Verification of Respirable Silica Containment of Large Process Equipment through the use of SF6 Tracer Gas

- PO125 -

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Silica

- **Types**
  - Amorphous
  - Crystalline
  - Tridimite
  - Cristobalite

- Well known diseases associated with long term exposures
Silica in Foundries

- 205 foundries
- 1,743 samples
- 11.4% silica (mean)
- 1.32 mg/m²
- 42% over NIOSH recommended level
- 20% greater than 1.2X OSHA PEL
Foundry Exposures

- Crystalline silica is used or found most everywhere in a foundry

- Rank Order (highest to lowest potential exposure)
  - Shakeout
  - Cleaning
  - Shoveling sand
  - Core making
  - Molding
  - Pouring
Furnace Charging

- No silica
- Metal fume
- Total dust
Cleaning Room

- Remove surficial sand
- Remove excess metal
- Remove cores
TumBlast Cleaner

- Batch
- Totally enclosed
- Ventilated
Wire Mesh Blaster

- Continuous
- Totally enclosed
- Ventilated
Study Purpose

Silica exposure related to escape from large process equipment in an environment such as a foundry is difficult if not impossible to determine by directly measuring respirable silica concentrations.
Challenges & Issues

- procedures to conduct airflow visualization tests of the ventilation system
- determination of ventilation rates
- selection of equipment and procedures for delivery of the compressed SF6 gas
- determination of the gas injection location
- development of the sampling strategy
- selection of direct reading equipment and analytical methods for air samples
Ventilation Rates

- Blasting equipment is used in many different industries
- Blasting prepares the surface a material
  - Deburr
  - Remove scale
  - Remove molding residue
- Different exhaust ventilation rates based on application
- Studied three different application ventilation rates
  - “Aluminum – die cast parts”
  - “Steel – forged parts”
  - “Foundry – cast parts”
Gas Leakage Rates

- Containment by the blasting equipment was evaluated using sulfur hexafluoride as a surrogate for respirable particulate and measuring its leakage rate under different operating parameters.

- ANSI/ASHRAE 110-1995 *An American National Standard, Method of Testing Performance of Laboratory Fume Hoods* was the method selected and adapted for the study.
Gas Leakage Rates

- **Injection rate** - ANSI/ASHRAE Section 4: rate of 4 lpm SF6 per 200 cfm of exhaust volume
- **Visual containment** - ANSI/ASHRAE 110-1995 Section 6: requires the use of smoke to determine visually if the hood can contain vapors. Face velocity measurements also taken in grid pattern of at least once every 1 ft² with a calibrated anemometer.
- Chapter 6 requires a tracer gas containment test be conducted as described in the ANSI/ASHRAE 110-1995, Method of Testing Performance of Laboratory Fume Hoods.
Chapter 6 Commissioning Tests - Visual escape of smoke beyond the plane of the sash when generated 6 inches into the hood shall constitute a failure during the performance test.

A control level for 5-minute average tests at each location conducted at a generation rate of 4 L/min per 200 cfm of exhaust air (about 700ppm) shall be no greater that 0.05 ppm (50 ppb) for “as manufactured” tests and 0.10 ppm (100ppb) for “as installed”.

Escape of more than the control levels stated above shall be acceptable at the discretion of the design professional in agreement with the responsible person. The “as used” 0.10 ppm level or more is at the discretion of the responsible person.
Field Measurement

- Two (2) MIRAN® SaphIRe™ model 100E portable analyzers
- Measure the presence and amount of SF$_6$ at various points outside the blasting equipment
- Calibrated Miran readings correlate directly to the SF$_6$ concentration in air
Lab Validation

- Gas samples for confirmation were collected and analyzed for SF$_6$ in accordance with NIOSH Method 6602.
Blast Equipment

- Projects a high velocity abrasive stream at an object
- Striking abrasive prepares the surface by removing burrs, scale, or adhering materials
- Variables
  - Abrasive (walnut shells to steel shot)
  - Delivery rate of abrasive
  - Horsepower applied to the wheel
  - Purpose in preparing the surface
- Machines are designed application specific: no ready-made “off the shelf” equipment
- Every machine has certain unit operations which appear from machine to machine
  - a cabinet
  - an elevator
  - air separator
  - abrasive tank
  - impeller(s)
Blasting Cabinet

- **Blasting Cabinet - Enclosed Area**
  - Metered abrasive at high velocity
  - Abrasive introduced in a designed pattern
  - Abrasive may ricochet off the part and interior walls of the cabinet
  - Some individual abrasive may find a path which allows escape even w/ doors closed
  - Majority accumulates by gravity in a trough
  - Elevator transports the abrasive and part's surface debris to the separator
  - Elevator is under negative exhaust pressure

- **TumBlast**
  - Exhaust air drawn from the cabinet - door open or closed
  - Door closed
    - cabinet is under negative pressure
    - makeup air through serpentine louvers
  - Blast cycle completed
    - purge cycle - abrasive stops, outside air flushes out airborne particulate
  - Door open
    - movement of air into the cabinet continues
    - larger open cross-sectional area
Separator

- Cleans the abrasive for recycled back into the blasting cabinet
- Air curtain is created
- Lighter weight contaminants are pulled away from the heavier abrasive
- Abrasive falls along a long lip which allows for a uniform processing of the abrasive
- Cleaned abrasive passes through a screen which removes tramp metal and larger items
- Cleaned abrasive is gravity fed to a storage tank
- New abrasive added as needed to maintain proper operation.
# TumBlast Equipment Ventilation Rates

<table>
<thead>
<tr>
<th>Industry</th>
<th>Cabinet</th>
<th>Separator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum (i.e. die cast)</td>
<td>2,000</td>
<td>1,500</td>
</tr>
<tr>
<td>Steel (i.e. forge)</td>
<td>2,500</td>
<td>2,100</td>
</tr>
<tr>
<td>Foundry (i.e. sand mold)</td>
<td>3,000</td>
<td>3,000</td>
</tr>
</tbody>
</table>
## Wire Mesh Belt Blast Equipment Ventilation Rates

<table>
<thead>
<tr>
<th>Industry</th>
<th>Minimum Exhaust Air Volume (CFM)</th>
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<tr>
<td>Cabinet</td>
<td>Separator</td>
</tr>
<tr>
<td>Aluminum (i.e. die cast)</td>
<td>2,600</td>
</tr>
<tr>
<td>Steel (i.e. forge)</td>
<td>4,000</td>
</tr>
<tr>
<td>Foundry (i.e. sand mold)</td>
<td>7,700</td>
</tr>
</tbody>
</table>
TumBlast Testing Methods
TumBlast Testing Methods
Wire Mesh Belt Testing Methods
TumBlast Equipment Results

-Cabinet-

- Tumblast Equipment Cabinet -
  Door Closed and Open
  Aluminum, Steel and Foundry Settings
  Average Concentration of Tracer Gas (SF6) Detected

<table>
<thead>
<tr>
<th>Setting</th>
<th>Door Closed</th>
<th>Door Open</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td>0.004</td>
<td>0.019</td>
</tr>
<tr>
<td>Steel</td>
<td>0.008</td>
<td>0.065</td>
</tr>
<tr>
<td>Foundry</td>
<td>0.008</td>
<td>0.082</td>
</tr>
</tbody>
</table>

As installed control level (0.10 ppm SF6)
TumBlast Equipment Results
- Separator -

Tumblast Equipment Separator
Door Closed and Open
Aluminum, Steel and Foundry Settings
Average Concentration of Tracer Gas (SF6) Detected

- Door Closed
  - Aluminum Setting: 0.016 ppm
  - Steel Setting: 0.010 ppm
  - Foundry Setting: 0.000 ppm

- Door Open
  - Aluminum Setting: 0.046 ppm
  - Steel Setting: 0.055 ppm
  - Foundry Setting: 0.034 ppm

As installed control level (0.10 ppm SF6)
Wire Mesh Belt Blast Equipment

Results

- Cabinet -

Wire Mesh Belt Cabinet
Entrance and Exit Rounds 1 and 2
Aluminum, Steel and Foundry Settings
Average Concentration of Tracer Gas (SF6) Detected

As installed control level (0.10 ppm SF6)

Concentration of SF6 (ppm)

Round 1
Round 2
Wire Mesh Belt Blast Equipment

Results

- Separator -

Wire Mesh Belt Separator
Rounds 1 and 2
Aluminum, Steel and Foundry Settings
Average Concentration of Tracer Gas (SF6) Detected

As installed control level (0.10 ppm SF6)

<table>
<thead>
<tr>
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<th>Round 1</th>
<th>Round 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum Setting</td>
<td>0.024</td>
<td>0.015</td>
</tr>
<tr>
<td>Steel Setting</td>
<td>0.027</td>
<td>0.033</td>
</tr>
<tr>
<td>Foundry Setting</td>
<td>0.000</td>
<td>0.002</td>
</tr>
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</table>
Conclusions

- Methods developed for laboratory hood performance testing can be utilized for the purpose of evaluating containment.
- The intended operation of blasting equipment contributes no airborne respirable silica to the foundry.
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