^3(n) \times \text{time}(n))] \} {480 \text{ minutes}} \)
Example of PEL Derivation:

The following example is based on collecting a respirable sample using a cyclone. If a total dust sample were collected (i.e., no cyclone used) the example would only differ in the value used to calculate the PEL.

**Step 1.** Calculate the percentage of quartz, cristobalite, and tridymite in the particulate collected.

Quartz: \[5.2\% \times (0.855/1.474)\] + \[4.8\% \times (0.619/1.474)\] = 3.0 + 2.0 = 5.0%

Cristobalite: \[2.3\% \times (0.855/1.474)\] + \[1.7\% \times (0.619/1.474)\] = 1.3 + 0.7 = 2.0%

Tridymite: none detected = 0%

**Step 2.** Calculate the PEL for the mixture.

\[
\text{PEL(mixture) = 10 mg/m}^3 \div \left[\% \text{ quartz} + (\% \text{ cristobalite} \times 2) + (\% \text{ tridymite} \times 2) + 2\right]
\]

\[
= 10 \div [5 + (2.0 \times 2) + (0 \times 2) + 2] = 10 \div 11.0 = 0.91 \text{ mg/m}^3
\]

**Step 3.** Calculate the employee's exposure (8 hour TWA).

\[
\text{Exposure} = \left[ (\text{mg/m}^3(1) \times \text{time}(1)) + (\text{mg/m}^3(2) \times \text{time}(2)) + ... + (\text{mg/m}^3(n) \times \text{time}(n)) \right] \div 480 \text{ minutes}
\]

\[
= [(2.1 \times 238) + (1.9 \times 192)] \div 480 = 1.8 \text{ mg/m}^3
\]

**Step 4.** Calculate the severity of the exposure.

\[
\text{Severity} = 1.8 \text{ mg/m}^3 \div 0.91 \text{ mg/m}^3 = 2.0
\]
The OSHA silica PEL is based on a sliding scale beginning at 5mg/m³ for respirable dust having 0% crystalline silica (OSHA nuisance dust PEL):

\[
\frac{10\text{mg/m}^3}{0 + 2}
\]

to a low of 0.098 mg/m³ where the dust consists of 100% crystalline silica.

\[
\frac{10\text{mg/m}^3}{100 + 2}
\]

When the crystalline dusts contain not only quartz but, cristobalite and tridymite species, the formula gets a bit more complicated because of the toxicological differences between the species. *Cristobalite and tridymite* are forms of silica derived from superheating quartz, have a different crystalline structure and are considered more fibrogenic to the lungs than quartz (OSHA-1970’s?).

The updated PEL derivation for atmospheres in which cristobalite and tridymite are present includes consideration for this increased toxicity:

\[
\text{PEL(mixture)} = 10 \text{mg/m3} \div [\% \text{quartz} + (\% \text{cristobalite} \times 2) + (\% \text{tridymite} \times 2) + 2]
\]
Current OSHA Personal Exposure Limits (PEL)

Dust containing *no* quartz:
PEL = 5 mg/m³
or
5000 µg/m³

Dust containing *all* quartz:
PEL = 0.1 mg/m³
or
100 µg/m³

PEL = \( \frac{10 \text{ mg/m}^3}{\% \text{ Quartz}} + 2 \)
The Advisor Genius: Comparing Silica Levels to the OSHA Limit

Before You Begin
The Genius performs calculations for a respirable dust sample. If your sample is collected as a total dust sample, you will need to make adjustments to the PEL and Severity the Genius calculates.

The Advisor Genius will ask you for the following information. You should find the data on the report of results from the laboratory analysis. The first two items will be asked by pop-up screens which will appear when you begin.

- Number of samples taken for one worker
- Sampling and analytical error (optional - see below)
- Total time for each air sample (in minutes)
- Average sample pump flow rate for each air sample (in liters/minute)
- Total weight of respirable dust collected for each sample (in milligrams)
- Percentage of quartz
- Percentage of cristobalite
- Percentage of tridymite

Note: If the laboratory report lists the silica concentrations in milligrams, then you should convert that mass to a percentage by dividing the sample weight (mg) by the dust weight (mg) and multiply the result by 100.

Optional

- Sampling and analytical error (SAE). This parameter is optional, but, if provided, will allow the uncertainty in the actual measurements to be factored into the calculation and the calculator will give a statistical range for the exposure.

Note: The Advisor Genius has been written using JavaScript. If your software does not support this, the Genius will not operate properly.
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 a value you may want to use an estimated value of 0.3.)

Can the material collected be classified as coal 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 %</th>
<th>Cristobalite %</th>
<th>Tridymite %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>238</td>
<td>1.7</td>
<td>0.855</td>
<td>5.2</td>
<td>2.2</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>192</td>
<td>1.7</td>
<td>0.619</td>
<td>4.8</td>
<td>1.7</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>1.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>1.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>1.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>1.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>1.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>0</td>
<td>1.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>0</td>
<td>1.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>0</td>
<td>1.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>430</strong></td>
<td><strong>1.47</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Calculate the Time Weighted Average based on the sampling period (430 minutes).

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>0.908</td>
<td>1.81</td>
<td>1.99</td>
<td>0.3</td>
<td>1.69</td>
<td>2.29</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.
Thus, **regardless of outcome studied, there is insufficient epidemiological evidence to support a lower PEL for cristobalite versus quartz.** For lung cancer, the relative risk estimates among workers exposed predominantly to cristobalite (SMR=1.3, 95% CI 1.0 – 1.6 for DE workers) do not differ consistently or substantively from study cohorts in which the workers were exposed to crystalline silica from quartz (SMR=1.4, 95% CI 1.0 – 2.0 for Finnish granite workers; SMR=1.2, 95% CI 1.0 – 1.3 for US granite workers; SMR=1.6, 95% CI 1.2 – 1.9 for US industrial sand workers; SMR=1.1, 95% CI 0.84 – 1.4 for China pottery workers; SMR=2.1, 95% CI 1.7 – 2.6 for China tin workers; SMR=1.2, 95% CI 1.0 – 1.4 for US gold miners; and SMR=1.8, 95% CI 1.5 – 2.1 for Australian gold miners) (as summarized by Steenland et al. 2001 (Steenland, Mannetje, et al. 2001)).

**Overall, the evidence for an association between occupational exposure to respirable crystalline silica (mainly cristobalite) and lung cancer among non-silicotics is weak, or lacking.** While there is stronger evidence of an association between occupational exposure to silica and lung cancer among silicotics, it remains unclear whether this increased risk for both diseases resulted from much higher exposures to crystalline silica decades prior to the epidemiological studies reporting increased risks.
NIOSH 7500 Analytical Method

- NIOSH 7500, Crystalline Silica by XRD
  - Analytes: respirable quartz, cristobalite, tridymite
  - Sampling: cyclone + cassette
  - Instrument: XRD
Cassette Assembly – Performed by the lab

• Filters Used:
  – 5 µm pore size
  – 37 mm diameter
  – Polyvinyl chloride (PVC)

• Pre-weights:
  – Weighed in sets of 10
  – Every 10th weight is re-weighed to ensure that the balance did not drift during weighing of the set
**Sampling – Exposure Assessment**

### Cyclone
- 10-mm nylon cyclone (Dorr-Oliver)
- Higgins-Dewell (HD) cyclone
- Aluminum cyclone + 5 µm PVC filter

### Flow Rate
- 1.7 ± 5 % L/min
- 2.2 ± 5 % L/min
- 2.5 ± 5 % L/min

**Tips from the lab:**
- Ensure the cassette is loaded into the cyclone properly
- Do not invert sampler assembly while using the cyclone

Outlet-side of Cassette (connect tubing here)
Sample Preparation – preformed in the lab

- Samples received
- Dried in a desiccator
- Cassettes are carefully opened to remove filters
- Filters are post-weighed, recorded
- Total respirable dust mass is calculated

‘Gravimetric Analysis’
NIOSH 0500
NIOSH 0600

Reporting Limit: 0.100 mg
Sample Preparation – preformed in the lab

- Removal of the filter
  - Low temperature plasma ashing (beaker)
    - 1 hr
  - Muffle furnace ashing (crucible)
    - 2 hr @ 600°C
  - Filter dissolution
    - Tetrahydrofuran (THF)
Sample Preparation – performed in the lab

- 15 mL of 2-Proponal is added to each beaker
- Cover and sonicate
- Obtain a silver membrane filter
  - 25 mm
  - 0.45 µm
- Attach funnel
Sample Preparation – performed in the lab

- Pour suspension into the funnel
- Walls of beaker are rinsed well
- Apply vacuum
- Remove the silver filter with the sample deposited on it
Sample Preparation – preformed in the lab

- Mount into XRD holder
- Place in tray
- Ready for analysis
X-Ray Diffractometer

PANalytical Cubix³ Diffractometer

X-ray Source

Detector

Goniometer

Sample
XRD Basics

- Bombardment of X-rays results in scattering of the X-rays off of atomic planes.
- X-Ray diffraction produces patterns that are indicative of the atomic planes in a material, which serve as a fingerprint for individual minerals.

\[ n\lambda = 2d\sin\theta \]

- Incident X-ray beam
- Diffracted beam
- Atomic Planes
- \( \lambda = 1.54 \text{ Å, CuK}\alpha \)
XRD Data

Counts

Position [°2Theta] (Copper (Cu))

Leading Edge Asbestos & Silica Analysis
XRD Data

Counts

Position [°2Theta] (Copper (Cu))

Quartz
Silver
Silver Chloride

Primary Quartz Peak
Secondary Quartz Peak
Primary Silver Peak

Counts

0 40000 160000 360000

RJ Lee Group
Leading Edge Asbestos & Silica Analysis
NIOSH 7500 - External Standard Method

• Create standards from a pure mineral
• Construct a calibration curve
• Compare unknown samples to known standard results to determine silica quantification
Calibration Standard Data

Quartz Detection Limit (0.005mg)
Calibration Curves

**Calibration Curve for Quartz 26.6° 2θ**

\[ y = 0.0007x - 0.4596 \]

\[ R^2 = 0.9995 \]

**Calibration Curve for Quartz 20.8° 2θ**

\[ y = 0.0032x + 3.6198 \]

\[ R^2 = 0.9952 \]
Interferences

- Mica*
- Potash
- Feldspars*
- Zircon
- Graphite
- Aluminosilicates

Best way to determine interferences: collect a bulk settled dust sample or send the bulk material in question for XRD analysis for phase identification.
LABORATORY REPORT

ABC Company
1 Industrial Way
Pittsburgh, PA 15200
ATTENTION: Crystal N. Silica
TELEPHONE: 724-XXX-XXX

REPORT DATE: June 4, 2014
SAMPLES RECEIVED: May 30, 2014
RJ LEE GROUP JOB NO.: PA30052014001
CLIENT JOB NO.: N/A
PURCHASE ORDER NO.: N/A

ANALYSIS: Respirable Dust and Crystalline Free Silica Dust on 5 µm PVC Air Filters
METHODS: Gravimetry, NIOSH 0600 and X-Ray Diffraction, NIOSH 7500

LOD: 0.005 mg Quartz, Cristobalite, and Tridymite
0.100 mg Respirable Dust

<table>
<thead>
<tr>
<th>Sample Identification</th>
<th>Air* Volume (liters)</th>
<th>Respirable Dust Mass (mg/filter)</th>
<th>Masses of Silica Minerals (mg/filter)</th>
<th>Free Airborne Dust Concentrations (mg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Client I.D.</td>
<td>RJ Lee Group</td>
<td></td>
<td></td>
<td>Weight Percentages of Crystalline Silica Minerals</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Quartz</td>
</tr>
<tr>
<td>Sample A</td>
<td>001</td>
<td>1200.</td>
<td>0.500</td>
<td>0.500</td>
</tr>
<tr>
<td>Sample B</td>
<td>002</td>
<td>1200.</td>
<td>0.500</td>
<td>0.250</td>
</tr>
<tr>
<td>Sample C</td>
<td>003</td>
<td>1200.</td>
<td>0.500</td>
<td>0.150</td>
</tr>
<tr>
<td>Sample D</td>
<td>004</td>
<td>1200.</td>
<td>0.500</td>
<td>0.100</td>
</tr>
<tr>
<td>Sample E</td>
<td>005</td>
<td>1200.</td>
<td>0.500</td>
<td>0.050</td>
</tr>
<tr>
<td>Blank</td>
<td>006</td>
<td>N/A</td>
<td>&lt; 0.100</td>
<td>1.050</td>
</tr>
</tbody>
</table>

* Supplied by the client.
N/A Not Applicable

Air volume during a worker’s shift
LABORATORY REPORT

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Pittsburgh, PA 15200
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<th>Airborne Dust Concentrations (mg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Quartz</td>
<td>Cristobalite</td>
<td>Tridymite</td>
</tr>
<tr>
<td>Sample A 001</td>
<td>1200.</td>
<td>0.500</td>
<td>0.500</td>
<td>&lt; 0.005</td>
<td>&lt; 0.005</td>
</tr>
<tr>
<td>Sample B 002</td>
<td>1200.</td>
<td>0.500</td>
<td>0.250</td>
<td>&lt; 0.005</td>
<td>&lt; 0.005</td>
</tr>
<tr>
<td>Sample C 003</td>
<td>1200.</td>
<td>0.500</td>
<td>0.150</td>
<td>&lt; 0.005</td>
<td>&lt; 0.005</td>
</tr>
<tr>
<td>Sample D 004</td>
<td>1200.</td>
<td>0.500</td>
<td>0.100</td>
<td>&lt; 0.005</td>
<td>&lt; 0.005</td>
</tr>
<tr>
<td>Sample E 005</td>
<td>1200.</td>
<td>0.500</td>
<td>0.050</td>
<td>&lt; 0.005</td>
<td>&lt; 0.005</td>
</tr>
<tr>
<td>Blank 006</td>
<td>N/A</td>
<td>&lt; 0.100</td>
<td>1.050</td>
<td>&lt; 0.010</td>
<td>&lt; 0.010</td>
</tr>
</tbody>
</table>

* Supplied by the client.
N/A Not Applicable

* Air volume during a worker's shift
N/A Mass of material on filter from microbalance

RJ Lee Group, Inc.
350 Hochberg Road, Monroeville, PA 15146
Tel: (724) 325-1776 | Fax: (724) 733-1799
**LABORATORY REPORT**

**ABC Company**  
1 Industrial Way  
Pittsburgh, PA 15200  
ATTENTION: Crystal N. Silica  
TELEPHONE: 724-XXX-XXX

**ANALYSIS:** Respirable Dust and Crystalline Free Silica Dust on 5 µm PVC Air Filters  
**METHODS:** Gravimetry, NIOSH 0600 and X-Ray Diffraction, NIOSH 7500

**LOD:** 0.005 mg Quartz, Cristobalite, and Tridymite  
0.100 mg Respirable Dust

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<thead>
<tr>
<th>Sample Identification</th>
<th>Air* Volume (liters)</th>
<th>Respirable Dust Mass (mg/filter)</th>
<th>Masses of Silica Minerals (mg/filter)</th>
<th>Weight Percentages of Crystalline Silica Minerals</th>
<th>Airborne Dust Concentrations (mg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Breathing Zone</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Respirable</td>
<td>Quartz</td>
</tr>
<tr>
<td>Sample A</td>
<td>001</td>
<td>1200.</td>
<td>0.500</td>
<td>0.500</td>
<td>&lt; 0.005</td>
</tr>
<tr>
<td>Sample B</td>
<td>002</td>
<td>1200.</td>
<td>0.500</td>
<td>0.250</td>
<td>&lt; 0.005</td>
</tr>
<tr>
<td>Sample C</td>
<td>003</td>
<td>1200.</td>
<td>0.500</td>
<td>0.150</td>
<td>&lt; 0.005</td>
</tr>
<tr>
<td>Sample D</td>
<td>004</td>
<td>1200.</td>
<td>0.500</td>
<td>0.100</td>
<td>&lt; 0.005</td>
</tr>
<tr>
<td>Sample E</td>
<td>005</td>
<td>1200.</td>
<td>0.500</td>
<td>0.050</td>
<td>&lt; 0.005</td>
</tr>
<tr>
<td>Blank</td>
<td>006</td>
<td>N/A</td>
<td>&lt; 0.100</td>
<td>1.050</td>
<td>&lt; 0.010</td>
</tr>
</tbody>
</table>

* Supplied by the client.  
N/A Not Applicable

---

* Air volume during a worker's shift  
* Mass of material on filter from microbalance  
* Mass of each mineral determined by XRD measurements using the calibration curves derived from standards

---

RJ Lee Group, Inc.  
350 Hochberg Road, Monroeville, PA 15146  
Tel: (724) 325-1776 | Fax: (724) 733-1799
# LABORATORY REPORT

**LABORATORY REPORT**

**ABC Company**  
1 Industrial Way  
Pittsburgh, PA 15200  
ATTENTION: Crystal N. Silica  
TELEPHONE: 724-XXX-XXX

**ANALYSIS:** Respirable Dust and Crystalline Free Silica Dust on 5 µm PVC Air Filters  
**METHODS:** Gravimetry, NIOSH 0600 and X-Ray Diffraction, NIOSH 7500

**REPORT DATE**  
June 4, 2014

**SAMPLES RECEIVED**  
May 30, 2014

**RJ LEE GROUP JOB NO.**  
PA30052014001

**CLIENT JOB NO.**  
N/A

**PURCHASE ORDER NO.**  
N/A

**LOD:**  
0.005 mg Quartz, Cristobalite, and Tridymite  
0.100 mg Respirable Dust

---

<table>
<thead>
<tr>
<th>Sample Identification</th>
<th>Client I.D.</th>
<th>RJ Lee Group</th>
<th>Air volume (liters)</th>
<th>Mass of total dust on filter from micro-balance</th>
<th>Respirable Masses of Silica Minerals (mg/filter)</th>
<th>Weight Percentages of Crystalline Silica Minerals</th>
<th>Airborne Dust Concentrations (mg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Quartz Cristobalite Tridymite</td>
<td>Respirable Quartz Cristobalite Tridymite</td>
<td>Respirable Quartz Cristobalite Tridymite</td>
</tr>
<tr>
<td>Sample A</td>
<td>001</td>
<td></td>
<td>1200</td>
<td>0.500</td>
<td>0.500 &lt; 0.005 &lt; 0.005</td>
<td>100.0 &lt; 1.0 &lt; 1.0</td>
<td>0.417 0.417 &lt; 0.004 &lt; 0.004</td>
</tr>
<tr>
<td>Sample B</td>
<td>002</td>
<td></td>
<td>1200</td>
<td>0.500</td>
<td>0.250 &lt; 0.005 &lt; 0.005</td>
<td>50.0 &lt; 1.0 &lt; 1.0</td>
<td>0.417 0.208 &lt; 0.004 &lt; 0.004</td>
</tr>
<tr>
<td>Sample C</td>
<td>003</td>
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<td>0.417 0.125 &lt; 0.004 &lt; 0.004</td>
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<td>Sample D</td>
<td>004</td>
<td></td>
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<tr>
<td>Blank</td>
<td>006</td>
<td></td>
<td>N/A</td>
<td>&lt; 0.100</td>
<td>1.050 &lt; 0.010 &lt; 0.010</td>
<td>N/A N/A N/A</td>
<td>N/A N/A N/A N/A</td>
</tr>
</tbody>
</table>

* Supplied by the client.  
N/A Not Applicable

---

**Air volume during a worker’s shift**  
**Mass of material on filter from micro-balance**  
**Mass of each mineral determined by XRD measurements using the calibration curves derived from standards**  
**Mass of mineral**  
\[
\frac{\text{Mass of mineral}}{\text{Mass of total dust}} \times 100
\]
LABORATORY REPORT

ABC Company
1 Industrial Way
Pittsburgh, PA 15200
ATTENTION: Crystal N. Silica
TELEPHONE: 724-XXX-XXX

REPORT DATE
June 4, 2014

SAMPLES RECEIVED
May 30, 2014

RJ LEE GROUP JOB NO.
PA30052014001

CLIENT JOB NO.
N/A

ANALYSIS:
Respirable Dust and Crystalline Free Silica Dust on 5 µm PVC Air Filters

METHODS:
Gravimetry, NIOSH 0600 and X-Ray Diffraction, NIOSH 7500

LOD:
0.005 mg Quartz, Cristobalite, and Tridymite
0.100 mg Respirable Dust

<table>
<thead>
<tr>
<th>Sample Identification</th>
<th>Air* Volume (liters)</th>
<th>Respirable Dust Mass (mg/filter)</th>
<th>Masses of Silica Minerals (mg/filter)</th>
<th>Weight Percentages of Crystalline Silica Minerals</th>
<th>Airborne Dust Concentrations (mg/m³)</th>
</tr>
</thead>
<tbody>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Quartz</td>
<td>Cristobalite</td>
</tr>
<tr>
<td>Sample A</td>
<td>001</td>
<td>1200.</td>
<td>0.500</td>
<td>0.500</td>
<td>&lt; 0.005</td>
</tr>
<tr>
<td>Sample B</td>
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<td>1200.</td>
<td>0.500</td>
<td>0.250</td>
<td>&lt; 0.005</td>
</tr>
<tr>
<td>Sample C</td>
<td>003</td>
<td>1200.</td>
<td>0.500</td>
<td>0.150</td>
<td>&lt; 0.005</td>
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<tr>
<td>Sample D</td>
<td>004</td>
<td>1200.</td>
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<td>0.100</td>
<td>&lt; 0.005</td>
</tr>
<tr>
<td>Sample E</td>
<td>005</td>
<td>1200.</td>
<td>0.500</td>
<td>0.050</td>
<td>&lt; 0.005</td>
</tr>
<tr>
<td>Blank</td>
<td>006</td>
<td>N/A</td>
<td>&lt; 0.100</td>
<td>1.050</td>
<td>&lt; 0.010</td>
</tr>
</tbody>
</table>

* Supplied by the client.
N/A       Not Applicable

RJ Lee Group
Leading Edge Asbestos & Silica Analysis

- **Air volume during a worker's shift**: The volume of air in liters that the worker breathed during their shift.
- **Mass of material on filter from micro-balance**: The mass of the material on the filter, determined by a micro-balance.
- **Mass of mineral**: Calculated as the mass of the mineral divided by the mass of total dust, then multiplied by 100.
- **Mass of total dust**: Determined by multiplying the mass of the mineral by 1000.
- **Air Volume**: The total volume of air breathed by the worker, measured in cubic meters (m³).

These calculations help in understanding the concentrations of crystalline silica minerals in workplace air samples.
Current OSHA Personal Exposure Limits (PEL)

**Current OSHA Personal Exposure Limits (PEL)**

\[
\text{PEL} = \frac{10 \text{ mg/m}^3}{\text{% Quartz} + 2}
\]

*Based on an 8 hour shift*
### Current OSHA Personal Exposure Limits (PEL)

<table>
<thead>
<tr>
<th>Sample Identification</th>
<th>Air* Volume (liters)</th>
<th>Respirable Dust Mass (mg/filter)</th>
<th>Masses of Free Silica Minerals (mg/filter)</th>
<th>Weight Percentages of Crystalline Silica Minerals</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Quartz</td>
<td>Cristobalite</td>
</tr>
<tr>
<td>Sample A 001</td>
<td>1200.</td>
<td>0.500</td>
<td>0.500</td>
<td>&lt; 0.005</td>
<td>&lt; 0.005</td>
</tr>
<tr>
<td>Sample B 002</td>
<td>1200.</td>
<td>0.500</td>
<td>0.250</td>
<td>&lt; 0.005</td>
<td>&lt; 0.005</td>
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<tr>
<td>Sample C 003</td>
<td>1200.</td>
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<td>0.150</td>
<td>&lt; 0.005</td>
<td>&lt; 0.005</td>
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<tr>
<td>Sample D 004</td>
<td>1200.</td>
<td>0.500</td>
<td>0.100</td>
<td>&lt; 0.005</td>
<td>&lt; 0.005</td>
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<tr>
<td>Sample E 005</td>
<td>1200.</td>
<td>0.500</td>
<td>0.050</td>
<td>&lt; 0.005</td>
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<tr>
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<td>&lt; 0.100</td>
<td>1.050</td>
<td>&lt; 0.010</td>
<td>&lt; 0.010</td>
</tr>
</tbody>
</table>

**PEL** = \[
\frac{10 \text{ mg/m}^3}{\% \text{ Quartz} + 2}
\]

**PEL_E = 0.83 mg/m³**

**PEL_D = 0.45 mg/m³**

**PEL_C = 0.31 mg/m³**

**PEL_B = 0.19 mg/m³**

**PEL_A = 0.10 mg/m³**

*Compare this value to the calculated PEL*

*Based on an 8 hour shift*
**Current OSHA Personal Exposure Limits (PEL)**

<table>
<thead>
<tr>
<th>Sample Identification</th>
<th>Client I.D.</th>
<th>Air* Volume (liters)</th>
<th>Respirable Dust Mass (mg/filter)</th>
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<td></td>
<td></td>
<td>Quartz Cristobalite Tridymite</td>
<td>Respirable Quartz Cristobalite Tridymite</td>
</tr>
<tr>
<td>Sample A</td>
<td>001</td>
<td>1200.</td>
<td>0.500</td>
<td>0.500 &lt; 0.005 &lt; 0.005</td>
<td>100.0 &lt; 1.0 &lt; 1.0</td>
<td>0.417 0.417 &lt; 0.004 &lt; 0.004</td>
</tr>
<tr>
<td>Sample B</td>
<td>002</td>
<td>1200.</td>
<td>0.500</td>
<td>0.250 &lt; 0.005 &lt; 0.005</td>
<td>50.0 &lt; 1.0 &lt; 1.0</td>
<td>0.417 0.208 &lt; 0.004 &lt; 0.004</td>
</tr>
<tr>
<td>Sample C</td>
<td>003</td>
<td>1200.</td>
<td>0.500</td>
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</table>

*PEL = \( \frac{10 \text{ mg/m}^3}{\% \text{ Quartz} + 2} \)

Samples A, B and C have Airborne Dust Concentrations OVER the calculated PEL

*Based on an 8 hour shift*
### New Proposed OSHA Personal Exposure Limits (PEL)

#### Sample Identification and Airborne Dust Masses of Free Weight Percentages of Airborne Dust

<table>
<thead>
<tr>
<th>Sample Identification</th>
<th>Client I.D.</th>
<th>Air Volume (liters)</th>
<th>Respirable Dust Mass (mg/filter)</th>
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<td>Sample A</td>
<td>001</td>
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<td>&lt; 0.005</td>
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<td>Sample B</td>
<td>002</td>
<td>1200.</td>
<td>0.500</td>
<td>0.250</td>
<td>&lt; 0.005</td>
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<td>Sample C</td>
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</table>

**New Proposed OSHA PEL for quartz:**

- 0.05 mg/m³
- 50 µg/m³

**New Proposed OSHA Action level for quartz:**

- 0.025 mg/m³
- 25 µg/m³

Compare this value to the new proposed OSHA PEL.
### New Proposed OSHA Personal Exposure Limits (PEL)

<table>
<thead>
<tr>
<th>Sample Identification</th>
<th>Client I.D.</th>
<th>Volume (liters)</th>
<th>Dust Mass (mg/filter)</th>
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</table>

**New Proposed OSHA PEL for quartz:**
- 0.05 mg/m³
- 50 µg/m³

**New Proposed OSHA Action level for quartz:**
- 0.025 mg/m³
- 25 µg/m³

Samples A, B, C and D are now OVER the new proposed PEL for quartz.
### New Proposed OSHA Personal Exposure Limit (PEL)

#### Samples A, B, C, and D
- New Proposed OSHA PEL for quartz: 0.05 mg/m³ or 50 µg/m³
- Samples A, B, C, and D are now OVER the new proposed PEL for quartz

#### Sample E
- New Proposed OSHA Action level for quartz: 0.025 mg/m³ or 25 µg/m³
- Sample E is at the proposed action level

<table>
<thead>
<tr>
<th>Sample Identification</th>
<th>Client I.D.</th>
<th>Volume (liters)</th>
<th>Dust Mass (mg/filter)</th>
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<td></td>
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<td></td>
<td>Quartz</td>
<td>Cristobalite</td>
</tr>
<tr>
<td>Sample A</td>
<td>001</td>
<td>1200.00</td>
<td>0.500</td>
<td>0.500</td>
<td>0.500</td>
<td>&lt; 0.005</td>
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<tr>
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<tr>
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<td>&lt; 0.100</td>
<td>1.050</td>
<td>1.050</td>
<td>&lt; 0.010</td>
</tr>
</tbody>
</table>
New Proposed OSHA Personal Exposure Limits (PEL)

- Concerns raised by the new proposed PELs
  - Regulatory compliance will be more difficult
  - Increased costs associated with monitoring and correcting non-compliance
  - Some question if crystalline silica can be reliably measured at these levels

Flow rate of 1.7 L/min for an 8 hour shift:

<table>
<thead>
<tr>
<th></th>
<th>Current PEL:</th>
<th>New Proposed PEL:</th>
<th>New Proposed Action Limit:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.1 mg/m³ (100 µg/m³)</td>
<td>0.05 mg/m³ (50 µg/m³)</td>
<td>0.025 mg/m³ (25µg/m³)</td>
</tr>
<tr>
<td></td>
<td>0.08 mg/filter (80 µg/filter)</td>
<td>0.04 mg/filter (40 µg/filter)</td>
<td>0.02 mg/filter (20 µg/filter)</td>
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</table>
# Muffle Furnace vs. Plasma Asher

<table>
<thead>
<tr>
<th>Test</th>
<th>Ashing Device</th>
<th>Crucible</th>
<th>Scraping</th>
<th>Crystalline Silica</th>
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<tbody>
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<td>Standard (µg)</td>
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<tr>
<td>5</td>
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<td>Partial</td>
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<td>96.1</td>
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</tbody>
</table>
For more information on LAB.055.1 SOF-V or Silica analysis please contact RJ Lee Group

VermicuLine: 724.387.1972
Vermiculite@RJLeeGroup.com

Don Ewert: 724.387.1856
dewert@RJLeeGroup.com