PCB-Caulk Replacement Project
Johnson Space Center
Houston, TX

William M Young CIH, CSP, CSC-ATG
William K Molenda, CSC-ATG
Penney M Stanch, NASA-JSC

16-May-2011 PCB Caulk Project at NASA JSC
Outline

- **Purpose**
  - NASA JSC facility history

- **Background**
  - OEL information
  - Material sampling

- **Work Plan**
  - Wet & Dry Procedures
  - Equipment
  - PPE

- **Sampling Plan**
  - Exposures

- **Results**
In June 2009 NASA’s Johnson Space Center (JSC) started a project to re-caulk, clean, and seal the Precast Exposed Aggregate Faced (PEAF) Panels on buildings at the center.

- NASA JSC in Houston, TX has over 130 buildings on an 1,620 acre campus.
  - Buildings in Mall area (built in 1960s) are primarily covered with PEAF Panels with caulk expansion joints between panels.
  - PEAF panels were high-pressure washed many times over the years.
  - Caulk between panels had been replaced in sections.
  - Gaps between PEAF Panels ranged from 1/8-inch to 1 inch wide.
  - Many buildings had developed leaks in caulking after Hurricane Ike hit the Center in September 2008.
In Sep 2009, EPA advisory identified polychlorinated biphenyl (PCB)-containing caulks as hazardous & provided guidance for removal; suggested work should avoid skin contact & keep surfaces wet to reduce dusts.

- PCBs are persistent in the environment *

No MSDSs for caulk used (present or past) at the facility were found to have PCBs listed in the ingredients & composition section.

Two caulks in stock for repairs were tested for PCBs with negative (ND) results.

* [http://www.epa.gov/pcbsincaulk/caulkexposure.htm](http://www.epa.gov/pcbsincaulk/caulkexposure.htm)
Background

- Twenty random caulking samples from 7 building exteriors had PCB concentrations ranging from (none detected) ND to 60,521 mg/kg (ppm) when analyzed for 7 common PCB congeners.
  - PCB-1254, n=9 None Detected (ND) to 60,521 mg/kg (or ~6.05% PCB-1254)
    - IUPAC Name: 1,2,3-Trichloro-4-(2,3-dichlorophenyl)benzene
  - PCB-1248: n=6 ND (<2.5mg/kg) to 4,165 mg/kg PCB-1248.
  - Five samples had no PCBs detected.
  - The average PCB concentration n=20 was 7,884 mg/kg.

- No detailed records of past maintenance or caulk replacement were available.
<table>
<thead>
<tr>
<th>Substance</th>
<th>ACGIH TLV (mg/m³)</th>
<th>OSHA PEL (mg/m³)</th>
<th>NIOSH REL (mg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCB-1242 Chlorodiphenyl (42% Cl)</td>
<td>1.0 S</td>
<td>1.0 S</td>
<td>0.001*</td>
</tr>
<tr>
<td>PCB-1254 Chlorodiphenyl (54% Cl)</td>
<td>0.5 S</td>
<td>0.5 S</td>
<td>0.001*</td>
</tr>
</tbody>
</table>

* Appendix A: NIOSH REL established “for most carcinogens were non-quantitative values labeled lowest feasible concentration (LFC)”

S – Skin Notation
### Other OELs in this Study

<table>
<thead>
<tr>
<th>Substance</th>
<th>ACGIH TLV (mg/m³)</th>
<th>OSHA PEL (mg/m³)</th>
<th>NIOSH REL (mg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total PNOC/PNOS</td>
<td>10</td>
<td>15</td>
<td>NE</td>
</tr>
<tr>
<td>PNOS-R</td>
<td>3</td>
<td>5</td>
<td>NE</td>
</tr>
<tr>
<td>Si- Quartz-R</td>
<td>0.025</td>
<td>10/% SiO₂+2</td>
<td>NE</td>
</tr>
<tr>
<td>Si-Cristobalite-R</td>
<td>0.025</td>
<td>(1/2)(10/% SiO₂+2)</td>
<td>NE</td>
</tr>
</tbody>
</table>

PNOC/PNOS – Particulates Not Otherwise Classified or Specified  
Si – silica  
R – Respirable  
NE – Not Established
Work Plan

In March 2010, JSC began the renovation project.

- All caulk was to be treated as PCB-contaminated.
- Cover ground below work with plastic to be rolled up for disposal daily.
- Used PPE is to be bagged for PCB disposal.
- Use manlifts to raise workers along PEAF Panels to remove caulk.
- Replacement caulk required that surface edges be roughened up with a grinder, then have a primer painted on, prior to injecting the new caulk to retain the warranty.

- 2 Contractors, 2 Procedures:
  - *Wet Procedure*
  - *Dry Procedure*
Procedure & Exposures

- Initially remove as much existing caulk as possible with reciprocating blade or utility knife wearing full-face respirator and coveralls
  - PCB (Skin contact)
- Grind PEAF Panel to provide abraded cleaned surface for new caulk. Grinders equipped with HEPA vacs
  - PCB (Skin and Inhalation)
  - Other (PNOC/PNOS) dusts
  - Silica (Si) Dust
- Insert backing rod
- Apply primer
- Apply new caulk

16-May-2011 PCB Caulk Project at NASA JSC
Sampling Plan

- Work plan to evaluate
  - Wet methods vs. dry methods,
  - Caulk removal blades (serrated vs. smooth),
  - Grinder blades, etc.
- Collect personal air monitoring for:
  - PNOC, PNOC-R, Silica-R,
    Grinder Dusts Bag
    Bulk–PCB, PCB vapors and dust
  - Evaluate PPE requirements
Wet Method

- Use experienced asbestos workers.
- Don PPE – Saranex-Coated Tyvek suit, initially FF Respirator w/P100 cartridges; after initial monitoring - Faceshield and side-shield safety glasses
- Use a mini-enclosure during grinding
- Wet the area
- Use reciprocating saw or utility knife to slice both sides of caulk
- Pull bulk caulk and put in containment
- Continuously wet the surface
- Use grinder to prepare surface
- Prime & apply caulk next day
- Air Monitoring
  - Personal PNOC & PNOC-R
  - Silica-R
Wet Method
Personal Air Sample Results

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Range (mg/m³)</th>
<th>Average (mg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PNOC-R</td>
<td>14</td>
<td>ND(&lt;0.008)-0.48</td>
<td>&lt;0.08</td>
</tr>
<tr>
<td>PNOC</td>
<td>32</td>
<td>ND(&lt;0.01)-5.23</td>
<td>&lt;0.84</td>
</tr>
<tr>
<td>Silica-R</td>
<td>20</td>
<td>ND(&lt;0.007)-0.016</td>
<td>&lt;0.011</td>
</tr>
</tbody>
</table>

Note: Results are for the time monitored, not adjusted for shifts.

- Evaluation for PCB exposure assumed worst case exposure by using highest concentration from bulk samples taken prior to project start (6.05% of PCB-1254), calculating 95th percentile of samples taken (9.13%), then applying it to maximum PNOC measured:
  
  \[0.09 \times 5.23 \text{ mg/m}^3 = 0.48 \text{ mg/m}^3 < \text{TLV and PEL}\]

- Therefore, estimated PCB exposure below the TLV & PEL.
Wet Method Changes/Learning

- Workers using wet methods were allowed to downgrade from full-face respirators to no respirators and face-shield PPE
- Saranex-Coated Tyvek coveralls were replaced with sleeved smocks to reduce heat stress
- Serrated blades were evaluated to eliminate grinding the surface with a disc grinder. The blades did not abrade the surface enough so smooth blades were used on the reciprocating saw to reduce dust.
Dry Method

- Use professional building waterproofers
- Don PPE – Tyvek suit, FF Respirator w/P100/OV cartridges
- Use reciprocating saw or utility knife to slice both sides of caulk
- Pull bulk caulk and put in containment
- Use grinder to prepare surface
  - Shroud & vacuum to minimize dust emission
- Apply primer & caulk on same day
- IH Air Monitoring Plan
  - Personal monitoring for PCB vapors and dusts
  - Personal & area monitoring for Silica-R
  - Personal & area monitoring for PNOC & PNOC-R (some in manlift)
## Dry Method
### Personal Air Sample Results

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Range** (mg/m³)</th>
<th>Average** (mg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PCB-1248</strong></td>
<td>5</td>
<td>0.0037 - 0.058</td>
<td>0.0165</td>
</tr>
<tr>
<td><strong>PCB-1254</strong></td>
<td>1</td>
<td>0.038</td>
<td>0.038</td>
</tr>
<tr>
<td><strong>7 Congeners</strong></td>
<td>6</td>
<td>All ND &lt;0.0196 - &lt;0.0685</td>
<td>&lt;0.0352</td>
</tr>
</tbody>
</table>

* PCB-1260, 1254, 1221, 1248, 1232, 1016 & 1242: all below reporting limit

** Results are for the time monitored, not adjusted for shifts

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Range** (mg/m³)</th>
<th>Average** (mg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PNOC-R</strong></td>
<td>3</td>
<td>&lt;0.01 - 0.22</td>
<td>&lt;0.17</td>
</tr>
<tr>
<td><strong>Cristobalite-R</strong></td>
<td>3</td>
<td>&lt;0.01 (ND)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td><strong>Quartz-R</strong></td>
<td>3</td>
<td>&lt;0.01 - 0.054</td>
<td>&lt;0.033</td>
</tr>
</tbody>
</table>
Dry Methods Change/Learning

- Had caulk-removal workers remain wearing Full-Face Respirators with P-100/OV cartridges and faceshields for grinding due to silica monitoring results
- Changed from Tyvek coveralls to two layers of long-sleeved work clothes to reduce heat stress, to be laundered or disposed of in waste
- Barrier monitoring resulted in concentrations ranging from well below exposure guidelines to non-detect for particulates, silica, & PCB
Summary

- Wet method reduced exposure by minimizing overall respirable particulate release. Dry method didn’t introduce delays for primer/caulk application.
- Removed caulks came in many forms, from dry powdery to tarry sticky. Varying textures were not sampled or packaged differently.
- During the course of the project, EPA modified recommended practices to include full containment for exterior caulk removal. Changes are ongoing.
- Initial recommendations were directed to school buildings. EPA is researching risks due to caulk.
- Exposure guidance lacking except for 2 of 209 PCB congeners
- Work was safely completed on schedule and under budget.
Questions?
What are PCBs?

Polychlorinated biphenyl (PCB) compounds were identified as carcinogens in the 1980’s.

- Studies found **liquids**, commonly used in electrical transformers, contained harmful amounts of PCB.
- There are over **209 congeners** of PCB identified primarily by the percent chlorine (% Cl) in the compound.
  - 7 congeners are typically identified for environmental impact,
  - 2 congeners have PELs and TLVs
- Studies in workers exposed to PCB-containing liquids have shown indications of:
  - liver damage; skin & eye lesions; irregular menstrual cycles; lowered immune defense systems; headaches, fatigue, coughing, unusual skin sores; risk of cancer; in children, poor cognitive development.
What are PCBs?

Studies in workers exposed to PCB-containing liquids have shown indications of:

- liver damage through changes in blood and urine.
- skin and eye lesions,
- irregular menstrual cycles, and
- lowered immune defense systems.
- headaches, fatigue, coughing, unusual skin sores.
- a risk of cancer and,
- in children, there were reports of poor cognitive development.

PCBs are persistent in the environment and occurred in caulks.
PCB Environmental Guidelines

- Seven congeners are typically identified for environmental impact, PCB-1016 (10 carbon atoms & 16% chlorine), 1221 (12 carbon atoms & 21% chlorine), 1232 (32% chlorine), 1242 (42% chlorine), 1248 (48% chlorine), 1254 (54% chlorine), and 1260 (60% chlorine).
  
  http://www.epa.gov/pcbsincaulk/

- Caulks with over 50 ppm PCB (of the 7 congeners) must be removed and are to be treated as Bulk Product Waste

- Contaminated soil and materials near buildings are to be treated as PCB Remediation Waste

- Other countries have Regs for other congeners
Dry Method Caulk Removal Area Air Sample Results

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Range (mg/m³)</th>
<th>Average (mg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PNOC</td>
<td>20</td>
<td>ND(&lt;0.01)-0.43</td>
<td>&lt;0.065</td>
</tr>
<tr>
<td>PNOC-R</td>
<td>12</td>
<td>ND(&lt;0.01)-0.03</td>
<td>&lt;0.015</td>
</tr>
<tr>
<td>Cristobalite-R</td>
<td>12</td>
<td>All ND(&lt;0.01)</td>
<td>ND(&lt;0.01)</td>
</tr>
<tr>
<td>Quartz-R</td>
<td>12</td>
<td>All ND(&lt;0.01)</td>
<td>ND(&lt;0.01)</td>
</tr>
<tr>
<td>PCB – 7 congeners</td>
<td>12</td>
<td>ND(&lt;0.0001) – 0.0096</td>
<td>&lt; 0.0019</td>
</tr>
<tr>
<td>ASTM D4861</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PCB – 7 congeners</td>
<td>4</td>
<td>&lt;0.0199-&lt;0.0250</td>
<td>&lt;0.0218</td>
</tr>
<tr>
<td>NIOSH 5503</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

PNOC – Particulates Not Otherwise Classified
R – Respirable
ND – none detected at a limit of detection

16-May-2011
PCB Caulk Project at NASA JSC
### Bulk Vacuum Shrouded Grinder Bag Results

<table>
<thead>
<tr>
<th>Bldg</th>
<th>N</th>
<th>PCB-1248 Range</th>
<th>PCB-1248 (avg-PPM)</th>
<th>PCB-1254 Range</th>
<th>PCB-1254 (avg-PPM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>3</td>
<td>47.8-89.2</td>
<td>64.7</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>B</td>
<td>1</td>
<td>2,420</td>
<td>2,420</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>C</td>
<td>2</td>
<td>ND</td>
<td>ND</td>
<td>1,504-4,985</td>
<td>3,245</td>
</tr>
</tbody>
</table>

ND – None Detected for 1016, 1221, 1232, 1242, 1260