What You Need to Know about Silicosis and Silicosis Prevention

Silica Hazard in Hydraulic Fracturing: Will We Repeat the Past?

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Crystalline Silica Polymorphs

- Silica refers to the chemical compound SiO2 (silicon dioxide).
- Occurs in two specific and distinct forms: amorphous and crystalline.
- Common crystalline forms of silica
  - **Quartz**
    - Tridymite
    - Cristobalite
- Quartz is the second most common mineral on earth (12% of Earth’s crust).
- Found in sand and gravel, rocks (e.g., such as granite, sandstone, flint and slate), and in coal and metallic ores.
Respirable Crystalline Silica

• What is Respirable Crystalline Silica (RCS)?
  – It is a crystalline silica particle capable of reaching the most distant regions of the respiratory system where oxygen-carbon dioxide transfer takes place.
  – Aerodynamic diameter of 10 micrometers or less.
What Is Silicosis?

- Dust disease of the lung (pneumoconioses)
  - Silicosis
  - Other examples of pneumoconioses
- Slowly progressive fibrosis of the lung (development of scar tissue)
- Inhalation and retention of respirable crystalline silica
  - High intensity of exposure
  - Long duration of exposure
- No treatment
- 100% preventable
- Can be disabling and lead to death
Spectrum of Silicosis

- Chronic Silicosis
  - Most common form (10-30 years of excessive exposure)
- Two Forms
  - Simple Silicosis
  - Complicated Silicosis (conglomerate)
- Accelerated
- Acute
Chronic Silicosis

• Simple Silicosis
  – Earliest form, usually no chest symptoms
  – Pulmonary fibrosis after years of exposure
  – Relatively low levels of RCS
  – Fibrosis predominates in upper lung zones
  – Radiographically small discrete nodules
  – Typically no pulmonary impairment

• Complicated Silicosis (Conglomerate)
  – Small lesions coalesce to form large lesions
  – Symptoms
    • Shortness of breath
    • Possibly cough and sputum production
Accelerated Silicosis

- Results from very high exposures - over a relatively short time (5-10 yrs)
- Radiographic Pattern similar to simple silicosis
  - Rounded nodular lesions in upper lungs
- Much faster progression
- Can be fatal in as little as ten years
Normal and Silicotic Lung
Chronic Silicosis

- Simple Silicosis
  - Small discrete nodules
    (lesions < 1 cm)

- Complicated Silicosis
  - Lesions increase in size
    (>1 cm)
  - Grow together to form larger masses
Normal Chest X-ray
Simple Silicosis
Complicated Silicosis
Silicosis Conclusions

- A fibrotic lung disease that produces scarring of the lungs
- Three Types
  - Chronic
    - Simple
    - Complicated
  - Accelerated
  - Acute
- Produces characteristic rounded nodules
- Fibrosis is irreversible and there is no treatment
- Completely preventable occupational disease
Silica Exposure Severity Index

- A sample result comparison, sometimes referred to as *Severity Index* (the sample value compared with the PEL) can be expressed as *exposure*

\[ SI = \frac{\text{Measured Value}}{\text{PEL}} \times 100\% = \% \text{ of Allowable Exposure} \]

\[ SI = \frac{50 \, \mu g/m^3}{100 \, \mu g/m^3} \times 100\% = 50\% \text{ or } \frac{1}{2} \text{ the PEL} \]

\[ SI = \frac{200 \, \mu g/m^3}{100 \, \mu g/m^3} \times 100\% = 200\% \text{ or twice the PEL} \]
MSHA Sampling Data Severities at Two Silica Flour Mills

1973: Mill A Mean 13, Mill B Mean 8
1974: Mill A Mean 0, Mill B Mean 2
1975: Mill A Mean 0, Mill B Mean 0
1976: Mill A Mean 3, Mill B Mean 3
1977: Mill A Mean 3, Mill B Mean 2
1978: Mill A Mean 9, Mill B Mean 11
1979: Mill A Mean 7, Mill B Mean 7

Legend:
- Mill A Mean
- Mill B Mean
1979 NIOSH Sampling Severities at Two Silica Flour Mills

![Bar chart showing severities at two silica flour mills for different roles: Bagger, Housekeeping, Mechanic, Shipping, and Supervisor. The chart compares the mean severities between Mill A and Mill B.](HH)
2013 NIOSH Sampling
Severities at Eleven Well Completion Sites

![Bar Chart](chart.png)

- T-Belt Operator: Arithmetic Mean 8, Max Concentration 21
- Sand Mover Operator: Arithmetic Mean 6, Max Concentration 29
- Hydration Unit Operator: Arithmetic Mean 2, Max Concentration 8
- Chem Truck Operator: Arithmetic Mean 2, Max Concentration 3
- Blender Operator: Arithmetic Mean 1, Max Concentration 5
- Sand Coordinator: Arithmetic Mean 1, Max Concentration 3
Comparison NIOSH Sampling Severities
Hydraulic Fracturing and Silica Flour

![Comparison NIOSH Sampling Severities Bar Chart](image-url)
“Those who cannot remember the past are condemned to repeat it.”

George Santayana
Radiographic Silicosis at Silica Flour Plants

<table>
<thead>
<tr>
<th>Current Workers, &lt; 1 yr exposure</th>
<th>Current Workers ≥ 1 yr exposure</th>
<th>Retired and other exposed workers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>Number</td>
<td>Number</td>
</tr>
<tr>
<td>Simple Silicosis</td>
<td>Complicated Silicosis</td>
<td>Total</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>25 (25%)</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0 (0%)</td>
</tr>
</tbody>
</table>

(Needs more detailed explanation and context for the numeric values and categories.)
Seven Steps of a Silicosis Prevention Program

- Management Commitment to Implementation;
- Occupation Health Program Implementation;
- Dust Exposure Assessment;
- Medical Surveillance;
- Dust Control;
- Employee Involvement; and
- Smoking Cessation Program.
Silicosis Prevention Company Commitment

• Truism – senior management commitment is imperative for a program to have a chance at success
  – Silicosis prevention cannot be only a health and safety department responsibility
• What is management commitment?
  – Commitment:
    • Understand silica and silicosis issues:
      – Again, silicosis prevention not only for health & safety
      – General understanding of silica health effects, IH issues
Silicosis Prevention Company Commitment

• Spend money, capital and expense:
  – Without “payback”
  – Example - During lean years, i.e., in 2009
    • EHS only employee meetings in 2009
• Compensation metrics:
  – Industrial sand company bonus for all management –
    7.5% for dust sampling metrics
• Management
  – H&S Manager, EH&S and dust committees
• Support objective scientific and medical research:
  – Objective research, in contrast to advocacy
  – Support via making available data
  – Financial support?
Background

- Silicosis in the workplace – a management failure.
  - Not caused by a brief lapse in attention, a one time (or even more frequent) violation of work rules
  - Not a function of an aged work force
  - Isn’t caused by impairment due to drugs or alcohol
  - Caused by subjecting workers to prolonged (years) unprotected overexposure to RCS
    - No excuse that they didn’t know (1) about silica and silicosis; (2) what the RCS exposures were; (3) how to reduce exposure
    - Had to “drop the ball” for consistently for years
Implementation of OHP

• Written program aimed to prevent silicosis and the progression of silicosis among workers.
• Objective is to achieve lifetime of work in a RCS environment without:
  – Developing silicosis
  – Suffering from pulmonary function loss
    • Quality of life
  – Experiencing premature mortality from silica exposure
Workplace Dust Surveys

• The goal of this part of the OHP is to collect enough personal breathing zone samples from all employees exposed to industrial sand so that cumulative individual exposure assessments can be made.

• Personal – Collected from worker’s breathing zone;

• General Area – Collected from ambient work environment; and

• Real-Time Aerosol Monitor (RAM) – Personal Data Ram (PdR) either from worker or from general area.
Personal Sampling

- Used for the purpose of determining the amount of respirable dust the worker breathes in during the workday;
- For comparison with occupational exposure limits and as a measure of dose in epidemiological studies;
- Evaluating the effectiveness of engineering controls;
- Evaluating changes in dust levels as a result of process changes; and
- Evaluating the adequacy of personal protective devices, such as respirators.
General Area Sampling

- Used to evaluate dust sources and the effectiveness of engineering controls, concentration changes due to process changes and work practices, and administrative controls;
- Appropriate to document dust levels in work areas thought to be relatively dust free, such as control rooms, offices, laboratories, and lunchrooms.
Real-Time Aerosol Monitor (RAM) or Personal data Ram (PdR)

• Exceptionally effective diagnostic tool;
• May be located at strategic locations within the workplace or placed directly on a worker;
• Provides instantaneous quantification of airborne respirable dust levels within the workplace;
• Used to identify workpractices which are increasing time weighted exposures; confirm attempted improvement or conversely, identify improvement opportunities;
• Useful in training when combined with a video camera.
Medical Surveillance Objectives

• Establish a Baseline for Assessing Changes
  – Each Worker Serves as His/Her Own Control
  – Ability to Recognize Early Changes is Greatly Enhanced

• Detect Abnormalities Consistent with Silicosis at an Early Stage

• Prevent Development of Complicated Silicosis
Medical Surveillance Objectives (cont’d)

• All silica exposed workers
• Every 2 to 4 years
• Inform the Worker of Occupational and Non-Occupational Abnormalities
• Identify Hazardous Working Conditions for Needed Controls
• Develop Data for Epidemiology Studies
Baseline and Periodic Exams

• Medical history that focuses on the presence of respiratory symptoms, smoking habits, and previous exposures to occupational dusts

• A physical examination to assess the general condition of the worker and respiratory status of the worker.

• A 14-by-17-inch posteroanterior (PA) chest X-ray.

• Pulmonary function tests that include spirometric measurements of forced expiratory volume in 1 second (FEV1) and forced vital capacity (FVC).
  – Such tests should be performed, calculated, and interpreted in accordance with the 2005 ATS-ERS Standardization of Spirometry guidelines.

• Baseline tuberculin skin test reactivity status or blood assessment of workers should be established.
Dust Control

• The control of hazards from exposures to RCS and the elimination of silicosis is the primary and single most important reason for developing a comprehensive silicosis prevention program.

• Little point to dust sampling, medical surveillance, training or any other program component if the results of those efforts do not prompt necessary controls measures.

• In other words, if this program element fails to control hazardous dust exposures the silicosis prevention program is a failure.

• Control dust exposures through the use of engineering, administrative controls and personal protection.
Silicosis Prevention Employee Involvement

- **Training:**
  - Training on disease and prevention
    - USS silicosis training won DOL award late 1990s
      - “Your Respiratory Health”
      - Present in small group “seminar” to all employees
      - Updated on a periodic basis
    - USS presented on training at National Conference to Prevent Silicosis, 1997
      - Unimin, Badger, USS, NISA present on other topics
      - The only companies that brought employees to conference
  - Cooperative training with MSHA/NIOSH-BoM
    - NISA and MSHA, with Unimin and USS assistance, developed training materials for mining industry
    - Developed MSHA materials out of Jackson
    - Building design study
Silicosis Prevention Employee Involvement

- Participation:
  - EH&S Committees
    - Dust issues addressed as part of program
  - Sampling:
    - Hourly employees trained to sample
    - All participate; personal samples
    - Trained to understand results; results reviewed; corrective action plans
  - Medical surveillance
    - Results provided to employee and personal MD
    - General wellness issues -- hypertension, high cholesterol, hypoglycemia – dominant finding
      - Several life saving early detections
Smoking Cessation Program

• Objective of this element is to reduce the impact of smoking on the health effects of silica exposure

• Three basic elements:
  – Adopt and implement a policy on smoking cessation
  – Education of worker concerning the health effects of smoking employees
  – Offer assistance to employees to stop smoking
Questions

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