USING LOW-CONCENTRATION HYDROGEN PEROXIDE VAPOR TO DECONTAMINATE A HOME FROM BACILLUS ANTHRACIS SURROGATES

Decontamination Conference May, 2018
By: R. Leroy Mickelsen, EPA
CBRN Consequence Management Advisory Division
Contributors

- Shannon Serre\textsuperscript{a}
- Joseph Wood\textsuperscript{b}
- M. Worth Calfee\textsuperscript{b}
- Shawn Ryan\textsuperscript{b}
- Abderrahmane Touati\textsuperscript{c}
- Rob Delafield\textsuperscript{c}
- Denise Aslett\textsuperscript{c}

\ \textsuperscript{a} CBRN Consequence Management Advisory Division, EPA
\textsuperscript{b} Decontamination and Consequence Management Division, National Homeland Security Research Center, U.S. EPA
\textsuperscript{c} Jacobs Technology, Inc., Dallas, TX.
Problem Statement

• There are limited resources to respond to a large *Bacillus anthracis* release.

• Many efficacious response resources
  • Produce highly toxic environments
  • Require specialized equipment and expertise

• As a near-the-zone business or home owner what remediation options do you have?
Overview

• An EPA, NHSRC study found that hydrogen peroxide (HP) vapor concentration as low as 5 ppm for four to seven days was efficacious, >6 log reduction for both *Bacillus anthracis* and surrogate spores. And that HP vapor could be disseminated with vaporizers.

• This present work reports field evaluations of this technique using:
  • a 3-bedroom home w/ central HVAC
  • off-the-shelf humidifiers
  • 3% liquid HP
  • spores on carpet and galvanized metal coupons to evaluate efficacy
Concept:

- Fill with 3% HP liquid
- Turn it on
- Walk away

- Return when it’s done.
Efficacy Testing in Each Room

- 3 carpet test coupons
- 3 galvanized metal test coupons
- *Bacillus atrophaeus*: 20,000,000 colony-forming unit (CFU)/coupon
- 1 negative control for each material
- 3 biological indicators (BIs) in Tyvek
- *Geobacillus stearothermophilus*: 2,000,000 CFU/BI on steel disks
- Temperature & humidity HOBO
- Hydrogen peroxide indicator strip
## Test Matrix

<table>
<thead>
<tr>
<th>Test Number</th>
<th>Number of Humidifiers</th>
<th>Amount of 3% Liquid HP (gallons)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>7</td>
<td>0</td>
<td>Water only</td>
</tr>
<tr>
<td>1</td>
<td>7</td>
<td>14</td>
<td>Two gallons 3% liquid HP in each humidifier</td>
</tr>
<tr>
<td>2</td>
<td>7</td>
<td>14</td>
<td>Same as Test 1 plus furniture and clothing added One humidifier was moved to hallway</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>6.8</td>
<td>Used fewer humidifiers and less HP liquid</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>12</td>
<td>Same as Test 3 humidifiers refilled at 72 hours</td>
</tr>
</tbody>
</table>
Test House Humidifier Placement, Test 0, 1 & 2

- Master Bedroom
- Master Bath
- Return Air
- Corner Bedroom
- Middle Bedroom
- Kitchen
- Den
- Living Room
- Instruments
- Garage

Legend:
- Blue square: Humidifier
- Black square: Registers (HVAC)
Test 1, HP Vapor Concentration (ppm) vs. Time (hr)

- **Concentration (ppm)**
- **Exposure Time (hours)**
- **Heating cycles**

- **Bathroom**
- **Den**
Test 1, Coupon Results (Average of three coupons)
Furniture Added:

- Three Beds w Bedding and Pillows
- Clothing
- Five Rugs
- Two Couches
- Two Chairs
- Three Boxes of Papers and Books
Test 2, HP Vapor Concentration (ppm) vs. Time (hr)

Concentration (ppm)

Exposure Time (hours)

- Bathroom
- Den

(b) w/ furniture
Test 1 & 2, HP Vapor Concentration (ppm) vs. Time (hr)

- **No furniture**
- **w/ furniture**

25% drop in HP vapor concentration

### Test Results

<table>
<thead>
<tr>
<th>Test</th>
<th>CT (ppm*hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test 2</td>
<td>655</td>
</tr>
<tr>
<td>Test 1</td>
<td>271</td>
</tr>
</tbody>
</table>

**Note:**
- CT (Carbonyl Technology)
Test 2, Coupon Results (Log Reduction)
Test House Humidifier Placement, Test 3 & 4

- Humidifier
- Registers (HVAC)
Test 4, HP Vapor Concentration (ppm) vs. Time (hr)

IDLH is 75 ppm

TLV is 1 ppm

(b)

Test 4: CT (ppm*hr) = 767

Test 1: CT (ppm*hr) = 271

Concentration (ppm)

Exposure Time (hours)
Test 4, Coupon Results (Log Reduction)

- Master Bedroom Closet
- Master Bathroom Floor
- Bathroom Sink
- Den
- Corner Bedroom Floor
- Middle Bedroom Closet
- Kitchen Floor
- Entry Closet
- Living Room / Dinning Area Floor
- Master Bedroom Closet (b)
- Den (b)
- Middle Bedroom Closet (b)
- Entry Closet (b)

- Log Reduction

- carpet
- steel
Bls Were Placed in Furniture
Test 4, BI Results From Hard to Reach Places

- Between couch cushions: + + +
- Under carpet (jute-backed): + + +
- Under entry door mat + + +
- Under one piece of paper: - - -
- Under five pieces of paper: - - -
- Under 10 pieces of paper: + + +
- Textbook + + +
- Pants pocket - - -
- Winter coat pocket + + +
- Switch plates (ext & ent) + + + + + +
- Inside pillowcase center bedroom - - -
- Between sheets center bedroom - - -
- Under comforter center bedroom - - -
- In light fixture center bedroom - - -
- Closed hall linen closet - - -
- Closed drawer kitchen + + +
- Open drawer kitchen - - -
- Window, bedroom - - -
- Door jam (front & back) + + + + + +
Summary: Increase in Response Capacity

• Scale up lab tests
• 1-gal 3% HP liquid/100 sq.ft., 8’ ceiling
• Off the shelf equipment
  • $180 vs. $80,000
• Easy to use
• Low vapor concentrations
  • 10ppm vs. 400ppm
• Longer exposure times
  • Days vs. 4 hours
• Conclusions: Effective
• By-products: water & oxygen
<table>
<thead>
<tr>
<th>Test Number</th>
<th>Number of Humidifiers</th>
<th>Amount of 3% Liquid HP (gallons)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>7</td>
<td>0</td>
<td>Water only</td>
</tr>
<tr>
<td>1</td>
<td>7</td>
<td>14</td>
<td>Two gallons 3% liquid HP in each humidifier</td>
</tr>
<tr>
<td>2</td>
<td>7</td>
<td>14</td>
<td>Same as Test 1 plus furniture and clothing added One humidifier was moved to hallway</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>6.8</td>
<td>Used fewer humidifiers and less HP liquid</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>12</td>
<td>Same as Test 3 humidifiers refilled at 72 hours</td>
</tr>
<tr>
<td>5</td>
<td>2 + 5</td>
<td>6.8</td>
<td>Similar to Test 3 but with 5 water only humidifiers</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>5.5 (8% Liquid)</td>
<td>Similar to Test 3 but with 8% liquid HP No HVAC fan...only floor fans running</td>
</tr>
<tr>
<td>7</td>
<td>2</td>
<td>5.5 (8% Liquid)</td>
<td>Similar to Test 3 but with 8% liquid HP HVAC fan on with floor fans running</td>
</tr>
</tbody>
</table>
What Next?

• Lab: decontamination of an EPA bio lab
• Summer test house w/ AC on, then AC off (floor fans on)
• Other test ideas? Talk to me

• Desorption: When is it safe to put head to pillow?
• How do we convey this information for public consumption?