Reuse of Personal Protective Equipment: Findings from Two Recent Studies on Filtering Facepiece Respirators and Emergency Medical Protective Clothing

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Overview

- OSHA, NIOSH and NPPTL
- Considerations for Single Use vs. Multiple Use PPE
- Two Recent Studies at NPPTL
  - Reusability of Filtering Facepiece Respirators
  - Improved Criteria for Emergency Medical Protective Clothing
- Concluding Remarks
Occupational Safety & Health Act (1970) established OSHA & NIOSH - To assure safe and healthful working conditions for all working men and women.
NPPTL Program Activities

Scientific Excellence

NPPTL Program Management

Outreach

Technology Evaluation

- Respirator Certification Program
- Quality Audit Program
- Certified Product Investigations
- Firefighter SCBA Investigations
- Long-term Field Evaluation

Policy & Standards Development

- Enhancements to 42 CFR Part 84
- Chemical, Biological, Radiological, and Nuclear (CBRN) Respirator Standards Development
- Guidance Document Development

Technology Research

- Respiratory Protection
- Protective Clothing & Ensembles
- Integration of Sensors & Electronics
- Human Performance
NIOSH NPPTL Program High Visibility Areas

**Mine Escape Issues**
- Respirator Certification
- Mine Emergency Respirator Investigations
- New Technology Research
- Escape Respirator Research
- Escape Respirator Standards
- MSHA Collaboration

**CBRN Issues**
- Respirator Standards Development
- CBRN PPT Research
- Respirator Certification
- NFPA/IAFF Collaboration
- TSWG IAA
- OSHA Collaboration

**Nanotechnology Issues**
- Filtration Research
- Protective Clothing Research
- Respirator Research
- Respirator Certification
- Workplace Guidance

**Pandemic Issues**
- N95 Respirator Research
- Standards (Total Inward Leakage)
- Respirator Certification
- FDA Collaboration
- National Academies Activities
- Pandemic Planning and Response
Considerations for Single vs. Multiple Use PPE

• Durability
• Economics
• Environmental - reduced hazardous waste, life cycle
• Selection based on hazard
• Government regulations and standards
• Shortages
• Social and psychological factors
Example of NPPTL Research

Reusability of Filtering Facepiece Respirators

Improved Criteria for Emergency Medical Protective Clothing
Reusability of Filtering Facepiece Respirators
Background

• CDC recommends the use of fit-tested disposable N95 respirators for healthcare personnel who are in close contact with infected patients (including 2009 H1N1 influenza)

• Filtering facepiece respirators (FFRs) are often discarded after each patient encounter

• 2006 IOM report - >90 million N95 FFRs will be needed to protect workers in the healthcare sector during a 42-day outbreak

http://www.cdc.gov/h1n1flu/guidelines_infection_control.htm

http://www.nap.edu/catalog.php?record_id=11637
Can disposable FFRs be reused after decontamination?
Project Objective

Conduct laboratory studies to understand the efficacy of decontamination and to assess the impact of decontamination on FFR performance.

Effect of decon on FFR filter performance, physical appearance and odor

Efficacy of biological decontamination processes

Assessment of decon strategies for FFR

Effect of decon on FFR fit
Effect of Decontamination on Filtration (Phase-I)

- **Two FFR Models**
  - 1 N95
  - 1 P100

- **10 Decontamination Methods:**
  - *Automated systems*: autoclave, vaporized hydrogen peroxide (VHP), ethylene oxide (EtO)
  - *Chemical*: isopropyl alcohol (IPA), bleach, liquid hydrogen peroxide (LHP), Soap & Water
  - *Physical*: ultraviolet germicidal irradiation (UVGI), microwave, heat

- Controls: water, no decon
Results (Phase-I)

- Autoclave
- 160º C dry heat
- IPA
- Soap & water  
  significant filter or physical degradation

- Bleach
- EtO
- Microwave  
  degraded filter performance, but particle penetration levels were still within expected levels

- VHP
- LHP
- UVGI  
  caused no significant change in filter performance

Effect of Decontamination on Physical Appearance, Odor, and Filter Performance (Phase-II)

- **Nine FFR Models**
  - 3 N95
  - 3 Surgical N95
  - 3 P100

- **Five Decontamination Methods**
  - Bleach
  - UVGI
  - VHP
  - EtO
  - Microwave
Results (Phase–II)

• Effects were **model specific**. FFRs tested have differences in their design (e.g., # of layers, face seal enhancements) and materials of construction (e.g., hydrophobicity)

• Inner face seal liner (P100) and material near metal nose clip (Surgical N95) on two FFR models **melted** in microwave

• All other combinations had **expected levels of laboratory performance** (filtration efficiency, air flow resistance)

• **Bleach had noticeable odor** - even after drying 22 hours - and low levels of chlorine gas were found after rehydration

Project Summary

• Some biological decontamination methods caused significant changes in physical appearance and/or degradation in filter performance; some of these effects were model specific

• Results are encouraging, but additional research is still necessary before these methods can be implemented in practice.
Publications

Improved Criteria for Emergency Medical Protective Clothing
Background – NFPA 1999

- Standard on Protective Clothing for Emergency Medical Operations
  - Sets minimum requirements for clothing items
  - Applies to emergency patient care and transportation prior to arrival at hospital or other health care facility
Background – NFPA 1999 (cont’d)

**Product Range**

- **Garments**
  - Partial body*
  - Single use
  - Reusable

- **Gloves**
  - Examination
  - Cleaning*
  - Work*

- **Footwear**
  - Reusable*
  - Single use covers*

- **Eye and face protection devices**

* Added for 2003 edition
Project Objective and Approach

- To provide the basis for and recommend appropriate design and performance criteria for PPE for emergency medical operations

- Provide support to NFPA Technical Committee on Emergency Medical Operations PPE through a series of investigations:
  - Determine specific hazards
  - Identify relevant PPE characteristics and features
  - Evaluate “acceptable” and “unacceptable” products to aid in setting recommended requirements
Garments – Key Issues

• Single Use vs. Multiple Use Garments Performance Criteria
  – NFPA 1999-2003 Edition physical property criteria address both single and reusable garments → acceptable for reusable; too high for single use
## Garments – Single Use Materials

<table>
<thead>
<tr>
<th>Material</th>
<th>Description</th>
<th>Weight (oz/yd²)</th>
<th>Thickness (mil)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>SMS polypropylene</td>
<td>1.04</td>
<td>10</td>
</tr>
<tr>
<td>B</td>
<td>PP microporous laminate</td>
<td>2.04</td>
<td>15</td>
</tr>
<tr>
<td>C</td>
<td>Flashspun PE</td>
<td>1.23</td>
<td>7</td>
</tr>
<tr>
<td>D</td>
<td>56% PET/44% PE</td>
<td>1.59</td>
<td>13</td>
</tr>
<tr>
<td>E</td>
<td>100% polyolefin</td>
<td>1.88</td>
<td>10</td>
</tr>
<tr>
<td>F</td>
<td>PE coated flashspun PE</td>
<td>2.64</td>
<td>10</td>
</tr>
<tr>
<td>G</td>
<td>PP microporous laminate</td>
<td>2.37</td>
<td>17</td>
</tr>
<tr>
<td>H</td>
<td>PE (no substrate)</td>
<td>0.91</td>
<td>3</td>
</tr>
<tr>
<td>I</td>
<td>PE coated PP (sleeve)</td>
<td>1.89</td>
<td>13</td>
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</table>
# Garments – Tensile Strength

<table>
<thead>
<tr>
<th>Material</th>
<th>Tensile Strength (N)</th>
<th>Machine</th>
<th>X-Machine</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td></td>
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<td>C</td>
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<tr>
<td>I</td>
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</tr>
</tbody>
</table>

**Multi use & Single use NFPA 1999-2003 criteria**

**Single use NFPA 1999-2008 criteria**
## Garments – Revised Performance Requirements in 2008 Edition

<table>
<thead>
<tr>
<th>Item</th>
<th>Property</th>
<th>Test Methods</th>
<th>Multiple Use†</th>
<th>Single Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Garment</td>
<td>Liquid integrity</td>
<td>ASTM F1359‡</td>
<td>No leakage</td>
<td>No leakage</td>
</tr>
<tr>
<td>Barrier layer</td>
<td>Biopenetration</td>
<td>ASTM F1761</td>
<td>Pass</td>
<td>Pass</td>
</tr>
<tr>
<td>Separable layer</td>
<td>Tensile strength</td>
<td>ASTM D5034</td>
<td>≥ 135 N(30 lbf)</td>
<td>≥ 50 N (11.2 lbf)</td>
</tr>
<tr>
<td></td>
<td>Burst strength</td>
<td>ASTM D3787</td>
<td>≥ 222.5 N</td>
<td>≥ 66 N</td>
</tr>
<tr>
<td></td>
<td>Puncture/tear</td>
<td>ASTM D2582</td>
<td>≥ 25 N</td>
<td>Not recomm.</td>
</tr>
<tr>
<td></td>
<td>Tear resistance</td>
<td>ASTM D5733* ASTM D5587**</td>
<td>≥ 36 N</td>
<td>≥ 17 N</td>
</tr>
<tr>
<td>Seams/closures</td>
<td>Strength</td>
<td>ASTM D751</td>
<td>≥ 135 N</td>
<td>≥ 50 N</td>
</tr>
<tr>
<td>Outer layer</td>
<td>Water absorption</td>
<td>AATCC 42‡</td>
<td>≤ 30%</td>
<td>N/A</td>
</tr>
<tr>
<td>Composite</td>
<td>Total heat loss</td>
<td>ASTM F1868</td>
<td>≥ 450 W/m²</td>
<td>≥ 450 W/m²</td>
</tr>
<tr>
<td>Hardware</td>
<td>Corrosion resistance</td>
<td>ASTM B117</td>
<td>No corrosion</td>
<td>N/A</td>
</tr>
<tr>
<td>Labels</td>
<td>Durability</td>
<td>ASTM D4966</td>
<td>Remain legible</td>
<td>N/A</td>
</tr>
</tbody>
</table>

* Single use; ** Multiple use; † After 25 industrial launderings; ‡ Modified method
Reference Information


- Final Report- available upon request

- Science Blog

http://www.cdc.gov/niosh/blog/nsb012009_emc.html
Thank you

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