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

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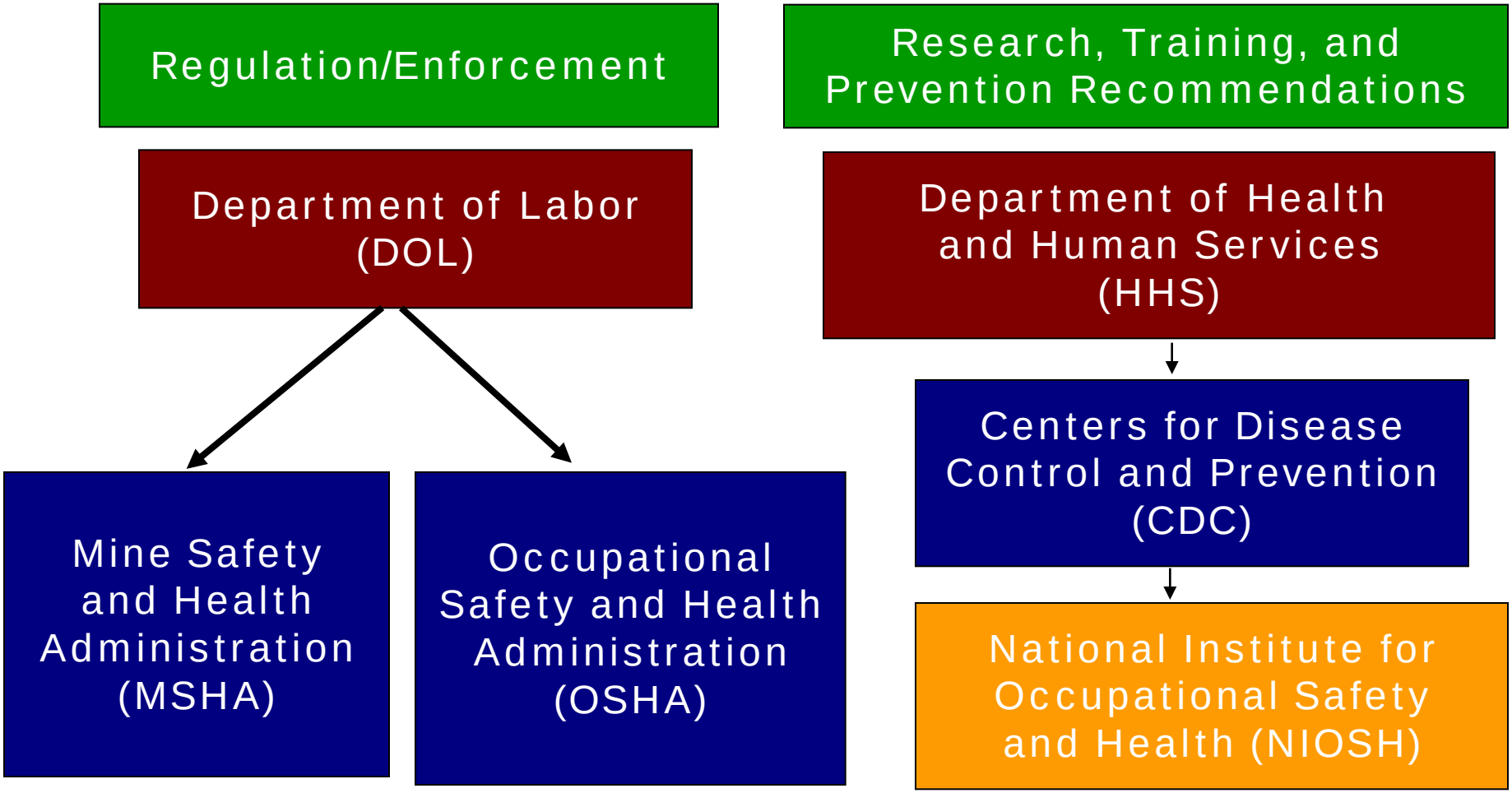
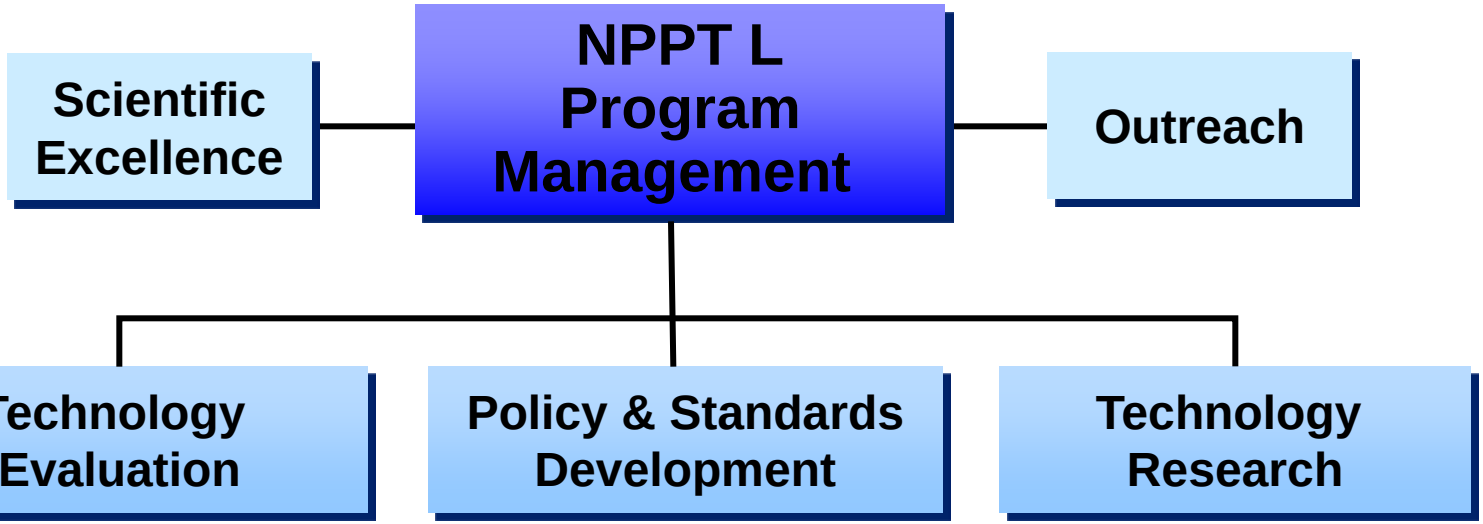
Overview

- **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



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

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

- 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

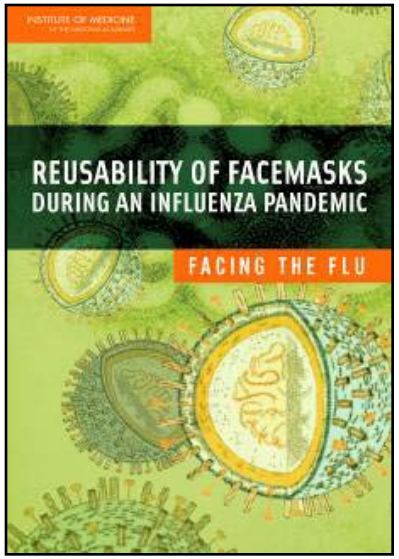
Background

- **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**

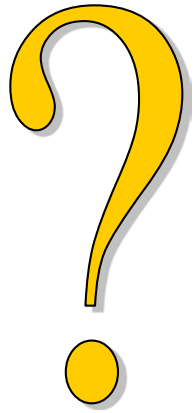
- **2006 IOM report - >90 million N95 FFRs will be needed to protect workers in the healthcare sector during a 42-day outbreak**

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



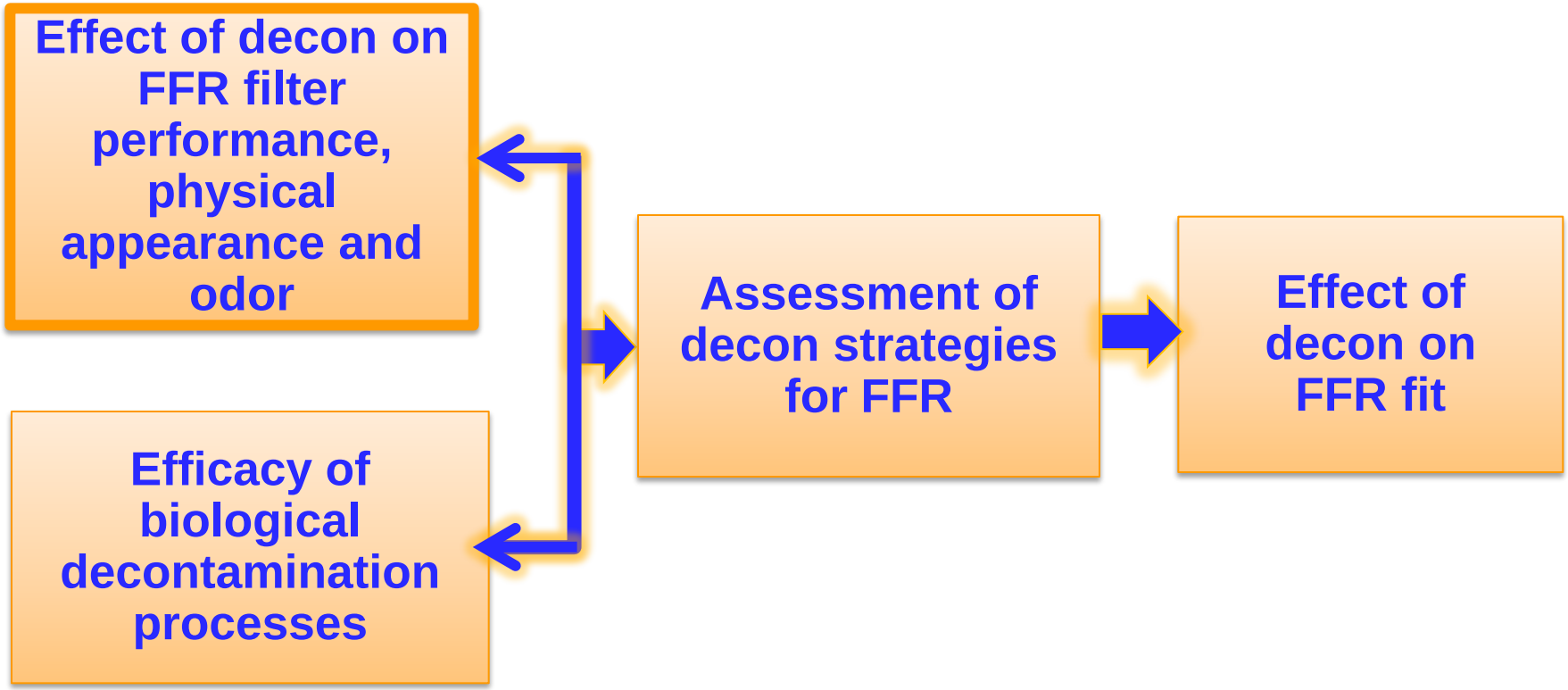
http://www.nap.edu/catalog.php?record_id=11637

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 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

•Viscusi DJ, King WP, Shaffer RE, Effect of Decontamination on the Filtration Efficiency of Two Filtering Facepiece Respirator Models. J of the International Society for Respiratory Protection, (2007) 24: 93-107

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

• Viscusi DJ, Bergman MS, Eimer BC, Shaffer RE, Evaluation of Five Decontamination Methods for Filtering Facepiece Respirators, Annals of Occupational Hygiene, (2009) 53(8):815-827

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

• Viscusi, DJ., King, WP., Shaffer, RE, Effect of Decontamination on the Filtration Efficiency of Two Filtering Facepiece Respirator Models. Journal of the International Society for Respiratory Protection, (2007) 24(2):93-107

• Viscusi DJ, Bergman M, Sinkule E, Shaffer RE, Evaluation of the Filtration Performance of 21 N-95 Filtering Facepiece Respirators after Prolonged Storage, American Journal of Infection Control, (2009) 6:381-386

• Fisher E, Rengasamy A, Viscusi DJ, Vo E, Shaffer RE. Development of a Test System to Apply Virus Containing Particles to Filtering Facepiece Respirators for the Evaluation of Decontamination Procedures. Applied and Environmental Microbiology (2009) 75(6):1500-1507

• Viscusi DJ, Bergman MS, Eimer BC, Shaffer RE, Evaluation of Five Decontamination Methods for Filtering Facepiece Respirators. Annals of Occupational Hygiene, (2009) 53(8):815-827

• Rengasamy S, Fisher E, Shaffer R., Evaluation of the Survivability of MS2 Viral Aerosols Deposited on Filtering Facepiece Respirator Samples Incorporating Antimicrobial Technologies, Am J Infect Control, (2010) 38:9-17

• Vo E, Rengasamy A, Shaffer R, Development of a Test System to Evaluate Procedures for Decontamination of Respirators containing Viral Droplets. Applied and Environmental Microbiology, (2009) 75(23):7303-7309.

• Fisher, E., and Shaffer, R.E., Survival of Bacteriophage MS2 on Filtering Facepiece Respirator Coupons (in press, Applied Biosafety).

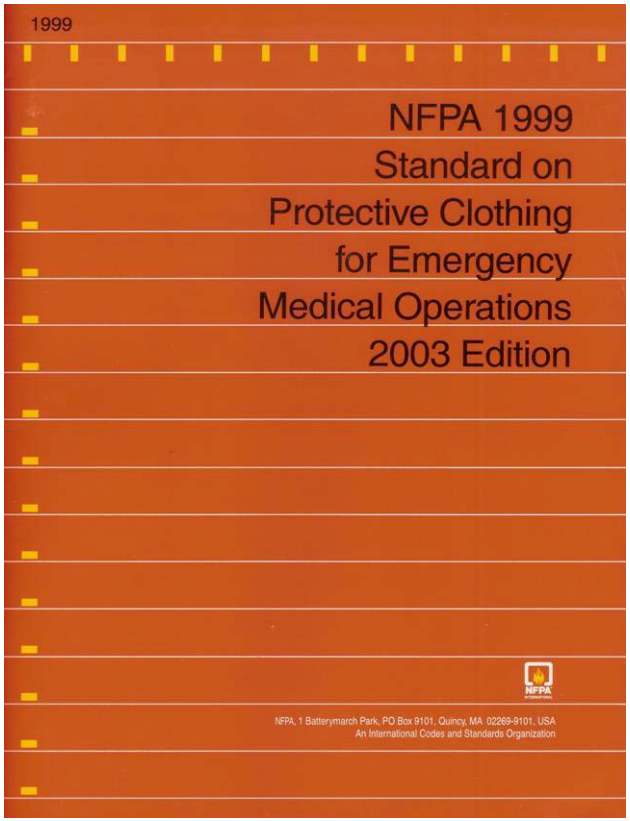
• Bergman M, Viscusi D,, Shaffer R., Heimbuch, B., and Wander, J., Evaluation of Multiple (3-cycle) Decontamination Processing for Filtering Facepiece Respirators (in press, Journal of Engineered Fibers and Fabrics).

• Fisher, E., and Shaffer, R.E., A Method to Determine the Available UV-C Dose for the Decontamination of Filtering Facepiece Respirators (submitted to Journal of Applied Microbiology).

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
  - First Ed (1992), Second Ed (1997), Third Ed (2003), Fourth Ed (2008)



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

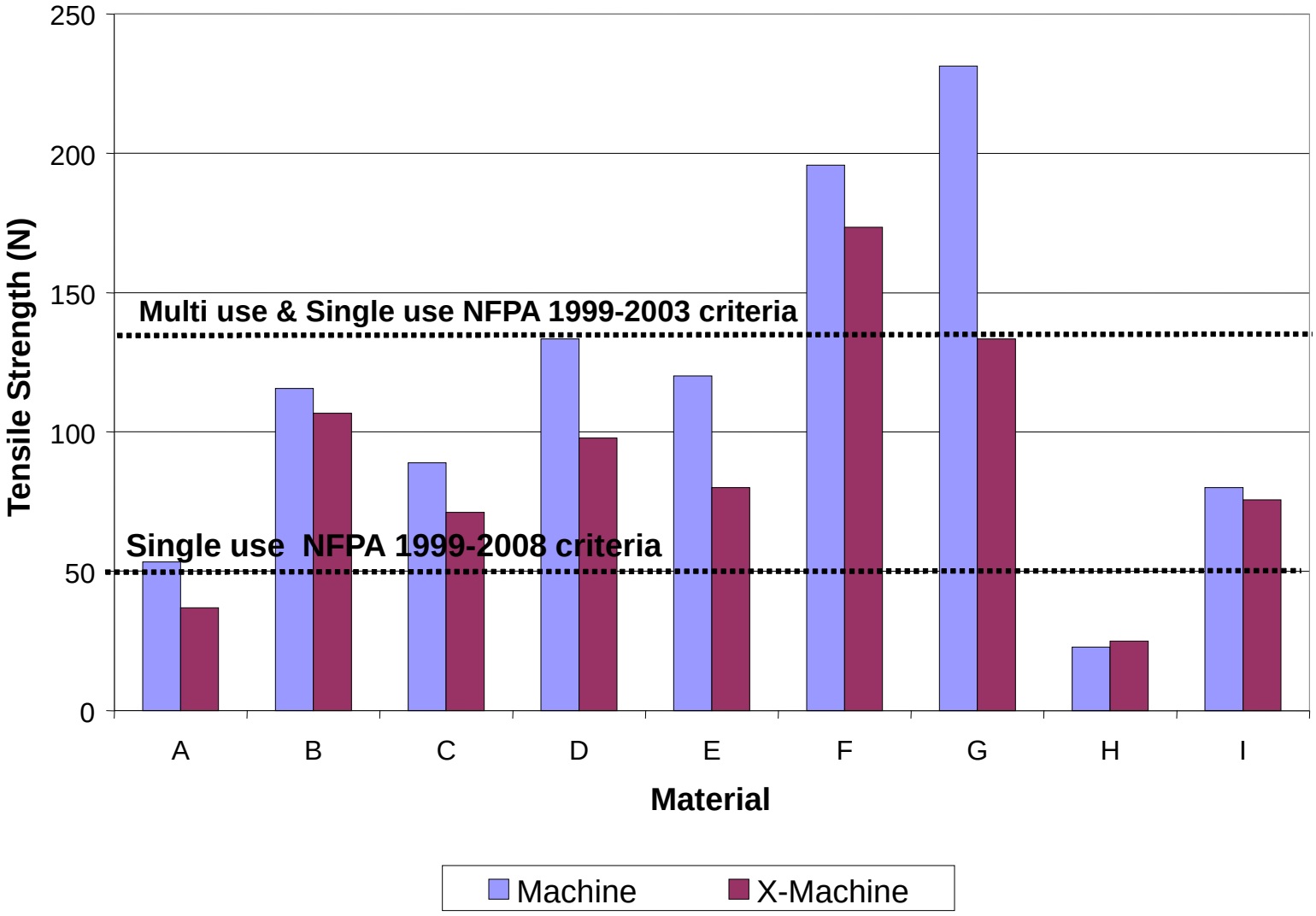
Garments – Key Issues

- **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

Material	Description	Weight (oz/yd^2)	Thickness (mil)
A	SMS polypropylene	1.04	10
B	PP microporous laminate	2.04	15
C	Flashspun PE	1.23	7
D	56% PET/44% PE	1.59	13
E	100% polyolefin	1.88	10
F	PE coated flashspun PE	2.64	10
G	PP microporous laminate	2.37	17
H	PE (no substrate)	0.91	3
I	PE coated PP (sleeve)	1.89	13

Garments – Tensile Strength



Garments – Revised Performance Requirements in 2008 Edition

Item	Property	Test Methods	Multiple Use†	Single Use
Garment	Liquid integrity	ASTM F1359‡	No leakage	No leakage
Barrier layer	Biopenetration	ASTM F1761	Pass	Pass
Separable layer	Tensile strength	ASTM D5034	≥ 135 N(30 lbf)	**≥ 50 N (11.2 lbf)**
	Burst strength	ASTM D3787	**≥ 222.5 N**	**≥ 66 N**
	Puncture/tear	ASTM D2582	≥ 25 N	**Not recomm.**
	Tear resistance	ASTM D5733* ASTM D5587**	≥ 36 N	**≥ 17 N**
Seams/closures	Strength	ASTM D751	≥ 135 N	**≥ 50 N**
Outer layer	Water absorption	AATCC 42‡	**≤ 30%**	N/A
Composite	Total heat loss	ASTM F1868	≥ 450 W/m^2	≥ 450 W/m^2
Hardware	Corrosion resistance	ASTM B117	**No corrosion**	N/A
Labels	Durability	ASTM D4966	Remain legible	N/A

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

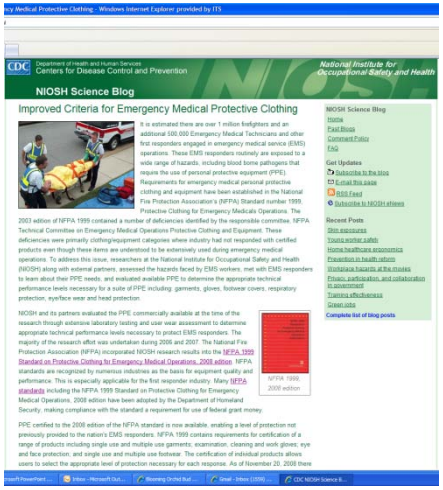
Reference Information

- **NFPA 1999 Standard on Protective Clothing for Emergency Medical Operations- 2008 Edition**

- **Final Report- available upon request**

- **Science Blog**

http://www.cdc.gov/niosh/blog/nsb012009_ems.html



http://www.cdc.gov/niosh/blog/nsb012009_ems.html

Thank you

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