Silica and Combustible Dust – What You Need To Know

Thomas Slavin
MS, MBA, CIH, CSP CSHM
Navistar, Inc
OSHA Silica Rulemaking

• High priority for OSHA
• Many years in the making
• Current status:
  – SBREFA hearings held
  – Peer review complete
  – Proposal now at OMB
Silica Rule Concerns

• Exposure level
  – Level to be proposed unknown
  – Three levels considered by SBREFA (100, 75 and 50 μg/m3)

• Other provisions
  – Think about the lead standard
  – Restricted areas
  – Clothes changes and showers
Is there a Health Concern?

- Silicosis is declining
- Cancer risk is debatable
- Dose response depends on models
- OSHA has a lot of discretion
Exposures usually occur several years prior to silicosis; many years prior to deaths.
Lung Cancer Risk

• Evidence not clear
  – Mostly in people with silicosis
  – Smoking not well accounted for

• Statistical Models are used to
  – Estimate exposure and response
  – Account for smoking

• New study explores threshold mechanisms
Threshold Mechanism

Dust exposure increases immune cells that seek out and destroy dust and bacteria on surface of lung.
Threshold Mechanisms

• Positive feedback loop in lung
  – Silica exposure increases immune cells
  – Immune cells release inflammatory chemicals and suppress repair
  – Inflammation increases immune cells

• Below threshold repair occurs

• Above threshold feedback loop becomes permanent, scarring occurs even after exposure ends

• Threshold seems to be above current PEL
Key Regulatory Issue Is Feasibility

• Technical Feasibility
  – Tough to meet current level

• Economic Feasibility
  – How much would it cost to meet a lower level?
There Is Substantial Non-Compliance with Current PEL (100 $\mu g/m^3$)

OSHA Silica Sample Results

OSHA Silica exposure results by occupation in the gray iron foundry industry

Respirable silica in micrograms/m3 (geometric mean)

Engineering controls not possible for some operations

Grinding operations are especially challenging
Economic Feasibility

• OSHA has accepted respirators as the only effective control to meet current PEL for many foundry operations

• Unfortunately, OSHA requires expensive trial and error before accepting PPE for compliance
Other OSHA Health Standards Elements

- Scope and application
- Action level
- PEL
- Methods of compliance
- Competent person
- Abrasive blasting
- Regulated areas
- Exposure assessment
- Respiratory protection
- Protective work clothing
- Hygiene facilities and practices
- Employee health screening
- Hazard communication
- Employee information and training
- Recordkeeping
Summary

- Silicosis cases are declining; Meeting current PEL could further improve worker health.
- Engineering controls not possible for all operations – but may be required anyway
- A poorly designed standard could add unnecessary cost
Silica Strategy

• Silica Panel to Address Epidemiology and exposure level
• Foundries have technical feasibility concerns
• AFS working with economist to develop economic feasibility argument
• Several standard details unknown
COMBUSTIBLE DUST
An Explosion of Interest

• 281 combustible dust fires and explosions in general industry from 1980 to 2005
  – 119 workers killed
  – 718 injured
• Chemical Safety Board investigations and reports
• Congressional hearings
• OSHA
  – established a National Emphasis Program (NEP)
  – has begun rulemaking
• Several citations have been issued under the NEP
Two Foundry Explosions

Jahn Foundry, Springfield, MA

- February 26, 1999
- 3 killed
- 9 injured
- Shell core
- Phenolic resin dust
- Most foundries use precoated sand
Two Foundry Explosions

Hayes-Lemmerz International, Huntington, IN

- October 29, 2003
- 1 killed
- 6 injured
- Aluminum dust explosion
- Fireball that erupted from furnace side well was likely result of an aluminum dust explosion in dust collector system
Dust Explosion Basics

Two additional requirements for a dust explosion

Figure 1. Classic fire triangle

Figure 2. Dust explosion pentagon
The “Typical” Explosion Event

Initial
Internal
Deflagration

Shock Wave

Process Equipment
The “Typical” Explosion Event

Initial Internal Deflagration

Dust clouds caused by Elastic Rebound

Process Equipment

Time, msec.

0  25  50  75  100  125  150  175  200  225  250  300  325
The “Typical” Explosion Event

Dust Clouds Caused by Elastic Rebound

Process Equipment

Secondary Deflagration Initiated

0  25  50  75  100  125  150  175  200  225  250  300  325

Time, msec.
The “Typical” Explosion Event

Process Equipment

Secondary Deflagration Propagates through Interior

Time, msec.
The “Typical” Explosion Event

Secondary Deflagration Causes Collapse and Residual Fires

Time, msec.

Do I have a combustible dust problem?

Do I have an OSHA problem?

What do I need to do?
Is my dust combustible?

- NFPA standard definitions are not helpful
  - Particle that presents a fire hazard (NFPA 654)
  - Any metal that will burn (NFPA 484)

- OSHA uses positive $K_{ST}$ to define combustible dust

- $K_{ST}$ is rate of pressure rise in specialized chamber
Several Issues with $K_{ST}$ test alone

- Many types of dust will have weak $K_{ST}$ values (<20)
- Dirt from a garden can have a positive $K_{ST}$
- False positives are common with 20 L test chamber compared to 1 M$^3$ chamber
Evaluation of the Hazard - tests

- Ignition sensitivity
  - Minimum ignition energy (MIE)
  - Minimum ignition temperature (layer or cloud)
  - Minimum explosible concentration (MEC)
- Explosion severity
  - Maximum explosion pressure
  - Maximum rate of pressure rise
  - $K_{ST}$ (normalized rate of pressure rise)
- Dust Properties
  - Particle size distribution
  - Moisture content as received and as tested
  - Electrical volume resistivity
- Etc.

Will the dust ignite?
How Powerful will an explosion be?
## Explosivity Index – NFPA 499

<table>
<thead>
<tr>
<th>Relative Rating Guideword</th>
<th>Ignition Sensitivity</th>
<th>Explosion Severity</th>
<th>Explosivity Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weak</td>
<td>&lt;0.2</td>
<td>&lt;0.5</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>Moderate</td>
<td>0.2 – 1.0</td>
<td>0.5 – 1.0</td>
<td>0.1 - 1.0</td>
</tr>
<tr>
<td>Strong</td>
<td>1.0 – 5.0</td>
<td>1.0 – 2.0</td>
<td>1.0 - 10</td>
</tr>
<tr>
<td>Severe</td>
<td>&gt;5.0</td>
<td>&gt;2.0</td>
<td>&gt;10</td>
</tr>
</tbody>
</table>

**Ignition Sensitivity based on:**
- Minimum ignition temperature
- Minimum ignition energy
- Minimum explosive concentration

**Explosion Severity based on:**
- Maximum explosion pressure
- Maximum rate of pressure rise (Kst)
For Combustible Metals (Al, Mg)

- Become familiar with NFPA 484
- Provide exhaust for grinding and polishing operations
- Dust collector outside or explosion vented
- Empty dust collector daily
- Keep dust in closed container
- Mix dust with inert material prior to disposal
- Vacuum rafters and other surfaces to prevent accumulation
Aluminum Particle Data – Size Matters

Smaller size particles have higher $K_{ST}$, lower ignition energy

From NFPA 484 (2009)
Why Size Matters - Settling Rate for Silica Particles in Still Air

<table>
<thead>
<tr>
<th>Diameter of Particle (microns)</th>
<th>Time to Fall 1 Foot (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>0.02</td>
</tr>
<tr>
<td>5</td>
<td>2.5</td>
</tr>
<tr>
<td>2</td>
<td>14.5</td>
</tr>
<tr>
<td>1</td>
<td>54</td>
</tr>
<tr>
<td>0.5</td>
<td>187</td>
</tr>
<tr>
<td>0.25</td>
<td>590</td>
</tr>
</tbody>
</table>

Dust from a blow down may stay suspended for days.
Metal chips

• Large particles can generate a mix of sizes.

• Size separation can occur at holes, leaks or with fugitive dust.

1/32 inch = 800 microns
For Non-metal Dust

- Check MSDS for combustible dust information
- Look at organic materials in molding and core making
  - Sea coal, binders, resins, etc.
- Check with fire insurance carrier
- Conduct screening test (ASTM 1226)
  - can exclude many dust types
  - Additional testing can be done on positive samples
Testing labs

• Chilworth Technology Inc.
  250 Plainsboro Road, Building 7
  Plainsboro, NJ 08536
  609-799-4499
  www.chilworth.com

• Ciba Expert Services
  1379 Ciba Road
  McIntosh, AL 36553
  251-436-2397
  Dean.Hamel@ciba.com

• Fauske & Associates, LLC
  16W070 83rd Street
  Burr Ridge, IL 60527
  630-322-8750
  www.fauske.com

• Kidde-Fenwal, Inc.
  Combustion Research Center
  90 Brook Street
  Holliston, MA 01746
  508-429-3190
  www.kidde-crc.com

• Fike Explosion Protection Services
  Fike Corporation
  704 SW 19th Street
  Blue Springs, MO 64015-4263
  816-229-3405
  www.fike.com

• EMSL Analytical Inc
  Building 12 Suite A,
  7330 S. Alton Way,
  Centennial, CO, 80112
References

- NFPA 499 Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas
- NFPA 664 Standard for the prevention of fires and explosions in wood processing and woodworking facilities
- NFPA 69 Standard on Explosion Prevention Systems
- Aluminum Association, Guide F-1, Guidelines for handling fines generated during various aluminum fabricating operations
- FM Global, Data Sheet No. 7-76, Prevention and Mitigation of Combustible Dust Explosions and Fire (2006 ed.)
- OSHA National emphasis program