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# **Improved Criteria for Emergency Medical Protective Clothing**

**Contract No. 214-2006-M-15870  
Final Report**

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## EXECUTIVE SUMMARY

Requirements for personal protective equipment used by emergency medical personnel have been established in National Fire Protection Association Standard (NFPA) number 1999, *Standard on Protective Clothing for Emergency Medical Operations*. The standard was first introduced in 1992 in response to OSHA's bloodborne pathogen regulations provided in 29 CFR Part 1910.1030. Originally, NFPA 1999 set criteria that applied to garments, gloves, and eye/face protection devices. In subsequent editions, distinctions were made between single and reusable garments on the basis of preconditioning by washing for reusable garments; in addition, the types of products covered by NFPA 1999 were expanded to address other items, including cleaning gloves, work gloves, footwear, and footwear covers. While the standard has been accepted within the emergency medical industry for some product areas (primarily reusable garments and examination gloves), there have been no certifications of cleaning gloves or single use protective garments. In addition, there has been relatively little industry response to eye/face protection devices, work gloves, and footwear. Feedback from industry has indicated that some of the criteria did not match the types of products that first responders typically use or need. It was also discovered that certain criteria in the current 2003 edition were actually mutually exclusive and prevented the certification of products. A detailed review of shortcomings in the standard identified cleaning gloves, single use garments, eye/face protection devices, footwear covers, helmets, visibility markings, and flammability criteria as areas of concern.

A research project was undertaken to investigate emergency medical PPE needs and to establish meaningful and appropriate criteria that became part of the newly revised NFPA 1999 (2008 Edition) standard. The research project included a detailed hazard assessment based on end user input, a review of industry products, the identification of product performance needs, the selection of test methods for evaluating products consistent with end user expectations, and the recommendation of design and performance criteria to establish appropriate levels of protection for workers engaged in emergency medical operations. The recommended criteria and test methods were incorporated by the NFPA into the 2008 Edition of NFPA 1999. As a consequence of this research program, the revised NFPA 1999 permits the certification of more types of protective clothing that will more closely fit the needs and requirements of first responders during emergency medical operations.

In order to provide support to the NFPA Technical Committee on Emergency Medical Operations Protective Clothing and Equipment, a series of investigations was undertaken to provide the basis for recommending specific, appropriate criteria for the protection of first responders during emergency medical operations. These investigations determined the specific hazards faced by first responders, identified the features and properties of specific PPE that protect against these hazards, and involved testing of products to assist in setting performance requirements. The specific steps of this process included:

1. Determining first responder needs specific to cleaning gloves, single use garments, footwear covers, and eye/face protection devices by listing specific hazards faced by first responders during emergency medical operations and PPE product features that are needed for EMS responder protection.

2. Identifying current products in use or products that could be used that first responders considered acceptable and unacceptable as a range of products for evaluation.
3. Determining the specific properties associated with single use garments, cleaning gloves, footwear covers, and eye/face protection devices that would be assessed or measured for providing protection against the specific hazards identified during the industry review.
4. Selecting available test methods that were investigated to assess or measure the specific properties identified above with the determination of the parameters associated with those test methods and necessary modifications to apply the specific test methods to the selected emergency medical protective clothing.
5. Establishing a test plan to evaluate the selected EMS PPE products by means of the chosen test methods and evaluation procedures.
6. Carrying out the test plan and analyzing the findings from the testing in order to determine the discrimination of product performance consistent with field expectations; tests were modified as needed to obtain appropriate levels of product discrimination.
7. Preparing recommended design assessment and performance criteria to address the specific hazards, performance properties, and test methods reviewed in this study.
8. Documenting study findings in this final report.

The results of this project in terms of recommended criteria and supporting documentation were provided to the NFPA Technical Committee on Emergency Medical Operations Protective Clothing and Equipment and extensively assisted this committee with their revision of the NFPA 1999 standard. Specific junctures in the standards development process were used to provide input in terms of public proposals and comments that fall within the study's period of performance. Input from this project enabled the correction of key problems and the addition of new criteria to promote appropriate levels of protective clothing for emergency medical personnel.

# TABLE OF CONTENTS

<b>EXECUTIVE SUMMARY .....</b>	<b>ii</b>
<b>INTRODUCTION.....</b>	<b>1</b>
<b>BACKGROUND .....</b>	<b>2</b>
<b>Origin and Development of NFPA 1999 .....</b>	<b>2</b>
First Edition.....	2
Second Edition .....	2
Third Edition.....	3
<b>Protection Principles Applied in NFPA 1999 .....</b>	<b>3</b>
Material Barrier Performance and Overall Product Integrity .....	3
Barrier Physical Strength and Durability .....	11
Tradeoffs for Protection and PPE Comfort/Functionality.....	17
<b>Revision Process for NFPA 1999 .....</b>	<b>21</b>
<b>Industry Reaction to NFPA 1999 .....</b>	<b>24</b>
<b>STUDY OBJECTIVES.....</b>	<b>26</b>
<b>STUDY APPROACH .....</b>	<b>26</b>
<b>Overview of Approach.....</b>	<b>26</b>
<b>Project Tasks .....</b>	<b>27</b>
<b>Interaction with End Users and NFPA Technical Committee.....</b>	<b>29</b>
<b>Specific Details on Individual Tasks .....</b>	<b>29</b>
Task 1 – Definition of EMS Responder PPE Needs .....	29
Task 2 – Identification of Current EMS PPE and Preferences .....	30
Task 3 – Determination of Relevant PPE Attributes and Properties .....	30
Task 4 – Selection and Development of PPE Test Methods .....	32
Task 5 – Establishment of PPE Test Plan .....	32
Task 6 – Testing and Evaluation of Candidate PPE .....	32
Task 7 – Preparation of PPE Criteria .....	32
Task 8 – Documentation of Study Findings .....	32
<b>INDUSTRY AND LITERATURE REVIEW FINDINGS.....</b>	<b>33</b>
Injuries and Fatalities for EMS Responders.....	33
Primary Sources of Information .....	33
Information from the Bureau of Labor Statistics for 2005 .....	34
Information from the RAND Publications.....	34
Interviews with EMS Providers on PPE Selection and Use.....	40
PPE Procurement.....	41
Choice of PPE for Use at a Particular Incident .....	46
Specific PPE Use Practices and Observations .....	46
Additional Comments.....	50

## TABLE OF CONTENTS (continued)

<b>Approaches for Establishing Acceptance Criteria</b> .....	50
Presentation of Sample Products at EMS Trade Show .....	50
Limited Field Trials with EMS Organizations .....	54
NFPA Technical Committee Judgments .....	54
<b>INVESTIGATION OF KEY PPE ITEM REQUIREMENTS</b> .....	55
<b>Revision of Garment Criteria</b> .....	55
Key Issues .....	55
Existing Criteria and Needs .....	56
Selection of Burst Strength Test Method .....	57
Determination of Garment Liquid Testing Approaches .....	60
Methodology for Evaluating Garment Physical Properties .....	62
Analysis of Physical Property Data .....	66
Determination of Appropriate Garment Physical Property Criteria .....	74
Discrimination between Full and Partial Body Garment Criteria .....	79
Establishment of Minimum Acceptable Visibility Criteria .....	80
Approaches for Measuring Garment Flammability .....	81
<b>Revision of Cleaning Glove Criteria</b> .....	84
Key Issues .....	84
Existing Criteria and Needs .....	84
Glove Assessments .....	86
Determination of Appropriate Physical Performance for Cleaning Gloves .....	89
Recommendation of Specific Cleaning Glove Criteria Changes .....	90
<b>Revision of Criteria for Footwear Covers</b> .....	92
Key Issues .....	92
Existing Criteria and Needs .....	93
Footwear Cover Assessments .....	95
Determination of Appropriate Physical Performance for Footwear Covers .....	98
Recommended Criteria Changes for Footwear Covers .....	101
<b>Revision of Criteria for Eye and Face Protection Devices</b> .....	102
Key Issues .....	102
Existing Criteria and Needs .....	104
End User Assessments .....	105
Development of Design and Performance Criteria .....	109
<b>Other Areas of PPE Criteria Recommendations</b> .....	111
Head Protection.....	112
Work Gloves .....	112
Footwear for Medical First Receivers .....	114
Biological Particulate Protection .....	114
<b>OVERALL CONCLUSIONS</b> .....	115

## **TABLE OF CONTENTS (continued)**

<b>REFERENCES .....</b>	<b>116</b>
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**Appendix A – NFPA 1999 Public Proposals Submitted as Part of Project**

**Appendix B – EMS Organization Interview Questions**

**Appendix C – Rating Forms Used in EMS Responder Sample Reviews and Field Trials**

## LIST OF FIGURES

Figure 1 – Relative Size of Bloodborne Pathogens .....	4
Figure 2 – Elbow Lean Test to Demonstrate Synthetic Blood Strike Through for Protective Clothing Materials.....	4
Figure 3 – Concept Applied in Viral Penetration Resistance Test .....	5
Figure 4 – Test Cell Used in Viral Penetration Resistance Test .....	6
Figure 5 – ASTM F1862 Test Apparatus for Evaluation of Synthetic Blood Strikethrough for Masks .....	7
Figure 6 – Example of Mask Failure in ASTM F1862 Test .....	7
Figure 7 – The “Shower Test” as Applied to a Garment to Measure Liquid-Tight Integrity.....	9
Figure 8 – A Liquid-Tight Integrity Test for Examination Gloves Involving the Suspension of the Glove Filled with Surfactant-Treated Water .....	9
Figure 9 – Gelbo Flexing of Material Specimen Showing Sample in Full Twisted and Compressed Condition.....	12
Figure 10 – Wynzenbeek Abrasion Test Apparatus Applied to Protective Clothing .....	12
Figure 11 – Specimen and Test Apparatus Used in Glove Tensile Testing .....	13
Figure 12 – Puncture Resistance Test Apparatus and Probe Geometry .....	15
Figure 13 – Cut Resistance Test Apparatus and Close-Up of Test Blade .....	16
Figure 14 – Taber Abrasion Test Method used for Cleaning Gloves.....	16
Figure 15 – Test Apparatus for Total Heat Loss Test.....	19
Figure 16 – Bennett Dexterity Test Being Performed on Work Gloves.....	20
Figure 17 – Number of Certified Manufacturers and Products According to NFPA 1999 as of March 2006 .....	25
Figure 18 – Project Technical Approach and Tasks.....	28
Figure 19 – Cause of Fatal Injuries for Firefighters, Police, and EMS Workers.....	36
Figure 20 – Nature of Injury for Firefighters, Police, and EMS Injuries, 1996-1998 .....	37
Figure 21 – Cause of Injury for EMS Line-of-Duty Fatalities, 1998-2001 .....	37
Figure 22 – Years of EMS Experience Reported by Trade Show Participants .....	51
Figure 23 – Estimated Number of Annual EMS Calls Reported by Trade Show Participants ....	51
Figure 24 – Frequency of Selected EMS PPE Use Reported by Trade Show Participants.....	52
Figure 25 –Tests Used to Evaluate Garment Material Burst Strength .....	58
Figure 26 – Comparison of Burst Strength Data for Selected EMS Garment Fabrics .....	59
Figure 27 – AATCC 22 Water Repellency Spray Test Method .....	60
Figure 28 – Tensile Strength Results for Selected Single-Use EMS Garment Fabrics.....	66
Figure 29 – Tear Resistance Test Method Approaches .....	67
Figure 30 – Comparison of Tear Resistance Data for Selected EMS Garment Fabrics .....	67
Figure 31 – Elmendorf Tear Resistance Results for Selected Single-Use EMS Fabrics.....	68
Figure 32 – Trapezoidal Tear Resistance Results for Selected Single-Use EMS Fabrics s .....	68
Figure 33 – Mullen Burst Strength Results for Selected Single-Use EMS Fabrics .....	69
Figure 34 – Ball Burst Strength Results for Selected Single-Use EMS Fabrics .....	69
Figure 35 – Puncture Propagation Tear Test Resistance Apparatus.....	70
Figure 36 – Puncture Propagation Tear Resistance Test Results for Selected Single-Use EMS Garments Fabrics.....	70
Figure 37 – Taber Abrasion Test Apparatus and Test Specimen Condition .....	71

## LIST OF FIGURES (continued)

Figure 38 – Taber Abrasion Resistance Test Results for Selected Single-Use EMS Garment Fabrics (Using H-18 Abradant Wheels).....	72
Figure 39 – Taber Abrasion Resistance Test Results for Selected Single-Use EMS Garment Fabrics (Using CS-10 Abradant Wheels).....	72
Figure 40 – Seam Strength Test Results for Selected Single-Use EMS Garments Fabrics .....	73
Figure 41 – Trade Show Respondent Ratings for Garment Material Strength.....	75
Figure 42 – Trade Show Respondent Ratings for Garment Material Single Use Durability .....	75
Figure 43 – Example of High Visibility Apparel.....	80
Figure 44 – Fabric Flammability Test Apparatus with Close Up of Flame.....	82
Figure 45 – Cut Resistance Test Results for Selected EMS Gloves .....	88
Figure 46 – Puncture Resistance Test Results for Selected EMS Gloves.....	88
Figure 47 – Trade Show Respondent Ratings for Cleaning Glove Strength .....	89
Figure 48 – Trade Show Respondent Ratings for Cleaning Glove Single Use Durability .....	90
Figure 49 – Examples of Disposable Footwear Covers.....	93
Figure 50 – Puncture Resistance Results for Selected Footwear Cover Wear Surface Materials .....	96
Figure 51 – Abrasion Resistance Results for Selected Footwear Cover Wear Surface Materials.....	97
Figure 52 – Slip Resistance Results for Selected Footwear Cover Wear Surface Materials .....	97
Figure 53 – Trade Show Respondent Ratings for Footwear Cover Strength.....	98
Figure 54 – Trade Show Respondent Ratings for Footwear Cover Single Use Durability.....	99
Figure 55 – Trade Show Respondent Ratings for Footwear Cover Traction.....	99
Figure 56 – Examples of Different Reusable Types of Eye and Face Protection Devices.....	103
Figure 57 – Examples of Different Surgical Mask Styles Used in EMS Operations .....	103
Figure 58 – Trade Show Respondent Ratings for Eye/Facewear Face Coverage .....	106
Figure 59 – Trade Show Respondent Ratings for Eye/Facewear Single Use Durability .....	106
Figure 60 – Trade Show Respondent Ratings for Eye/Facewear Physical Protection .....	107
Figure 61 – Trade Show Respondent Ratings for Eye/Facewear Barrier Qualities .....	107
Figure 62 – Trade Show Respondent Ratings for Eye/Facewear Visibility .....	108
Figure 63 – Trade Show Respondent Ratings for Eye/Facewear Donning Ease.....	108
Figure 64 – Two Selected New Target Locations on Medical Face Masks for Liquid Integrity Test.....	111
Figure 65 – Test Results Comparing Abrasion Resistance of Different Work Glove Shell Materials.....	113



## LIST OF TABLES

Table 1 – Material Barrier and Product Integrity Tests in NFPA 1999 .....	10
Table 2 – Examination Glove Tensile Strength Criteria in Industry Specifications .....	14
Table 3 – Overview of Physical Hazard and Durability Requirements Applied to EMS Protective Clothing in NFPA 1999 (2003 Edition) .....	18
Table 4 – Human Factors and Comfort Related Tests Applied to EMS Protective Clothing in NFPA 1999 (2003 Edition) .....	21
Table 5 – Revision Schedule for 2008 Edition of NFPA 1999 .....	23
Table 6 – Range of Protective Clothing Addressed in NFPA 1999 (2003 Edition) .....	24
Table 7 – Current Performance Criteria Applied to Selected EMS Product Categories in NFPA 1999 (2003 Edition) .....	31
Table 8 – Emergency Medical Technicians and Paramedics: Nonfatal Injuries and Illnesses Involving Days Away From Work, 2005 .....	34
Table 9 – Underlying Data Supporting Figure 19, Cause of Fatal Injuries for Firefighters, Police, and EMS Workers .....	38
Table 10 – Underlying Data Supporting Figure 20, Nature of Injury for Firefighters, Police, and EMS Injuries, 1996-1998 Based on National Estimates .....	38
Table 11 – Underlying Data Supporting Figure 20, Cause of Injury for EMS Line-of-Duty Fatalities, 1998-2001 .....	39
Table 12 - EMS Providers Included in Survey .....	42
Table 13 – PPE Used by Fire Service-Based EMS .....	43-44
Table 14 – PPE Used by “Third Service” and Private EMS .....	45
Table 15 – Product Rating Categories for Trade Show Participants .....	53
Table 16 – Existing and Initially Proposed Criteria for EMS Garments .....	57
Table 17 – Comparison of Ball and Mullen Burst Test Results for Selected Garment Materials .....	58
Table 18 – Comparison of Water Repellency and Absorption for Selected EMS Garment Materials .....	61
Table 19 – Garment Materials Selected for Physical Property Investigation .....	62
Table 20 – Description of Selected Physical Property Tests .....	63-65
Table 21 – Summary of Physical Property Test Results for Selected Single-Use EMS Garment Materials .....	65
Table 22 – Garment Types and Sampled Seam Locations .....	73
Table 23 – Garment Material Rankings Based on Physical Property Performance .....	74
Table 24 – Field Trial 1 Ratings for Disposable Garments: Percentage Deemed Acceptable or Unacceptable, by Attribute .....	76
Table 25 – Field Trial 2 Ratings for Disposable Garments: Percentage Deemed Acceptable or Unacceptable, by Attribute .....	77
Table 26 – Revised Criteria for EMS Garments .....	79
Table 27 – Flammability Test Results for Selected Single-Use EMS Garment Fabrics .....	83
Table 28 – Flammability Test Results for Other EMS PPE Items .....	83
Table 29 – Existing and Initially Proposed Criteria for EMS Cleaning Gloves .....	85
Table 30 – Assessment of Selected Gloves for Key Cleaning Glove Properties Specified in NFPA 1999 (2003 Edition) .....	87
Table 31 – Characteristics of Gloves Used in Cut and Puncture Resistance Testing .....	87
Table 32 – Revised Criteria for EMS Cleaning Gloves .....	91

## **LIST OF TABLES (continued)**

Table 33 – Hazards Associated with Common Disinfectant Chemicals.....	92
Table 34 – Existing Criteria for EMS Footwear Covers.....	94
Table 35 – Test Results for Selected EMS Footwear Cover Materials.....	95
Table 36 – Field Trial Ratings for Disposable Footwear Covers: Percentage Deemed Acceptable or Unacceptable, by Attribute .....	100
Table 37 – Final Recommended Criteria for EMS Footwear Covers .....	102
Table 38 – Types of Eye and Face Protection Devices Considered in Study .....	105
Table 39 – Recommended Performance Criteria for New Categories of Eye and Face Protection Devices.....	110
Table 40 – NFPA 1994 Classes of Protective Ensembles .....	114

## INTRODUCTION

Firefighters, emergency medical technicians, and other first responders often provide medical aid as part of their response activities. It is estimated that the fire service alone is now providing over 15 million medical aid calls each year [1]. For the large majority of fire departments, medical aid calls represent over 66 percent of the total emergency calls and the overall proportion of these calls is growing [2]. In addition, there are 17,000 transporting ambulance services and over 52,000 ambulances, in which victims of various accidents are transported to medical facilities [3]. These medical aid calls involve the potential for treating patients that may have blood or body fluids containing bloodborne pathogens such as HIV or Hepatitis. For example, the International Association of Fire Fighters (IAFF) has estimated that as many as 1 in 29 fire fighters are exposed to a communicable disease [4]. Medical aid calls further involve other physical hazards during their execution, particularly in the extrication of victims from vehicle accidents, as well as exposure to difficult accident environments, such as during building collapses and other disasters.

First responders typically rely on a variety of different types of personal protective equipment to reduce or eliminate these exposures and their potential consequences. Requirements for emergency medical personal protective equipment have been established in National Fire Protection Association Standard (NFPA) number 1999, *Protective Clothing for Emergency Medical Operations* [5]. Most recently, the 2003 edition of NFPA 1999 established a number of new clothing/equipment categories to reflect the varying needs of emergency responders for different approaches for personal protection. While this edition of the NFPA 1999 standard had been in place for several years, there are a number of deficiencies in the standard that were identified by the responsible committee, the NFPA Technical Committee on Emergency Medical Operations Protective Clothing and Equipment. These deficiencies primarily concern some of clothing/equipment categories where industry has not responded with certified products even though these items are understood to be extensively used during emergency medical operations. Among these items were single-use garments, cleaning gloves, footwear covers, and eye/face protection devices (eye and face protection devices in particular have been part of the standard since its first promulgation in 1992). In contrast, a review of industry certification records showed over 120 products that have been certified to NFPA 1999 as reusable garments and examination gloves. There are also some styles of emergency medical footwear that have been certified. Therefore, this project was undertaken to determine the reasons for the lack of certified products, to understand emergency medical end user needs for personal protection, and to apply specific criteria that are commensurate with those needs as well as permit industry to provide appropriate personal protective equipment to the emergency medical services.

In addition, there are emerging concerns for exposure of EMS personnel to other hazards, including trauma while providing care inside moving emergency vehicles and possible exposure to contaminated substances and victims during WMD incidents. The latter area extends both to emergency scene workers and medical first receivers. It also includes responses of EMS personnel to industrial accidents where hazardous substances other than liquidborne pathogens are encountered. Furthermore, there has been extensive recognition for emergency medical responder exposure to the airborne pathogen hazards, historically including tuberculosis and more recently including SARS and avian flu.

## BACKGROUND

### Origin and Development of NFPA 1999

**First Edition.** NFPA 1999, *Standard on Protective Clothing for Emergency Medical Operations*, was developed in response to rising concerns in the mid to late 1980s for first responder exposure to blood and body fluids contaminated by bloodborne pathogens, including HIV and Hepatitis. This standard was originally developed to address protective garments, gloves, and facewear designed to protect persons providing emergency medical care against exposure to liquid-borne pathogens during emergency medical operations. NFPA 1999 minimum performance criteria for protective clothing were developed to reflect requirements in Occupational Safety and Health Administration (OSHA) Final Rule (29 CFR 1910.1030) *Protecting Health Care Workers from Occupational Exposure to Bloodborne Pathogens* [6]. The Final Rule states:

*When there is occupational exposure, the employer shall provide at no cost to the employee, appropriate personal protective equipment, such as, but not limited to, gloves, gowns, laboratory coats, face shields or masks, and eye protection, and mouthpieces, resuscitation bags, pocket masks, or other ventilation devices. Personal protective equipment will be considered “appropriate” only if it does not permit blood or other potential infectious materials to pass through to or reach the employee's work clothes, street clothes, undergarments, skin, eyes, mouth, or other mucous membranes under normal conditions of use and for the duration of time which the protective equipment will be used.*

NFPA 1999 established specific performance criteria that involve exposing protective clothing materials to a surrogate virus challenge utilizing a specific time and pressure protocol. This procedure had been documented to discriminate between current protective clothing materials and to correlate with visual penetration results that are obtained with a human factors evaluation [7]. The test became adopted as a standard viral penetration test by ASTM under the designation Test Method F1671 [8] and it was applied to each type of clothing in the original edition of NFPA 1999.

Material testing was also supplemented by overall product liquidtight integrity testing. In the case of garments, this involved a shower-like test that was also standardized by ASTM as Test Method F1359 [9]. Likewise, gloves were tested for integrity using a procedure where whole gloves were filled with water and observed for leakage. A spray-like test was created for evaluating eye and face protection devices. Additional garment requirements were included to cover material strength, physical hazard resistance, seam strength, and closure strength. Additional requirements for gloves included minimum performance for tensile and elongation properties in an “as received” condition as well as following heat aging and isopropyl alcohol immersion. For eye and face protection devices, a visibility test was provided. For the first edition, the selection of test methods and performance requirements was based on surveys of emergency medical services (EMS) personnel and a technical study supported by the U.S. Fire Administration [10].

**Second Edition.** In 1997, the second edition incorporated single-use and reusable items of EMS protective clothing. Prior to that edition, there was no differentiation between single-use and reusable items. Items that were reused may not have continued to provide biopenetration barrier

protection. Reusable items were considered to be cost-effective for certain items of EMS clothing such as garments. Durability conditioning was added to the test methods of items that would be identified as not for single use only. EMS gloves remained a single-use item only, which was consistent with NFPA 1581, *Standard on Fire Department Infection Control Program* [11].

The first edition allowed partial body garments, such as sleeve covers or apron-type gowns, and also allowed the biopenetration barrier protection to be less in area than the area covered by the garment (such as only the front of a smock or jacket having the biopenetration barrier protection). The second edition continued to permit partial body garments, but did *not* allow partial biopenetration barrier protection in a garment. Biopenetration barrier protection was required for the full area covered by the garment.

**Third Edition.** In the third edition (2003), the Technical Committee added new requirements for emergency medical work gloves, emergency medical footwear, and cleaning gloves. Emergency medical work gloves were introduced to provide the barrier protection from blood and liquid-borne pathogens that all EMS PPE provides, but at a higher level of physical protection for incidents where rough or sharp surfaces could be contacted, such as during extrication operations. Emergency medical footwear requirements were established to permit footwear to be configured as either a single-use, disposable bootie to pull over work shoes or as normal footwear designed for multiple uses. Both types of footwear were intended to provide the same barrier protection from blood and liquid-borne pathogens as other items of EMS PPE. The cleaning gloves were provided are single-use items to protect wearers during cleaning and decontamination of EMS equipment. Project work began with this edition as the starting point.

### **Protection Principles Applied in NFPA 1999**

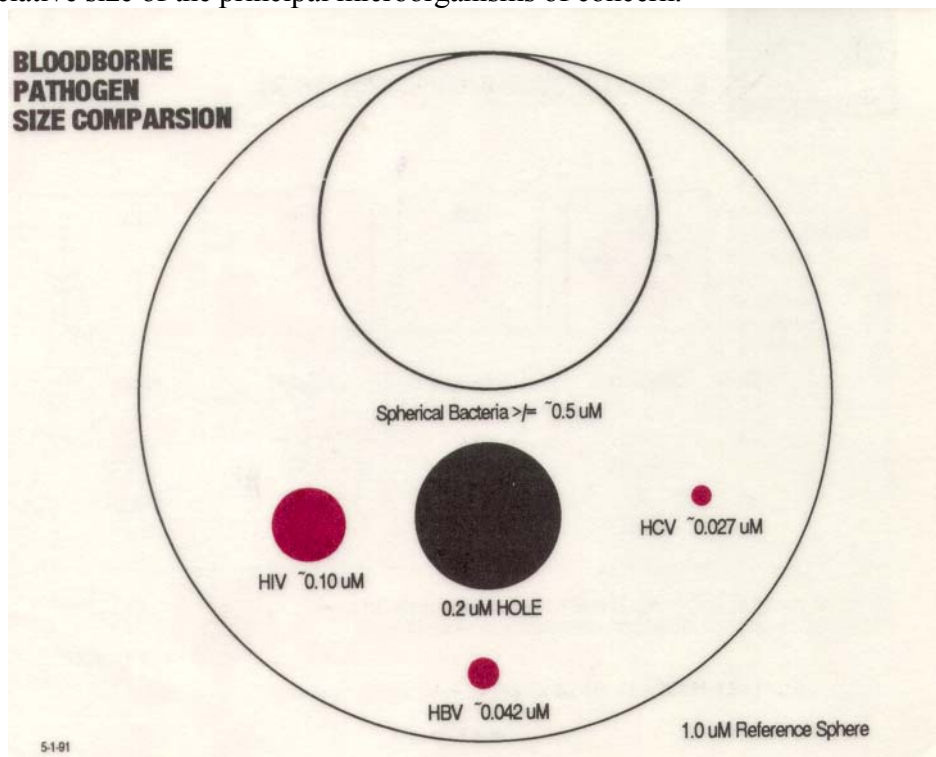
Criteria in NFPA 1999 were developed to represent certain principles of protection that included:

1. Protection from bloodborne pathogens as demonstrated by the combination of material barrier performance and overall product integrity in preventing the inward leakage of blood and other potentially infectious fluids
2. Reasonable levels of physical protection that establish adequate strength and durability for maintaining protection from bloodborne pathogens over the expected service life and use conditions for the particular types of personal protective equipment
3. The ability for end users to wear each type of personal protective equipment without significant inhibition of their functionality or ability to provide emergency patient care

The evolution of requirements to address each of these areas is covered in the sections below.

**Material Barrier Performance and Overall Product Integrity.** NFPA 1999 offers specific performance criteria that involve exposing protective clothing materials to a surrogate virus challenge to determine if the virus will pass through the material. The surrogate virus, Bacteriophage Phi-X174, was chosen to mimic the size (27 nanometers) and shape of target micro-organisms,

namely Hepatitis B Virus and the Human Immunodeficiency Virus (that causes AIDS). Figure 1 shows the relative size of the principal microorganisms of concern.



**Figure 1 – Relative Size of Bloodborne Pathogens**  
(Figure courtesy of W. L. Gore & Associates)

The conditions of the test entail subjecting protective clothing material specimens in a special test cell to the viral challenge for one hour with the sixth minute of the exposure at 13.8 kPa (2 psi). These conditions were chosen because they already existed in a related method – ASTM F903 [12] – that was applied for assessing liquid chemical penetration through protective clothing materials [13]. Research at Kansas State University was performed to show how these test conditions best correlated with a human factors evaluation where visible blood strikethrough occurred [14], which was known as the elbow lean test and is shown in Figure 2.

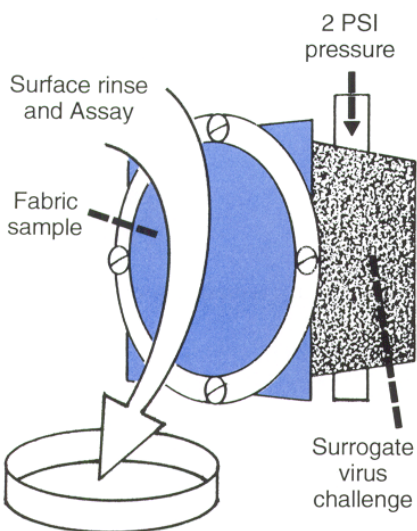


**Figure 2 – Elbow Lean Test to Demonstrate Synthetic Blood Strike Through for Protective Clothing Materials**

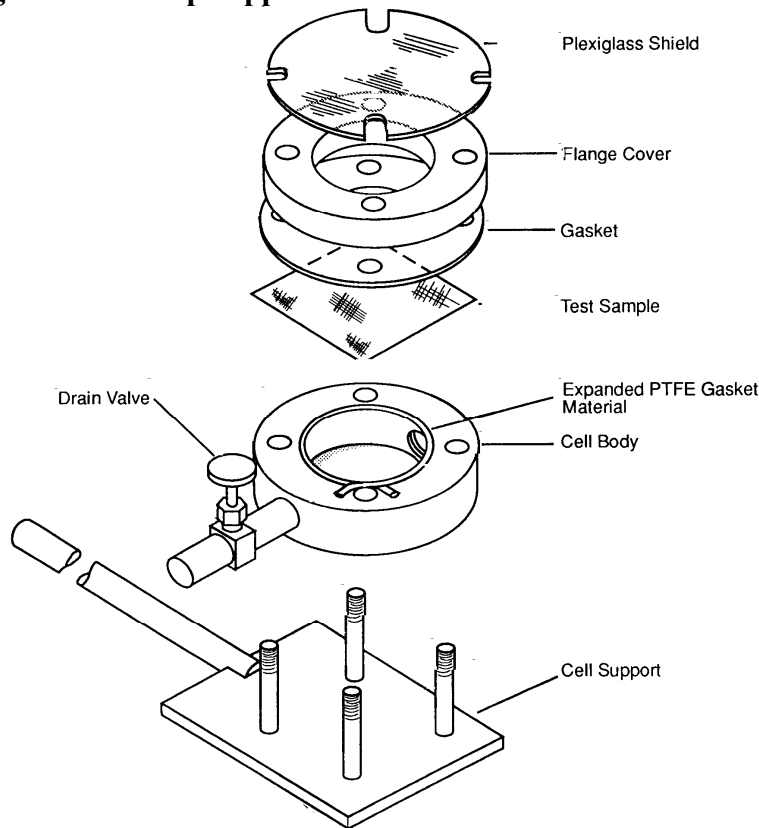
The elbow lean test represents a simple way to demonstrate blood strikethrough. In this test, an ink pad is saturated with synthetic blood, the test material is placed over the saturated pad, followed by a blotter, and then an individual leans on the blotter to see if the synthetic blood will penetrate onto the blotter. The specific research performed showed how a controlled version of this test provided the best correlation with the then proposed ASTM viral penetration resistance test as compared to a number of other tests and tests conducted under different conditions. This correlation is important because it establishes the basis of quantifiable penetration with clothing field effectiveness as specified by OSHA in 29 CFR Part 1910.1030 that defines protective clothing as appropriate when it keeps blood and body fluids off the wearer's skin or underclothing.

A key part of the consideration for setting test conditions was the selection of pressure. A few studies have documented the range of pressures to which protective clothing is subjected while in use [14-16]. These pressures have been found to be as high 124 kPa (18 psi). These pressures arise when individuals wearing protective clothing lean or press on surface that are may be wet with blood or body fluids (such as in the case of an emergency medical responder kneeling on a contaminated roadway). Nevertheless, the correlation from the Kansas State University research was important because the pressure applied in the viral penetration resistance test is hydrostatic as compared to the mechanical pressure that is more characteristic of exposure.

At the conclusion of the 1-hour exposure period in the viral penetration, the opposing surface of the material is rinsed with an assay fluid and this fluid is then cultured to determine if any virus are present. The culture is performed using *E. Coli*. Plaques form when a Bacteriophage is present with the number of plaques indicating the number of penetrating Bacteriophage. Consequently, the viral penetration resistance test is able to detect a single penetrating virus, thus establishing the basis for clothing material viral penetration resistance. Materials pass the viral penetration test when no liquid is observed to penetrate the specimen and no viral simulant is detected in the assay fluid. Figure 3 shows the conceptual operation of the test while the test cell is shown in Figure 4.



**Figure 3 – Concept Applied in Viral Penetration Resistance Test**

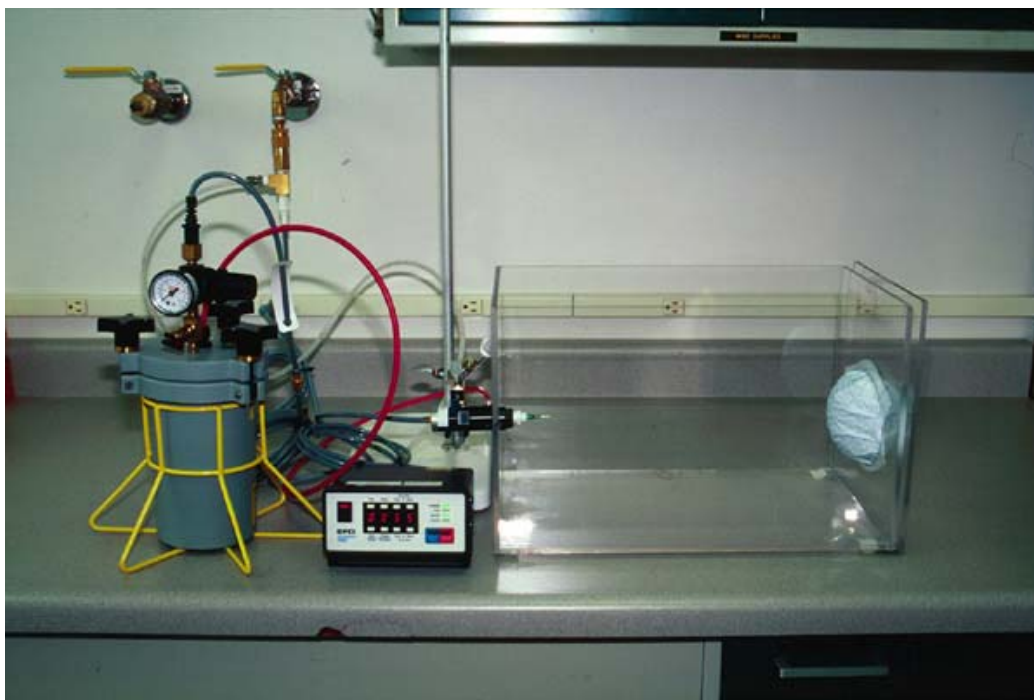


**Figure 4 – Test Cell Used in Viral Penetration Resistance Test**

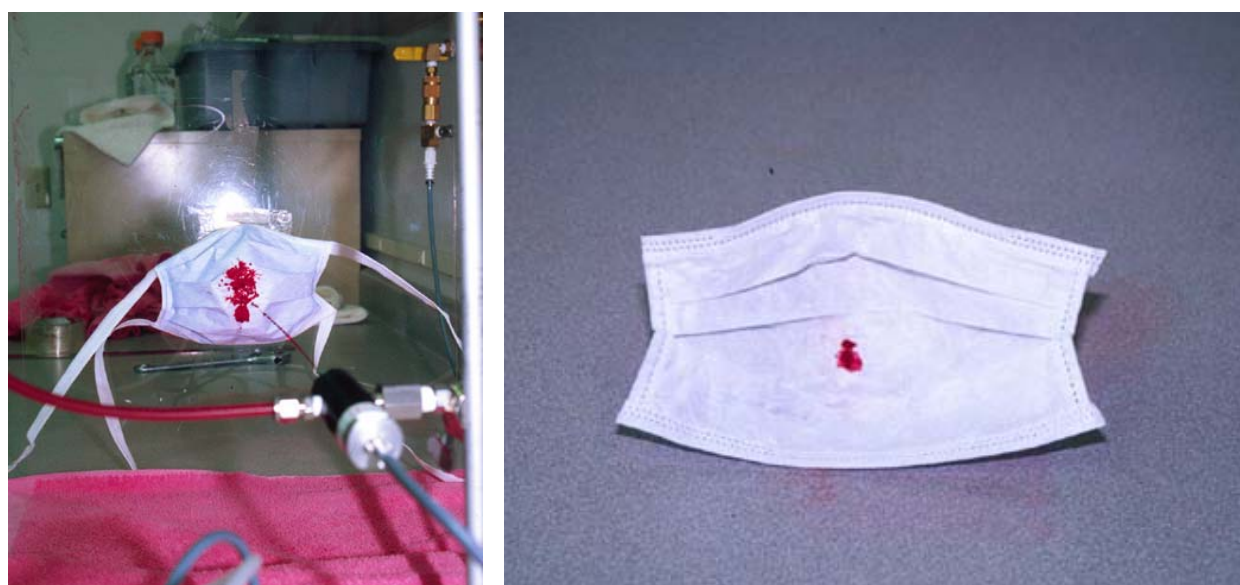
The viral penetration resistance test method (ASTM F1671) has become a fundamental part of the performance criteria for each of the clothing items in NFPA 1999. Modifications of the viral penetration resistance test are applied for testing whole gloves, where the glove is filled with 1000 mL of Bacteriophage challenge and an exterior rinse of the glove is assayed. The test is applied with a pass/fail criterion. Any observed liquid penetration of the Bacteriophage challenge solution or assayed virus, as shown by observed plaques in the culture, is used as the basis for failing a test.

One exception exists for the application of ASTM F1671 for defining EMS protective clothing performance. This exception exists for medical face masks (more commonly known as surgical masks), which must permit sufficient breathability when covering the mouth and nose of emergency first responders. In this test, 2 mL of synthetic blood is projected against the mask using a pneumatic valve at pressures simulating human blood pressure. The synthetic blood is intended to represent actual blood and also to simulate other body fluids in terms of viscosity and surface tension. The standardized test, ASTM F1862 [17], involves testing a large number of masks (at least 32) in order to establish statistical confidence in the results since some variations of passing and failing performance can be found in evaluating a lot of masks. The test procedures define the target area as the center of the mask. Any strikethrough of synthetic blood shows up as a red stain on the interior side of the mask. Figures 5 and 6 show the performance of the test and a representative mask failure.





**Figure 5 – ASTM F1862 Test Apparatus for Evaluation of Synthetic Blood Strikethrough for Masks**



**Figure 6 – Example of Mask Failure in ASTM F1862 Test**

Additional requirements were established to evaluate overall liquid-tight integrity of each protective clothing item. This approach was used because material performance alone was considered insufficient to guarantee that blood and other body fluids did not get through the clothing and onto the emergency responder. Integrity tests were needed to assure that the clothing design was appropriate to prevent inward leakage of potentially contaminated liquids. Thus, depending on the type of clothing item, different types of overall product tests were developed or selected and then applied to the complete clothing item. This approach was further linked to the hazards of blood and other body fluids by choosing test liquids that simulated the low range of surface tension for biological liquids. It was well established throughout industry that ease of liquid penetration was generally a function of liquid surface tension [18].

Garments are evaluated for liquid tight integrity in a shower-like test as specified in ASTM Test Method F1359. In this test, a garment specimen is placed on a manikin and is sprayed from five nozzles with water that is treated with a surfactant to a surface tension of 34 dynes/cm. Figure 7 shows a garment being evaluated. The spray is conducted at a certain volumetric rate and is continued for a specified time. Following the exposure period, the manikin is carefully undressed and a water-markable undergarment is inspected for signs of liquid penetration. Any penetration of liquid constitutes failure of the garment. The standard specifies sealing off interface areas such as the sleeve ends and top of the collar to prevent any liquid penetration through these openings; thus the test becomes more of means for evaluating closure systems and seams to ensure that liquid is channeled away from pathways to the garment interior. The test was originally designed for hazardous chemical liquid splash protective clothing, but was found applicable for emergency medical operations. In the first two editions, an exposure time of 20 minutes was used; however, the exposure period was reduced to 8 minutes. Exposure times are set to permit sufficient time for liquid to leak or wick to the interior so any penetration can be readily distinguished; the test and exposure times do not simulate actual exposure.

Examination gloves are also subject to a liquid tight integrity test. This test involves suspending the glove and filling it with water to beyond the fingers (1000 mL). It has been standardized by the U.S. Food and Drug Administration (FDA) and also as ASTM Test Method D5151 [19]. The method is commonly used as a quality control check for the manufacturing of medical examination gloves. NFPA applies the test to a large number of specimens, but also has modified the test to use surfactant-treated water in lieu of plain water. In the test, gloves are examined 2 minutes after being filled with water for pinhole leaks (Figure 8). Only a small percentage of gloves are permitted to leak. The statistical basis for this qualification comes from the FDA, which has historically established an Acceptable Quality Limit of 1.5 for surgical gloves; this same limit is used for emergency medical gloves in NFPA 1999.<sup>1</sup> The test is applied to examination and cleaning gloves.

The effectiveness of the 1000 mL water leak test has been evaluated for its ability to detect the potential for viral penetration of gloves. A controlled study by the FDA did show that virus might pass through punctured gloves that showed no water leakage [20]. For this reason, the biopenetration for gloves is conducted on whole gloves.

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<sup>1</sup> The Acceptable Quality Limit (AQL) of 1.5 means that rate of sampling is conducted to demonstrate that 1.5% of all tested gloves can be expected to fail when tested according to the evaluation procedures. When a failure is found, the sample size is often expanded to ensure that the failure is not an anomaly.



**Figure 7 – The “Shower Test” as Applied to a Garment to Measure Liquid-Tight Integrity**



**Figure 8 – A Liquid-Tight Integrity Test for Examination Gloves Involving the Suspension of the Glove Filled with Surfactant-Treated Water**

For purposes of evaluating products in NFPA 1999, the ASTM D5151 test was modified to use a surfactant-treated water to achieve a surface tension of 40 dynes/cm in lieu of distilled water. This change was made for consistency with the other techniques that are used in assessing the liquid tight integrity of emergency medical protective clothing based on the established range of blood and body fluid surface tensions [21]. Another change is used with the ASTM D5151 test method applied to footwear covers, in which the footwear cover is filled to within 25 mm (1-inch) of the top of the footwear cover in order to assess overall liquid integrity. This results in the use of a substantial volume of surfactant-treated water that creates a hydrostatic pressure head inside the footwear cover. Similar practices are applied to footwear and work gloves.

Originally, an early form of the projected synthetic blood penetration resistance test, described above, also served as means for evaluating eye and face protection device integrity. In the 2003 edition of NFPA 1999, the synthetic blood projection method is used for evaluating the integrity of all face protection devices. This approach is used because there are no industry integrity methods for evaluating eye and face protection. ANSI Z87.1 [22], which addresses occupational eye and face protection, classifies eye and face protection devices as having splash protection, but does not establish a performance test to assess this property.

Table 1 provides a summary of the different barrier and integrity tests that are applied to emergency medical protective clothing as part of the 2003 edition of NFPA 1999.

**Table 1 – Material Barrier and Product Integrity Tests in NFPA 1999**

<b>Type of Clothing Item</b>	<b>Material Barrier Test Applied</b>	<b>Product Integrity Test Applied</b>
Garments	Viral penetration per ASTM F1671 on barrier layer and barrier layer seams	Liquid integrity test on whole garment per ASTM F1359
Examination Gloves	Modified viral penetration per ASTM F1671 on whole glove	Liquid integrity test on whole gloves (1000 mL) per modified ASTM D5151
Cleaning Gloves	Modified viral penetration per ASTM F1671 on whole glove	Liquid integrity test on whole gloves (1000 mL) per modified ASTM D5151
Work Gloves	Viral penetration per ASTM F1671 on barrier layer and barrier layer seams	Glove worn by test subject and repeatedly clenched in container at 25 mm from top of glove
Face Protection Devices	Viral penetration per ASTM F1671 on barrier layer and barrier layer seams	Projected synthetic blood spray test per ASTM F1862
Footwear	Viral penetration per ASTM F1671 on barrier layer and barrier layer seams	Footwear immersed in tray to 75% of height following flexing
Footwear Covers	Viral penetration per ASTM F1671 on materials representative of footwear cover construction	Liquid integrity test per modified ASTM D5151 with footwear filled to within 25 mm of top

**Barrier Physical Strength and Durability.** Another important principle required by NFPA 1999 was that the barrier material or the clothing item itself had sufficient material strength, physical hazard resistance, and durability to ensure that barrier characteristics of the clothing were maintained over the expected period of use and under the anticipated physical conditions. Early and current editions of NFPA 1999 used a range of physical properties that had been historically applied to the respective products.

Garment materials are evaluated for tensile strength, tear resistance, burst strength, and puncture propagation tear resistance. When these properties were first selected, they were taken from what was then NFPA 1993 [23], a standard that pertained to support function protective clothing for hazardous material operations in the absence of any other information.<sup>2</sup> Few studies were available to adequately define the most appropriate properties or specific levels that could apply to the majority of emergency medical service conditions. The property levels in NFPA 1993 were based on a NFPA committee study where sample garments were worn by individuals through different simulated tasks and a subjective determination was made on the suitability of these materials. The responsible committee chose specific properties and performance levels that were found to accommodate what end users considered acceptable products in the market place; however, the products included in the original NFPA 1993 study were all relatively robust single-use chemical protective clothing items and did not account for any medical products. The NFPA committee first believed that the majority of emergency medical protective clothing would be disposable [10].

The same approach that was applied to hazardous materials protective garment materials for assessing durability was also originally applied to emergency medical protective garments. In this approach, garment materials were subjected to multiple cycles of repeated flexing and abrasion prior to biopenetration resistance testing. The Gelbo flex test (ASTM F 392 [24]) was selected as a rigorous means for ascertaining wear of garment materials as a result of use. In this test, material samples are placed on a test apparatus that reproducibly twists and compresses the sample through a 440 degree rotation and 155 mm (6-inch) stroke. This device is shown in Figure 9. This action replicates wringing the material as if it were a rag. The same samples were then subjected to abrasion using a Wyzenbeek Abrader according to ASTM D 4157 [25] as shown in Figure 10. In this test, a rectangular shaped sample is clamped into a material holder under tension and is rubbed against a drum with an abradant under a specified head pressure for a specified number of cycles. The sample is slightly oversized so that a sufficiently sized specimen can be removed from the abraded and flexed sample for subsequent biopenetration resistance testing.

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<sup>2</sup> Originally, work on NFPA 1999 was undertaken by the Subcommittee on Hazardous Chemicals Protective Clothing, which was the same committee responsible for hazardous chemical protective clothing standards such as NFPA 1991 (vapor-protective ensembles), NFPA 1992 (liquid splash protective ensembles and clothing), and NFPA 1993 (support function protective clothing). The latter standard was intended for decontamination support and work outside the “hot” zone of a hazardous chemical emergency. Since the first edition of NFPA 1999 in 1992, the entire project for fire service protective clothing and equipment was reorganized in January 1995 by the Standards Council. The new project has a Technical Correlating Committee on Fire and Emergency Services Protective Clothing and Equipment and eight technical committees operating within it. The Technical Committee on Emergency Medical Services Protective Clothing and Equipment is now responsible for NFPA 1999.



**Figure 9 – Gelbo Flexing of Material Specimen Showing Sample in Full Twisted and Compressed Condition**

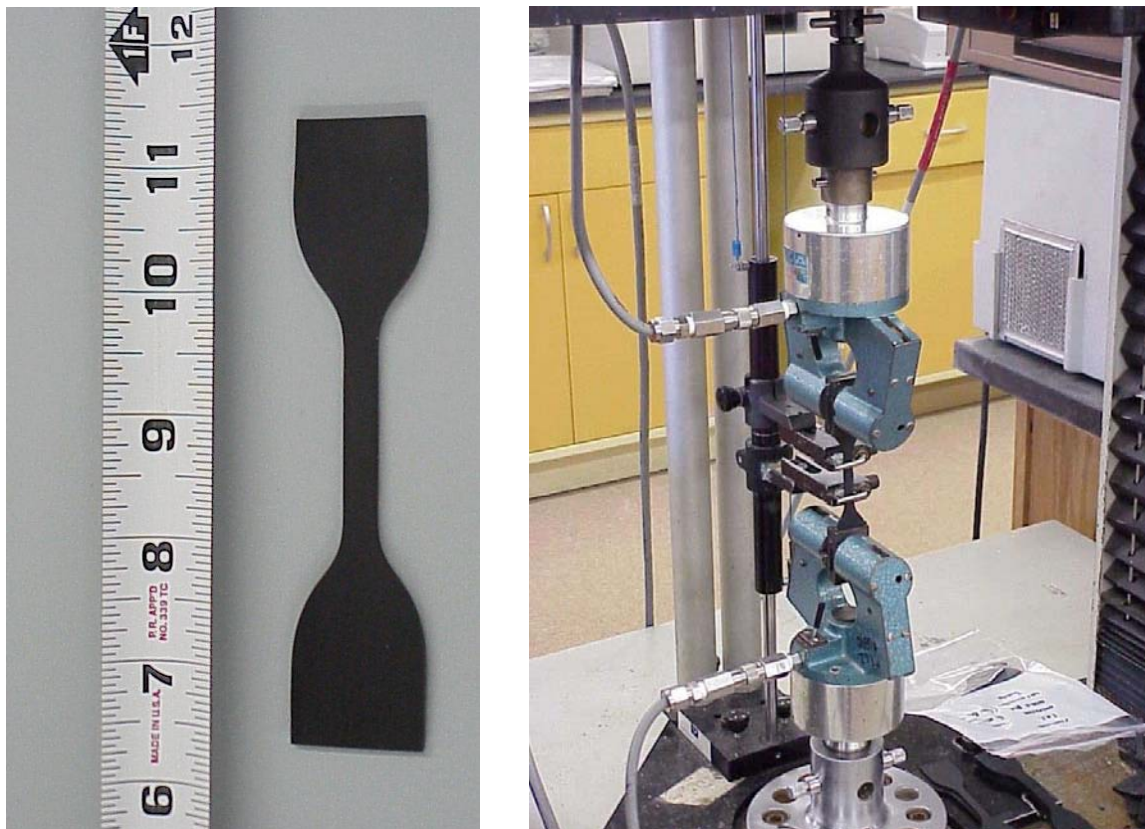


**Figure 10 – Wynzenbeek Abrasion Test Apparatus Applied to Protective Clothing**



In the second edition of NFPA 1999, the NFPA Technical Committee decided to replace the repeated flexing and abrasion preconditioning procedures with 25 cycles of laundering and to make a distinction between single-use and reusable emergency medical protective garments. The laundering was instated to simulate garment wearing but was only applied to garments that were marketed as reusable. Manufacturers that designated their garments as disposable had to label these products as “For Single Use Only.” No specific study was used to justify the changes from flexing/abrasion preconditioning to laundering other than industry experience.

Strength and durability performance properties are also applied to other emergency medical protective clothing products. Examination gloves are tested for tensile strength, elongation, and puncture resistance. Conventional rubber tensile testing practices are applied for both strength and elongation according to ASTM D412 [26]. In this testing, a “dog bone” shaped specimen is taken from the glove and subjected to tensile testing where the force is measured when the specimen breaks as shown in Figure 11. This testing is applied to glove samples both after room temperature conditioning and after heat aging (exposure in an oven for 166 hours at 70°C). The heat aging precondition is intended to simulate the effects from storage under high temperature conditions. Natural rubber and many synthetic elastomeric materials used in gloves are subject to significant changes in breaking strength due to the effects of elevated temperature exposures as may occur when gloves are left in the compartment of a vehicle on a hot weather day [27].



**Figure 11 – Specimen and Test Apparatus Used in Glove Tensile Testing**

Using the same apparatus, the elongation of the glove material is measured at the highest point before it breaks (ultimate elongation). This measurement provides an indication of how much the glove will “stretch” before breaking; it is a key property as it affects potential breakage of the glove when it is donned. This test is applied both after the same heat aging described above and after immersion in isopropanol for 2 hours.

Specific criteria for ultimate strength and ultimate elongation have been set for all examination gloves in NFPA 1999 regardless of the material type. This approach is contrary to industry practice as established in examination glove specifications (ASTM D3578 [28], ASTM D5250 [29], ASTM D6319 [30] and ASTM D6977 [31]) where different ultimate tensile strength and elongation criteria are applied. Table 2 provides a comparison of industry tensile and elongation specifications for examination gloves constructed of different materials.

**Table 2 – Examination Glove Tensile Strength Criteria in Industry Specifications**

Material	Specification	As Received		After Heat Aging	
		Ultimate Tensile Strength (Mpa)	Ultimate Elongation (%)	Ultimate Tensile Strength (Mpa)	Ultimate Elongation (%)
Natural rubber (Type I)†	ASTM D3578	18	650	14	500
Natural rubber (Type II) †	ASTM D3578	14	650	14	500
PVC	ASTM D5250	9	300	Not tested	Not tested
Nitrile	ASTM D6319	14	500	14	400
Neoprene	ASTM D6977	14	500	14	400

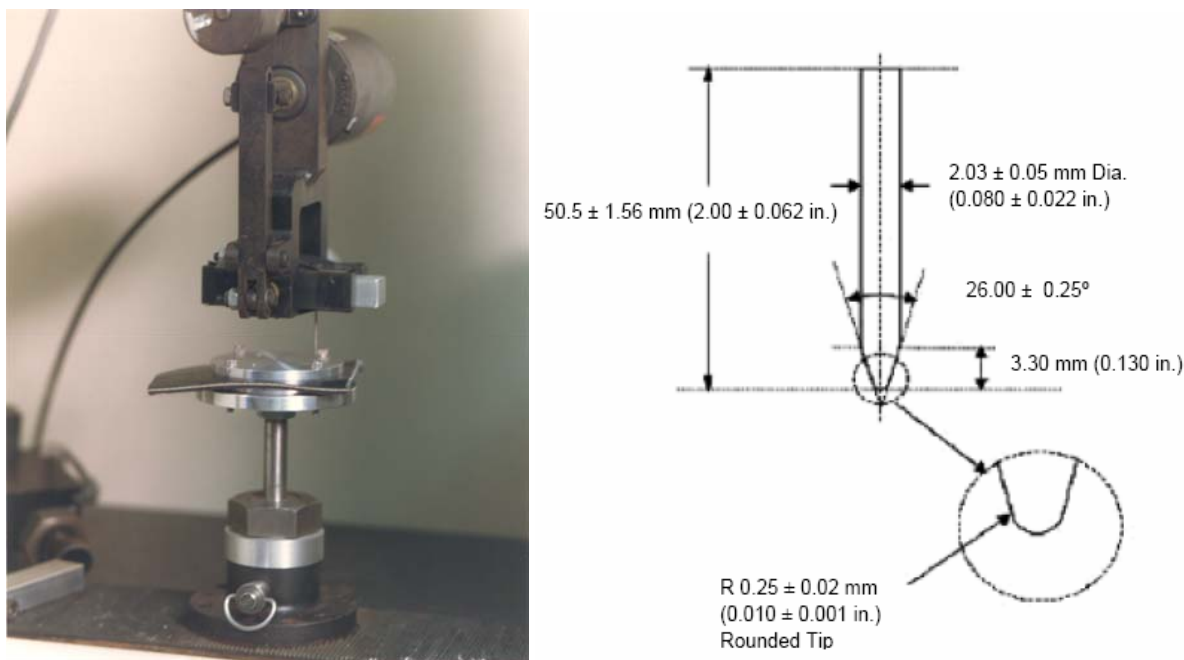
† Type I natural rubber gloves are distinguished from Type II gloves by their relative strength at a specific level of elongation

Examination gloves are also subjected to puncture resistance in accordance with ASTM F1342 [32]. In this test method, the force is measured for pushing a puncture probe through the material that is placed in a holder. The material is not supported, that is, there is nothing directly under the material to represent the mass of a limb or finger. The specific probe that is used in this testing has the geometry shown in Figure 12. This probe geometry is intended to simulate the physical characteristics of a 4d (penny) nail and does not represent the specific “sharp” hazards, such as hypodermic needles as would be encountered in emergency medical operations.<sup>3</sup>

In the introduction of cleaning gloves into NFPA 1999-2003, many of the same physical performance properties were applied as for examination gloves. However, since these gloves were positioned to provide greater physical protection, more rigorous and additional criteria were incorporated.

<sup>3</sup> At the time this report was prepared, work had begun in ASTM F23 Committee on Protective Clothing and Equipment on the development of a needle puncture resistance test method. The new test method is entitled, *Test Method for Protective Clothing Material Resistance to Hypodermic Needle Puncture*.



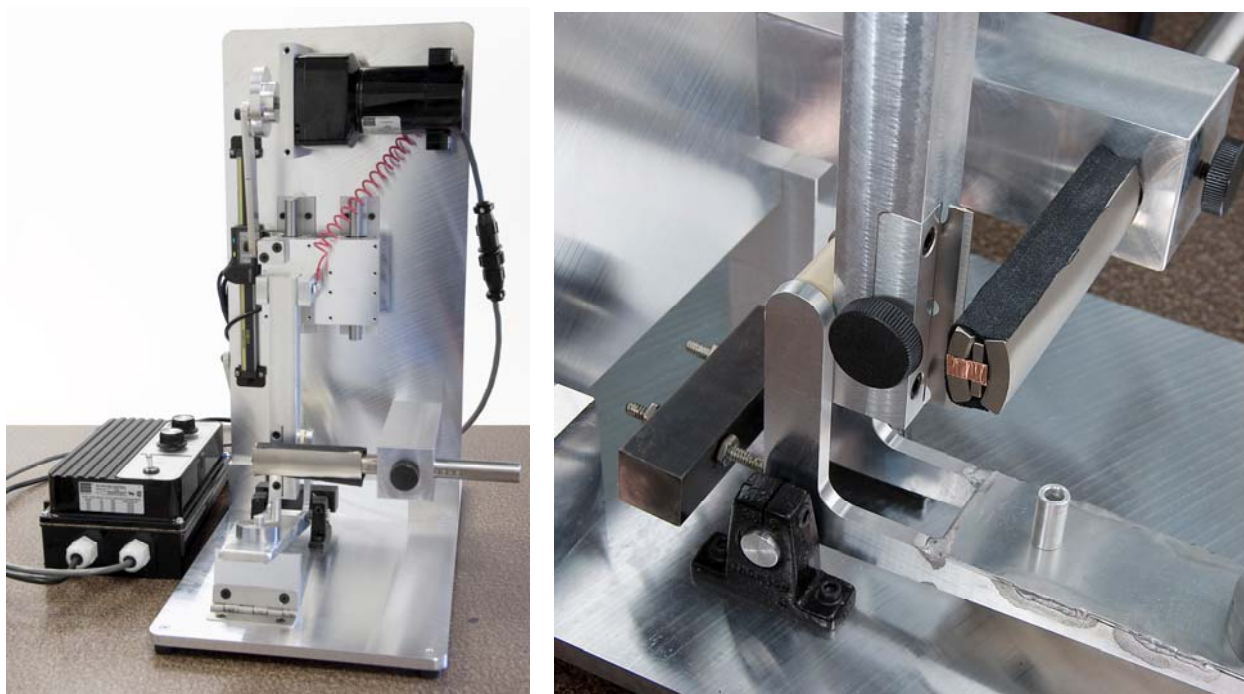


**Figure 12 – Puncture Resistance Test Apparatus and Probe Geometry**

For example, requirements were included for higher tensile strength, lower elongation, and higher puncture resistance based on the expectation that the glove should provide greater physical protection.<sup>4</sup> Additional requirements were added for cut resistance and abrasion resistance. The cut resistance requirement takes into account the likelihood of hand exposure to sharp edges during medical scene or ambulance clean up or other physically hazardous environments where cleaning gloves are chosen. In this test, a special apparatus is used to move a blade across a sample that is mounted on metal mandrel. The apparatus uses a weighted arm for positioning the blade above the sample as shown in Figure 13. The weight of this arm can be adjusted to simulate different cut hazards. The distance that the blade travels before cutting through the material specimen and contacting the metal mandrel is measured. A criterion of 25 mm of cut distance has been established in ASTM F1790 [33] as a distance for discriminating cut resistance performance of materials [33]. In the NFPA 1999 testing, a weight of 60 grams is used for cleaning gloves. When this test is applied to other EMS protective clothing items, such as work gloves, footwear covers, and footwear, different weights are used (200, 25, and 400 grams, respectively).

The abrasion test that is applied in NFPA 1999 to cleaning gloves is what is referred to as the rotary platform, double head abrasion test or Taber test (D3884) [34]. In this test, a circular specimen of the glove material is placed on a platform, which rotates under two weighted arms that hold abrasive wheels (see Figure 14). The wheels roll on the material specimen in a circular pattern until wear-through of the material is observed. The number of cycles for wear-through is used as the end point of the test. Unfortunately, in the 2003 edition of NFPA 1999, the weight on the test arms was not specified.

<sup>4</sup> The lower ultimate elongation requirement was based on the fact that a more physically robust material would not have the same “stretch” as an examination glove.



**Figure 13 – Cut Resistance Test Apparatus and Close-Up of Test Blade**



**Figure 14 – Taber Abrasion Test Method used for Cleaning Gloves**

In the case of emergency medical work gloves, many of the same physical criteria that are applied to rescue gloves in NFPA 1951 [35] are selected as criteria in NFPA 1999. These include puncture resistance, cut resistance, and abrasion resistance using the same general procedures as applied to cleaning gloves; however, levels for each of these properties are set much higher than for cleaning gloves. Similarly, durability is assessed for overall liquid integrity and biopenetration by laundering of the gloves prior to the application of the integrity and barrier test. In this case, NFPA 1999 specifies laundering of gloves for 10 cycles using the same washing and drying conditions that are specified for multiple-use garments.<sup>5</sup>

Emergency medical footwear is subjected to different physical tests depending on the area of footwear being tested:

- The footwear upper is evaluated for cut resistance (ASTM F1790), puncture resistance (ASTM F1342), and abrasion resistance (ASTM D3884).
- The footwear toe is tested for impact and compression resistance (ANSI Z41 [36])
- The outer sole is tested for puncture resistance (ANSI Z41), flex fatigue (based on NFPA procedure), and abrasion resistance (ASTM D1630 [37]).

Footwear durability is addressed through an old Footwear Industries of America test method that entails repeatedly flexing the footwear for 100,000 flexes.

Footwear covers, also introduced in the 2003 edition of NFPA 1999 were positioned as a disposable or single-use item to be worn over regular footwear for liquid protection of primary footwear. The concept applied in establishing these criteria was to rely on some physical and durability properties so that the cover would remain intact during expected use. Performance criteria include cut, puncture and abrasion resistance on the primary construction material and a separate puncture test on the wear surface material.<sup>6</sup>

The 2003 edition of NFPA 1999 did not apply any specific physical property or durability criteria to face protection devices. Table 3 provides an overview of the physical hazard resistance and durability criteria that exist in the 2003 edition of NFPA 1999.

**Tradeoffs for Protection and PPE Comfort/Functionality.** The wearing of any PPE encumbers the end user and results in different tradeoffs of comfort, functionality, and other human factors related to clothing use. Thus in setting barrier and physical performance requirements, the committee endeavored to implement where possible specific criteria either through design or performance aspects of product use that partly bound protection properties. The following are examples of how these tradeoffs were established for emergency medical protective clothing with respect to comfort and functionality performance.

**Table 3 – Overview of Physical Hazard and Durability Requirements Applied to**

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<sup>5</sup> Originally, this requirement was set at 25 cycles, but was later changed by amendment to 10 cycles.

<sup>6</sup> The wear surface is the portion of the footwear cover that comes into contact with the floor or walking surface.

### EMS Protective Clothing in NFPA 1999 (2003 Edition)

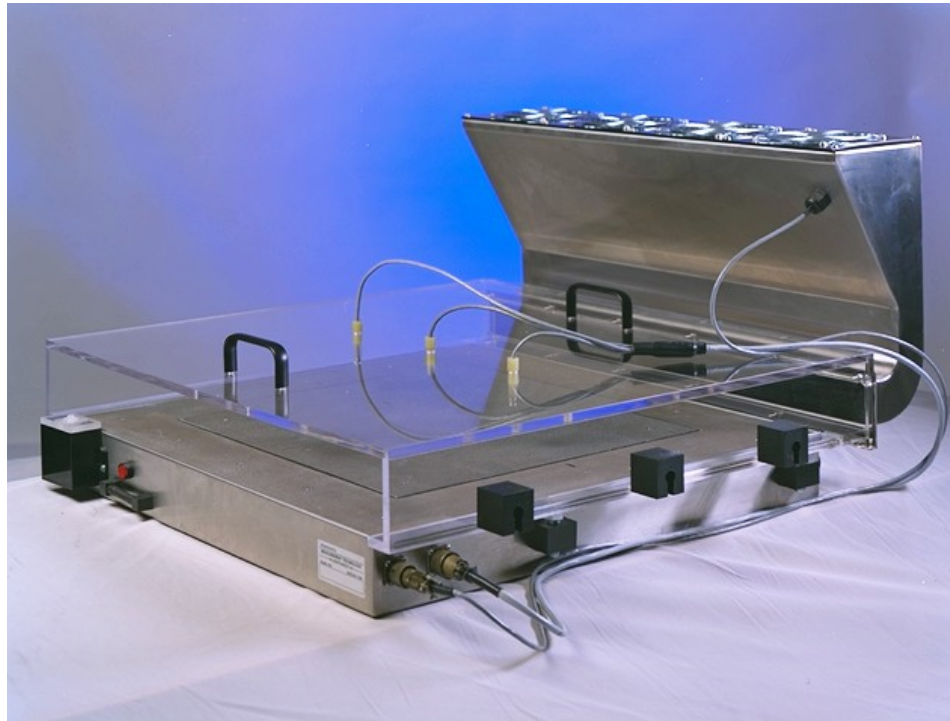
Property	Test Method	Garment (single use)	Garment (multiple use)	Examination gloves	Cleaning gloves	Work gloves	Footwear upper	Footwear toe	Footwear sole	Footwear cover
Tensile strength (grab)	ASTM D751	◆	□							
Burst strength (Mullen)	ASTM D751	◆	□							
Puncture propagation tear resistance	ASTM D2582	◆	□							
Tear resistance (trapezoidal)	ASTM D5598	◆	□							
Seam/closure strength	ASTM D751	◆	□							
Ultimate tensile strength	ASTM D412			□	□					
Ultimate elongation	ASTM D412			□	□					
Puncture resistance (clothing/gloves)	ASTM F1342			◆	◆	□	◆			◆
Puncture resistance (footwear sole)	ANSI Z41								◆	◆
Cut resistance	ASTM F1790				◆	□	◆			◆
Abrasion resistance (Taber)	ASTM D3884				◆	□	◆			
Abrasion resistance (Footwear abrader)	ASTM D1630								◆	◆
Impact and compression resistance	ANSI Z41							◆		
Laundering durability (25 cycles)	NFPA procedure		◆							
Laundering durability (10 cycles)	NFPA procedure					◆				
Heat aging	ASTM D573			◆	◆					
Isopropanol immersion	NFPA procedure			◆	◆					
Glove flexing	NFPA procedure			◆	◆					
Footwear flexing	FIA 1203						◆			

◆ Requirement applied without special preconditioning (other than room temperature conditioning)

□ Requirement applied follow one or more special preconditions

In 2003, a total heat loss test requirement was added for garments. The total heat loss test measures conductive and evaporative heat loss from a material that is related to the stress and comfort wearing

properties of garments. The test involves a guarded hot plate that is heated to skin temperature, saturated with water, and covered with a permeable material that allows vapor to pass through, simulating human sweating (see Figure 15). The hot plate and specimen are placed in an atmospheric chamber, where the air temperature, relative humidity, and air velocity are tightly controlled. First, the resistance to evaporation of water vapor is measured for the bare plate. Then a test is conducted with the material specimen on top of the plate. The evaporative resistance is measured by relating the power needed by the plate for maintaining a constant temperature to the difference in water vapor pressure in the atmospheric chamber and the pressure at the plate surface.



**Figure 15 – Test Apparatus for Total Heat Loss Test**

Gloves are assessed for minimum dexterity to prevent products from being overly robust. In the case of examination gloves and cleaning gloves, the Crawford Small Parts Dexterity Test [38] is used. In this test, test subjects perform a series of inserting small screws into a test board using a screwdriver. The testing is conducted both with and without gloves after a sufficient learning period has been provided to establish subject familiarity with the required hand functions. The impact of gloves on wearer dexterity is assessed through the degradation of the test time that takes place in comparing gloved trials with bare-handed trials. A similar test, the Bennett Dexterity Test, is used where test subjects are timed in placing smooth steel pins in a pegboard per ASTM F2010 [39] for work gloves as shown in Figure 16. These pins are considerably larger than the small screws that are used in the small parts test and are inserted by hand.





**Figure 16 – Bennett Dexterity Test Being Performed on Work Gloves**

Both examination gloves and cleaning glove materials are subjected to determinations of latex protein content using a standardized test protocol established in ASTM D5712 [40]. It is well established that a significant proportion of the population has allergic reactions to latex rubber, sometimes causing severe anaphylaxis [41-42]. In the early 1990s, the U.S. Food and Drug Administration started regulating claims by manufacturers with respect to latex content, particularly as they related to product labeling. Based on this information, the committee decided to create a minimum performance criterion in which a limit of 50  $\mu\text{g/g}$  was established as the maximum level of latex protein for both examination and cleaning gloves.

Another case of a human factors test is the ability of a test subject to see clearly through an item of facewear. The test subject's visual acuity is checked while wearing any face protection device that covers the eyes.

The outer soles of footwear and wear surface of footwear covers are checked for traction using a test method (ASTM F489 [43]) that measures the coefficient of friction of the footwear material (sole or wear surface) against a flat vinyl composition tile surface. The test is conducted under dry conditions.

Table 4 provides a summary of the different requirements in NFPA 1999-2003 that pertain to human factors evaluation and comfort properties.

**Table 4 – Human Factors and Comfort Related Tests Applied to  
EMS Protective Clothing in NFPA 1999 (2003 Edition)**

<b>Type of Clothing Item</b>	<b>Properties Measured</b>	<b>How Measured</b>
Garments	Total heat loss	Per ASTM F1868, Procedure C on overall composite (all garment layers)
Examination gloves	Dexterity	Crawford Small Parts Dexterity Test
	Protein Levels	Per ASTM D5712
Cleaning gloves	Dexterity	Crawford Small Parts Dexterity Test
	Protein Levels	Per ASTM D5712
Work gloves	Dexterity	Modified pegboard test per ASTM F2010
Face protection devices	Visual acuity	Use of Snelling eye chart for individuals with corrected vision while wearing face protection device
Footwear	Traction (coefficient of friction)	Per ASTM F489
Footwear covers	Traction (coefficient of friction)	Per ASTM F489

Unfortunately, the NFPA committee found decisions for these tradeoffs to be difficult in that a too generous requirement did little to address clothing impact on the wearer while a too rigorous requirement created constraints on available product technologies.

### **Revision Process for NFPA 1999**

NFPA standards are subject to revision at least every 5 years. The revision process consists of several steps that begin with the conclusion of the past revision and conclude with the approval of the new edition. For the NFPA project on Fire and Emergency Services Protective Clothing and Equipment, these steps include:

1. Solicitation of public proposals for revision of the standard
2. Action on proposals by the relevant NFPA Technical Committee
3. Review of Technical Committee actions on proposals by the Technical Correlating Committee
4. Publication of the Report on Proposals (ROP)
5. Solicitation of public comments on the draft standard (ROP draft)
6. Action on comments by the NFPA Technical Committee
7. Review of Technical Committee actions on comments by the Technical Correlating Committee
8. Publication of the Report on Committees (ROC)
9. Notice of intent to submit motions at the NFPA Annual Meeting
10. NFPA membership review of the ROC
11. NFPA Standards Council review of the ROC
12. Publication of the revised standard

When one revision cycle is concluded, the standard automatically becomes open to suggestions for changes from the public. The NFPA process permits recommendations to come from any individual whether a member of NFPA or not. Specific suggestions for changes in the standard are submitted in the form of “public proposals.” Public proposals must follow a specific format where the specific section of the standard is identified along with a recommended change and justification for the change. Approximately 2½ years following the promulgation of the existing edition, NFPA formally solicits public proposals and establishes a closing date by which all public proposals must be received.

Following the closing date for public proposals, a meeting of the NFPA Technical Committee (TC) is held to review and act on all public proposals. This review may encompass more than one meeting but generally must be concluded approximately 6-7 months following the public proposal closing date. In the review of public proposals, the Technical Committee must decide to accept, accept in principle, accept in part, or reject each public proposal. The committee itself may propose its own changes to the standard that differ from those submitted from the public. As result of these actions, the existing standard is revised into a new draft that includes the accepted public proposals and other changes agreed to by the committee. The ROP draft and proposal actions are submitted to a letter ballot of the Technical Committee. A 2/3 majority is required.

After acting on each of the public proposals, the specific actions are forwarded to the NFPA Technical Correlating Committee (TCC) on Fire and Emergency Services Protective Clothing and Equipment. As part of the their review on the public proposals, the TCC may make provide notes on the Technical Committee’s actions for issues that the Technical Committee should consider in further development of the standard.<sup>7</sup> The TCC notes and Technical Committee actions are submitted to a letter ballot of the TCC where a 2/3 majority is required for the standard to advance. The TC actions and TCC notes are then published with the draft revised standard as the Report on Proposals (ROP). The availability of the ROP is announced on the NFPA website as well as other forums and sent to anyone requesting a copy.

A period for public comments is established with the availability of the ROP and permits additional outside review of the standard. During this time, anyone can submit comments for changes to the draft, revised standard. As with public proposals, the suggested changes must be in a form that clearly identifies the affected section(s), shows the specific change, and provides a statement on the substantiation of the change. The public comment period is approximately 2 months long.

With the receipt of the public comments, one or more meetings of the Technical Committee are held to review and act on each comment in a manner similar to the handling of the public proposals. The exception is that the committee can decide to hold a comment which it believes it cannot fully consider because further study is needed. Comments that are held automatically become proposals for the next revision of the standard. Based on this review, the Technical Committee compiles a list of actions for all the received public comments.

The TCC then reviews the Technical Committee actions and can modify certain actions that it believes are not in correlation with other relevant standards. The actions of the TCC together with

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<sup>7</sup> The Technical Correlating Committee is generally responsible for the scope, definitions, and certification sections of NFPA PPE standards. It further ensures consistency with requirements with other NFPA PPE standards as appropriate.



the actions of the Technical Committee are published as the Report on Comments (ROC). Unlike the ROP, the committee does not assemble a new revised draft of the standard, which in this case reflects the accepted comments; instead the ROC includes the draft published in the ROP together with the actions on the comments so that the NFPA membership can review how the standard will be modified.

The ROC is then published. NFPA members that are dissatisfied with the handling of the public comments may file an intention to make a motion at the NFPA annual meeting. This action permits the member to raise the specific issue at the Annual NFPA membership meeting that is held every June. If a specific motion is raised, the issue is debated on the floor and subject to a vote by the NFPA members present. A 2/3 majority is required for the motion to carry. Normally, NFPA standards are not debated at the annual meeting because most of the details of interest are handled by the Technical Committee and TCC. In fact, if no notices of intent to make a motion at the NFPA Annual meeting are filed, then the standard will be automatically approved.

Following the NFPA Annual Meeting and handling of any motions, the record for the development of the standard is reviewed by the NFPA Standards Council. The council then decides whether to issue the standard.<sup>8</sup> A promulgation date of a couple of weeks after the Standards Council meeting is usually set for the standard.

Since NFPA follows a defined schedule, specific dates are known in advance and constitute important deadlines for the standards development/revision process. The specific dates relevant to 2008 edition revision for NFPA 1999 are shown in Table 5.

**Table 5 – Revision Schedule for 2008 Edition of NFPA 1999**

<b>Standards Development Step</b>	<b>Date</b>
Closing date for public proposals	December 2005
Final TC meeting to finalize actions on public proposals and to prepare revised draft of standard	May 2006
TCC review of TC actions on public proposals and draft standard	October 2006
Publication of ROP	December 2006
Opening of public comment period	January 2007
Closing of public comment period	March 2007
Final TC meeting to finalize actions on public comments	May 2007
TCC review of TC actions on public comments	June 2007
Publication of ROC	September 2007
Deadline for intent to file a motion at annual meeting	October 2007
If no motions, Standards Council meeting to review record of standards development	January 2008
If no motions, promulgation of standard	February 2008

In some cases, recommendations may address changes to the standard that are of an emergency nature. These changes are considered for Tentative Interim Amendments (TIAs) and are submitted

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<sup>8</sup> One reason that the Standards Council might not issue a standard is that an appeal is raised on the proper development of the respective standard.

as a petition to the NFPA Standards Council. The Standards Council solicits public review of any proposed TIAs. Both the TC and TCC review and vote on the technical merit and emergency nature of the proposed amendment and the Standards Council uses this information together with the public input to determine whether the amendment should be issued.

In the case of NFPA 1999, there have been two amendments:

1. An amendment was made in September 2005 to address changes in the conditioning of work gloves prior to barrier testing to better reflect the intended service life of the gloves.
2. A second amendment was issued in January 2006 to correct problems with the criteria applied to cleaning gloves. Specifically, a more appropriate dexterity test was substituted for the then current test and adjustments were made in the physical property criteria.

The latter amendment was made in recognition of certain limitations for some of the criteria within the standard. The subject project represents an attempt to further research those limitations and make corrections to other requirements in the standard for specific PPE items.

### **Industry Reaction to NFPA 1999**

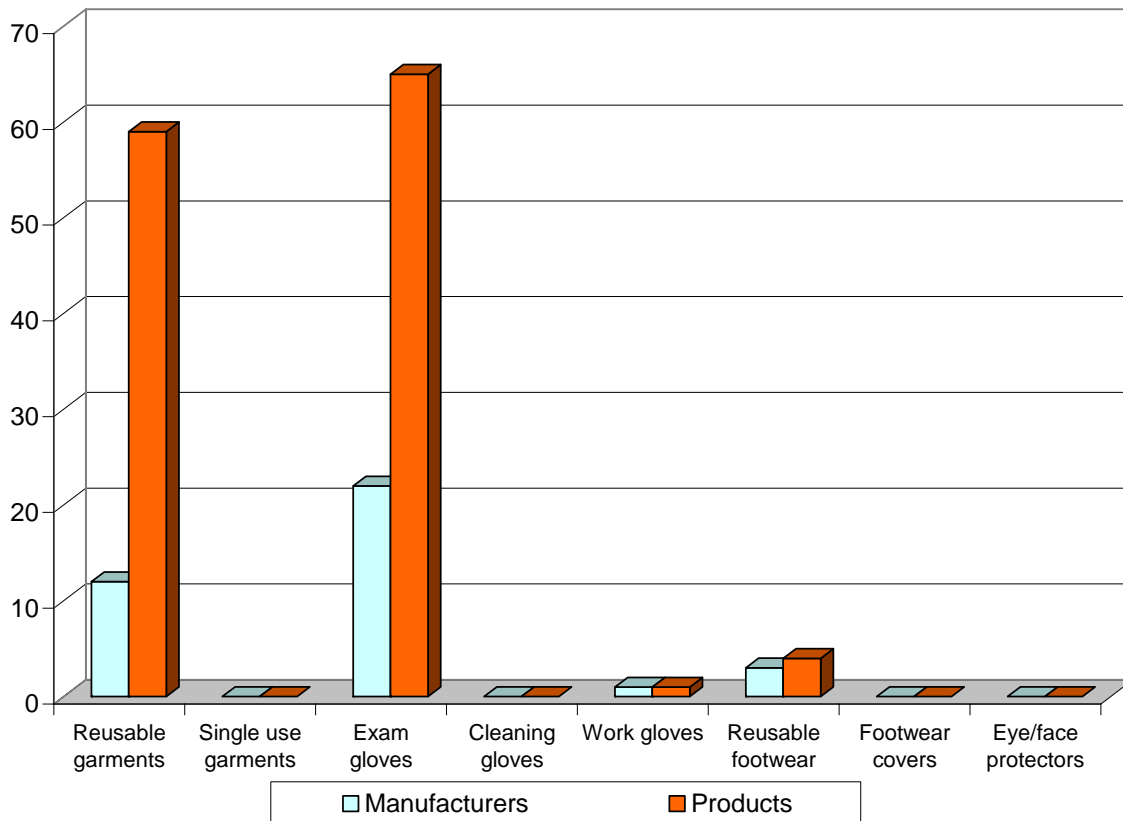
The 2003 edition of NFPA 1999, *Standard on Protective Clothing for Emergency Medical Operations*, added a number of new product categories to address the protective needs of first responders during emergency medical operations. Included as these new items were footwear, footwear covers, work gloves, and cleaning gloves that were added to supplement the existing categories of examination gloves, garments, and eye/face protective devices. Table 6 shows the range of protective clothing items covered in NFPA 1999-2003. These choices were created to afford first responders the ability to select appropriate clothing items based on the perceived risks of the emergency medical service being provided.

**Table 6 – Range of Protective Clothing Addressed in NFPA 1999 (2003 Edition)**

<b>General Type</b>	<b>Specific Type</b>	<b>Intended Service Life</b>
Garments	Disposable garments, partial or full body*	Single use
	Reusable garments, partial or full body*	Multiple uses
Gloves	Examination gloves	Single use
	Cleaning gloves	Single use
	Work gloves	Multiple uses
Face protection devices	No breakdown of types is provided	Not specified
Footwear	Footwear covers (boot height)	Single use
	Full foot and ankle footwear	Multiple uses

\* Specified by the manufacturer

While the 2003 edition of the standard had been available to the industry for over 3 years and a number of products had been certified to this standard at the time this study had been initiated, there were no certifications of cleaning gloves or single use protective garments to NFPA 1999. In addition, there has been relatively little industry response to face protection devices, work gloves, and footwear. In fact, most of the certifications that have taken place for either footwear or work gloves have been the results of multiple certifications of the same products to different NFPA standards and not specifically to NFPA 1999. Figure 17 depicts current levels of product certification to NFPA 1999 by the two leading certification organizations – Underwriters Laboratories and Safety Equipment Institute. Feedback from industry and those manufacturers that could provide products for consideration has indicated that some of the criteria are not commensurate with the types of products that first responders typically use or need. The lack of certification for products that were knowingly being used and selected as part of emergency medical operations became a major impetus for this project.



**Figure 17 – Number of Certified Manufacturers and Products According to NFPA 1999 as of March 2006**

## **STUDY OBJECTIVES**

The objective of this project was to support the improvement of criteria for specific types of emergency medical personal protective equipment that are used by first responders. This objective specifically was defined to cover single use garments, cleaning gloves, footwear covers, and eye/face protection devices. A secondary objective of the project was to support the NFPA Technical Committee on Emergency Medical Services Protective Clothing and Equipment in its standards development process for modification of NFPA 1999 during its 2008 revision process. The project was intended to provide technical support for the committee to justify changes to the standard, particularly as related to changes in performance criteria.

The translation of the project objectives into criteria that measure its success included:

1. The identification and documentation of specific end user information related to protection during emergency medical services.
2. The development of specific PPE criteria in response to emergency medical first responder protection needs.
3. The modification of criteria for selected areas of PPE that permit certification of products that meet first responder protection needs (as quantified by the number of certified products in the relevant product categories with NFPA 1999).

## **STUDY APPROACH**

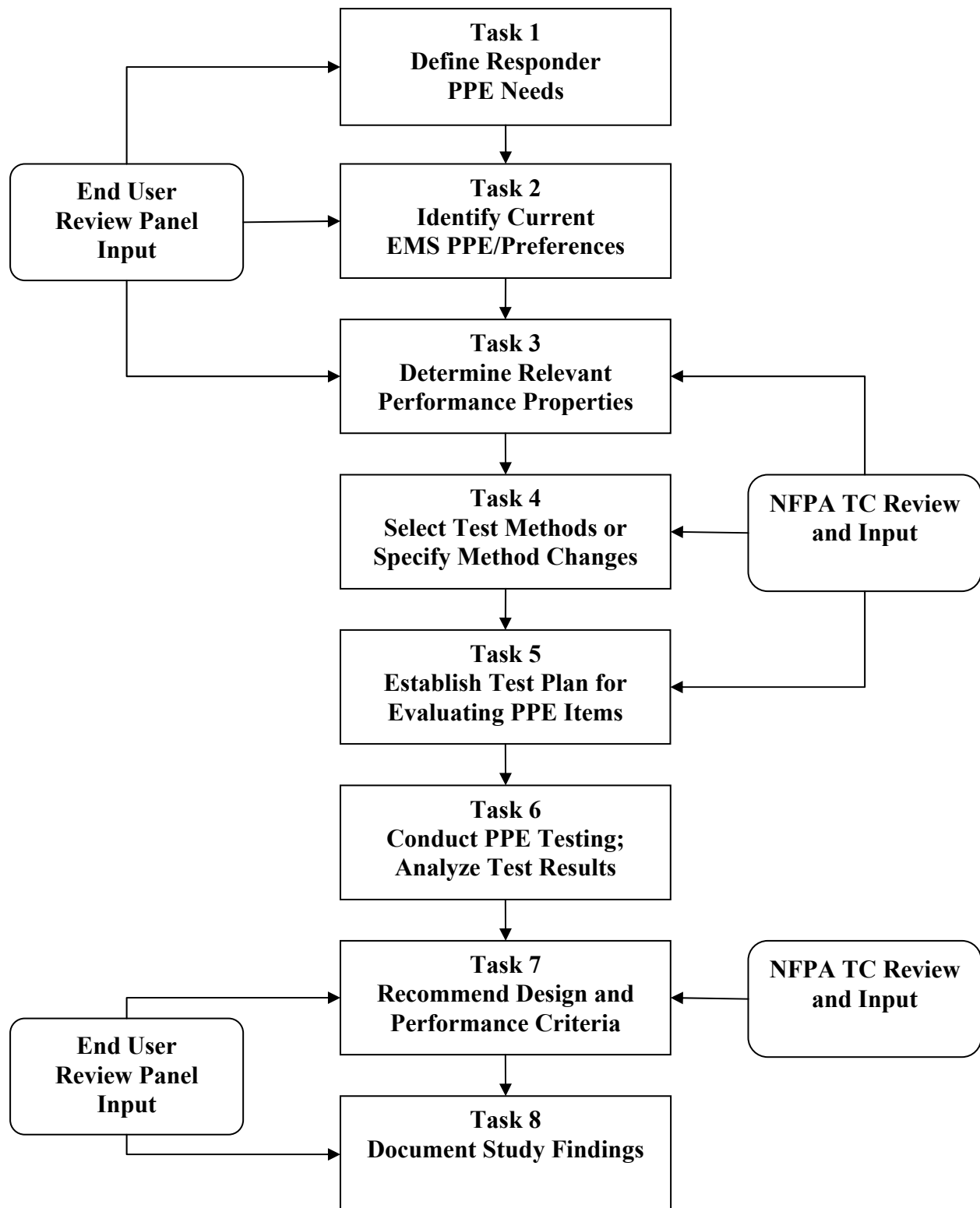
### **Overview of Approach**

New criteria and changes to existing criteria for selected categories of emergency medical protective clothing in NFPA 1999 were determined by examining protection needs based on end user input together with specific end user experience with different types of products. Some of this interaction occurred through participation with end user groups, at NFPA meetings, and through selected interviews. Relevant performance properties were determined by matching needed product performance with specified hazards identified by end users in the delivery of medical aid. For example, protection needs and product durability were established based on end user qualification of sample product performance under a variety of work environments. This information was then used to identify appropriate tests, and product testing was carried out to determine if the selected tests discriminated material performance consistent with end user field observations. If tests were found to provide results that were inconsistent with field observations, then the selected tests were either modified or different tests were identified. Recommendations of specific performance levels were based on end user experience with a range of products representing the span of product characteristics.

## **Project Tasks**

In order to provide support to the NFPA Technical Committee on Emergency Medical Operations Protective Clothing and Equipment, a series of investigations was undertaken that provided the basis for recommending specific, appropriate criteria for the protection of first responders during emergency medical operations. These investigations determined the specific hazards faced by first responders, the first responders' use of various forms of personal protective equipment against emergency medical hazards, and the features and properties of specific PPE necessary to protect against these hazards; in addition, testing of products was performed to assist in recommending performance requirements. The specific project tasks undertaken in this study, shown in Figure 18, included the following:

1. Determine first responder use and needs specific to cleaning gloves, single use garments, footwear covers, and eye/face protection devices to determine specific hazards faced by first responders during emergency medical operations and PPE product features of these items that are needed for protection.
2. Identify current products in use or products which could be used that first responders consider acceptable and unacceptable as a range of products for evaluation.
3. Determine the specific properties associated with cleaning gloves, single use garments, footwear covers, and eye/face protection devices that can be assessed or measured for providing protection against the specific hazards identified by user input (Task 1).
4. Select available test methods that can be investigated to assess or measure the specific properties identified in step 3. Determine the parameters associated with those test methods and determine if modifications are necessary to apply the specific test methods to the emergency medical protective clothing listed in Task 1.
5. Establish a test plan to evaluate the products identified in Task 2 using the methods selected or modified in Task 4.
6. Carry out the test plan and analyze the findings from the testing to determine if the selected test methods discriminate product performance consistent with field expectations. Modify the tests and repeat the process of applying the modified tests to products, as necessary.
7. Prepare recommended design assessment and performance criteria to address the specific hazards, performance properties, and test methods reviewed in this study.
8. Document study findings in a report that is suitable for presentation to the NFPA Technical Committee on Emergency Medical Operations Protective Clothing and Equipment, and as a separate technical publication.



**Figure 18 – Project Technical Approach and Tasks**

## **Interaction with End Users and NFPA Technical Committee**

Figure 18 shows that input in the execution of several tasks came from an End User Review Panel and the NFPA Technical Committee (TC) on Emergency Medical Service. This input was essential to provide appropriate understanding and direction with respect to end user needs and PPE use practices along with specific objectives of the NFPA Technical Committee. Additional detail on the end user review panel is provided in a later section. Continued interaction with the NFPA Technical Committee during the study allowed communication of specific project findings with the committee, thus affording information to support specific decisions with respect to product criteria and testing methods. These periods of interaction were linked to the standards development schedule for NFPA 1999, but also occurred primarily at technical junctures of the project.

## **Specific Details on Individual Tasks**

**Task 1 – Definition of EMS Responder PPE Needs.** First responder use and needs specific to cleaning gloves, single use garments, footwear covers, and eye/face protection devices were identified through interviews to determine specific hazards faced by first responders during emergency medical operations and PPE product features of these items that are needed for their protection. Information was gathered from a selected number of organizations representing the range of providers for emergency medical services. As will be described in the sections below, it was found that different PPE practices for EMS occur both geographically (due to climate) as well as by the type of organization. Emergency medical services are provided by a number of different organizations:

- Fire-Department based EMS that provides aid and then transport
- Fire-Department based EMS with private ambulance services providing transport
- Separate public EMS departments
- Public EMS through Fire Department or separate department, with private ambulance services providing back-up if needed
- Private, for-profit ambulance services as primary responders

Interviews were aimed at characterizing the specific information with respect to each department:

- The department's mode of delivering EMS services
- The level of emergency medical service provided (basic, intermediate, advanced)
- The call volume for the organization, including estimates for a breakdown in the activity by type of response
- Specific practices for using PPE
- Process for PPE selection
- Types of PPE and adequacy in performing emergency medical services, including specific attributes for how PPE does or does not provide protection
- Instances of PPE issues or problems
- Levels of compliance with NFPA 1999 and other standards
- Other factors affecting PPE selection and use

The collection of information was focused on the 4 primary categories of concern but also included details on each type of PPE used by the organization, in order to gain a better understanding for why an organization might choose different garments (single versus reusable), gloves (exam, cleaning, or work), or footwear (covers versus boots or shoes).

The interviews were performed one-on-one and required two or more sessions with each organization and the involvement of different personnel from each organization to obtain the necessary information.

**Task 2 – Identification of Current EMS PPE and Preferences.** Simultaneous to Task 1, current products in use or products that could be used in each product category were identified through a review of industry information and data received during the interview. The interviews described in the Task 1 description were a key means for gathering detailed information on product use as reflected by the posed questions. In this review of PPE use and practices, an assessment was made to define the types of PPE in use and the preferences for different types of equipment by emergency responders. The purpose for gathering this information was to list several candidate products for evaluation against specific recommended criteria. Products in this list included products considered acceptable (in terms of certain performance areas) as well as products that were either found inappropriate or known to have performance limitations. Product lists were compiled in the following areas:

- Reusable garments
- Limited use garments of different designs (coveralls, smocks, aprons, sleeve protectors and footwear covers)
- Cleaning gloves, including some gloves considered too thin to be used for cleaning applications
- A variety of different eye and face protection devices (medical face masks, safety glasses, faceshields, respirator facepieces, and other items)

The identification of specific products was undertaken to represent different types or classes of products as opposed to keying on certain manufacturer-specific items. For each type or class of product, specific end user criticisms or recognition of limitations were compiled.

**Task 3 – Determination of Relevant PPE Attributes and Properties.** The specific properties associated with cleaning gloves, single use garments, footwear covers, and eye/face protection devices that can be assessed or measured for providing protection against the specific hazards were determined primarily from information gained from the end user organization interviews, but also based on feedback from the NFPA Technical Committee. For each generic product design and performance requirement identified in Task 1, one or more corresponding properties were identified (see Table 7). For example, in determining the need for limited durability of single use garments to prevent ripping and tearing during an individual use in an outdoor, roadside environment, relevant properties identified were burst and tear resistance. Applicable design attributes were also determined for product features that do not lend themselves to testing or measurement. Information from the end user organizations was used to identify other performance properties or design attributes not covered in the standard but considered important for product use.



**Table 7 – Current Performance Criteria Applied to Selected  
EMS Product Categories in NFPA 1999 (2003 Edition)**

<b>Property Category</b>	<b>Type of Sample</b>	<b>Performance Property</b>	<b>Test Method</b>
Cleaning Gloves	Whole item	Overall integrity	ASTM D 5151
	Whole item	Viral penetration resistance	ASTM F 1671*
	Glove material	Tensile strength/elongation	ASTM D 412**
	Glove material	Puncture resistance	ASTM F 1342
	Glove material	Cut resistance	ASTM F 1790
	Whole item	Dexterity/hand function	NFPA test method
	Glove material	Protein content	ASTM D 5712
	Glove material	Chemical permeation resistance	ASTM F 739
	Glove material	Abrasion resistance	ASTM D 3389
Garments (single use)	Whole item	Overall integrity	ASTM F 1359
	Barrier material	Viral penetration resistance	ASTM F 1671
	Garment material	Tensile strength	ASTM D 751
	Garment material	Burst strength	ASTM D 751
	Garment material	Puncture propagation tear res.	ASTM D 2582
	Garment material	Tear resistance	ASTM D 5733
	Garment seams	Seam strength	ASTM D 751
	Garment closures	Closure strength	ASTM D 751
	Garment material	Water repellency	AATCC 22
	Garment material	Total heat loss	ASTM F 1868
Footwear covers	Cover material	Cut resistance	ASTM F 1790
	Cover material	Puncture resistance	ASTM F 1342
	Wear surface	Abrasion resistance	ASTM D 1630
	Wear surface	Puncture resistance	ANSI Z41
	Wear surface	Slip resistance	ASTM F 489
	Barrier material	Viral penetration resistance	ASTM F 1671
	Whole item	Overall integrity	ASTM D 5151*
Face/Eye Protection Device	Whole item	Visual acuity	NFPA test method
	Whole item	Overall integrity	ASTM F 1862
	Barrier material	Viral penetration resistance	ASTM F 1671

\* Test is modified for use in NFPA 1999

\*\* Requires conditioning of sample prior to applying test (other than ambient conditioning)

**Task 4 – Selection and Development of PPE Test Methods.** Available test methods that could be investigated to assess or measure the specific properties identified in Task 3 were selected. This step was accomplished by reviewing available standardized testing approaches available from ASTM International, the American Association of Textile Chemists and Colorists (AATCC), the Nonwoven Industrial Association (INDA), European Committee on Standardization (CEN), the International Standards Organization (ISO), and other organizations. For each selected test method, the parameters in each test were reviewed and a determination was made if modifications to the test were necessary to apply the specific test procedures to the specific category of emergency medical protective clothing. Some experiments were undertaken to identify test modifications, when warranted.

**Task 5 – Establishment of PPE Test Plan.** A test plan was established to evaluate the products identified in Task 2 using the methods selected or modified in Task 4. The test plan described the tests to be carried out, the testing location, any modifications to the test method that were made, the type of samples evaluated, and the manner in which results were reported. In addition, some industry data was acquired for physical properties associated with exam and cleaning gloves to form a foundation for further investigating appropriate performance criteria.

**Task 6 – Testing and Evaluation of Candidate PPE.** The test plan was carried out and the findings analyzed to determine if the selected test methods discriminated product performance consistent with field expectations and experience. When variances were found with field expectations, the test methods were reviewed and modified. Alternatively, different test methods were selected in some cases. The modified or alternative tests were then applied in additional testing of the same products, as needed.

**Task 7 – Preparation of PPE Criteria.** Recommended design assessment and performance criteria were prepared to address the specific hazards, performance properties, and test methods reviewed in this study. Recommendations of criteria were based on the initial end user input for qualifying products as having acceptable or unacceptable performance relative to the generic product requirements provided in Task 1 as well as input from the NFPA Technical Committee. Additional supporting information for suggested criteria was provided, such as information that may appear from other research or product studies identified throughout the project.

The proposed PPE criteria included a number of public comments that were submitted during the NFPA 1999 revision process. As is required by NFPA, individual public comments that include the recommended change and a substantiation statement for the change were submitted. The substantiation statements were based on this study's findings. The comments submitted as a result of this study are provided in Appendix A.

**Task 8 – Documentation of Study Findings.** The study findings were documented in a report that is suitable for presentation to the NFPA Technical Committee on Emergency Medical Operations Protective Clothing and Equipment.

## INDUSTRY AND LITERATURE REVIEW FINDINGS

### Injuries and Fatalities for EMS Responders

While extensive information is available for casualties and fatalities suffered by the fire fighters and police officers, limited data exist specifically for EMS responders. Fatalities are due in nearly all cases to vehicular or helicopter accidents. The total number of fatalities per year is typically low. Primary injury areas include:

- sprains, strains
- cuts, bruises
- needle sticks or other exposures to infectious disease (although the contracting of disease is low)
- injuries due to physical assault

The following resources were used to search for relevant data:

- NFPA reports
- National Association of Emergency Medical Technicians
- National Highway Traffic Safety Administration
- Pubmed/Medline
- Bureau of Labor Statistics

**Primary Sources of Information.** NFPA provides information about firefighter injuries and fatalities in the report, “Firefighter Fatalities in the U.S., 2005” [44]. These data would encompass injuries and fatalities during EMS response with firefighters acting in the EMT/paramedic capacity. In the category “operating in non-fire emergencies” (which would include EMS calls but also hazmat or other call), four (4) deaths were reported. For “nonfire emergency,” 12,250 firefighter injuries were reported, with the highest number (7,150; 58.4%) occurring under the “sprain, strain, muscular pain” category. Tables from this publication are attached as a separate file.

The NHTSA’s publication, “Traffic Safety Facts 2005,” includes data for fatalities involving emergency vehicles. In 2005, two (2) ambulance drivers and seven (7) ambulance passengers (either EMS personnel or patients) were killed in crashes in which the emergency vehicle was traveling with emergency signals (red lights, sirens, etc) in use.

A search of the literature in the Pubmed/Medline database yielded a number of relevant journal citations. A representative list of citations is included at the end of this report.

The best sources for information were the Bureau of Labor Statistics and reports prepared for NIOSH by the Rand Science and Technology Policy Institute: *Protecting Emergency Responders, Vol. 1: Emergency Responder Injuries and Fatalities: An Analysis of Surveillance Data* [45] and *Protecting Emergency Responders, Vol. 2: Community Views of Safety and Health Risks and Personal Protection Needs* [46].

**Information from the Bureau of Labor Statistics for 2005.** Injury and fatality statistics are available on the Bureau of Labor Statistic website. In 2005, the total number of fatal occupational injuries for Emergency Medical Technicians and Paramedics was ten (10), of which nine (9) were transportation incidents [47]. Table 1 lists the number of illnesses or injuries entailing days lost from work for Emergency Medical Technicians and Paramedics for the year 2005. These data reflect private industry only.

**Table 8 – Emergency Medical Technicians and Paramedics: Nonfatal Injuries and Illnesses Involving Days Away From Work, 2005<sup>A</sup>**

<b>Nature of Illness or Injury</b>	<b>Number</b>
Sprains, Strains	1970
Fractures	60
Cuts, Punctures	90
Bruises	300
Heat Burns	- <sup>B</sup>
Chemical Burns	- <sup>B</sup>
Amputations	- <sup>B</sup>
Carpal Tunnel Syndrome	- <sup>B</sup>
Tendonitis	20
Multiple Traumatic Injuries and Disorders, - TOTAL	40
- With fractures, burns, and other injuries	- <sup>B</sup>
- With sprains and bruises	30
Pain (back pain and “pain, except back”)	360
Back pain, hurt back only	190
All other natures	210
<b>TOTAL</b>	<b>3050</b>

<sup>A</sup>Private industry, occupation code 29-041;

Source: <http://www.bls.gov/iif/oshwc/osh/case/ostb1665.pdf> - 11/13/2006

<sup>B</sup>Data not available or did not meet BLS criteria for inclusion

**Information from the RAND Publications.** Several findings were produced in the RAND publications relative to EMS personal protective clothing protection needs.<sup>9</sup> In addition, the RAND publications provide extensive statistics relative to injuries and fatalities. These findings and statistics are provided below and are listed by individual report. Specific acknowledgements are provided to the source for each of these findings or statistical presentations.

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<sup>9</sup> Note: The Rand publications are copyrighted, and per their website: “Permission is given to duplicate this electronic document for personal use only, as long as it is unaltered and complete. Copies may not be duplicated for commercial purposes.” Relevant sections are quoted with this section.

Protecting Emergency Responders, Vol. 1: Emergency Responder Injuries and Fatalities: An Analysis of Surveillance Data and Protecting Emergency Responders [45]

*“General-population sources contain information on police and firefighters, but EMS personnel are not typically broken out. However, an analysis of NEISS data made available to RAND by NIOSH researchers breaks injuries down by nature of injury and part of body involved for all three emergency response services, and allows the injuries to be compared across services. This study, which is not publicly releasable, is the only source of information on EMS nonfatal injuries, other than infectious disease exposures, we found. As a result, only very basic generalizations about EMS injuries can be made. However, changes in occupation coding for federal government data sources currently being implemented will enable researchers to break out injuries to emergency medical technicians and paramedics from SOII and other databases, increasing the amount of available EMS injury data. It is likely that once these changes are implemented, the quality and quantity of EMS injury data will be similar to those of law enforcement data.” (p. 28)*

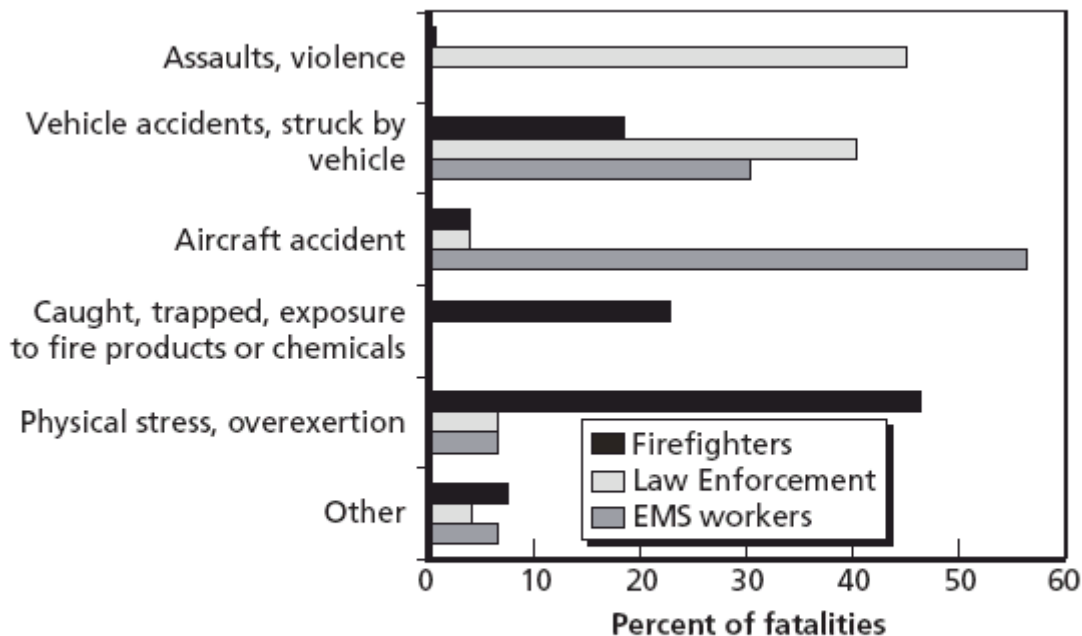
*“The firefighter deaths include those that occur when firefighters are performing EMS duties, and an average of at least 11 additional non-firefighter emergency medical responders died in the line of duty each year between 1998 and 2001. Excluding those associated with September 11, responder fatalities have decreased substantially from the level in the early 1980s, when over 300 responders died each year. EMS injury and fatality rate data are difficult to find. An investigation of National NEMSMS fatality data and the CFOI estimates the occupational fatality rate of EMS responders to be about 2.5 times the rate for all workers. No information is available on the incidence rate of EMS injuries.” (p. 31)*

*“EMS Injuries and Fatalities -- Data on EMS responder injuries and fatalities are limited. A recently published analysis of EMS line-of-duty fatalities using data from the Census of Fatal Occupational Injuries and NEMSMS data estimated an average of 19 EMS responder deaths per year from 1992 to 1997. The information available on causes of fatalities indicates that emergency medical responders are most often killed in aircraft and motor vehicle accidents (Figure 4.12). From 1998 through 2001, over one-half (56 percent) of the 46 line-of-duty fatalities reported to the National EMS Memorial Service were due to rescue helicopter crashes, and another 25 percent were due to motor vehicle accidents.<sup>21</sup> Other causes of death include drowning (2 percent), being struck by vehicles while on foot (4 percent), and heart attacks or other physical stress (7 percent).*

*“Other than the fatality data in Figure 4.12 and the NEISS data included in Figure 4.3, the only data sources for injuries to EMS workers focus on infectious disease exposures. Among emergency responders, emergency medical personnel have the highest risk of exposure to infectious disease: From 1996 to 1998, 85 percent of exposures reported by firefighters occurred when performing EMS duties, compared with only about 10 percent on the fireground. The most common exposures in 1993–*

1998 (an exposure does not necessarily mean that the responder was infected) were to tuberculosis (about 32 percent of exposures), HIV/AIDS (about 18 percent), meningitis (about 11 percent), and hepatitis A, B, and C (about 12 percent together). At least one police officer has died of AIDS complications after being assaulted by a suspect with an HIV infected needle.

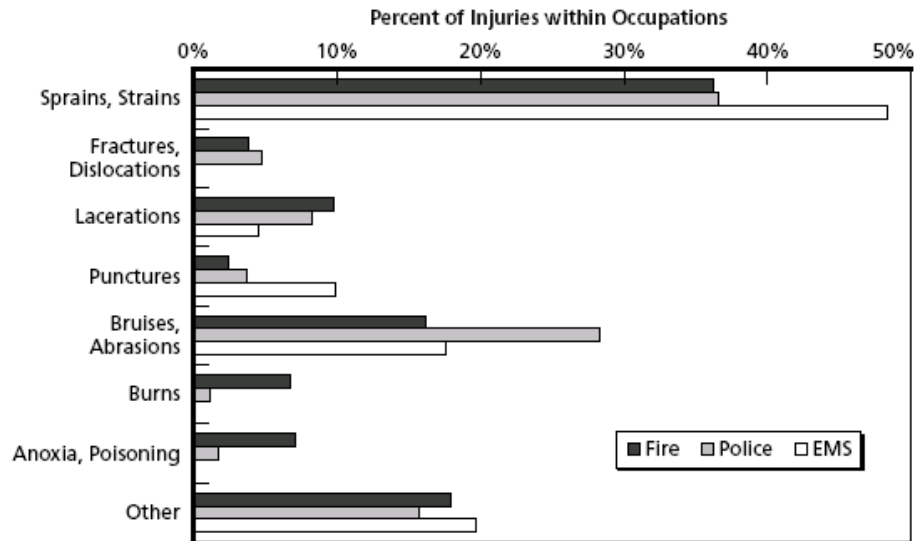
“Emergency responders are exposed to diseases through a variety of mechanisms. Blood-borne pathogens are of the greatest concern. According to a surveillance of hospital-based emergency medical technicians, 65 of 354 (18 percent) EMTs for whom records are available reported exposure to bodily fluids between June 1995 and February 11, 2002, with four being exposed more than once. About half of the exposures were due to percutaneous injuries such as needle sticks, while the other half were due mostly to skin and mucous membrane exposures. Six of the EMTs were tested for tuberculosis after respiratory exposure (none was infected), while six other EMTs tested positive for tuberculosis during routine testing.” (p. 49-50)



SOURCE: NFPA (1995–2000a), National Law Enforcement Officers Memorial Fund (2002a), and National EMS Memorial Service (2002).

NOTE: Data are for 1995–2000 for firefighters, 1992–2001 for police, and 1998–2001 for EMS.

**Figure 19 – Cause of Fatal Injuries for Firefighters, Police, and EMS Workers**  
(Source: Figure 4.2 on p. 34 from [45])

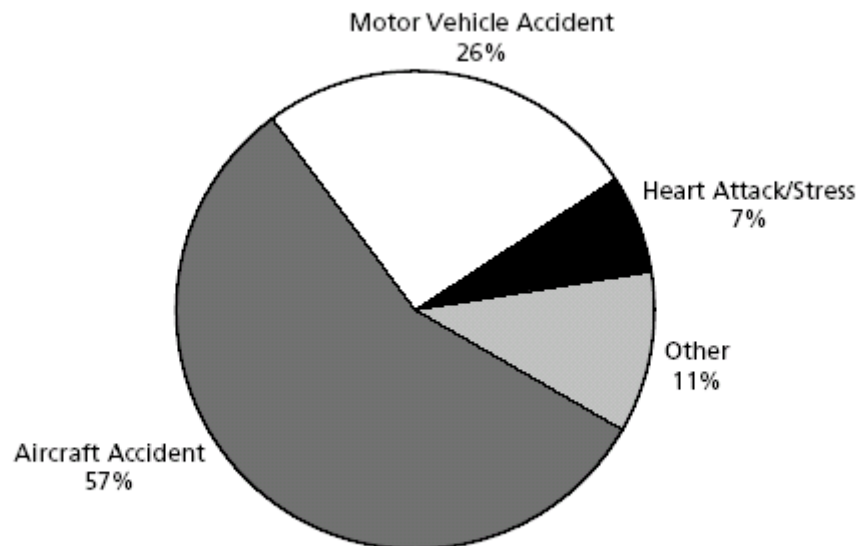


SOURCE: L. L. Jackson, NIOSH, unpublished data.

<sup>a</sup>These estimates represent preliminary data and should not be cited or quoted.

RAND TR1004.3

**Figure 20 – Nature of Injury for Firefighters, Police, and EMS Injuries, 1996-1998**  
Based on National Estimates<sup>a</sup> (Source: Figure 4.3 on p. 35 of [45]).



SOURCE: National EMS Memorial Service (2002).

RAND TR100-4.12

**Figure 21 – Cause of Injury for EMS Line-of-Duty Fatalities, 1998-2001**  
(Source: Figure 4.12 pm on Page 50 of [45])

**Table 9 – Underlying Data Supporting Figure 19, Cause of Fatal Injuries for Firefighters, Police, and EMS Workers (Source: Table B.2 on Page 67 from [45])**

Cause of Injury	Fire	Police	EMS
Assaults, violence	1	45	0
Vehicle accidents, struck by vehicle	18	40	30
Aircraft accident	4	4	57
Caught, trapped, exposure to fire products or chemicals	23	0	0
Physical stress, overexertion	46	7	7
Other	8	4	7
Total	100	100	100
Total sample size to calculate percentages	589 <sup>a</sup>	1,575	46

SOURCE: NFPA (1995-2000a), National Law Enforcement Officers Memorial Fund (2002a), and National EMS Memorial Service (2002).

NOTES: Data are for 1995–2000 for firefighters, 1992–2001 for police, and 1998–2001 for EMS. Total percentages may not add due to rounding.

<sup>a</sup>Data averaged from two sources: 589 records from USFA, 579 records from NFPA. Near-complete overlap.

**Table 10 – Underlying Data Supporting Figure 20, Nature of Injury for Firefighters, Police, and EMS Injuries, 1996-1998 Based on National Estimates (Source: Table B.3 on Page 67 from [45])**

Nature of Injury	% of Fire Injuries	% of Police Injuries	% of EMS Injuries
Sprains, strains	36.2	36.6	48.3
Fractures, dislocations	3.8	4.7	— <sup>a</sup>
Lacerations	9.7	8.2	4.5
Punctures	2.4	3.7	9.9
Bruises, abrasions	16.2	28.3	17.6
Burns	6.7	1.1	— <sup>a</sup>
Asphyxiation, hazmat inhalation	7.1	1.7	— <sup>a</sup>
Other (1)	16.7	14.2	15.3
Other (2)	1.2	1.5	4.4
Total	100.0	100.0	100.0

SOURCE: L. L. Jackson, NIOSH, unpublished data. Total percentages may not add due to rounding.

NOTES: Other (1) is reported by the source, and corresponds to injuries coded as "other." Other (2) is not reported by the source, and corresponds to injuries coded by nature but occurring infrequently and therefore not coded above.

<sup>a</sup>Indicates these injuries are not broken out from the "other" category.



**Table 11 – Underlying Data Supporting Figure 20, Cause of Injury for EMS Line-of-Duty Fatalities, 1998-2001 (Source: Table B.12 on Page 92 from [45])**

Cause	Fatalities					Percent
	1998	1999	2000	2001	Total	
Aircraft accident	9	10	6	1	26	57
Motor vehicle accident	5	2	2	3	12	26
Heart attack/stress	1			2	3	7
Struck by vehicle		2			2	4
Drowning	1				1	2
Illness				1	1	2
Homicide					0	0
Other				1	1	2
Total	16	14	8	8	46	100

SOURCE: RAND tabulation of National EMS Memorial Service (2002), excluding those EMS responders (total of 6 fatalities) covered by the U.S. Fire Administration Firefighter Fatality Database.  
NOTE: Total percentages may not add due to rounding.

## Protecting Emergency Responders, Vol. 2: Community Views of Safety and Health Risks and Personal Protection Needs [46]

### ***Emergency Medical Responders***

*“Because the labor force and activities of the emergency medical services are more difficult to define precisely than those of the fire service, injury and fatality data for emergency medical responders are more uncertain than the data for firefighters. By far, the main cause of emergency medical responder line-of-duty deaths for which data are available is vehicle accidents. Our analysis of National EMS Memorial Service (2002) data indicates that there were at least 58 emergency medical responder line-of-duty deaths, or an average of about 11 per year, between 1998 and 2002. We found that about half of all deaths resulted from rescue helicopter accidents, and approximately another third were due to ground transportation accidents or a responder being struck by a vehicle. An analysis of fatality data for 1992–1997 from three different databases by Maguire et al. (2002) gives a higher fatality rate: 114 deaths over 6 years, or 19 deaths per year. Maguire et al. found a similarly high proportion of transportation-related causes: Nearly 60 percent were due to ground transportation accidents, and another 17 percent were caused by air ambulance crashes. Other major causes of fatalities were cardiovascular incidents (11 percent) and homicides (9 percent).*

*Among hospital-based emergency medical technicians, 18 percent of those whose records were publicly available reported exposure to potentially infectious bodily fluids between June 1995 and February 2002, with 1 percent being exposed more than once. About half of the exposures were due to percutaneous injuries, such as needle sticks, while the other half were due mostly to skin and mucous membrane exposures (Panlilio, 2002). Note that these numbers do not reflect actual infections.*

*In contrast to these data, which indicate that the primary hazards are vehicle accidents, heart attacks, and assaults, the primary concern among emergency medical service responders that was voiced during their discussions with RAND was exposure to infectious diseases. This discrepancy may reflect the status of current protective technologies: Decreasing the number of injuries from vehicle accidents and assaults may be viewed as being doable through better use of existing protective technologies and practices, whereas participants saw less possibility for greater personal protection from infectious diseases.” (p. 20-21)*

## **Interviews with EMS Providers on PPE Selection and Use**

A number of interviews were conducted to ascertain the types of PPE typically used by emergency medical responders. Emergency medical services are delivered in several modes, including:

- Fire Service-based EMS (rendering aid and transporting)
- Fire Service-based EMS (rendering aid) and private (for-profit) EMS (transporting)
- “Third Service” (separate) public EMS department (rendering aid and transporting), either stand-alone or hospital-based
- Contracts with private (for-profit) EMS (rendering aid and transporting)

In addition, public EMS departments may contract with private EMS for back-up services. EMS personnel may be paid or volunteer, and are primarily paid in large cities.

The National Association of Emergency Medical Technicians (NAEMT) provides this information about the United State EMS on its website<sup>10</sup>:

*“Estimates about the U.S. market suggest that it has:*

- *17,000 transporting ambulance services (includes fire departments)*
- *26,000 fire departments (most of which provide some sort of EMS and about half of which offer ambulance transport)*
- *52,000 ambulances*
- *600,000 EMTs*
- *142,000 paramedics*
- *1,009,000 firefighters (many of whom are cross-trained in EMS)”*

Based upon recommendations from NAEMT and from other contacts in the field, ten EMS providers were selected to participate in interviews pertaining to EMS personal protective clothing and equipment. The goal was to include a diverse group reflecting varying modes of service delivery and department demographics. For example, FDNY has the largest Fire Service-based EMS in the United States, while the Austin/Travis County EMS operates under the less-common third service EMS mode.

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<sup>10</sup> Information quoted from NAEMT website: [http://www.naemt.org/aboutEMSAndCareers/ems\\_faq.htm](http://www.naemt.org/aboutEMSAndCareers/ems_faq.htm)

One contact shared the survey with colleagues from neighboring departments, and so an additional three (unsolicited) interviews were completed. These included Norfolk Fire and Rescue, Suffolk Fire and Rescue, and James City County Fire Department, all in Virginia.

The interviewed organizations included:

- Fire Service-based EMS: Lakeland (FL), Corpus Christi (TX), Bellaire (TX), Nashville (TN), New York City (NY), Fairfax County (VA), Norfolk (VA), Suffolk (VA), and James City County (VA)
- “Third Service” EMS department: Polk County (FL) and Austin/Travis County (TX)
- Private EMS: Mohawk<sup>11</sup> and American Medical Response

EMS providers were contacted by telephone and the appropriate individuals identified, such as Medical Supervisor or EMS Chief. Survey responses were taken by telephone in most cases. Responses for the Bellaire Department were obtained in person, with input provided by several personnel in a round-table format.

Respondents were asked questions pertaining to:

- Demographic information
- Mode of delivery for emergency medical services
- Procedures for researching, evaluating, and selecting EMS PPE
- Method by which PPE was selected for particular responses
- Specific details about different PPE elements
- Problems, desired features, and other comments about EMS PPE

The requirement to limit the number of interviews to less than ten participants did result in too few responses to generate statistics about EMS PPE use. However, the responses did provide an overview into the use of PPE by emergency medical responders. The survey results are summarized in Tables 12, 13, and 14, and are further discussed below.

As part of the interview process, it was noted that there are distinctions between organizations that provide aid and transportation versus those that simply provide aid. An organization may provide aid, but not necessarily transportation, which in turn affects the types of PPE provided. Many locations also contract private services for back-up.

Interview questions are provided in Appendix B.

**PPE Procurement.** Respondents were queried about the procedures in place for evaluating, selecting, and procuring PPE. Departments considered standards such as NFPA 1581 and NFPA 1999 (as well as applicable ASTM and ANSI standards), user feed-back on items currently in use, and sometimes informal “field tests” of new PPE. Some larger department commissioned a main team to consider, evaluate, and recommend PPE while decisions at smaller departments might be made by a chief and one or two others. Bids for PPE were typically competitive bids, not strictly

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<sup>11</sup> Mohawk provided very limited response because of the diversity of its services.

low-bid, to ensure that desired specifications were met. Sometimes specific brands were detailed in specifications.

**Table 12 - EMS Providers Included in Survey**

<b>Type</b>	<b>Organization</b>	<b>Number of EMS Responders</b>	<b>EMS Call Volume</b>
Fire Service-Based EMS	Lakeland FD	150 Firefighter/EMT-1; 24 FF/paramedic	~17,000/year
	Corpus Christi FD	400 FF, at least 75% firefighter/paramedic	>20,000/year
	Bellaire FD	21 FF (mostly paramedic)	~1040/year
	Nashville FD	110 FF/paramedics plus 160 paramedics in med. transport	~60,000/year
	FDNY	~2000 EMT & ~550 paramedics	1,700,000/year
	Fairfax County Fire & Rescue	1150 FF/EMT-1 plus 350 FF/paramedics	98,000/year
	Norfolk Fire-Rescue	500 FF/paramedics	40,000 year
	Suffolk Fire & Rescue	178 EMT & 48 paramedics	14,000/year
	James City County FD	92 FF/paramedics	8,000/year
Separate EMS Department	Polk County EMS	Unavailable	~60,000/year
	Austin/Travis County EMS	~200 paramedics	> 80,000/year
Private EMS	Mohawk	180 (per website)	Unavailable
	American Medical Response (serving 15 states)	~20,000 EMT and paramedics	100,000/year in Northern California

**Table 13 – PPE Used by Fire Service-Based EMS**

<b>Product Category</b>	<b>Lakeland</b>	<b>Corpus Christi</b>	<b>Bellaire</b>	<b>Nashville</b>	<b>FDNY</b>	<b>Fairfax County</b>	<b>Norfolk</b>	<b>Suffolk</b>	<b>James City County</b>
<b>Reusable garments</b>	No	No	No	No	Yes Combined NFPA 1951 and 1999 garment	No	No	No	No
<b>Disposable garments</b>	Brand A Flashspun PE S - XXL	Brand B SMS S - XL	Brand C SMS Universal size*	Brand D Flashspun PE Universal size	Brand E Spunlace woodpulp Universal size	Brand F Flashspun PE Medium	Brand G Flashspun PE Universal size	Brand H SMS Universal size*	Brand I Flashspun PE Universal size
<b>Sleeves</b>	Yes	No	No	Brand D Flashspun PE Universal size	Brand E Spunlace woodpulp Universal size	Brand F Flashspun PE Medium	Brand G Flashspun PE Universal size	Brand H SMS Universal size*	Brand I Flashspun PE Universal size
<b>Exam gloves</b>	Brand J Latex and Latex-free S - XL	Brand K latex and nitrile S - XL	Brand K latex and nitrile S – XL*	Brand L latex and nitrile S- XL	Brand K nitrile only S - XL	Brand M nitrile only S - XL	Brand K latex and nitrile S - XL	Brand N nitrile only “all sizes”	Brand L nitrile only S- XL
<b>Footwear covers</b>	No	Rarely used	No	Brand D Flashspun PE Universal size	Sometimes	No	No	Rarely used*	Brand O SMS Universal size
<b>Safety footwear</b>	No	No	No	Yes	Yes	Yes	No	Yes	No

<b>Product Category</b>	<b>Lakeland</b>	<b>Corpus Christi</b>	<b>Bellaire</b>	<b>Nashville</b>	<b>FDNY</b>	<b>Fairfax County</b>	<b>Norfolk</b>	<b>Suffolk</b>	<b>James City County</b>
<b>Faceshield</b>	Brand L combo shield/mask	Brand L combo shield/mask	Brand P Clear plastic 7 mil*	Brand Q Clear plastic 10 mil	Only as part of helmet	No (on disposable mask)	Brand L combo shield/mask	Brand H Clear plastic Universal size*	Brand L combo shield/mask
<b>Safety glasses</b>	Brand R	Brand R	Brand S	Brand T	Brand U	Brand V	Brand X	Brand X	Brand Y
<b>Surgical masks</b>	See faceshield	Brand B Cone mask	As part of kit	No	No		See facehield	Brand AD	See faceshield
<b>Particulate respirator or mask</b>	Brand Z N95 Flatfold	Brand Z N95 Flatfold	Brand Z N95 Flatfold	Brand Z N95 Flatfold	Brands Z and AA Flatfold and cone Brand P APR	Brand Z N95 Flatfold	Brand AA and AB N95 Flatfold	Brand AC N95 Cone	Brand AD Flatfold
<b>Helmet**</b>	No	No	No	No	No	Brand AE EMS helmet Brand AF Rescue helmet	No	No	No
<b>Reflective vest</b>	Yes	Yes	Yes	Yes	No (orange non- reflective)	Yes	Yes	Yes	Yes

\* Provided as part of kit; \*\*EMS departments typically have bunker gear, including fire fighter helmets, available if needed

**Table 14 – PPE Used by “Third Service” and Private EMS**

<b>Product Category</b>	<b>“Third Service” EMS</b>		<b>Private EMS</b>	
	<b>Polk County</b>	<b>Austin/Travis County</b>	<b>Mohawk</b>	<b>Amer. Med. Response</b>
<b>Reusable garments</b>	No	No	No	No
<b>Disposable garments</b>	Brand A Flashspun PE S – XL	Brand C SMS L only	Various types in service	Brand G Flashspun PE M - L
<b>Sleeves</b>	Yes	No	Yes	Brand G Flashspun PE Universal size
<b>Exam gloves</b>	Brand L Nitrile S - XXL	Brand K Nitrile S – XXL	Brand L Latex and nitrile S-XL	Brand K Latex and nitrile S – XXL
<b>Footwear covers</b>	Rarely used	Available but not used	Not provided	Sometimes used
<b>Safety footwear</b>	No	Yes	Yes	Yes
<b>Faceshield</b>	Yes	Brand L Combination shield/mask	No	Yes, various suppliers and types
<b>Safety glasses</b>	Yes	Brand V	Brand X	Goggles, Brand Y
<b>Surgical masks</b>	Yes	See faceshield	Brand X	No
<b>Particulate respirator or mask</b>	Brand Z N95 Flatfold	Brand Z N95 Flatfold	Brand Z N95 Flatfold	Brand Z N95 Flatfold
<b>Helmet**</b>	No	Brand AE EMS Helmet	No	Yes
<b>Reflective vest</b>	Yes	Yes	Yes	Yes

\*\*EMS departments typically have bunker gear, including fire fighter helmets, available if needed

For items such as gloves, for which many manufacturers supply appropriate products that perform as desired, the brands purchased may vary frequently, depending on cost. Departments may receive some of their PPE through a hospital, and the source for those products will depend on what contracts that the hospital makes.

FDNY provided a more detailed summary of their approach:

*“Non-disposable PPE: After 9/11, the Chief of EMS undertook a project to explore the highest level of PPE for EMS members available as the PPE issued at the time was proven to be inadequate to protect members from household chemicals, thermal and particulate protection.*

*“After contacting all manufacturers of PPE to submit their products that they marketed to the EMS community, it was apparent that a tri-certified garment meeting NFPA standards 1951, 1992 and 1999 provided the EMS member with the highest degree of protection rather than just the 1999 Standard alone. The project report was processed and a grant application request was submitted. The grant was awarded.*

*“Disposable PPE: This type is selected by the Medical Equipment Unit to provide body fluid protection and is also available to the EMS members in the form of isolation kits.”*

**Choice of PPE for Use at a Particular Incident.** The EMS responders typically selected which PPE to use for a particular incident based upon dispatch information and then “gut instinct” at the scene. In addition to the “decision tree” training that is part of EMT coursework, departments incorporate internal SOPs. The yearly blood-borne pathogen training may be utilized to emphasize these protocols. At a minimum, protective exam gloves were used at all incidents. The second most used item was eye and face protection. Garments of one form or another (including disposable items such as gowns and sleeves) were generally only worn when large quantities of blood or body fluids are expected. One respondent desired more detail from the dispatcher in order to have appropriate PPE selected by the time he reached the scene.

The response provided by Norfolk, VA was typical:

*“PPE tiers available include everything from a pair of exam gloves through full body cover with respiratory protection. The EMS responder is responsible for determining an appropriate level of protection for the incident. The supervisor on the call has the ability to upgrade the worn PPE when he/she feels it is necessary. Norfolk Fire-Rescue follows recommendations of OSHA and CDC for provider protection requirements.”*

**Specific PPE Use Practices and Observations.** PPE use varied among the EMS organizations interviewed. Examination gloves are generally the only item of PPE that was universally applied and other PPE use was based on the situation. There was only limited use of standards uniforms with barrier capabilities and these were only used by fire service organizations.



Specific reference to NFPA 1999 in PPE procurement specifications varied among EMS organizations. The greatest awareness occurred in the fire service-based EMS; however, there was some acknowledgement of the standard by private ambulance companies.

In Tables 13 and 14, different brands of PPE are indicated generically without reference to specific manufacturers. Often, particularly for gloves, the brand used might change fairly often, depending on bids. For the purpose of this report, only the brand in use was reported, though questions were asked about why one brand might have been selected over another brand, especially if for reasons other than cost. The following sections detail the responses in the interviews to different types of PPE used for EMS.

***Protective Garments and Sleeves.*** When garments are used, the majority of respondents indicated that only disposable gowns were used. One of the departments (FDNY) had recently transitioned to a multi-standard certified garment. Norfolk mentioned using an EMS jacket that had been tested to NFPA 1999. However, the majority of interviewed organizations stated that disposable garments were used that were constructed of either flashspun polyethylene or various form of polypropylene. Some garments that were identified by respondents did not have true barrier materials that would qualify against the viral penetration resistance requirements of NFPA 1999. When a range of sizes was offered, size Large was often used. The majority of garments indicated tended to be partial body clothing (sleeves, aprons, head covers) as opposed to full body garments such as jackets and pants or coveralls. Approximately three-quarters of the respondents used protective sleeves, made of the same material as the disposable garment. Two departments mentioned use of disposable caps similar in style to bouffant caps used in standard healthcare settings.

A number of departments relied on isolation kits that are kept on vehicles for an array of disposable garments. These kits often combine a partial body garment like an apron with disposable gloves, face mask, and in some cases safety glasses.

Routine use of specialized garments was limited. Most organizations used garments only as needed (less than 10% of responses) as determined by the likelihood of blood or body fluid exposure. For example, child birth situations would generally dictate use of full body garments (coveralls or jacket/pant sets). Similarly, protective garments were often used at automobile accident victim extrications. Some garment use was found to be weather-dependent. The likelihood for garment use often increased in cold or wet weather conditions, based on respondent answers.

In ranking desired features for disposable clothing, the following needs were identified:

1. Provide ease of rapid donning and doffing
2. Be constructed of lightweight materials with no restriction in movement
3. Keep liquids off uniform and skin

For reusable clothing and garments, the following needs were stated:

1. Must be comfortable

2. Can be easily put on
3. Stay durable under different physical conditions
4. Maintain appearance with multiple launderings

**Protective Gloves.** Respondents considered gloves the most often used item of PPE. In fact, each interviewed organization indicated that examination gloves would be used on all calls where any patient or victim contact occurred. Nitrile gloves were specified most often, although six departments also offered latex rubber options. The principal reason for offering nitrile gloves was to overcome the issues associated with individuals that are or become sensitized to natural rubber proteins. A variety of different suppliers were identified for these gloves. In nearly all cases, these gloves were certified to NFPA 1999.

Most respondents were generally satisfied with tear-resistance and dexterity provided by their examination gloves; however, the most common identified issue was breakage during donning. A second issue was protection of wearer hands against sharps. Double gloving was infrequently identified as a means for achieving improved physical protection.

Some interviewed organizations indicated use of different gloves:

- Fairfax Fire & Rescue mentioned that two thicknesses of glove were available. The thicker gloves were offered for use when members were concerned about the physical hazards associated with a particular response, such as might occur during a vehicle victim extrication.
- American Medical Response described thick vinyl gloves, used for especially bloody trauma, that provide additional physical protection that extended beyond the wrist.
- Bellaire mentioned the availability of leather gloves for use as needed. Some other organizations indicated the use of leather gloves in conjunction with examination gloves when there were concerns for sharps and other physical hazards.
- FDNY uses an extrication glove for specific physical hazards in combination with examination gloves. Fairfax County supplies special operation gloves for the same purpose. Not all extrication gloves would include barrier materials.

Not all organizations use cleaning gloves. Dishwashing-style gloves were commonly indicated for cleaning applications by some organizations. In many cases, these gloves would be reused. The most important need for cleaning gloves was the provision for physical protection while allowing good hand dexterity.

**Protective Footwear.** The interviewed organization stated a variety of different practices for foot protection. Most EMS departments provide disposable booties or shoe covers. However, these items were rarely used. When booties or shoe covers were used, sizing was a primary complaint, as these some of the respondents indicated that certain styles of footwear covers would not fit over large shoes or boots. In addition, some organizations complained the cover bottoms would easily wear out on rough surfaces.

For reusable footwear, fire service personnel often wear station boots. Other organizations wear standard occupational footwear (many of these footwear items do not meet industry toe impact/compression resistance requirements). Three departments required steel-toed shoes or boots. In some organizations, fire fighter boots would be available if needed. Long wearing comfort, when footwear is worn over entire shift, was the principal concern for reusable footwear.

**Face and Eye Protection.** A wide variety of practices were found to be in place for the different interviewed organizations with respect to face and eye protection. Safety glasses are routinely used and preferred over goggles, primarily due to comfort and the availability of safety glasses prescription lenses. In general, the ANSI Z87.1 standard was met for specified products. Contemporary styling was further considered useful for encouraging wearer compliance. Face shields were also provided for use; however, face shield fogging was a principal complaint. Surgical masks were also commonly used and included either the pleated or cone mask designs. Most of the surgical masks used were included in isolation or infection control kits. Several of the specified surgical masks incorporated a face shield. There were relatively few criticisms of these items; however, any concerns about the extent of overall face exposure were not generally recognized, though most organizations agreed that the face area was one of the more vulnerable parts of the body for blood and body fluid exposure.

**Respiratory Protection.** When specified, N95 particulate filtering facepieces certified to 42 CFR Part 84 [48] of one manufacturer were used by three-quarters of the respondents. Other organizations used N95 masks from other manufacturers. None of the organizations interviewed considered differences of filter material efficiency between N95 and P100 respirators.

**Head Protection.** Most departments provided turnout gear, including fire fighter helmets, for use as needed. American Medical Response provides a type of rescue helmet for their employees. The offering of this PPE item was principally to counteract head injuries inside vehicles during victim transport. Fairfax County supplies EMS helmets from a particular manufacturer for most emergency medical responders and a type of rescue helmet for paramedics.<sup>12</sup> Respondents thought that a non-firefighter helmet for routine wear (i.e., in ambulance during transport) might interfere with performance; however, several departments are investigating this issue.

**High Visibility Vests.** All respondents, except for FDNY, use high visibility vests, for incidents in heavy traffic. These meet highway safety standards and the criteria in ANSI/ISEA 107; however, it was unknown if each product was independently certified. FDNY uses a non-reflective orange vest but uses high visibility materials on its tri-certified jackets and pants.

One respondent mentioned concern that an intoxicated driver might unintentionally steer towards the reflective vest (as such a driver might follow the headlights of a car ahead of him). EMS drivers also typically position vehicles to provide the most protection for the responders and victims. In addition, departments may use other protective equipment, such as flashers on open doors and improved safety flares.

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<sup>12</sup> The specified EMS helmets did not meet any particular standard except for the top impact requirements of ANSI Z89.1 [49].

**Additional Comments.** Respondents were invited to provide additional comments on EMS PPE. Concerned by personnel vulnerabilities in certain response situations, Austin/Travis County EMS issues ballistic vests. A need for a uniform suitable for extrication work was noted by Nashville FD; turnout gear is too heavy for this while a regular uniform worn with a disposable gown is not rugged enough. This article would incorporate padded elbows and knees and offer protection from glass shards. Corpus Christi FD mentioned the need to consider the “macho image” in order to make PPE more appealing to the users; in particular, the disposable gowns do not fit this image. FDNY commented that they are addressing the need for thermal protection for EMS and duty uniforms should be all-cotton rather than polyester blends. Flammability of garments and other PPE was only considered an issue for extrication. Organizations indicated that flame resistant clothing is used when needed, but agreed that clothing should not be a hazard. Greater awareness and use of NFPA 1999 was perceived as positive step for industry

### **Approaches for Establishing Acceptance Criteria**

In addition to information gathered through a review of the literature and interviews with EMS providers, three specific approaches were used to help determine “acceptable” and “unacceptable” products. These included:

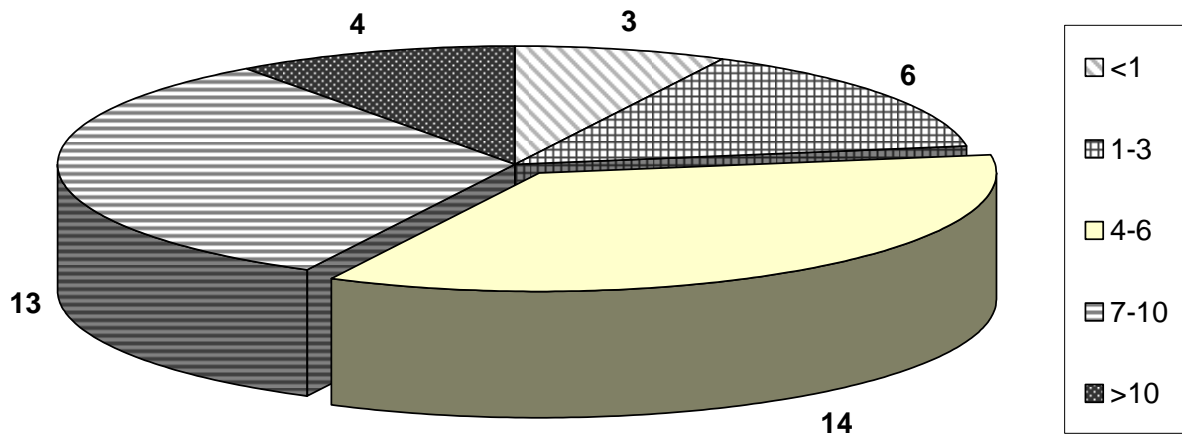
1. The presentation of a range of products in selected EMS categories at a trade show to allow attending end users rate or rank products, according to specific performance areas
2. Selection of end user groups, which were given sample garments and asked to conduct exercises to rank or rate product acceptability (end user panel)
3. Judgment by the NFPA Technical Committee on which products should be considered appropriate

**Presentation of Sample Products at EMS Trade Show.** A regional trade show oriented towards Emergency Medical Service providers was used as a forum to collect information about preferences and limitations for an array of different EMS PPE items. Trade show booth space was obtained and information and sample products were shown to trade show participations for rating and ranking products in specific performance areas. In this process, information on the participant’s organization was collected that included (a sample questionnaire is provided in Appendix C):

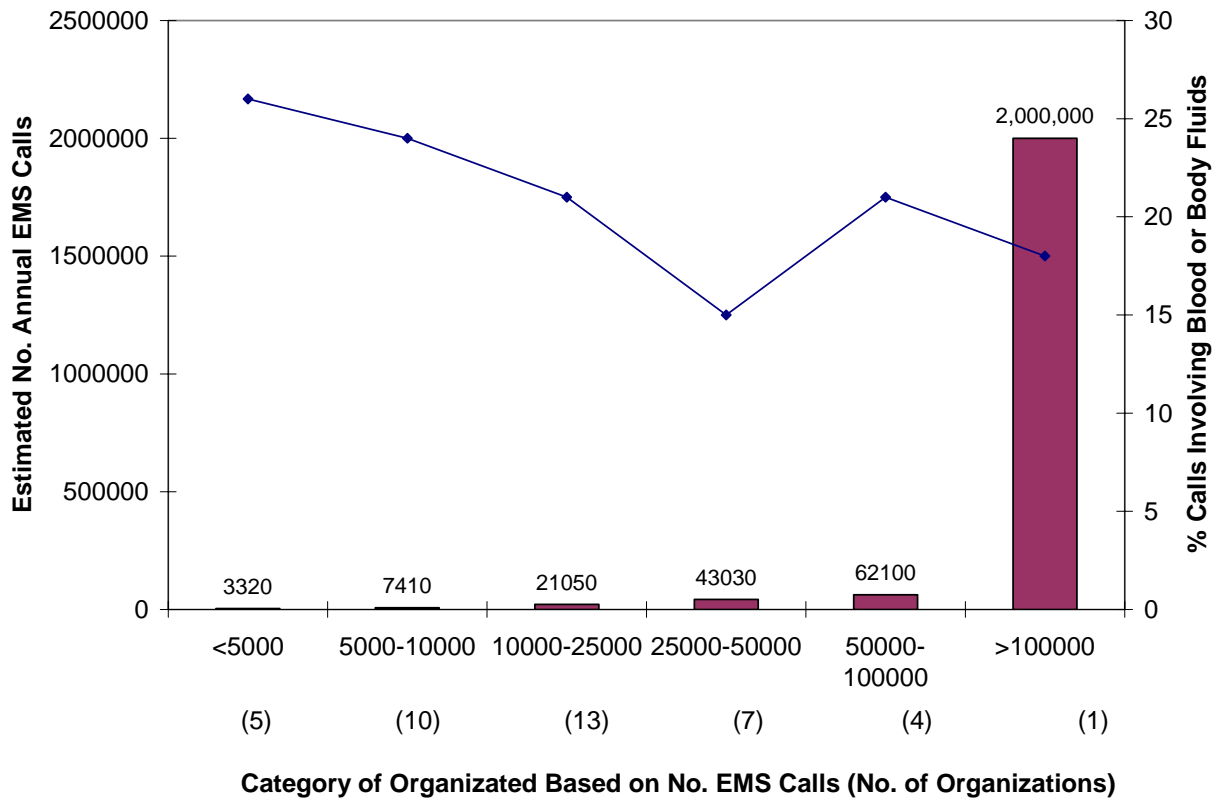
- The number of years of experience that the individual had as an EMS provider
- How many calls the individual made in a given year
- The percentage of overall EMS calls that involved blood or body fluid exposures

Figures 22 and 23 provide the range of results for the 40 EMS providers that were interviewed.

Individual respondents were then asked what types of PPE items they used and the frequency for the use of those items (indicated as every call, as needed, or never). Additional information was recorded to indicate when and how each type of PPE item was used. For some specific items, the specific type of item was further classified. For example, in the case of disposable garments, respondents were able to choose between coverall, apron, or other.

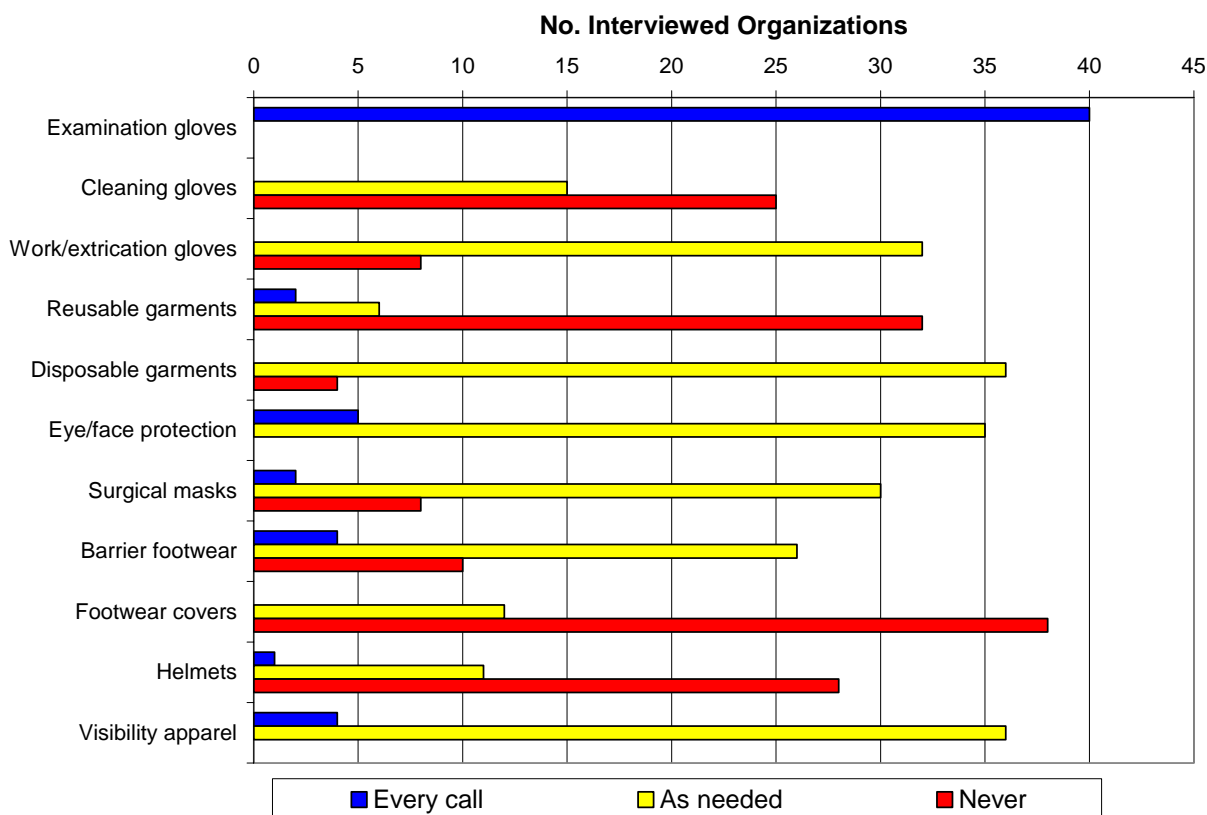


**Figure 22 – Years of EMS Experience Reported by Trade Show Participants**



**Figure 23 – Estimated Number of Annual EMS Calls Reported by Trade Show Participants (31 different departments represented)**

The results of trade show respondent feedback for the relative use of different PPE items are shown in Figure 24.



**Figure 24 – Frequency of Selected EMS PPE Use Reported by Trade Show Participants**

In addition to the product use frequencies, general responses were collected about PPE failures and problems or unaddressed needs. These findings and responses confirmed many of the findings that were derived from the initial EMS organization interviews, including:

- Examination gloves were described as the most frequently used item (on every call) – most organizations were satisfied with the choice of products with the only complaint that sometimes gloves stick together or break in donning. Almost all departments indicated providing nitrile gloves at least as an alternative.
- The large majority of organizations used examination gloves for any cleaning of equipment following an incident.
- Most organizations stated that they had extrication gloves available, but few of the organizations described gloves that had barrier materials. In many cases, individuals stated that they wore leather gloves over examination gloves if they were concerned about physical hazards.
- Most organizations regarded eye and face protection or surgical masks as the next leading item of PPE worn for EMS calls; while goggles were often used, some users complained about fogging; surgical masks were often worn for face protection and include face shields; a number of the organizations also indicated disposable face shield use.

- Many of the trade show participants thought that their footwear might contain some type of barrier, but were unsure. Most organizations indicated use of standard footwear; footwear covers were rarely used.
- Only a couple of organizations questioned stated that they used any type of helmet. In some cases, helmet use was an individual option.
- Nearly all organizations stated that they used high visibility vests but were unsure if these vest met industry standards.
- The number one complaint of PPE items was discomfort in wearing barrier clothing, particularly outdoors.

The last area of questioning involved having trade show participants view different items of EMS protective clothing, generally representing a range of physical strength, durability, or other relevant characteristics and having the individuals rate the clothing as acceptable or unacceptable.<sup>13</sup> In this part of the interaction with the trade show participant, the follow types of items were rated for acceptability:

- 9 different types of disposable garments
- 6 different types of disposable footwear covers
- 7 different types of cleaning gloves (excluding work gloves)
- 10 different types of protective eye and facewear, including surgical masks

The types of PPE items reviewed by tradeshow participants were the same items that were evaluated for different product categories. Each type of item was reviewed on the basis of six rating categories as shown in Table 15.

**Table 15 – Product Rating Categories for Trade Show Participants**

<i><b>Disposable Garment Ratings</b></i>	<i><b>Footwear Cover Ratings</b></i>
1. Strength	1. Strength
2. Single use durability	2. Single use durability
3. Body coverage	3. Height
4. Barrier qualities	4. Barrier qualities
5. Comfort	5. Traction
6. Donning ease	6. Donning ease
<i><b>Cleaning Glove Ratings</b></i>	<i><b>Eye/face Protection Device Ratings</b></i>
1. Physical hazard resistance	1. Face coverage
2. Single use durability	2. Single use durability
3. Length and fit	3. Physical protection
4. Dexterity	4. Barrier qualities
5. Grip	5. Visibility
6. Tactility	6. Donning ease

<sup>13</sup> Individuals were also afforded the response of not rating the clothing if unsure.

Therefore, the rating responses served as an indication for judging how results related to the selected performance area corresponded with end user rankings. The results of this rating process are provided in the respective product category subsection. Since some trade show participants felt uncomfortable, a “not rated” response was provided as an alternative.

**Limited Field Trials with EMS Organizations.** Limited field trials were conducted with two different organizations. In these field trials, the respective organizations were provided with samples of disposable garments and footwear covers to help further refine product rankings and determinations of acceptability for specific areas of performance. In particular, 6 of the disposable garment types and 4 of the disposable footwear covers that were used during the tradeshow reviews were used. A dozen of each item was provided to each organization and the organization was asked to evaluate the items based on sample wearing, but cautioned not to use the items in actual EMS responses. Thus, individuals from the two organizations evaluated the acceptability of the item by actual wearing and conducting simulated tasks as might be done during an EMS response. For example, one of the participating organizations undertook the following exercises to evaluate garments:

- Donning and doffing
- Reaching for, pulling, and carrying different types of objects
- Crawling on rough surfaces
- Climbing ladder

Each individual then ranked the product as acceptable or unacceptable in several categories using the same performance categories and rating system that was applied for tradeshow participants (sample rating forms are provided in Appendix C). These data are presented as part of the sections of disposable garments and footwear covers to augment existing determinations and judgments of product performance.

**NFPA Technical Committee Judgments.** The judgment of the technical committee members was often relied upon in the absence of specific end user feedback, rating information, or field trial findings. While no specific systematic approach was applied, decisions for individual criterion were ultimately the decision of the technical committee following the NFPA standards development approval process. The following principles were followed in this process.

- In general, technical committee judgments were applied conservatively with consideration for a balance of safety and limiting the impact of clothing effects on the end users.
- The decision-making process attempted to not restrain new technology or be design limiting.
- Where possible, technical committee members were shown samples of clothing that provided a range of test results for setting specific performance property pass/fail criteria.
- End user observations and input on acceptable product performance was weighed more heavily than opinions offered by other interests.



## INVESTIGATION OF KEY PPE ITEM REQUIREMENTS

Several different investigations of PPE design and performance issues were carried out as part of the contract effort. These investigations were aimed at understanding why certain types of EMS protective clothing, which were known to be used in the field, were not being certified. The background research yielded extensive information detailing when items were used and the problems or limitations associated with these items. This input helped frame specific research in developing new or revised criteria for the evaluation of selected PPE items covered in the NFPA 1999 standard. The specific efforts undertaken included:

- Proper positioning of design and performance criteria for disposable garments versus reusable garments, with specific areas of inquiry for physical properties, liquid absorption or repellency, flammability, and visibility
- Reconciliation of performance property inconsistencies for cleaning glove criteria
- Classification and adjustment of design and performance criteria for eye and face protection devices to recognize the different types of eye and face protection products in use
- Refinement of specific design and performance criteria for footwear covers

In addition, recommendations were made for other categories of PPE that were identified in the project review process and based on committee needs; these included:

- Development of initial criteria for head protection
- Revision of abrasion resistance techniques for work gloves
- Creation of a new category of protective footwear for first responders
- Addition of biological and particulate protection criteria for complete EMS ensembles intended for use in terrorism incident responses

While the latter changes in the NFPA 1999 standard were not part of the original scope of the project, some limited support was provided in each area.

The findings of this project work are detailed in each of the following sections. For each major area of work, the key issues are identified, current criteria are discussed, and the specific research that was carried out to address the issue is described.

### Revision of Garment Criteria

**Key Issues.** Specific research was undertaken to support improvement of criteria in several areas. The key issues for the investigation of garment criteria included:

- Determining the appropriate burst resistance test to be applied to single and multi-use garments
- Choosing between liquid absorption and repellency tests for garment material performance
- Setting appropriate performance properties and levels for single use garments in contrast to

multi-use garments in order to account for differences in physical testing due to intended use and service life

- Discriminating design and performance features between full body and partial body garments
- Deciding on the applicability of flammability testing
- Specifying visibility performance for garments, when needed

**Existing Criteria and Needs.** In the 2003 edition of NFPA 1999, the manufacturer must designate garment as single use or for multiple use. Other than the appearance of the special caveat “For Single Use Only” on the product label and the determination of garment and material performance following 25 cycles of laundering, no other distinctions between single and multi-use garments existed. In addition, the design criteria in this edition required that garments:

- Must be designed to cover any portion of torso
- Be permitted to be full or partial body coverage garments
- Have a barrier layer that is a single non-separable layer
- Include barrier layer for all covered portions of the body
- Allow booties

These design criteria were developed to permit flexibility in the design of different kinds of garments because first responders have a variety of situations involving blood or body fluids. For example, it was considered beneficial that items such as sleeve protectors and aprons be allowed as some response organizations utilize these items as needed. The requirements that the barrier layer be a single non-separate layer and all covered body areas include a barrier layer were based on the desire that all parts of the garment that the wearer could see would offer protection.

Though general requirements described how full body coverage garments must cover the body, no specifications were provided for the area of coverage for partial body garments such as aprons or sleeve covers. In addition, the 2003 edition of NFPA 1999 did not provide any provision for use of high visibility material even though this primary concern for EMS providers, who could be involved in vehicular accidents, was raised during the last revision.

In terms of performance, the existing criteria for garments were divided between a liquid integrity test, a biopenetration resistance test, and various physical property tests for defining the strength and durability of the garments. The lack of different physical property levels was a significant concern because the levels were set at values too high for most disposable garment products, which are used only once, but too low for reusable garments.<sup>14</sup> Though premature, the committee proposed changes for single use garments as part during the early stages in the revision of NFPA 1999 based on limited test information provided by one vendor. The existing and initially proposed garment criteria appear in Table 16.

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<sup>14</sup> This general perception was held by the technical committee in its review of physical property data for both certified and non-certified garments representing a range of products in use by EMS providers. Most multi-use garments that are certified exceed the physical property requirements in NFPA 1999-2003 by a large margin. In contrast, some end users and committee members felt that some disposable garments held up well in use but could not meet the strength/durability requirements set in NFPA 1999-2003.

**Table 16 – Existing and Initially Proposed Criteria for EMS Garments**

Item	Property	Test Methods	Current Criteria Multiple Use†	Initially Proposed Single Use Criteria
Garment	Liquid integrity	ASTM F1359‡	No leakage	No leakage
Barrier layer	Biopenetration	ASTM F1671	Pass	Pass
Each separable layer	Tensile strength	ASTM D5034	≥ 135 N	≥ 100 N
	Burst strength	ASTM D3787* ASTM D3786**	≥ 345 kPa	≥ 100 N
	Puncture/tear	ASTM D2582	≥ 25 N	≥ 15 N
	Tear resistance	ASTM D5587* ASTM D5733**	≥ 36 N	≥ 25 N
Seams/closures	Strength	ASTM D751	≥ 67 N/50 mm	≥ 50 N/50 mm
Outer layer	Water repellency	AATCC 22	Rating ≥ 70 ‡	N/A
Composite	Total heat loss	ASTM F1868	≥ 450 W/m <sup>2</sup>	≥ 450 W/m <sup>2</sup>
Hardware	Corrosion resistance	ASTM B117	No corrosion	N/A
Labels	Durability	ASTM D4966	Remain legible	N/A

† Current criteria for single and multiple use in NFPA 1999-2003; applied for single-use garment materials after room temperature conditioning; applied to multiple-use garment materials separately after room temperature conditioning and laundering conditioning (25 cycles of whole garment washing and drying per industrial laundering procedure)

‡ Only the area of the manikin covered by the garment is tested

\* Test method applied to multiple use garment material

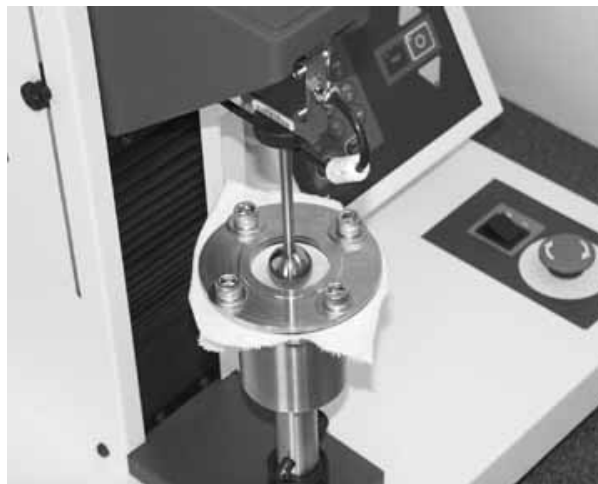
\*\* Test method applied to single use material

**Selection of Burst Strength Test Method.** The 2003 and earlier editions of NFPA 1999 specified testing of garment materials using the oil-filled diaphragm based procedures in ASTM D751, *Methods for Testing Coated Fabrics* [50]. This method is essentially identical to ASTM D 3786, *Test Method for Hydraulic Bursting Strength of Textile Fabrics-Diaphragm Bursting Strength Tester Method* [51]. Concerns existed for the use of this test method for the range of materials to be evaluated, which span lightweight unsupported nonwoven materials used in disposable garments to relatively thick coated fabrics or laminates supported on woven fabrics that are often used in reusable garments. Specifically, some material may elongate without truly bursting when subjected to a hydraulic style burst test. The ASTM D3786 method uses an expanding oil-filled diaphragm to cause the material to burst in a specially designed test apparatus called a Mullen Burster (see Figure 25). The burst force is reported as the pressure of oil underneath the diaphragm at the time the material breaks.

An alternative burst test is the ball burst test that is specified in ASTM D3787, *Test Method for Bursting Strength of Textiles-Constant-Rate-of-Traverse (CRT) Ball Burst Test* [51]. In this test, the material specimen is placed in a horizontal clamping device that is positioned on a tensile testing machine and an 1-inch steel ball is attached to the other arm of the test machine and lowered at a constant rate (30 cm per minute) until it pushes through (Figure 25). The burst strength is reported as the maximum force measured as ball ruptures the material.



**(a) Mullen Burst Test (ASTM D3786)**



**(b) Ball Burst Test (ASTM D3787)**

**Figure 25 –Tests Used to Evaluate Garment Material Burst Strength**

In order to discern the best choice of test methods to characterize garment material burst strength, ten different representative single use and multiple use garment materials were tested to both methods by Underwriters Laboratories (UL). Test results are shown in Table 17.

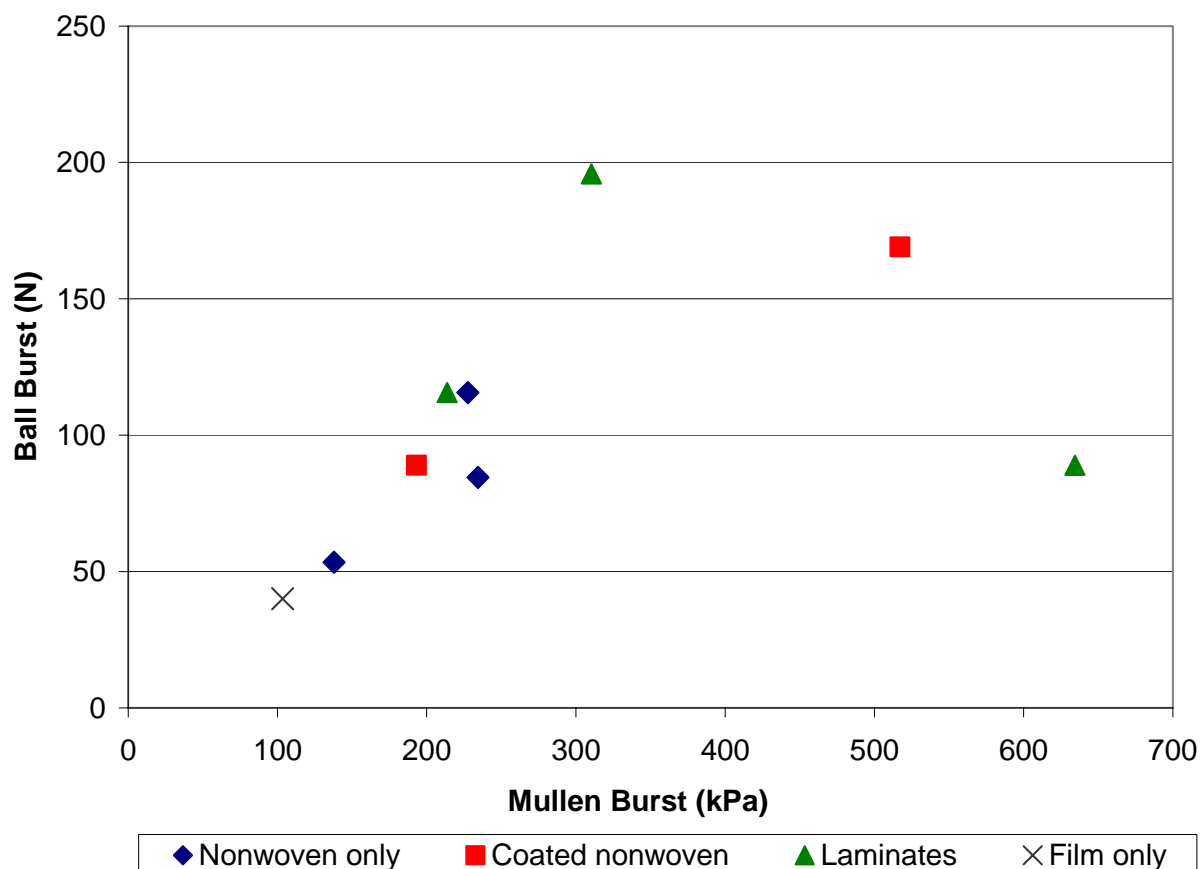
**Table 17 – Comparison of Ball and Mullen Burst Test Results for Selected Garment Materials**

<b>Material</b>	<b>Material Type</b>	<b>Ball Burst (N)</b>	<b>Mullen Burst (kPa)</b>
1	Reusable barrier (laminate)	925.5	>800*
2	Reusable barrier (laminate)	920.5	>800*
3	Reusable barrier (laminate)	689.0	>800*
4	Reusable barrier (coated fabric)	115.5	792
5	Single use (SMS)	88.5	520
6	Single use (SMS)	134.5	>250*
7	Single use (Polyethylene)	134.5	>250*
8	Single use (Polypropylene)	86.5	240
9	Single use (SMS)	85.0	>260*
10	Single use (Polypropylene)	114.5	250

\* specimens extended and did not burst

As indicated in Table 17, a number of both reusable and single use material specimens could not provide an accurate Mullen burst measurement; however, all test materials would easily show a measurable ball burst strength result.

Given the fact that initial data observations indicated that the ball burst test would be more appropriate for measuring burst strength for all garment material types, the committee investigated a means for setting the new performance value for each type of garment. For this purpose, a second series of tests were run with different materials employed in this study for other physical property determinations. As with the UL provided data, both Mullen burst and ball burst strengths were measured. In this case, materials were classified as nonwoven fabric only, coated nonwoven fabrics, laminates, or unsupported films.<sup>15</sup> While the test laboratory provided distinct measurements for each evaluated material, the plot of ball burst versus Mullen burst values failed to show any reasonable correlation between the two property measurements as shown in Figure 26. In particular, laminate burst strength showed no consistent relationship, making it impossible to discern a proportional relationship that could be used to estimate a reasonable property criterion. Based on the findings learned from this part of the investigation, the committee decided to use field performance information to setting performance limits relative to burst strength based on the ASTM D3787 ball burst test method.

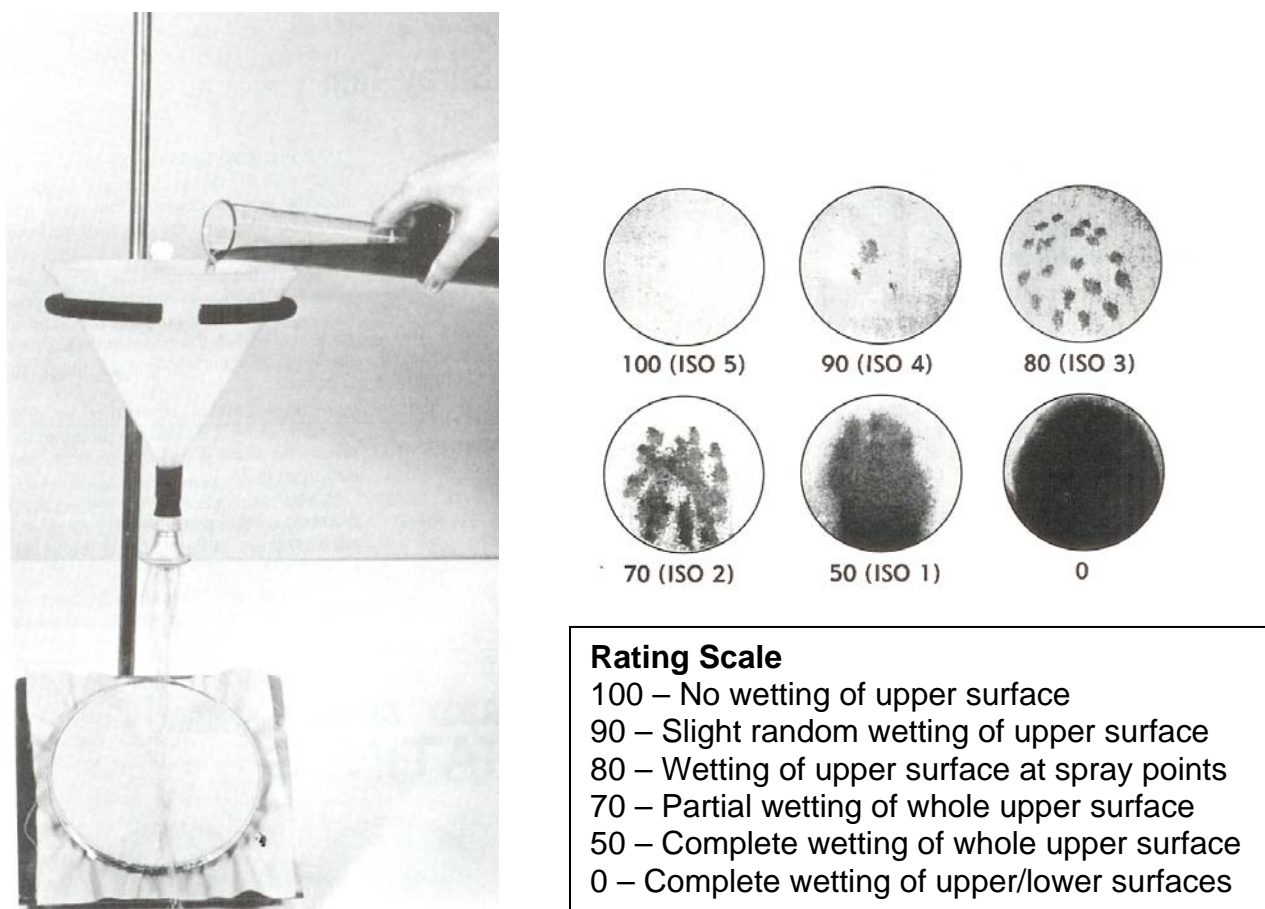


**Figure 26 – Comparison of Burst Strength Data for Selected EMS Garment Fabrics**

<sup>15</sup> Only one unsupported film was included in this test series.

**Determination of Garments Liquid Testing Approaches.** Another issue facing the committee with respect to garment performance criteria was the choice of liquid testing approaches beyond the viral penetration resistance testing specified for barrier performance. EMS responders are sometimes concerned about the retention of liquid in their clothing. Materials may absorb liquid and some of this absorption is dependent on how well materials actually repel liquid. The ideal material would be one that easily sheds any liquid, reduces the residence time of that liquid on the garment surface, and thereby lessens the opportunity of absorption into garment layers.

The 2003 edition of NFPA 1999 applied liquid repellency criteria per AATCC 22 [52], requiring a repellency rating that is greater than 70. In this test, material specimens are laid on an incline and 500 mL of water is poured through a funnel connected to a special nozzle that sprays the water onto the specimen at a specified height (150 mm), as shown in Figure 27. The test operator then observes the wetting condition of the material specimen's upper and lower surface in order to apply one of the standard spray test ratings set in the test method.



**Figure 27 – AATCC 22 Water Repellency Spray Test Method**

The committee felt that there were potential problems with continuing this test method in the 2008 edition of NFPA 1999.

- Test results rely on the subjective determination of the test operator.
- The concern exists that repellency might not be a good predictor of liquid retention, particularly for garments that use both outer shell and barrier fabrics or for those that comprise a barrier sandwiched between two layers of a fabric.
- Garments soiled with liquids could be removed, cleaned and disinfected, and as long as the liquid retention was minimized, the risk to the wearer would be low.

The alternative property of liquid absorption was investigated in this study. With the assistance of Underwriters Laboratories, eight different single use and reusable EMS garment fabrics were tested for both water repellency and water absorption. For water absorption, the former procedures specified in Federal Test Method Standard 191A, 5504 [54] were used. However, since federal standards are being discontinued, a similar method based on AATCC 42 [55] was used.<sup>16</sup> The test used a similar apparatus as specified in AATCC 22, but the spray nozzle is positioned higher at 60 cm above the center of the specimen. In addition, the specimen is set into a 150 mm diameter embroidery hoop. Water absorption is determined by measuring the percentage weight gain of the specimen after the specimen has been placed between two sheets of blotter paper and pressed with a 1 kg roller. Results for this testing are presented in Table 18 below.

**Table 18 – Comparison of Water Repellency and Absorption for Selected EMS Garment Materials**

<b>Material Description</b>	<b>Spray Rating per AATCC 22</b>	<b>Water Absorption per Modified AATCC 42</b>
Navy PET shell	90-100	0.3/6.3*
Fluorescent PET shell	80	0.4/17.9*
PBI/Kevlar shell	50-70	1.3/12.7*
Nomex III rip stop shell	70	3.7/14.9*
Nomex III plain weave shell	70	1.4/18.4*
PBO/Kevlar shell	50-70	0.2/9.7*
Non-woven flashspun PE	100	5.6
Non-woven polypropylene	100	2.5

\* Following 25 cycles of laundering as specified in NFPA 1999-2003

<sup>16</sup> The U.S. government has discontinued the use of Federal Test Method Standards (for textiles, these methods were part of Federal Standard 191A) and has transitioned many of these tests methods to consensus organizations such as ASTM International and the American Association for Textile Chemists and Colorists. For Test Method 5504, no specific consensus method has been created; therefore, the method is based on a modified form of AATCC 42, *Water Resistance, Impact Penetration Test*. This method has been adopted in the 2007 edition of NFPA 1951, *Standard on Protective Ensemble for Technical Rescue Operations*.

The results of these tests showed materials with relatively low repellency (spray) ratings could still lead to low levels of water absorption. The testing also demonstrated better quantification of material retention of liquid, which was in fact the committee's principal purpose for instituting a liquid resistance test.<sup>17</sup>

**Methodology for Evaluating Garment Physical Properties.** The primary disparity between single use and multi-use garment criteria is the lack of distinction in material physical property criteria that define material strength and durability in line with end user expectations and intended use. The goal of this specific investigation was to provide the basis for unique physical property criteria that could be applied to single use garments. A second goal was to determine if the current criteria in NFPA 1999-2003, applied to both single use and multi-use EMS garments was still applicable to multi-use garments only.

*Selection of materials.* For the purpose of this study, nine different materials representative of disposable EMS garments being used in the industry were selected. These materials included nonwoven fabrics, coated nonwoven fabrics, nonwoven laminates, and unsupported films. These materials primarily were found in various full body and partial body garments, including protective sleeves. No attempt was made to qualify the materials as compliant to the existing edition of NFPA 1999; rather the specific objective in selecting materials was to provide a range in materials representing what end users would consider for protective garments to be used in emergency medical operations. The selected materials along with their weight and thickness are presented in Table 19.

**Table 19 – Garment Materials Selected for Physical Property Investigation**

<b>Material Designation</b>	<b>Description</b>	<b>Weight (g/m<sup>2</sup>)</b>	<b>Thickness (mm)</b>
A	Spunbond/meltblown/spunbond (SMS) polypropylene	35	0.25
B	Polypropylene-based microporous laminate	69	0.38
C	Flashspun polyethylene	42	0.18
D	56% polyester/44% polyethylene blend	54	0.33
E	100% polyolefin	64	0.25
F	Polyethylene film coated flashspun polyethylene	89	0.25
G	Polypropylene microporous laminate	80	0.43
H	Polyethylene film (no substrate)	31	0.08
I	Polyethylene coated polypropylene (sleeve)	64	0.33

<sup>17</sup> The committee opted to stay with water as the test liquid even though different biological liquids, such as blood and other body fluids, exhibit much lower levels of surface tensions and purportedly would result in differences for measured absorption masses for the tested fabrics. Part of the decision to use a water test liquid was based on an uncertainty as to what level of liquid retention would constitute a hazard to the wearer. The proposed level of 30% was adopted since it was the same requirement established for firefighter protective garments in NFPA 1971 [56].



*Test Methods.* Current and proposed test methods were selected for the evaluation of each garment material. The selected test methods included those physical properties specified in NFPA 1999-2003, as well as analogous or selected test methods of interest. Specific test methods applied in this study included:

- Tensile strength – ASTM D 5034 [57]
- Tear resistance (trapezoidal) – ASTM D 5733 [58]
- Tear resistance (Elmendorf) – ASTM D 1424 [59]
- Burst strength (Mullen) – ASTM D 3786
- Burst strength (ball) – ASTM D 3787
- Puncture propagation tear resistance – ASTM D 2582 [60]
- Abrasion resistance (Taber) – ASTM D 3884
- Seam strength – ASTM D 1683 [61]

Table 20 provides a description of the applied test methods.

**Table 20 – Description of Selected Physical Property Tests**

<b>Performance Property</b>	<b>Description</b>	<b>Application and Limitations</b>
Tensile strength* (ASTM D 5034)	A 100-mm (4.0-in.) wide specimen is mounted centrally in clamps of a tensile testing machine and a force applied until the specimen breaks. Values for the breaking force and the elongation of the test specimen are obtained from machine scales, dials, autographic recording charts, or a computer interfaced with the testing machine.	Tensile strength is reported in pounds force (lb <sub>f</sub> ) or Newtons (N). A higher reported tensile strength indicates a stronger material.
Tear resistance - trapezoidal* (ASTM D 5587 for woven fabrics, and ASTM D 5733 for nonwoven fabrics)	An outline of an isosceles trapezoid is marked on a rectangular material specimen. The specimen is slit at the base of the small side of the trapezoid to start the tear. The non-parallel sides of trapezoid marked on the specimen are clamped into parallel grips of a tensile testing machine. The separation of the jaws is continually increased to apply a force to propagate the tear along the specimen. At the same time, the force developed is recorded. The force to continue the tear is calculated from autographic chart recorders or microprocessor data collection systems. Option 1 uses the average of the five highest measured forces as the reported tear resistance. The procedure for testing nonwoven materials is identical except that the maximum recorded force is reported as the tear resistance.	Tear resistance is a measurement of the ease with which a fabric can be torn apart. Tear resistance is reported in pounds force (lb <sub>f</sub> ) or Newtons (N). A higher reported tear resistance indicates a stronger material.

<b>Performance Property</b>	<b>Description</b>	<b>Application and Limitations</b>
Tear resistance – Elmendorf * (ASTM D 1424)	A slit is centrally precut in a test specimen held between two clamps and the specimen is torn through a fixed distance by use of pendulum-type device. The resistance to tearing is in part factored into the scale reading of the instrument and is computed from this reading and the pendulum capacity.	Tear resistance is a measurement of the ease with which a fabric can be torn apart. Tear resistance is reported in pounds force (lb <sub>f</sub> ) or Newtons (N). A higher reported tear resistance indicates a stronger material.
Burst strength – Mullen (ASTM D 3786)	A specimen is clamped over an expandable diaphragm. The diaphragm is expanded by fluid pressure to the point of specimen rupture. The difference between the total pressure required to rupture the specimen and the pressure required to inflate the diaphragm is reported as the bursting strength.	Burst strength indicates how easily a material can be ruptured when a force is applied by a blunt object normal to the material's surface. Mullen burst strength is reported in pounds per square inch (psi) or Pascals (Pa). A higher reported burst strength indicates a stronger material.
Burst strength – Ball (ASTM D3787)	A specimen is securely clamped without tension between grooved, circular plates of the ball burst attachment secured to the pulling (movable) jaw for the constant-rate-of-traverse (CRT) testing machine. A force is exerted against the specimen by a polished, hardened steel ball that is attached to the pendulum-actuating (fixed) clamp of the machine, until rupture occurs.	Burst strength indicates how easily a material can be ruptured when a force is applied by a blunt object normal to the material's surface. Ball burst strength is reported in pounds force (lb <sub>f</sub> ) or Newtons (N). A higher reported burst strength indicates a stronger material.
Puncture propagation tear resistance * (ASTM D 2582)	A material specimen is draped over the material holder platform on a puncture propagation tear tester. A carriage on which a puncture probe is mounted slides down a vertical track, striking the material sample, causing it to tear. The length of the tear is related to the force required to propagate that tear.	This test simulates how material may be snagged and torn by a protruding nail or other similar sharp object. Puncture tear forces are reported in pounds force (lb <sub>f</sub> ) or Newtons (N). A higher reported puncture tear force indicates a stronger material.
Abrasion resistance – Taber (ASTM D 3884)	A specimen is abraded using rotary rubbing action under controlled conditions of pressure and abrasive action. The test specimen, mounted on a platform, turns on a vertical axis, against the sliding rotation of two abrading wheels. One abrading wheel rubs the specimen outward toward the periphery and the other, inward toward the center. The resulting abrasion marks form a pattern of crossed arcs over an area of approximately 30 cm <sup>2</sup> . Resistance to abrasion is evaluated by various means.	In this study, the abrasion end point was the number of cycles to wear through of the material. A higher number of reported cycles to abrasion indicates a more abrasion resistant material.

Performance Property	Description	Application and Limitations
Seam strength (ASTM D 1683)	For woven and nonwoven materials, the strength of a seam is measured in the same way as material tensile strength. The applied force is longitudinal and perpendicular to the seam. A force is applied until seam failure occurs. An observation is made whether the break occurs at the seam or in the material adjacent to the seam.	Seam strength is reported in pounds force (lb <sub>f</sub> ) or Newtons (N). A higher reported seam strength indicates stronger seams, that are less likely to separate or break open when garments are strained through use.

\* These properties are reported in the two directions based on the way the material is made – one value represents the direction parallel to the roll (warp or machine direction); the other direction represents the direction perpendicular to the roll (fill or cross machine direction)

*Test Results.* A summary of all test physical property test results are provided in Table 21. Individual test results for each property are discussed in the following subsections.

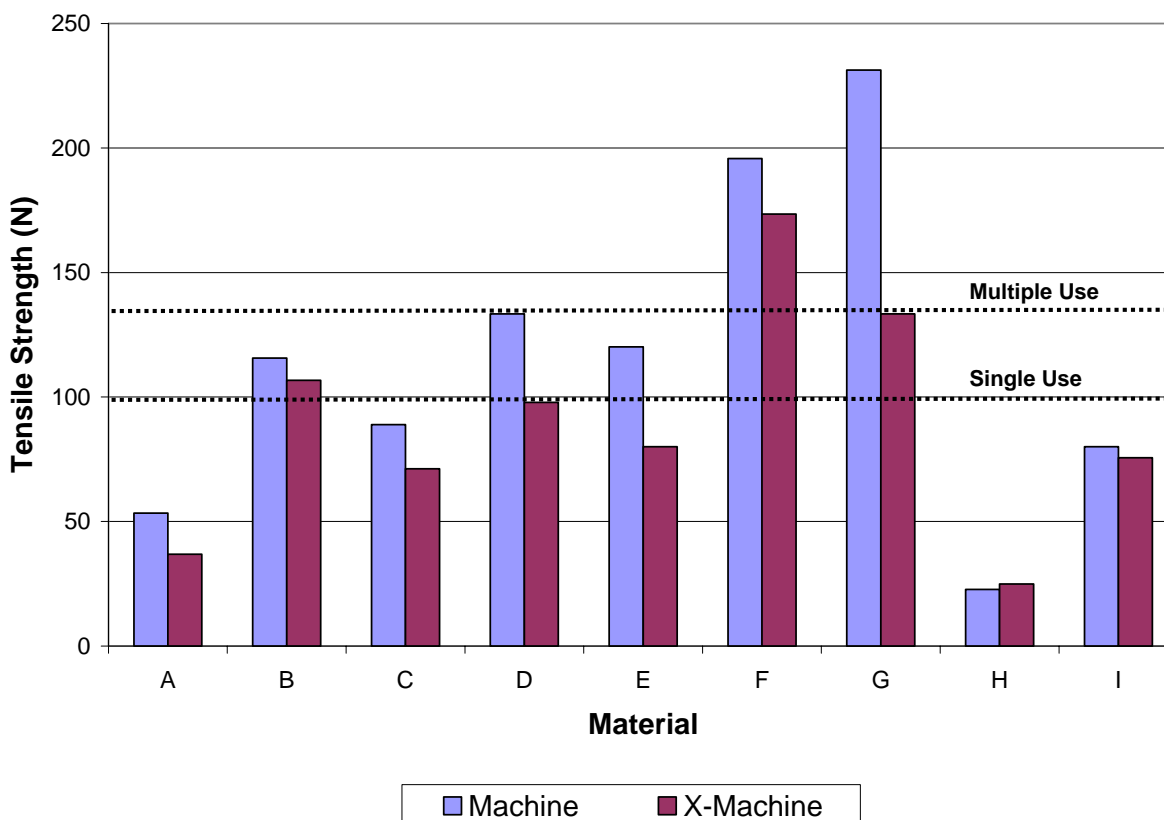
**Table 21 – Summary of Physical Property Test Results for Selected Single-Use EMS Garment Materials**

Material	Tensile strength	Trapezoidal Tear resistance	Elmendorf Tear Resistance	Mullen burst strength	Ball burst strength	Abrasion resistance	Seam strength
<i>Units</i>	<i>N</i>	<i>N</i>	<i>N</i>	<i>kPa</i>	<i>N</i>	<i>cycles</i>	<i>N</i>
A	53 37	22.2 16.9	4.9 4.9	138	53	5.8	29.4
B	116 107	42.3 18.7	4.4 8.5	214	116	32	60.1
C	89 71	24.5 18.7	15.1 12.0	234	85	51	60.5
D	133 98	32.5 20.9	8.5 2.7	228	116	29	85.4
E	120 80	40.9 25.4	9.3 4.4	634	89	31	71.2
F	196 173	30.2 21.8	11.6 16.0	517	169	709	151
G	231 133	53.4 27.1	10.2 4.4	310	196	29	107
H	23 25	5.8 11.6	0.4 1.8	103	40	5	N/A
I	80 76	28.0 29.4	6.7 5.8	193	89	137	81.8

**Note** – Where 2 values are given, the top number is the measurement in the machine direction while the bottom number is the measurement in the cross machine direction.

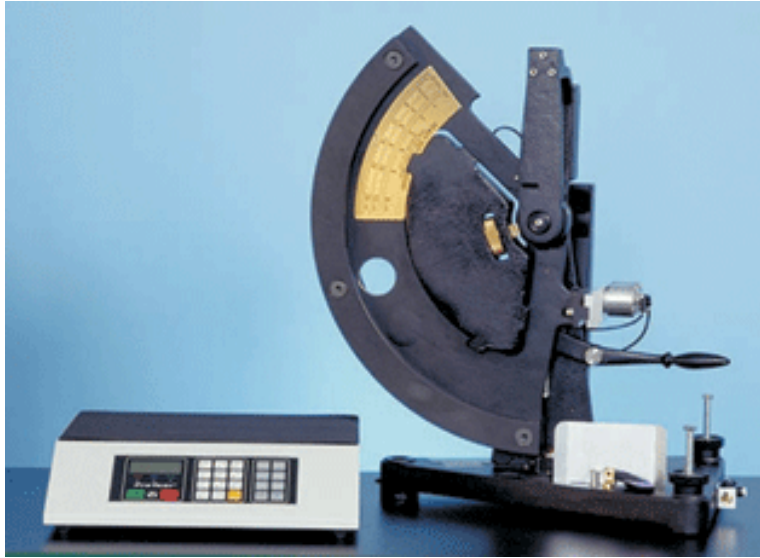
**Analysis of Physical Property Data.** Test data for each material for each physical property were separately analyzed as described in the following subsections.

**Tensile Strength Results.** The results for testing the tensile strength for each fabric are shown in Figure 28. This chart shows that only two of the tested fabrics (Materials F and G) would meet the existing NFPA 1999-2003 criteria (as indicated with the “multiple use” line). Both of these materials are the heaviest of the selected fabrics – Material F is a more likely chemical protective clothing fabric than EMS fabric. At the lower initially recommended criteria, several other materials could be considered as acceptable, including materials B, D, and E.



**Figure 28 – Tensile Strength Results for Selected Single-Use EMS Garment Fabrics**

**Tear Resistance Results.** Two different tear resistance tests were examined – Elmendorf and trapezoidal tear resistance. The Elmendorf test uses a pendulum type device with a rectangular notched fabric specimen with tear measured off a dial on the device. In contrast, the trapezoidal tear test uses a trapezoidal shaped specimen that has a cut in the short dimension with the tear force measured on a tensile testing machine. Both tests are shown in Figure 29. While both methods measure the ease of continuing a tear in a notched or cut fabric, previous work has shown that these tear resistance tests rank order materials differently [62]. No specific correlation is yielded when these measurements are compared as illustrated in Figure 30.



(a) Elmendorf Tear Testing Apparatus



(b) Trapezoidal Tear Test

Figure 29 – Tear Resistance Test Method Approaches

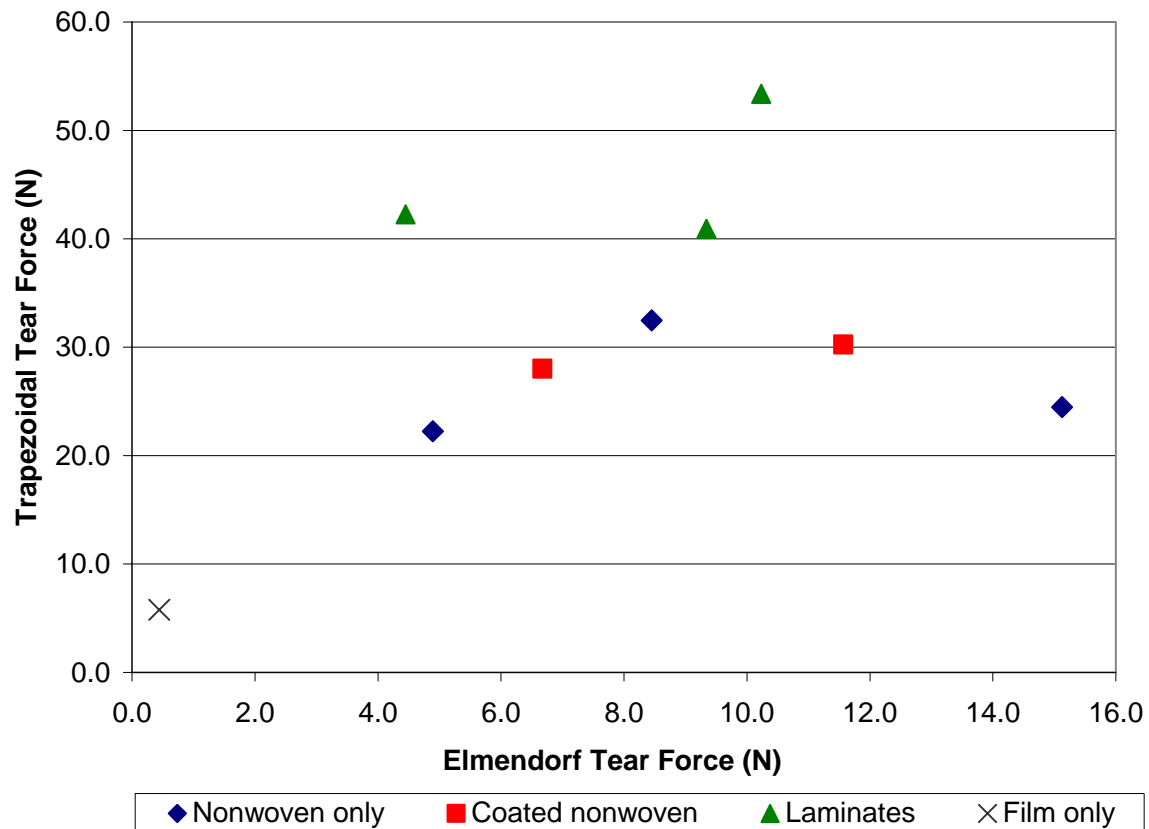
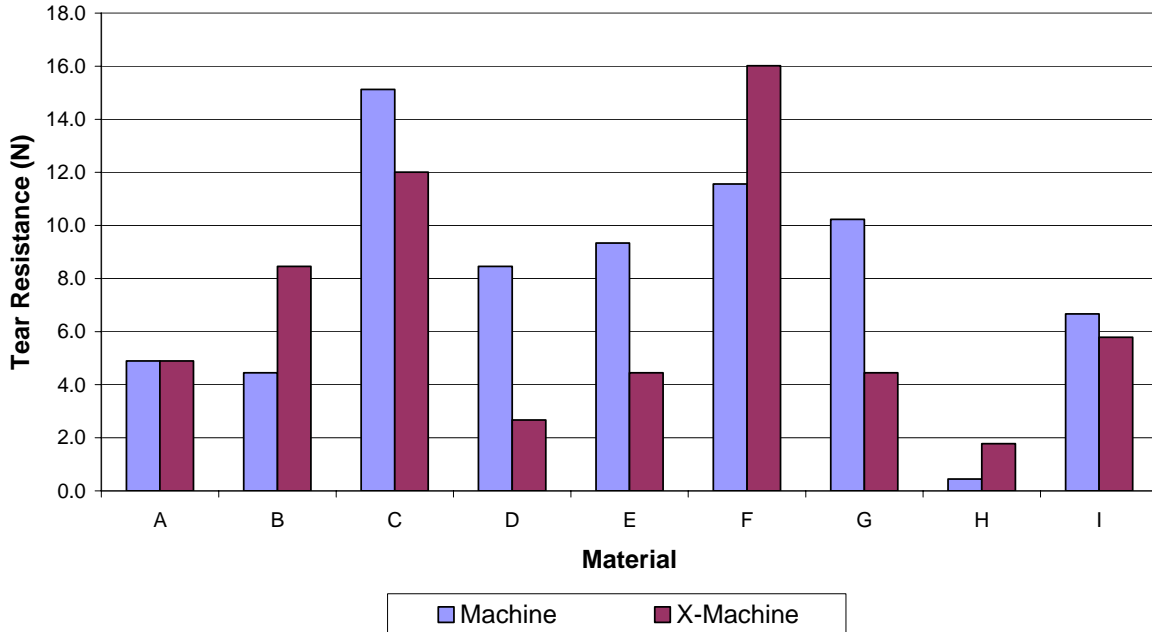
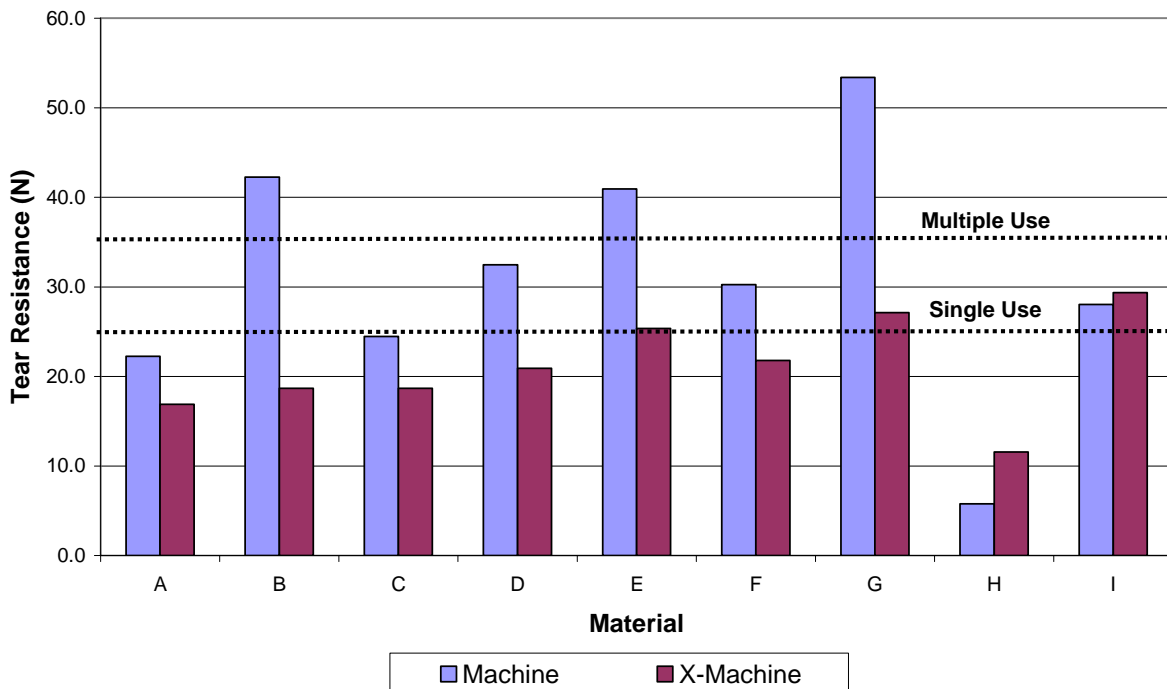


Figure 30 – Comparison of Tear Resistance Data for Selected EMS Garment Fabrics

Test results for both tear resistance tests are displayed in Figures 31 and 32, respectively. These graphs show a different ranking of fabric performance and illustrate that current values easily eliminate several fabrics from possible compliance (based on both levels for trapezoidal tear resistance).

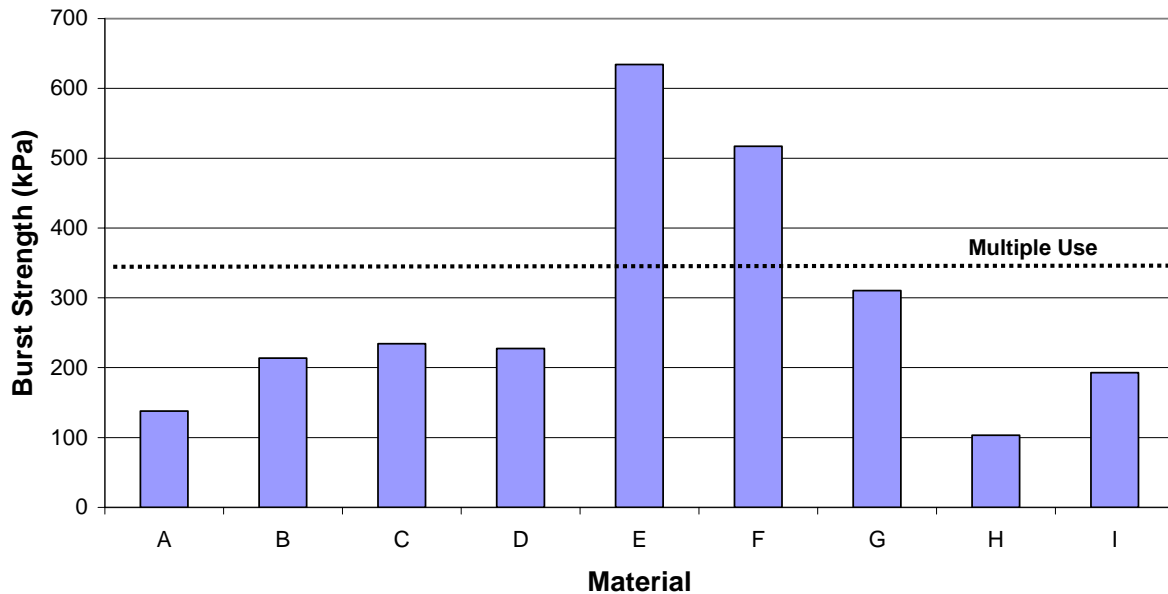


**Figure 31 – Elmendorf Tear Resistance Results for Selected Single-Use EMS Fabrics**

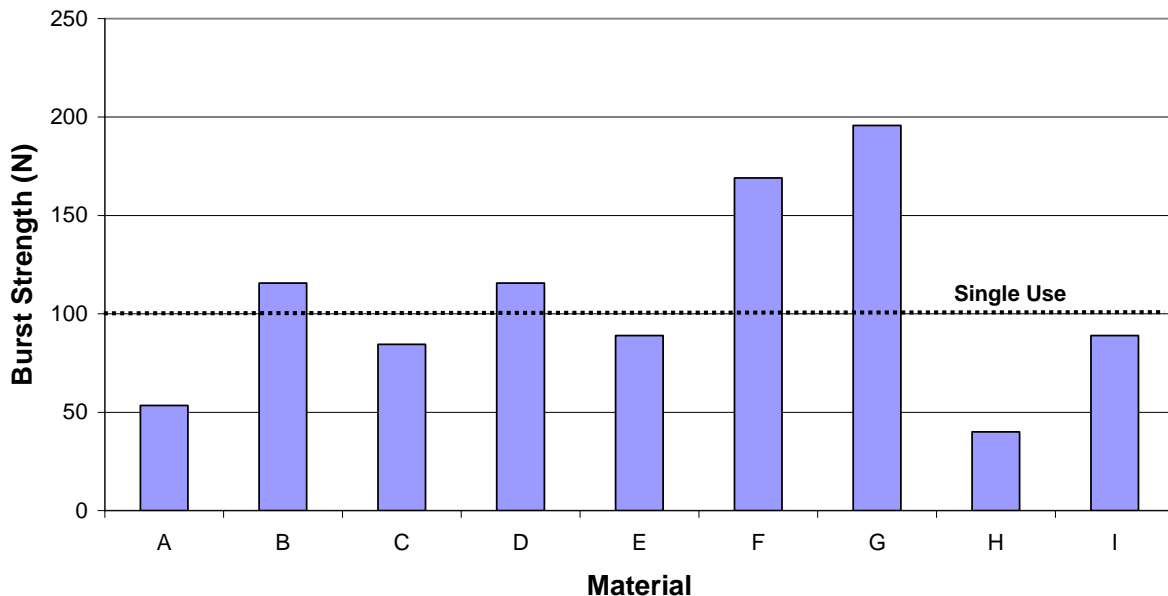


**Figure 32 – Trapezoidal Tear Resistance Results for Selected Single-Use EMS Fabrics**

**Burst Strength Results.** Differences in the two burst strength test methodologies were discussed in a preceding subsection. The results of these tests for the selected fabrics are shown in Figures 33 and 34, for Mullen and ball burst tests, respectively. The initially recommended single use criteria using the ball burst test approach shows a greater accommodation of available single-use EMS fabrics.



**Figure 33 – Mullen Burst Strength Results for Selected Single-Use EMS Fabrics**



**Figure 34 – Ball Burst Strength Results for Selected Single-Use EMS Fabrics**

**Puncture Propagation Tear Resistance (PPT) Results.** This test evaluates “snagging” resistance of fabrics and emulates the damage incurred when a garment snags a physical hazard, such as a protruding nail. In the test, a puncture probe mounted on a vertically sliding carriage strikes an included specimen, first puncturing the material and then causing a tear (see Figure 35). The length of the tear relates to the force required to puncture and propagate tear in fabric. Even with the lightest weighted carriage, some disposable materials exhibit a “V” shape tear, which leads to difficulties in interpreting test results. Test results for the selected single-use EMS fabrics are shown in Figure 36. Specific PPT results could not be characterized for two fabrics due to non-straight tears.

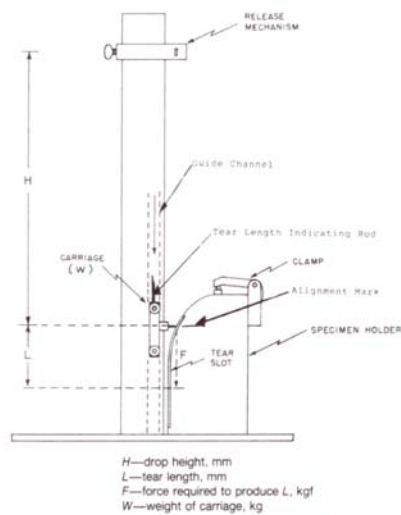


FIG. 1 Puncture-Propagation of Tear Tester

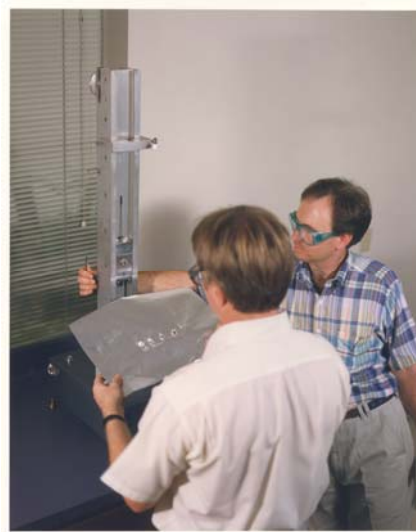


Figure 35 – Puncture Propagation Tear Test Resistance Apparatus

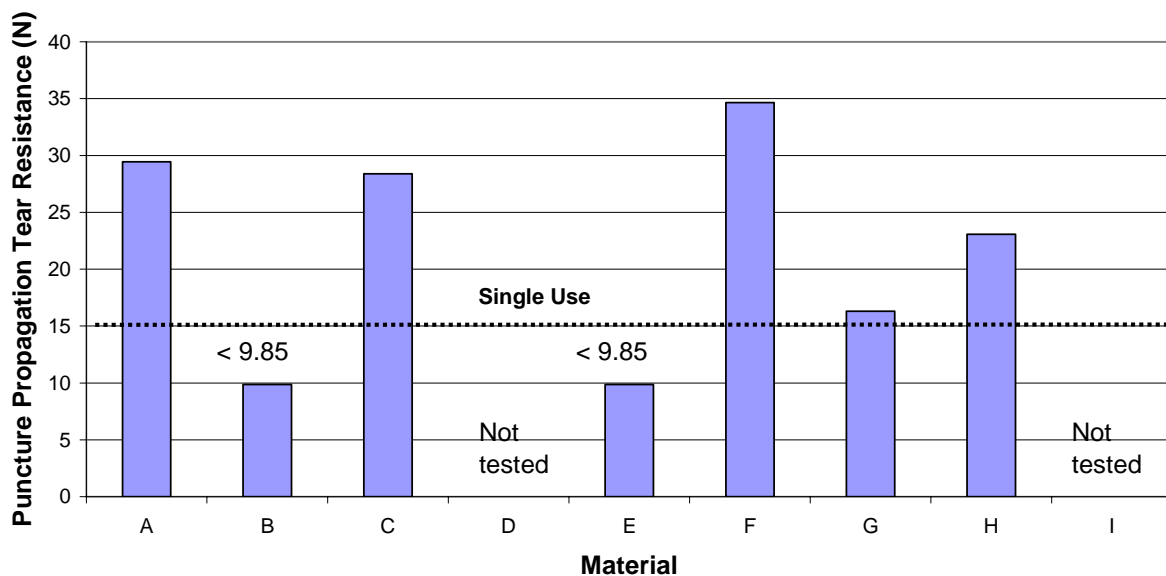


Figure 36 – Puncture Propagation Tear Resistance Test Results for Selected Single-Use EMS Garments Fabrics

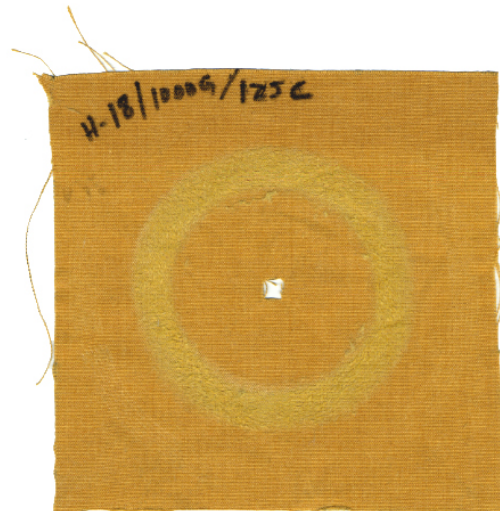


**Abrasion Resistance Results.** Abrasion resistance was not a currently specified physical property test in NFPA 1999-2003 for protective garments. Abrasion tests evaluate garment material durability to repeated rubbing on various types of surfaces. There are several common approaches used for measuring abrasion that include:

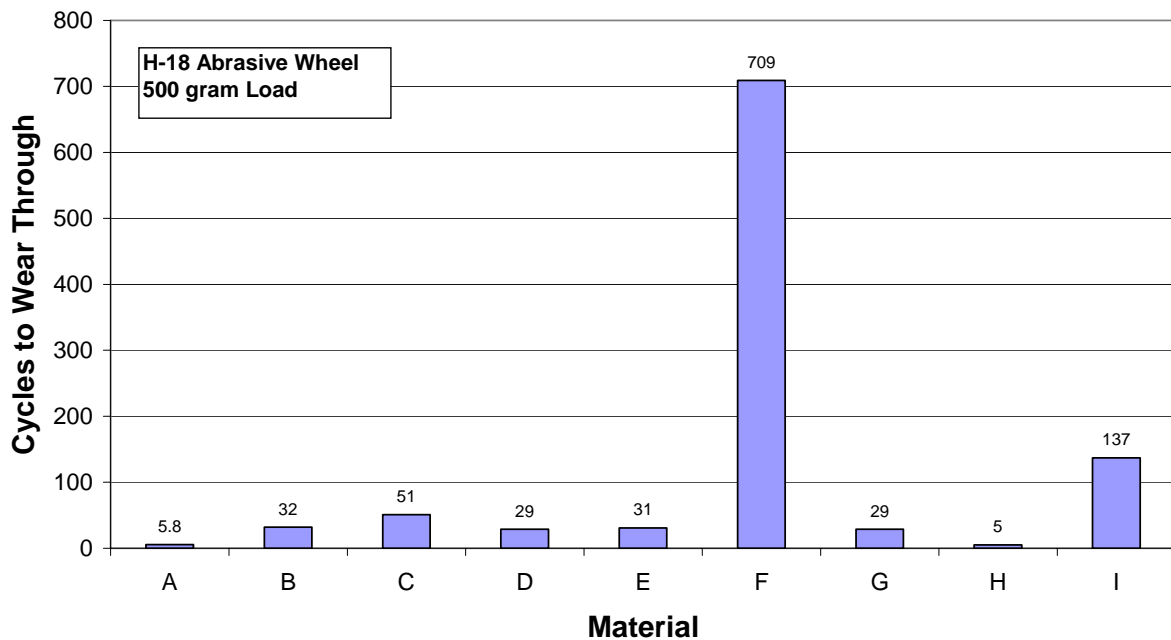
- Wyzenbeek: used as a preconditioning technique for barrier materials
- Martindale: often applied to labels (in NFPA standards)
- Taber: assesses loose fibers or wear-through

Test parameters for abrasion tests include the abrasion action, type of abrasant, pressure applied on the material or abrasant, the tension of material during abrasion, and the end point. End points are the basis for concluding a test and providing a test result. In some cases, a test is run for a specific number of cycles and then subjected to some other test to determine how the property might change. This additional property measurement can be a simple assessment such as mass or thickness change or a more complicated determination such as changes in strength or barrier performance. Another frequently applied end point is the number of cycles required to cause a specific change in the material. For a barrier material such as those used in EMS garments, the creation of wear or holes in a fabric that can lead to liquid penetration is an appropriate way of discerning single-use durability.

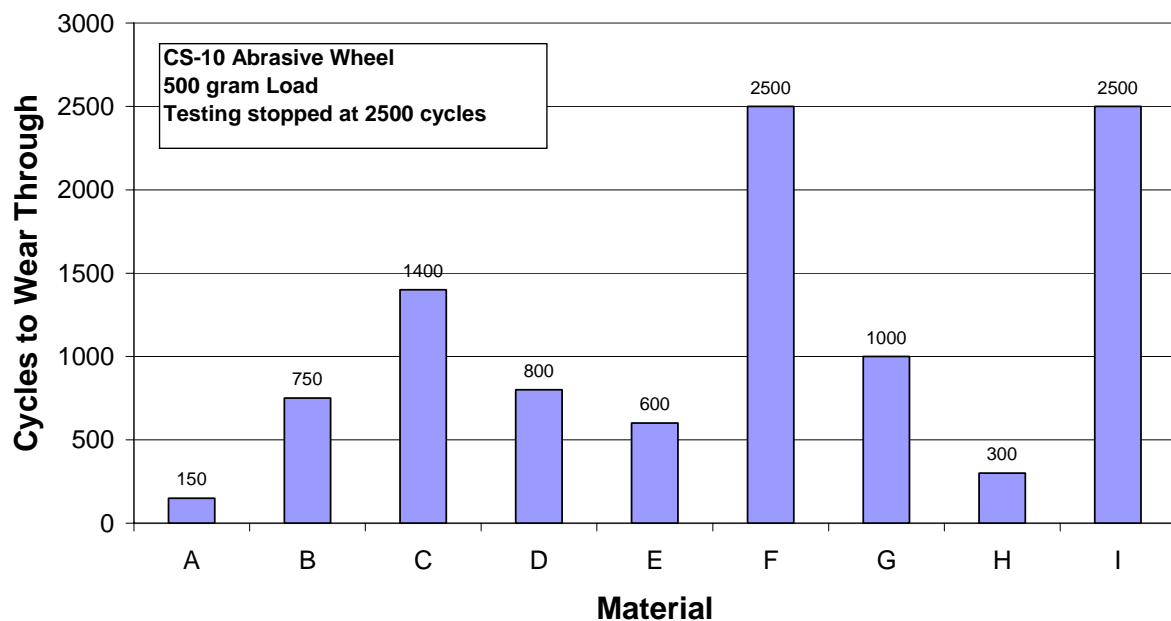
For the purposes of this study, the Taber abrasion method (ASTM D3884) was appropriate. In this test, the material specimen is placed on a turntable that rotates underneath two weight arms that hold abrasant wheels. These wheels create a circular path on the material specimen. Figure 37 shows a photograph of the test apparatus and typical condition of sample following abrasion. Two different abrasant wheels were used – the Calibrade H18 wheel that provide a relatively rough surface and the Calibrase CS-10 wheel, which is a smoother surface. For both sets of tests, the same applied mass was used at 500 grams loading on each wheel and the end point was number of cycles to wearthrough. Both sets of tests are shown in Figures 38 and 39.



**Figure 37 – Taber Abrasion Test Apparatus with Sample Abraded Fabric Specimen**



**Figure 38 – Taber Abrasion Results for Selected Single-Use EMS Garments Fabrics (using H-18 Abradant Wheels)**



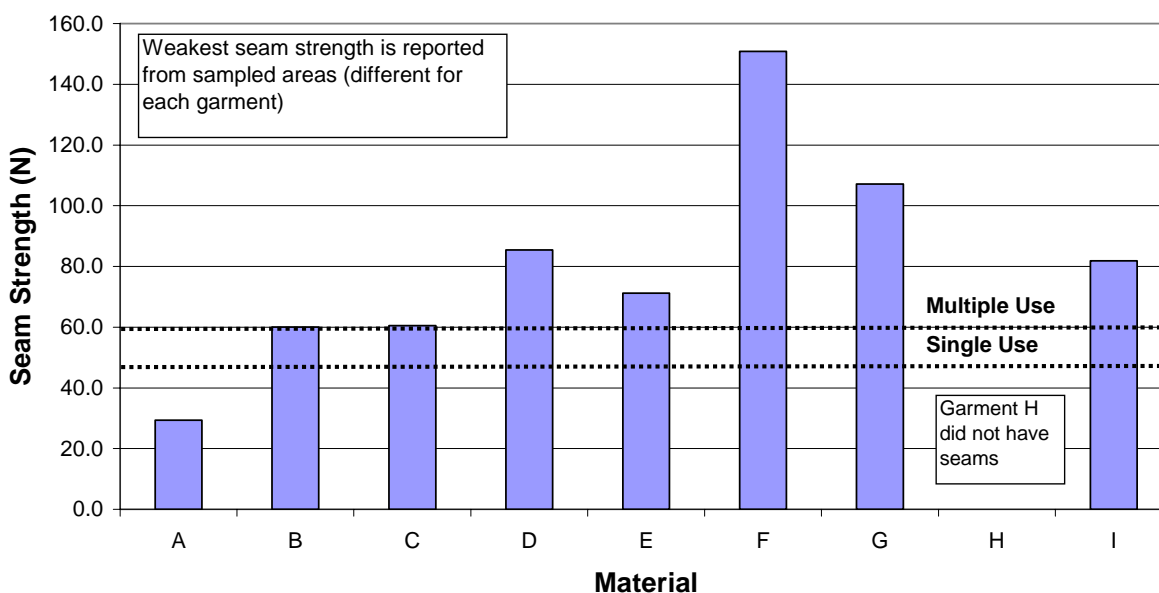
**Figure 39 – Taber Abrasion Results for Selected Single-Use EMS Garments Fabrics (using CS-10 Abradant Wheels)**

The abrasion resistance test results generally ranked the materials the same. For some materials, the test using the CS-10 abradant wheel was stopped at 2500 cycles when total wear through was not achieved. The use of the H-18 abradant wheel was definitely considered a more severe challenge. The test was considered to be a better evaluation of single-use EMS garment materials because of the types of surfaces that responders could encounter (e.g., roadway asphalt).

*Seam Strength Results.* With the exception of material H, which was provided in a disposable gown that did not have seams, seam strength was evaluated for each material type based on the types of seams provided in the respective garments. Seam strength testing used a similar approach where seam specimens are pulled in a tensile testing machine until breakage occurs. The break occurred either in the seam or in the adjacent material (for this testing, the material generally broke before the seam). Different seam locations were sampled for test specimens as described in Table 22. Figure 40 provides the results of seam testing as based on the weakest seam strength.

**Table 22 – Garment Types and Sampled Seam Locations**

Material	Garment Type	Sampled Seam Locations
A	Smock	Shoulder, arm hole, under arm, side seam
B	Coverall	Inseam, under arm, horizontal back seam, vertical back seam
C	Coverall	Inseam, arm hole, shoulder seam, horizontal back seam
D	Lab coat	Shoulder, arm, arm hole
E	Isolation gown	Arm, arm hole, shoulder
F	Sleeved apron	Arm hole, under arm, shoulder
G	Shirt	Arm hole, under arm, shoulder, side seam
I	Sleeve protector	Sleeve side seam



**Figure 40 – Seam Strength Test Results for Selected Single-Use EMS Garments Fabrics**

**Determination of Appropriate Garment Physical Property Criteria.** Material performance was ranked for each of the tested physical properties. These rankings are shown in Table 23.

**Table 23 – Garment Material Rankings Based on Physical Property Performance**

<b>Tensile Strength</b>	<b>Elmen. Tear</b>	<b>Trap Tear</b>	<b>Mullen Burst</b>	<b>Ball Burst</b>	<b>Taber* Abrasion</b>	<b>Puncture Tear**</b>	<b>Seam*** Strength</b>
G	F	G	E	G	F	F	F
F	C	B	F	F	I	A	G
D	G	E	G	B	C	C	D
E	E	D	C	D	B	H	I
B	B	F	D	E	E	G	E
C	D	I	B	I	D	B	C
I	I	C	I	C	G	E	B
A	A	A	A	A	A	---	A
H	H	H	H	H	H	---	---

**Note** – Ranking is in descending order from highest to lowest performance (best performing materials are listed at the top of each column); where machine and cross machine direction data were provided, rankings were based on the lowest of the two reported values.

\* Based on H-18 abrasant wheel test results

\*\* Two materials were not tested and ranked

\*\*\* No seams were provided for material H

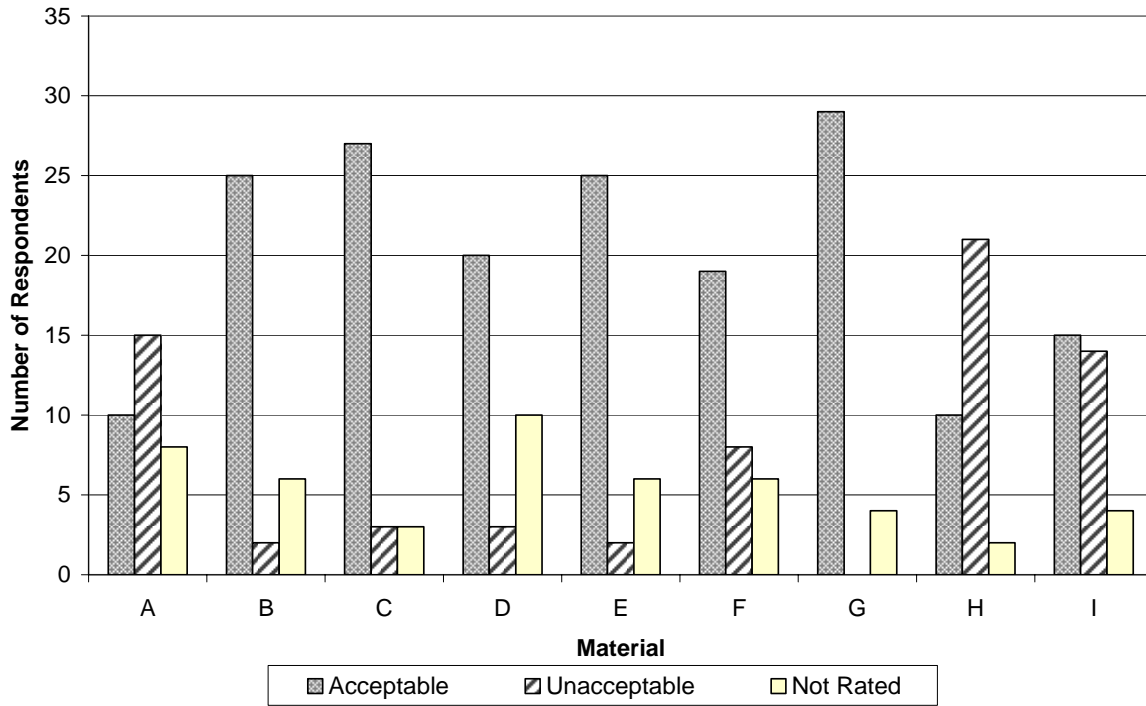
This rank ordering of materials provided the basis for comparing field observations and end user comments for the acceptability or unacceptability of products. Three specific sources of field user input were obtained as part of this investigation, which included:

1. Trade show rankings or product acceptability
2. Limited field trial 1
3. Limited field trial 2

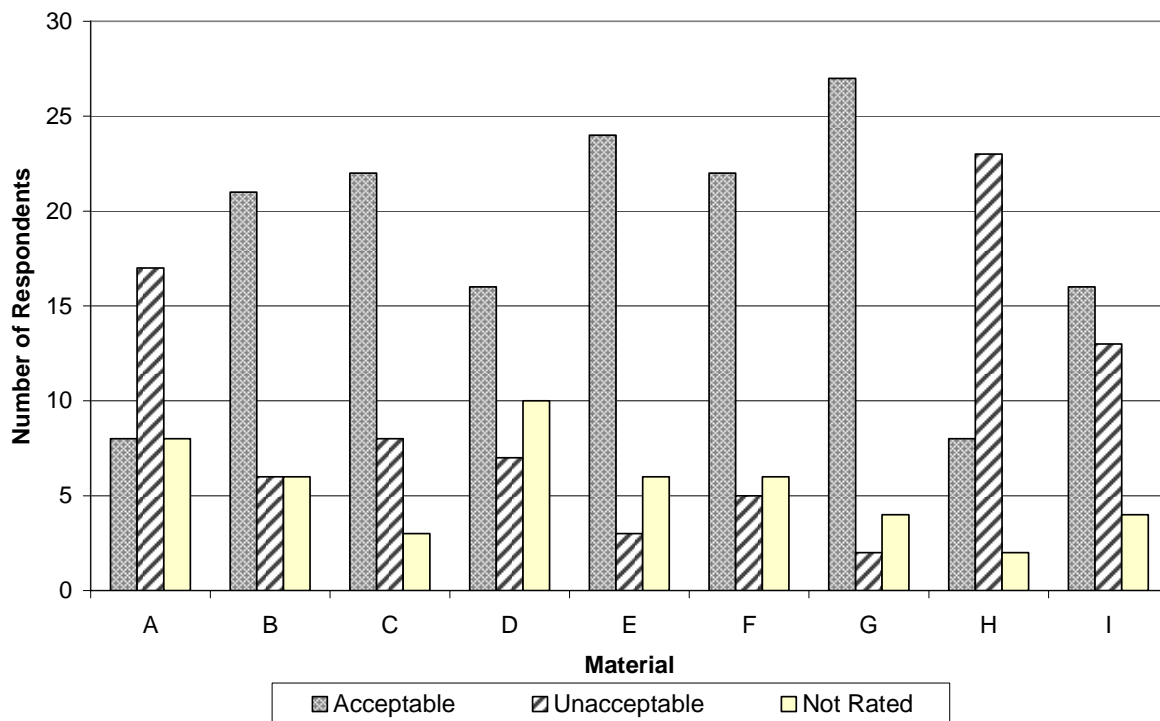
In each case, garments were rated for strength and single use durability. For the trade show rankings, products made from materials A through I were available. In both limited field trials, garments based on materials A through F, H, and I were available for rating.

Material rankings for strength and single use durability are provided in Figures 41 and 42.<sup>18</sup> Tables 24 and 25 provide the ratings for garments in the limited field trials.

<sup>18</sup> Other property ratings (for design, barrier qualities, comfort, and donning ease) are provided in Appendix C.



**Figure 41 – Trade Show Respondent Ratings for Garment Material Strength**



**Figure 42 – Trade Show Respondent Ratings for Garment Material Single Use Durability**

**Table 24 – Field Trial 1 Ratings for Disposable Garments: Percentage Deemed Acceptable or Unacceptable, by Attribute**

Disposable Garment Ratings	Quantity Tested*	Strength		Single Use Durability		Design (Body Coverage)		Barrier Qualities		Comfort		Donning Ease	
		A	U	A	U	A	U	A	U	A	U	A	U
A – SMS Polypropylene Coverall	6	50%	50%	50%	50%	67%	33%	100%	0%	67%	33%	67%	33%
B – Polypropylene Microporous Coverall	6	100%	0%	100%	0%	100%	0%	100%	0%	100%	0%	83%	17%
C- Flashspun Polyethylene Smock	6	50%	50%	67%	33%	0%	100%	50%	50%	0%	100%	100%	0%
E – Polyethylene/ Flashspun Polyethylene Sleeved Apron	6	50%	50%	50%	50%	100%	0%	50%	50%	50%	50%	50%	50%
F- Polyolefin Isolation Gown	6	100%	0%	100%	0%	67%	33%	100%	0%	67%	33%	67%	33%
H - Polyethylene Gown	6	18%	82%	33%	67%	33%	67%	67%	33%	33%	67%	18%	82%
I – Polypropylene Sleeve	4	50%	50%	25%	75%	0%	100%	100%	0%	100%	0%	100%	0%

A= Acceptable; U = Unacceptable

\* Not all items were evaluated in the same quantities

**Table 25 – Field Trial 2 Ratings for Disposable Garments: Percentage Deemed Acceptable or Unacceptable, by Attribute**

Disposable Garment Ratings	Quantity Tested*	Strength		Single Use Durability		Design (Body Coverage)		Barrier Qualities		Comfort		Donning Ease	
		A	U	A	U	A	U	A	U	A	U	A	U
A – SMS Polypropylene Coverall	10	80%	20%	80%	20%	100%	0%	100%	0%	100%	0%	90%	10%
B – Polypropylene Microporous Coverall	6	100%	0%	100%	0%	100%	0%	100%	0%	100%	0%	83%	17%
C- Flashspun Polyethylene Smock	6	50%	50%	100%	0%	0%	100%	50%	50%	0%	100%	100%	0%
E – Polyethylene/ Flashspun Polyethylene Sleeved Apron	6	50%	50%	50%	50%	100%	0%	50%	50%	50%	50%	50%	50%
F- Polyolefin Isolation Gown	6	100%	0%	100%	0%	67%	33%	100%	0%	67%	33%	67%	33%
H - Polyethylene Gown	6	33%	67%	33%	67%	33%	67%	33%	67%	33%	67%	67%	33%
I – Polypropylene Sleeve	10	80%	20%	60%	40%	0%	100%	100%	0%	100%	0%	100%	0%

A= Acceptable; U = Unacceptable

\* Not all items were evaluated in the same quantities

These ratings along with committee analysis provided guidance in deciding which physical properties best ranked material-based garments based on performance data differences and also assisted the determination of cutoffs for acceptable versus non-acceptable performance. Since the findings for acceptable and unacceptable product performance were not always clearcut, the committee had to exercise some judgment in deciding where to set minimum performance criteria. This judgment was also applied in determining whether the resetting of some physical property levels for multi-use garments was needed.

Based on the information provided by this study and other NFPA Technical Committee deliberations, the following findings were used with respect to setting physical property and other performance criteria for single and multi-use EMS protective garments:

- The committee ultimately decided that Material C was considered reasonably strong and durable for single uses; in most instances, physical property levels that permitted the acceptance of Material C were applied in setting physical property criteria for single-use garment materials.
- Unsupported (kit) material H was clearly unacceptable; Material A (lightweight nonwoven SMS polypropylene) was also generally unacceptable. The setting of physical property levels was chosen to exclude these materials in nearly all cases.

Specific performance criteria changes included:

- Single-use physical properties were aligned with end user expectations (primarily based on Material C).
- The puncture/tear test (ASTM D 2582) was eliminated for single use garments since the property cannot always be properly measured for nonwoven materials and does not discriminate performance consistent with end user expectations.
- The tear resistance requirement was raised for multiple user garments since the then current requirement was considered too low. The Elmendorf test was dismissed from possible use because it did not discriminate material performance consistent with end user expectations for single-use garment materials.
- The ball burst test method (ASTM D 3787) was applied to both types of garments materials to overcome testing problems and to provide rankings more consistent with field observations
- Water absorption resistance testing replaced repellency testing and this requirement was applied only to multiple use garments since most end user contended that the wearing time for single-use garments was generally short and these garments could be more readily replaced than multi-use garments.
- Corrosion resistance requirements for hardware were applied to multiple use garments only because most single use garments do not contain metal hardware and their wearing time is too short to have the effects of corrosion take place.
- Label durability requirements are also only applied to multiple use garments.

The revised criteria as proposed and accepted for the new edition of NFPA 1999 appear in Table 26.



**Table 26 – Revised Criteria for EMS Garments**

Item	Property	Test Methods	Multiple Use Garments†	Single Use Garments
Garment	Liquid integrity	ASTM F1359‡	No leakage	No leakage
Barrier layer	Biopenetration	ASTM F1671	Pass	Pass
Each separable layer	Tensile strength	ASTM D5034	≥ 135 N	≥ <b>50 N</b>
	Burst strength	ASTM D3787	≥ <b>222.5 N</b>	≥ <b>66 N</b>
	Puncture/tear	ASTM D2582	≥ 25 N	<b>Not applicable</b>
	Tear resistance	ASTM D5587* ASTM D5733**	≥ 36 N	≥ <b>17 N</b>
Seams/closures	Strength	ASTM D751	≥ <b>135 N</b>	≥ <b>50 N</b>
Outer layer	Water absorption	AATCC 42 (modified)	≥ 30%	<b>Not applicable</b>
Composite	Total heat loss	ASTM F1868 [63]	≥ 450 W/m <sup>2</sup>	≥ 450 W/m <sup>2</sup>
Hardware	Corrosion resistance	ASTM B117 [64]	No corrosion	<b>Not applicable</b>
Labels	Durability	ASTM D4966 [65]	Remain legible	<b>Not applicable</b>

Note – Bold face entries indicate changes from the original proposed revisions.

† Applied to multiple-use garment materials separately after room temperature conditioning and laundering conditioning (25 cycles of whole garment washing and drying per industrial laundering procedure)

‡ Only the area of the manikin covered by the garment is tested

\* Test method applied to multiple use garment material

\*\* Test method applied to single use material

Separate categories of single-use versus multiple use garments were established in the standard to accommodate these proposed changes.

**Discrimination between Full and Partial Body Garment Criteria.** The NFPA committee also considered differences in criteria needed between full and partial body EMS protective garments. For single use garments, the ease of donning was found to be a paramount consideration and end users wanted consistent minimum areas of protection to be established for these items. This finding was partly attributed to the fact that first responders generally preferred partial body garments due to reasons of comfort and ease of use. The committee set specific coverage requirements for sleeve protectors, aprons, and sleeved aprons (smocks). These types of garments were considered to be the most likely partial body garments to be used by EMS responders based on end user feedback. Criteria were set as follows:

- Aprons should be designed to protect the front torso of the wearer from the neck to below the knees.
- Sleeve protectors should be designed to protect the arm of the wearer from the wrist crease to a distance of no less than 405 mm (16 in.) from the wrist crease.
- Sleeved aprons (or smocks) should be designed to protect the front torso of the wearer from the neck to below the knees and arm of the wearer to the wrist crease.

Even though these criteria originated for single-use garments, the committee decided to apply these criteria to multiple-use garments as well. In addition, the committee decided that total heat loss testing that is applied as a measure of garment material breathability (for stress relief) should be applicable only to full body garments.

**Establishment of Minimum Acceptable Visibility Criteria.** A standing proposal from the revision process for the 2003 edition of NFPA 1999 was the consideration of visibility requirements for EMS garments. Given the proximity of EMS responders to vehicle traffic and other moving equipment hazards in providing patient care and transport, high visibility garments are frequently used, such as those pictured in Figure 43. These garments must incorporate fluorescent materials and retroreflective materials to address both daytime and nighttime conspicuity. Some manufacturers choose to incorporate visibility materials as part of certified and non-certified EMS protective garments.

ANSI/ISEA 107 [66] establishes requirements for three classes of high visibility apparel garments, based on the specific hazards of being seen and being struck by moving vehicles or equipment. This standard sets requirements for:

- Minimum area for background (fluorescent) and retroreflective materials by class
- Color, colorfastness, and strength requirements for background material
- Retroreflection, durability, and other performance requirements for retroreflective material



**Figure 43 – Examples of High Visibility Apparel**

Relatively large areas of fluorescent material are required for the higher performance Class 2 and Class 3 products. For example, Class 2 products require 0.5 square meters (775 in.<sup>2</sup>) of background material and 0.13 square meters (201 in.<sup>2</sup>) of retroreflective striping. Class 2 products are generally considered the minimum acceptable products for EMS workers where responses are carried out alongside roadways. Class 3 products must have 0.8 square meters (1240 in.<sup>2</sup>) fluorescent material and 0.2 square meters (310 in.<sup>2</sup>) of retroreflective material. Class 3 products are intended for those situations where vehicular speeds are relatively high and the greatest visibility of roadside workers is needed.

There is also a new standard, ANSI/ISEA 207 [67], which is specifically for public safety high visibility vests. This category would seem to address EMS first responders; however, the requirements for ANSI/ISEA 207 are different from ANSI/ISEA 107 and not in line with new Department of Transportation (DOT) regulations that dictate compliance of high visibility protective clothing with ANSI/ISEA 107 requirements.<sup>19</sup>

While the committee deliberated specific inclusion of visibility requirements, end users pointed out that visibility hazards vary with the type of organization and roles of emergency responders. For this reason, it was recommended that visibility requirements be optional but when visibility materials were used on garments for the purpose of providing high visibility of the wearer, the garment would be required to meet minimum requirements.<sup>20</sup> To this end, the committee opted to apply criteria from ANSI/ISEA 107 for any specific performance class (1, 2, or 3) in order for the manufacturer of the garment to claim high visibility performance. A specific requirement was also made for providing specific label language to indicate this performance or its absence if other visibility materials were on the garment but not in attainment of ANSI/ISEA 107 requirements.

**Approaches for Measuring Garment Material Flammability.** Some concerns were raised to the committee for addressing the flammability of garment materials. It was recognized that EMS garments did not need to be flame resistant, but rather, if incidentally contacted by flame, the materials should not contribute to the injuries of the wearer by promoting rapid burning. End users pointed out that if flame resistance was needed, then NFPA 1951 for technical rescue and recovery garments would be the more appropriate specification.

*Test Method Selection and Parameters.* A review of available flame resistance test methods and specifications showed tests that were either too aggressive or too weak:

- ASTM D 6413 [68] typically applied to garments and other clothing articles intended for possible flame contact uses a relatively long exposure time and discriminates the relative burning behavior of intrinsically flame-resistant fabrics or those treated with flame retardants.
- ASTM D 1230 [69] or the procedures contained in Title 16 Code of Federal Regulations Part 1610 [70] are for general wearing apparel, but do not discriminate burning times for fabrics as ignition conditions are relatively innocuous.

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<sup>19</sup> Federal regulation 23 CFR 634 requires workers on the right of-way of a Federal-aid highway who are exposed to traffic or heavy equipment to wear high visibility apparel that is defined as compliant to ANSI 107-2004 performance Class 2 or Class 3. It is possible to be compliant with Federal high visibility regulation 23 CFR 634 either by incorporating ANSI-compliant high visibility fluorescent and retroreflective materials into NFPA 1999 compliant apparel such as a jacket, parka, shirt, and so on, or through the use of a supplemental high visibility garment. High visibility component materials incorporated into primary apparel should comply with the requirements of prevailing standards applying to the chosen ensemble, such as NFPA 1999, ANSI 107, and so on. At the time the report was prepared, this compliance to ANSI 207-2006 is not sufficient to meet the requirements of 23 CFR part 634.

<sup>20</sup> Excluded from this requirement were visibility markings used for the identity of the organization or individual.

As part of this study, a new test based on procedures in ASTM D 1230, which is similar to 16 CFR 1610, was developed. In this test, the specimen is positioned at a 45 degree incline and a 5/8 inch high butane-fueled flame is used to contact the edge of the specimen. In addition, two different exposure periods were applied – 1 and 3 seconds.<sup>21</sup> The equipment used in the testing is identical to test stands used for both ASTM D 1230 and 16 CFR 1610 (see Figure 44). The test measures the time of flame spread once the specimen ignites, if it does ignite. Flame spread is measured from the time of the application of the flame to the time the flame advances the length of the specimen, burning a cord horizontally positions across the top of the specimen. This rate of burning is used to judge the potential hazards of the fabric igniting.



**Figure 44 – Fabric Flammability Test Apparatus with Close Up of Flame**

*Flammability Test Results.* These tests were applied to the original nine selected single use fabrics evaluated for physical properties with the results provided in Table 27. These results were reported as:

- Ignition (yes or no – DNI)
- Ignited but extinguished (IBE)
- Flame spread time

Table 27 showed that many of the materials did not ignite under either 1 or 3 second exposure condition. Other materials ignited but extinguished before the flame could advance up the length of the specimen. Two of the selected garment materials showed flame spread times at both exposure conditions.

The committee considered the application of these criteria to other items of EMS protective clothing including footwear covers, cleaning gloves, and certain types of eye and face protection devices, as well as reusable garments. Additional data for some representative products are provided in Table 28.

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<sup>21</sup> Normally the bottom surface of the specimen is contacted by flame as part of either ASTM D 1230 or 16 CFR Part 1610. The proposed procedures were similar to the discontinued NFPA 702 standard [68].

**Table 27 – Flammability Test Results for Selected Single-Use EMS Garment Fabrics**

Material	Description	Time of Flame Spread (s) for Flame Exposure Time	
		1 sec	3 sec
A	SMS polypropylene	DNI†	DNI
B	PP microporous laminate	13	10.5
C	Flashspun PE	10.3	5.8
D	56% PET/44% PE	IBE (2-3)‡	DNI
E	100% olefin	DNI	DNI
F	PE coated flashspun PE	IBE (4-15)	DNI
G	PP microporous laminate	IBE (5-16)	IBE (4-11)
H	PE	IBE (2)	DNI
I	PE coated PP (sleeve)	IBE (3-4)	DNI

†DNI – Did not ignite

‡IBE – Ignited but extinguished (value in parentheses is time of continued fabric burning)

**Table 28 – Flammability Test Results for Other EMS PPE Items**

Material (type)	Time of Flame Spread (s) for Flame Exposure Time	
	1 sec	3 sec
Reusable non-FR barrier material 1	12.4	13.0
Reusable non-FR barrier material 2	19.9	16.9
Reusable non-FR barrier material 3	16.5	14.5
Reusable FR barrier material	DNI†	DNI
Reusable non-FR shell material (navy)	25.4	23.4
Reusable non-FR shell material (fluorescent)	18.7	18.3
8 mil nitrile rubber cleaning/utility glove	9.2	8.8
10 mil natural rubber cleaning/utility glove	10.5	12.5
15 mil nitrile rubber cleaning/utility glove	23.6	18.8
22 mil natural rubber cleaning/utility glove	28.2	24.4

†DNI – Did not ignite

*Test Findings and Proposed Criteria.* The 3 second flame exposure did not provide further differentiation of fabric flammability. It was also demonstrated that the test could be applied to different types of EMS protective clothing items. For setting criteria, the committee defaulted to the old minimum Class 3 criteria that had been established in NFPA 702 [71]. These criteria require the rate of flame spread be greater than 3.5 seconds. Fabrics that exhibit a relatively fast rate of burning are considered dangerous to the wearer.

## Revision of Cleaning Glove Criteria

**Key Issues.** Cleaning gloves were added as a new product category in the 2003 Edition of NFPA 1999. Cleaning gloves were addressed in NFPA 1999 to meet the protection needs as set forth in NFPA 1581, *Standard on Fire Department Infection Control*, and were to be used by first responders for cleaning gear and vehicles following an incident. Paragraph 7.2.3 in the 2000 Edition of NFPA 1581, stated:

*Cleaning gloves shall be reusable, heavy-duty, mid-forearm length, and designed to provide limited protection from abrasions, cuts, snags, and punctures. Gloves shall provide a barrier against body fluids, cleaning fluids, and disinfectants.*

While the 2003 edition criteria were established to address these performance areas, there was limited interest in certifying products to the new cleaning glove requirements. For those manufacturers that attempted to certify products, they found that they could not achieve certification for their gloves even though the types of submitted products clearly met the intent of NFPA 1581 and were successfully used in the marketplace. Cleaning glove manufacturers discovered that in order to meet some requirements, they would fail others; thus, some contradictions in the new installed criteria were revealed. For example, NFPA 1999-2003 sets a very high requirement for puncture resistance because of the potential contact with sharps, but at the same time requires fine hand dexterity that cannot be met if the glove is thick enough to meet the puncture resistance requirement. Other specific problems were identified with tensile requirements for certain materials. Natural rubber and nitrile have much different elongation properties as compared to Neoprene, a suitable candidate material for cleaning gloves. Other issues included concerns about the number of required sizes and whether a latex protein content requirement was necessary

**Existing Criteria and Needs.** Table 29 shows the performance criteria for cleaning gloves both in the 2003 Edition and as initially proposed for the revised standard. Criteria are split between whole glove and glove material requirements, and entail barrier/integrity, physical strength/durability, and functional properties. The uniqueness of criteria for barrier gloves is found in the need for resistance to hazardous substances other than blood and body fluids, combined with the need for greater robustness (compared to examination gloves) for physical protection where rough surfaces or sharp objects may be encountered. For this reason, cleaning gloves are tested for permeation resistance to common disinfectants, such as glutaraldehyde (40%), isopropanol (70%), sodium hypochlorite (5%), and hydrogen peroxide (30%). Cut and abrasion resistance are added as physical properties to ensure that gloves protect against physical hazards, and the puncture resistance requirement is significant higher.

Areas of focus for this part of the study investigation included:

- Review of the minimum sizing criteria
- Modification of the dexterity test and setting of criteria as related to end user choices
- Changes to glove tensile properties
- Reexamination of the puncture resistance requirement
- Determination of the appropriateness of maximum protein level in natural rubber gloves
- Investigation of new permeation test practices

**Table 29 – Existing and Initially Proposed Criteria for EMS Cleaning Gloves**

Item	Property	Test Methods	Current Criteria	Initially Proposed Single Use Criteria
Whole gloves	Liquid integrity	ASTM D5151	No leakage	No Change
	Biopenetration	ASTM F1671, modified	Pass	No Change
	Dexterity	Small parts test † ASTM F2010 ‡	< 120%	< 200%
Glove material	Ultimate tensile	ASTM D412	> 15 MPa	>12.5 MPa
	Ultimate elongation	ASTM D412	> 400%	> 300%
	Puncture resistance	ASTM F1342	> 20 N	> 12 N
	Cut resistance	ASTM F1790	<25 mm @ 60g	No Change
	Protein levels	ASTM D5712	< 50 ug/g	No Change
	Permeation resistance	ASTM F739	Breakthrough Time ≥ 1 hour (each chemical*)	No Change
	Abrasion resistance	ASTM D3884	Wearthrough > 1000 cycles	No Change

† Test method for current criteria; ‡ Test method for proposed criteria

\* gluteraldehyde (40%), isopropanol (70%), sodium hypochlorite (5%), and hydrogen peroxide (30%)

Sizing for cleaning gloves is based on European Norm 420 [72], which provides general requirements for gloves and the 2003 Edition of NFPA 1999 that includes specification of hand and glove size based on hand circumference and length. NFPA 1999-2003 specified that all gloves be at least 305 mm long but otherwise meet the hand circumference requirement for each of the numerical sizes (size 6 through size 11). No minimum number of sizes is specified, but the requirement could be inferred to require that manufacturers provide 6 different sizes of gloves. This requirement is generally in excess of industry practice.

The 2003 edition specified the same dexterity test as used for examination gloves, though at a higher level of permitted hand function degradation. The recommendation was made to use ASTM F 2010 since end user feedback did not indicate the same levels of hand function (dexterity and tactility) as needed for examination gloves and that most functions involving cleaning gloves would entail use of cleaning tools and rags.

Tensile properties, particularly for measurement of ultimate tensile strength and elongation are more a function of the specific type of rubber material than an indication of adequate product strength.<sup>22</sup> For example, natural rubber provides more significant elongation than a synthetic rubber such as

<sup>22</sup> ASTM International Committee D11 sets separate standards on different types of examination gloves, including those based on natural rubber (ASTM D3578), polyvinyl chloride (ASTM D5250), nitrile rubber (ASTM D6319), and Neoprene (ASTM D6977). All of these standards employ ultimate tensile strength and elongation criteria, but set different limits based on the type of material.

Neoprene. Setting a requirement based on natural rubber would de facto eliminate Neoprene gloves. However, at the same time if the requirement was set to accommodate Neoprene, poor quality natural rubber products could be qualified.

Puncture resistance is also a function of the material and its thickness, but setting a puncture requirement based on the incumbent test is difficult. The test method (ASTM F1342) is based on a puncture probe geometry that simulates a 4d lath nail. While this shape and diameter is certainly inconsistent with needles and other implements found in a healthcare setting, the more difficult problem is deciding on an appropriate minimum puncture resistance.

Maximum latex protein levels are set for gloves containing natural rubber. In NFPA 1999-2003, this requirement was extended to both examination and cleaning gloves, and in fact represents the only industry requirement in the United States that sets a maximum latex protein level for any gloves.<sup>23</sup> Nevertheless, this same practice is not applied to industrial gloves, which are similar to cleaning gloves. Part of the justification for this exemption of practice is based on type of expected fit differences between examination and cleaning gloves; examination gloves conform more to the wearer hands providing greater contact of the material with the skin.

In other standards, the permeation resistance criteria are moving towards the use of cumulative permeation masses in lieu of the more commonly specified breakthrough times. This transition in laboratory chemical test practices is due to the eventual goal of relating the mass of permeating chemical to actual doses to the wearer's skin, which in turn can be related to the specific toxicity of the chemical.

**Glove Assessments.** Five different gloves were evaluated for key properties as specified in NFPA 1999-2003. All of the gloves that were tested were considered by end users to be gloves suitable for cleaning operations. The gloves further represented three different types of materials that would be likely polymer bases for cleaning gloves. The results of these assessments are provided in Table 30. These results bear out the key discrepancies with the existing criteria:

- Ultimate tensile strength and elongation are limiting criteria by material
- The puncture resistance criterion eliminates most gloves
- Dexterity requirements cannot be met by relatively thick gloves
- The inclusion of a latex protein requirement precludes industrial natural rubber gloves

To gain a better understanding of the puncture resistance requirement, a second series of gloves was evaluated for both cut and puncture resistance. A description of these gloves is provided in Table 31. The gloves were selected to include a range of thicknesses and materials and to allow end user determinations of acceptability through interviews and rating exercises. Cut and puncture resistance test results are shown in Figures 45 and 46.

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<sup>23</sup> The U.S. Food and Drug Administration limits manufacturer claims for protein levels in examination gloves. Manufacturers who can reliably reduce the levels of latex proteins in their gloves to a known level may make a labeling claim, if they submit supporting data in their 510(k) submission. At present, FDA does not allow a protein labeling statement or claim below the current 50µg/dm<sup>2</sup> sensitivity limit of the Lowry test method (ASTM D5712).



**Table 30 – Assessment of Selected Gloves for Key Cleaning Glove Properties Specified in NFPA 1999 (2003 Edition)**

<b>Requirement</b>	<b>Criteria</b>	<b>Mfgr. A Nitrile</b>	<b>Mfgr. B Nitrile</b>	<b>Mfgr. A Neoprene</b>	<b>Mfgr. B Neoprene</b>	<b>Mfgr. B Natural Rubber</b>
Thickness	None	15 mil	11 mil	17 mil	20 mil	20 mil
Ultimate tensile	≥ 15 MPa	37 MPa	22 MPa	17 MPa	14 MPa	15 MPa
Ultimate elongation	≥ 400%	374%	440%	588%	653%	745%
Puncture resistance	≥ 20 N	17 N	32 N	15 N	13 N	9 N
Cut resistance*	≥ 25 mm	>50 mm	>50 mm	>50 mm	>50 mm	>50 mm
Abrasion resistance**	≥ 1000 cycles	>2000 cycles	>2000 cycles	>1000 cycles	>2000 cycles	>12000 cycles
Dexterity	≤ 120%	205%	158%	210%	255%	230%
Protein level	≤ 50 ug/g	Not applicable	Not applicable	Not applicable	Not applicable	FAIL

Note – Shaded boxes indicates failing values

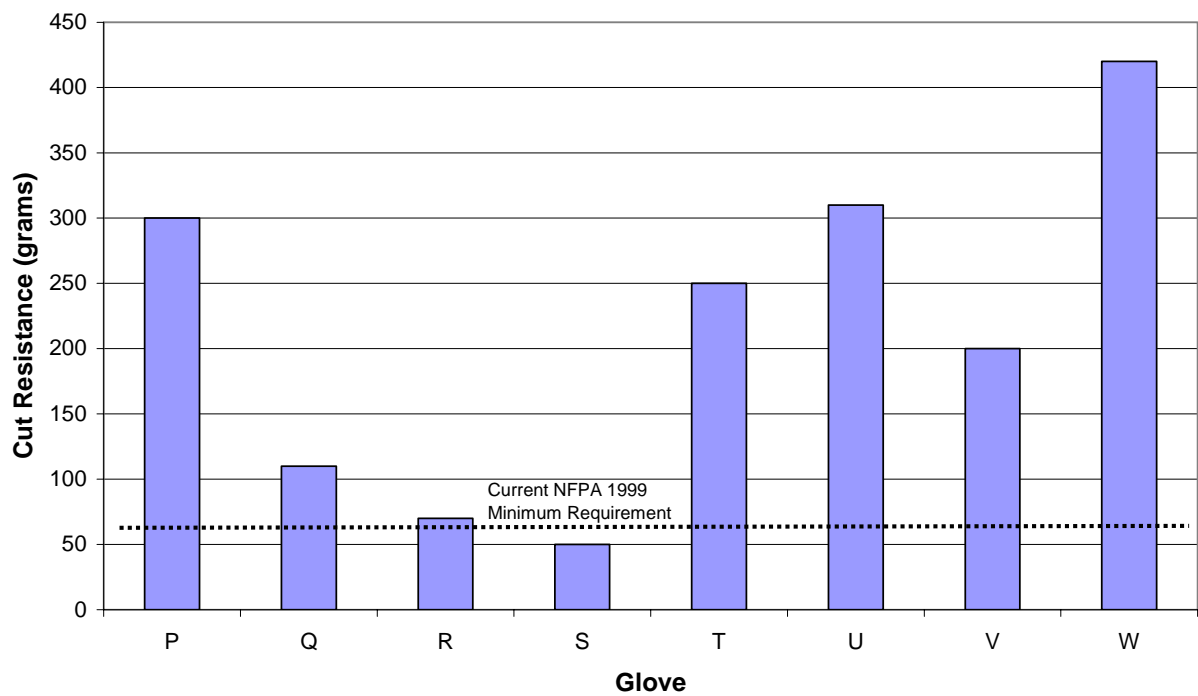
\* Performed under a load of 60 grams

\*\* Conducted with an H-18 Calibrate abrasant wheel under a load of 500 grams

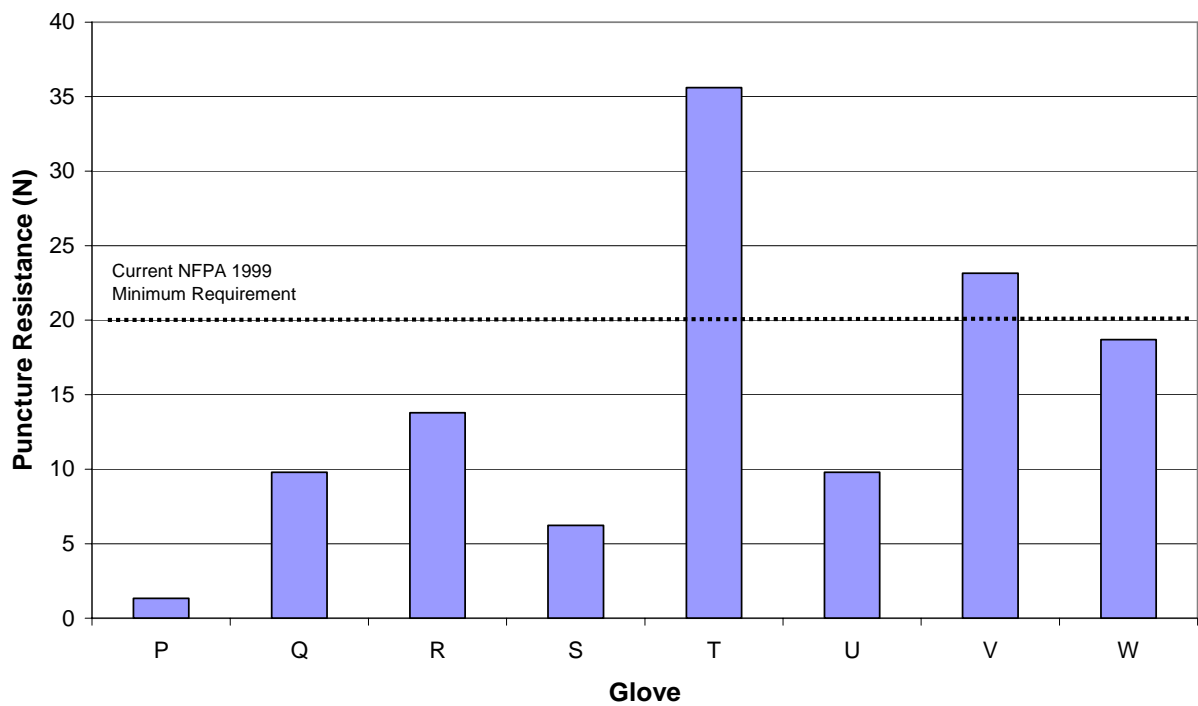
**Table 31 – Characteristics of Gloves Used in Cut and Puncture Resistance Testing**

<b>Glove Designation</b>	<b>Description</b>	<b>Thickness (mil)</b>
P	Neoprene/natural rubber/nitrile blend*	6
Q	Nitrile*	8
R	Natural rubber*	10
S	Natural rubber*	12
T	Nitrile	15
U	Natural rubber	20
V	Nitrile coated knit cotton	30
W	Natural rubber	24

\* Ambidextrous style gloves



**Figure 45 – Cut Resistance Test Results for Selected EMS Gloves**

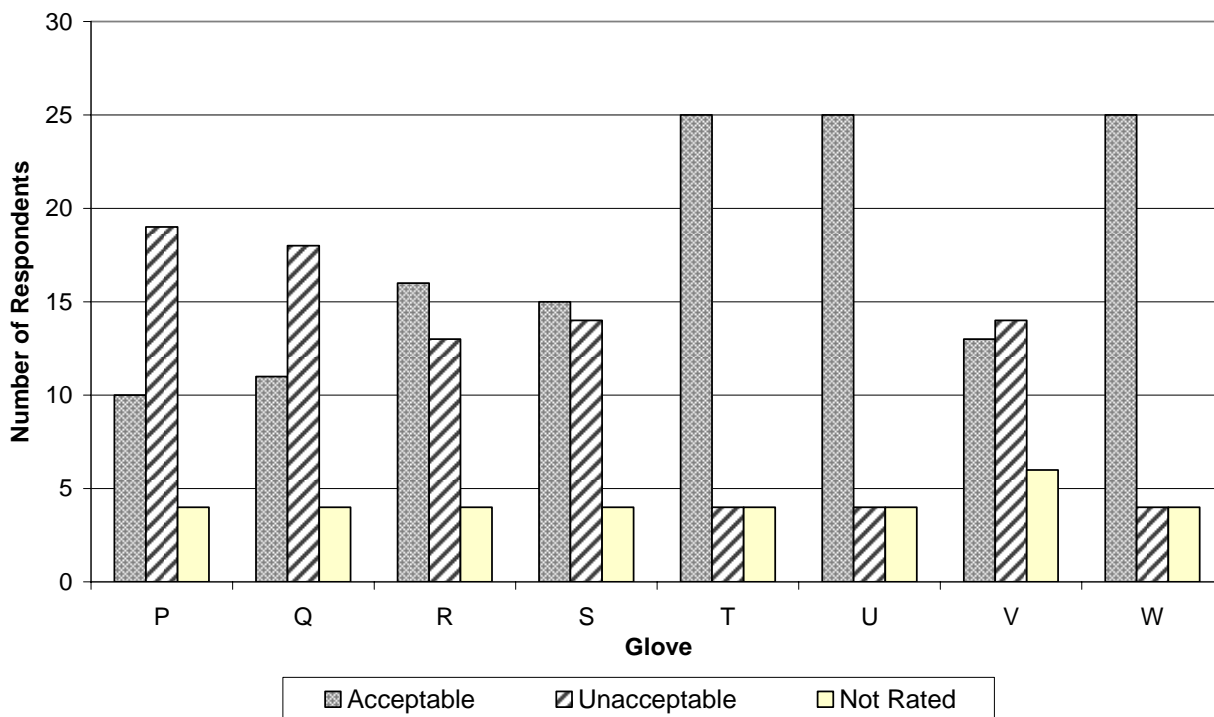


**Figure 46 – Puncture Resistance Test Results for Selected EMS Gloves**

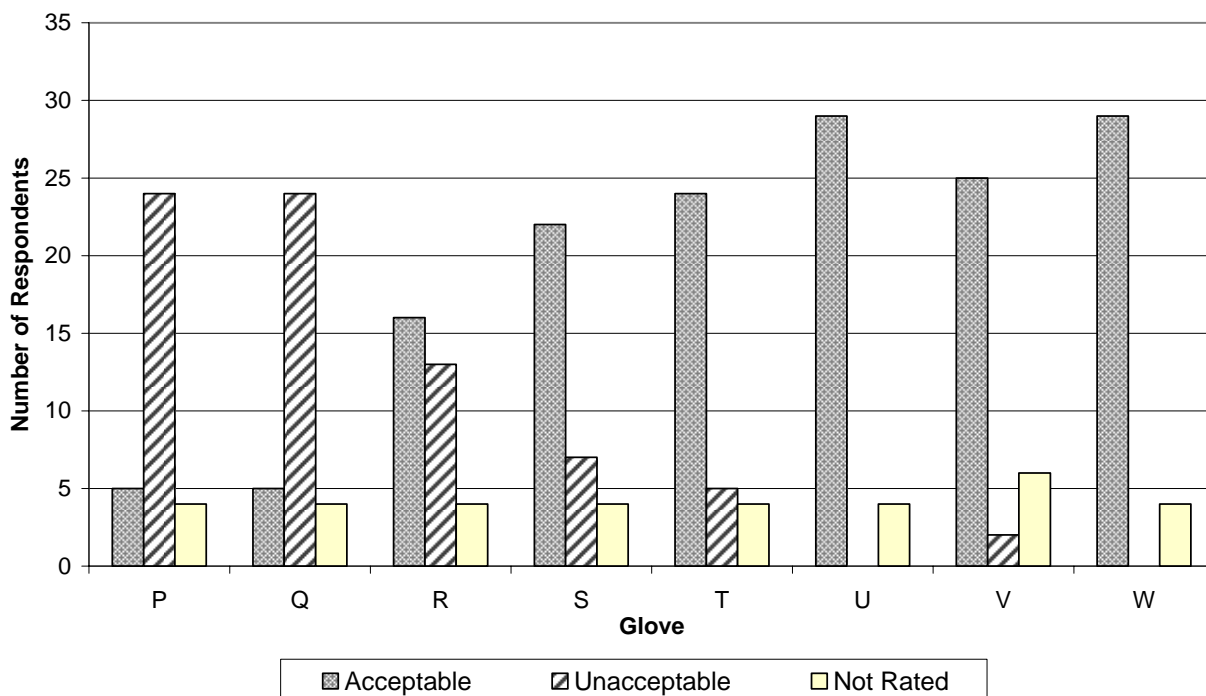
The testing of the selected gloves for cut resistance showed all but glove (S) as meeting the 2003 requirements. The lowest cut resistances were reported for the two relatively thin natural rubber gloves. It is well known in the glove industry that thin gauge natural rubber gloves have poor resistance to cutting. Even relatively thin synthetic gloves, represented by gloves P and Q, provide adequate cut resistance compared to the NFPA 1999 requirement.

In terms of puncture resistance, only two of the eight selected gloves provided a measured puncture force above the minimum requirement in NFPA 1999-2003. One of the gloves (Glove V) would likely not be suitable for cleaning operations given its lining, which could be easily contaminated through repeated use. These results demonstrate that puncture resistance requirement is clearly the most limiting of criteria for cleaning gloves. This requirement in combination with a rigorous dexterity requirement made it impossible to certify existing gloves to cleaning glove requirements in NFPA 1999-2003.

**Determination of Appropriate Physical Performance for Cleaning Gloves.** Feedback from the tradeshow interviews and product ratings were used to help determine the acceptable limits for physical performance of cleaning gloves. Figures 47 and 48 show how various styles of gloves (that were tested for puncture and cut resistance) were rated for their physical strength and single-use durability.



**Figure 47 – Trade Show Respondent Ratings for Cleaning Glove Strength**



**Figure 48 – Trade Show Respondent Ratings for Cleaning Glove Single Use Durability**

The rating results by trade show respondents show a demarcation between thin and thick gloves. While many organizations may consider examination gloves to be fine for many clean up operations, a number of respondents did feel that these gloves would fail to provide the needed robustness in terms of strength and durability. Their perspective was generally that cleaning gloves should have the physical characteristics of dishwashing gloves. The preponderance of ratings reflected that sentiment in that Gloves P through S generally received lower ratings.

**Recommendation of Specific Cleaning Glove Criteria Changes.** For cleaning glove design criteria, the committee specified that EN 420 should be used for hand circumference only and that cleaning gloves should be offered in a minimum of four sizes. Recommendations for changing performance criteria included (these criteria are shown in Table 32):

1. Use of 100% “pass” requirement for glove leakage
2. Removal of the ultimate elongation test
3. Reduction of puncture resistance requirement from 20 N to 10 N
4. Change of the dexterity test from a small parts to a gross tool manipulation test
5. Addition of criteria for tactile function
6. Elimination of latex protein requirement
7. Establishment of permeation resistance testing using measured cumulative permeation
8. Application of a flammability test for the glove material

**Table 32 – Revised Criteria for EMS Cleaning Gloves**

<b>Item</b>	<b>Property</b>	<b>Test Method</b>	<b>New Criteria</b>
Whole gloves	Liquid integrity	ASTM D5151	<b>No leakage for any gloves</b>
	Biopenetration	ASTM F1671, modified for whole glove test	Number of plaque forming units = 0/mL
	Dexterity	<b>ASTM F2010</b>	<b>Change from barehanded control <math>\leq 200\%</math></b>
	<b>Tactility</b>	<b>EN 420, Clause 5.2</b>	<b>Permit pick up of 2.5 mm pin</b>
Glove material	Ultimate tensile	ASTM D412	$\geq 12.5$ MPa
	Puncture resistance	ASTM F1342	$\geq 10$ N
	Cut resistance	ASTM F1790	Blade travel distance $\geq 25$ mm at 60 gram load
	Permeation resistance	ASTM F739 [73], 1-hour exposure period	<b>Cumulative permeation <math>\leq 6.0</math> <math>\mu\text{g}/\text{cm}^2</math> for each test chemical*</b>
	Abrasion resistance	ASTM D3884, H-18 wheel, 500 gram load	No wear through after 1000 cycles
	<b>Flammability</b>	<b>ASTM D1230, modified: 1 second edge exposure</b>	<b>Flame spread time <math>\geq 3.5</math> seconds</b>

Note – Boldface type indicates change from 2003 Edition

\* test chemicals include gluteraldehyde (40%), isopropanol (70%), sodium hypochlorite (5%), and hydrogen peroxide (30%)

The committee felt that four gloves sizes would be appropriate for cleaning gloves given their relatively loose fit and lessened need for high levels of tactility (compared to examination gloves).<sup>24</sup> The EN 420 glove sizing standard was retained as most glove manufacturers follow this standard with the sizing of their products for general industry; however, the committee further specified that cleaning gloves have a standard length of 305 mm.

The decision to change the glove integrity criteria to require compliance of each tested sample was made because cleaning gloves are expected to be more robust and durable than examination gloves, where an acceptable quality limit allows a certain percentage of gloves to fail.

After reviewing the end user input and the available test data on different products, the committee removed the ultimate elongation test from the criteria for cleaning gloves. The committee felt that the ultimate tensile strength test better captured the property of glove resistance to breaking as might occur during donning. Likewise, a dividing line was set between examination gloves (at thicknesses of usually 6 mil and below) and thicker gloves for establishing the minimum puncture resistance

<sup>24</sup> To ensure adequate levels of tactility, the committee added a new test for demonstrating appropriate tactile function of gloves on test subjects. The new test is based on an established European Norm (EN 420) where a procedure is provided that determines the smallest diameter of a metal pin that can be reproducibly picked up by test subjects wearing the gloves.

requirement. The committee further felt that the maximum latex protein requirement could be eliminated for cleaning gloves since their wearing causes less intimate contact with the hands.

Criteria for defining permeation resistance testing for common disinfectants were changed from a basis on breakthrough times (at greater than 1 hour) to a basis on cumulative permeation masses. The selected criteria were taken from recent changes in other NFPA standards where permeation resistance testing is also required. The new criteria assume permeation of the chemical at a level just below the minimum defined permeation rate that has been used to define the breakthrough time ( $0.1 \mu\text{g}/\text{cm}^2\text{min}$ ) for the total exposure period of 60 minutes, thus yielding a criterion of equal to or less than  $6.0 \mu\text{g}/\text{cm}^2$ . The new criterion is considered to be extremely conservative as the chosen disinfectant test chemicals have limited skin absorption toxicity, though three of four chemicals are skin irritants as indicated in Table 33 below.<sup>25</sup>

**Table 33 – Hazards Associated with Common Disinfectant Chemicals**

<b>Chemical</b>	<b>Exposure Limit*</b>	<b>Skin Hazard</b>
Glutaraldehyde	0.05 ppm (ceiling short term)	Irritant
Hydrogen Peroxide	1 ppm (time-weight average)	Irritant
Isopropanol	200 ppm (time-weight average)	None
Sodium Hypochlorite	None	Strong irritant

\* Based on respiratory exposure

The same flammability test that was developed for garments was also instituted for cleaning gloves on the basis that some cleaning solvents could pose flammability issues and that the gloves should not contribute to the hazards of the wearer by burning rapidly.

### **Revision of Criteria for Footwear Covers**

**Key Issues.** Footwear covers were a new area of EMS PPE that were first added to the 2003 Edition for NFPA 1999. As part of this investigation, end user feedback indicated that footwear covers can sometimes be used in situations where excessive amounts of blood and body fluids may be encountered, and are often included as parts of healthcare PPE kits. The types of products that can be found in both the healthcare and general industry include the following characteristics:

- Footwear covers may be of either shoe or boot height; shoe covers tend to extend just above the laces for standard shoes while boot covers can have various heights rising anywhere from about 2 to 12 inches above the wearer's ankle.
- The majority of footwear covers are formed from a single non-woven disposable material; however, some covers may incorporate a different material on the wear surface.<sup>26</sup>

<sup>25</sup> It is expected that different cumulative permeation values will be set for individual chemicals as skin toxicity and irritancy effects become better understood.

<sup>26</sup> The wear surface is the part of the footwear cover that comes in contact with the ground when worn.

- Alternative footwear covers may be formed by joining two pieces of plastic together along the peripheral edge.
- Footwear covers often include elastic at the top (in the case of shoe covers) or at both the top and ankle area (in the case of many boot covers).
- Where a secondary material is not used, these covers may include embossing of a rubberized material or other raised material on the wear surface of the cover.

Examples of some footwear covers are shown in Figure 49.



**Figure 49 – Examples of Disposable Footwear Covers**

Many of the disposable footwear covers available to EMS responders include sewn seams, which are not taped. Consequently, these covers do not hold out liquids. Likewise, some covers are created of materials, which by themselves, are not effective barriers to bloodborne pathogens or other liquids. In some cases, footwear cover use is primarily intended to keep the majority of contamination off of the primary footwear that may already incorporate barrier materials.

End users that were familiar with footwear cover use often considered these products as commodities, having low expectations for both durability and protection. However, universal complaints included:

- Lack of consistent coverage for needed areas of the primary footwear item
- Difficulty in donning
- Breakdown of wear surface materials on rough surfaces
- Lack of traction or slipperiness on smooth surfaces

**Existing Criteria and Needs.** When footwear cover criteria were first developed as part of the 2003 Edition of NFPA 1999, a minimum height of 100 mm was chosen to be consistent with the minimum height required for reusable footwear (also introduced as part of the 2003 Edition). Inconsistent measuring instructions for determining footwear height were provided.

The approach used for establishing performance criteria was to apply the same criteria as provided for reusable footwear, but exempt and reduce certain requirements as shown in Table 34. The specific criteria involved the following criteria:

- Both types of footwear were subjected to full item integrity requirements and materials must meet viral penetration requirements.
- Both types of footwear were required to meet the same level of wear surface abrasion and slip resistance.
- Reduced physical requirements were provided for footwear covers in terms of upper puncture resistance, upper cut resistance, and sole puncture resistance.
- Footwear covers were not tested for hardware strength or corrosion resistance.

**Table 34 – Existing Criteria for EMS Footwear Covers**

Item	Property	Test Methods	Current Criteria
Whole footwear cover	Liquid integrity	ASTM D5151, modified	No leakage
Footwear cover upper material	Biopenetration	ASTM F1671	Pass
	Puncture resistance	ASTM F1342	> 4.5 N
	Cut resistance	ASTM F1790	< 25 mm @ 25 g
Footwear cover wear surface	Abrasion resistance	ASTM D1630	Abrasion rating > 65
	Puncture resistance	ANSI Z41, § 5	> 45 N
Footwear cover seams	Biopenetration	ASTM F1671	Pass

In first assessing footwear cover issues, the committee proposed that footwear cover materials also meet the same criteria being proposed for single-use garments, with the thinking that footwear cover material strength and durability should be equal to that of the garment because the lower leg and foot would be subject to similar physical abuses (excepting the wear surface). To this end, initially proposed criteria included footwear cover tensile strength, burst strength, tear resistance, and puncture propagation tear resistance.

However, other issues were identified by the committee during the course of this study. These issues arose primarily from the incorrect adaptation of reusable footwear performance criteria to footwear covers, and included:

- Difficulty in applying the liquid integrity test to whole footwear covers (the test involves a large volume of surfactant treated liquid in the test item that was difficult to contain and one that created a relatively large pressure head on the seams, relative to how the test was performed for other EMS PPE items, i.e., gloves)
- The inability to perform rubber based sole abrasion tests on footwear cover wear surfaces
- An overly rigorous requirement for footwear cover wear surface puncture resistance (the committee had simply applied a factor in reducing the criteria from that specified for reusable footwear)
- The utilization of a method for measuring the wear surface coefficient of friction that did not account for differences in footwear design and materials in use.



**Footwear Cover Assessments.** Testing in this study focused on two primary areas; (1) reconciliation of the types and levels of physical property testing performed on footwear cover upper materials, and (2) development of appropriate test approaches and criteria for footwear cover wear surfaces.

The concept of applying single-use garment material physical property criteria to footwear cover materials was considered sensible since many of the same materials used in garments were also used in footwear covers (e.g., meltblown/spunbond/meltblown polypropylene and flashspun polyethylene). In fact, two of the materials included in the garment evaluations (Materials C and I) were also commonly found in footwear covers.

Test results were gathered for three representative footwear cover materials for both the proposed single-use criteria and the previously applied cut and puncture resistance data. These data are shown in Table 35.

**Table 35 – Test Results for Selected EMS Footwear Cover Materials**

Property	Test Method	Proposed Criteria	Material C Flashspun Polyethylene	Material I Polyethylene Coated Poly- Propylene	Material K Skid-resistant Spunbond Polypropylene
Thickness	ASTM D1117	None	0.18 mm	0.33 mm	0.36 mm
Weight	ASTM D3776	None	42 g/m <sup>2</sup>	64 g/m <sup>2</sup>	87 g/m <sup>2</sup>
Tensile strength (grab)	ASTM D5034	≥100 N	89 N 71 N	80 N 76 N	102 N 129 N
Tear resistance (trapezoidal)	ASTM D5733	≥ 25 N	24 N 19 N	28 N 29 N	25 N 41 N
Burst strength (ball)	ASTM D3787	≥ 100 N	84 N	89 N	111 N
Puncture propagation tear resistance	ASTM D2582	≥ 15 N	28.4 N	<10 N	16.5 N
Puncture resistance	ASTM F1342	≥ 4.5 N	4.5 N	6.7 N	5.0 N
Cut resistance	ASTM F1790	≥ 25 gms*	70 grams	25 grams	100 grams

Note – Shading indicates failing values.

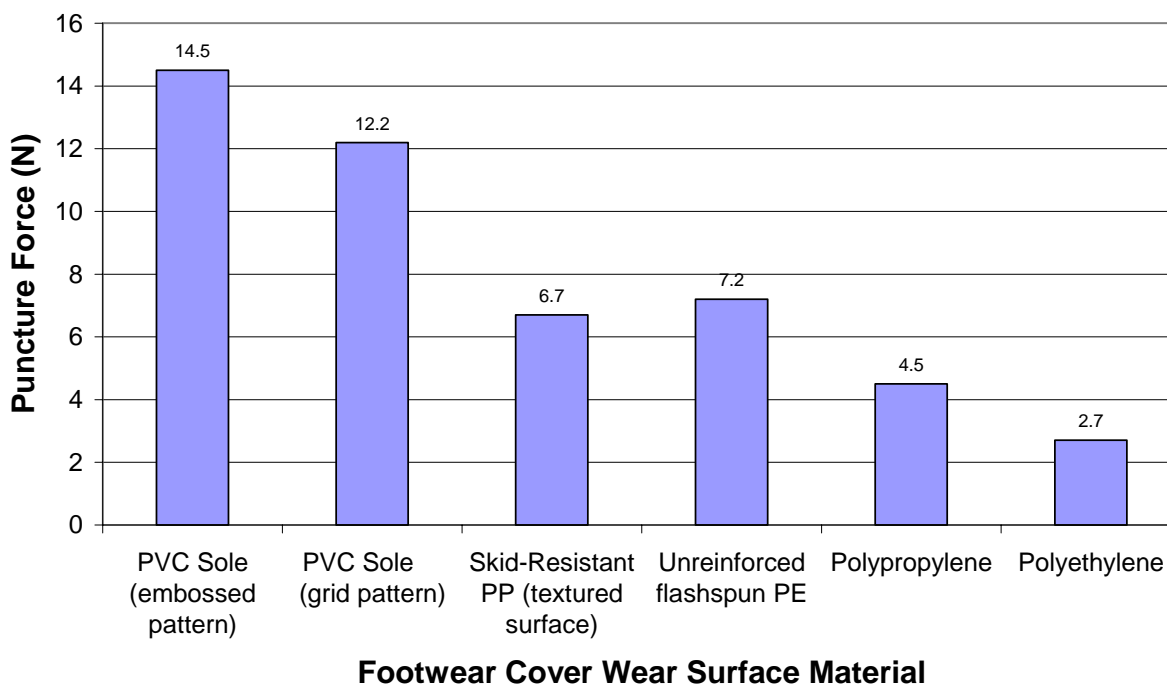
\* The method as applied in NFPA 1999 generally measures distance of blade travel under specified load; for these data, the interpolated load required to cause a blade travel distance of 25 mm was determined.

Data for footwear cover upper material physical strength showed that many of the proposed single-use garment criteria would eliminate one or more common footwear cover materials. Surprisingly, each of the tested footwear cover materials would have met the prior imposed puncture and cut resistance criteria. Nevertheless, the committee felt that garment criteria would best characterize the strength and durability of the footwear cover materials and sought adjustments in these criteria for both single-use garment and footwear cover materials.

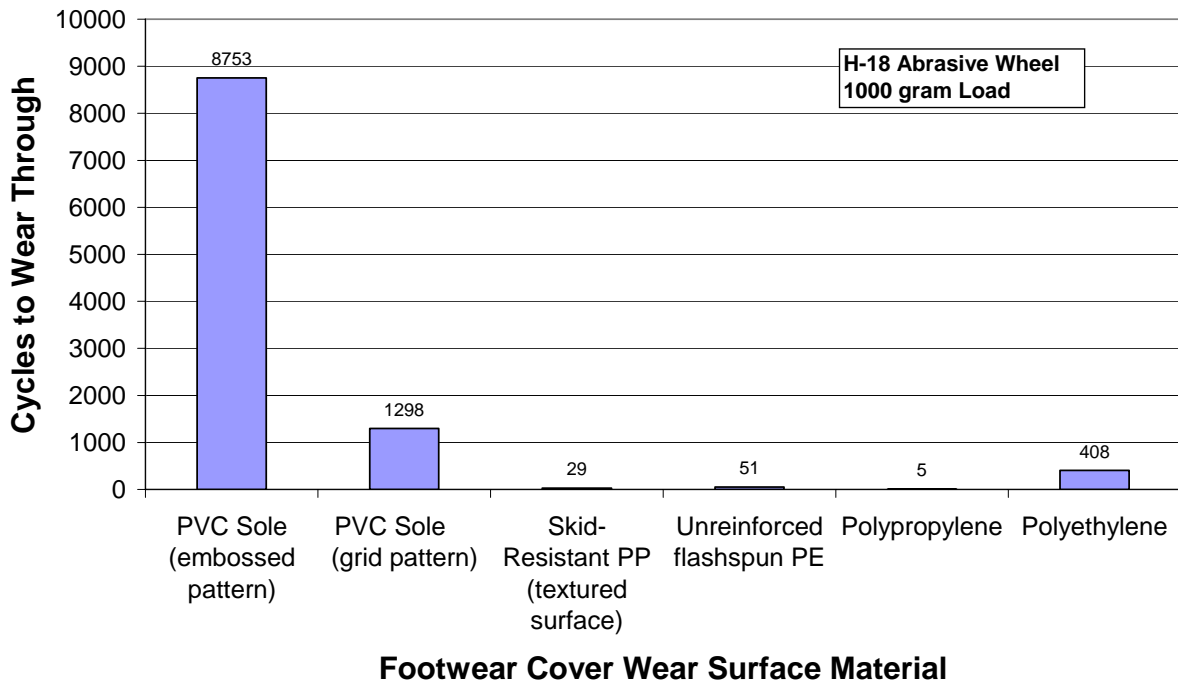
In assessing the footwear cover wear surface, three different test methods were investigated:

1. Puncture resistance per ASTM F1342
2. Taber abrasion resistance per ASTM D3884, using the H-18 abrasant wheel and a 1000 gram applied load
3. Slip resistance (measurement of coefficient of friction) using ASTM F489

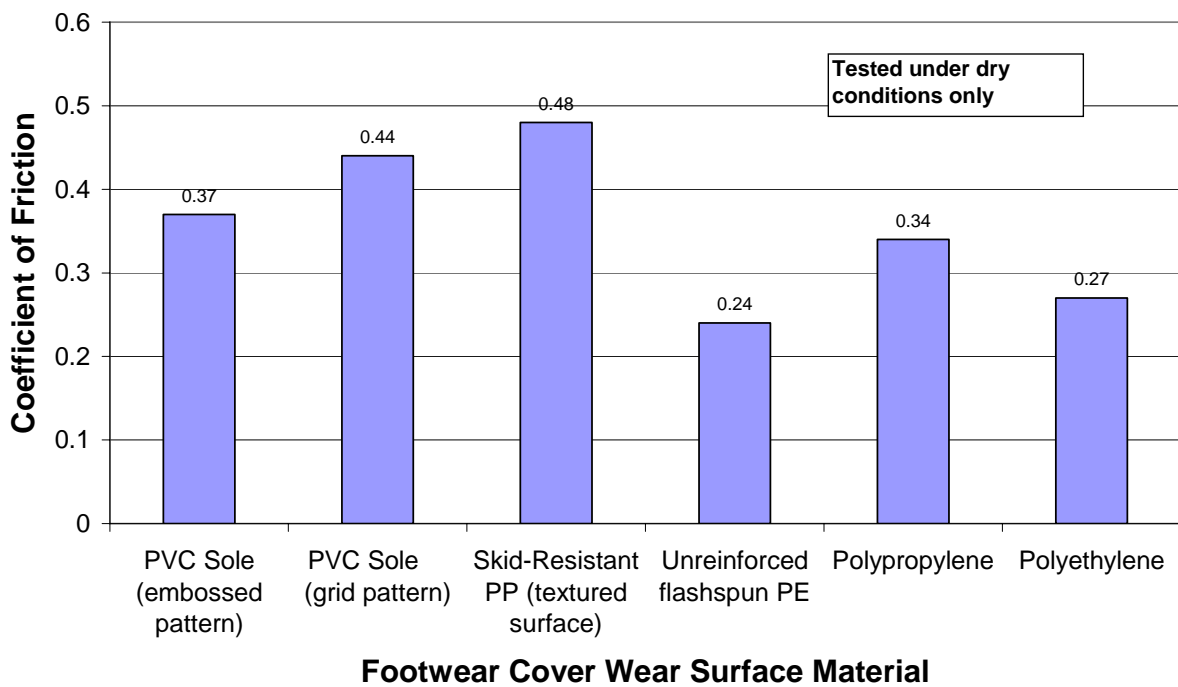
Six different types of footwear cover wear surfaces were evaluated for these properties, including a range of materials, secondary materials, and texturing, were evaluated for these properties. Results for each of these properties are displayed in Figures 50 through 52.



**Figure 50 – Puncture Resistance Results for Selected Footwear Cover Wear Surface Materials**



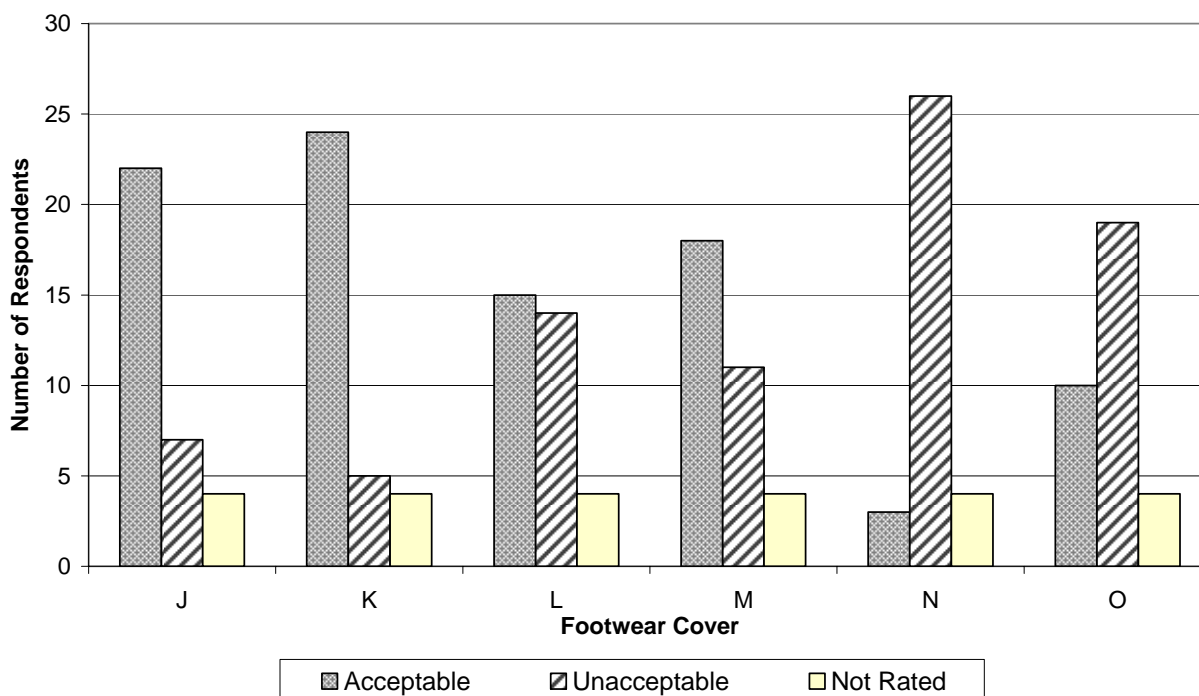
**Figure 51 – Abrasion Resistance Results for Selected Footwear Cover Wear Surface Materials**



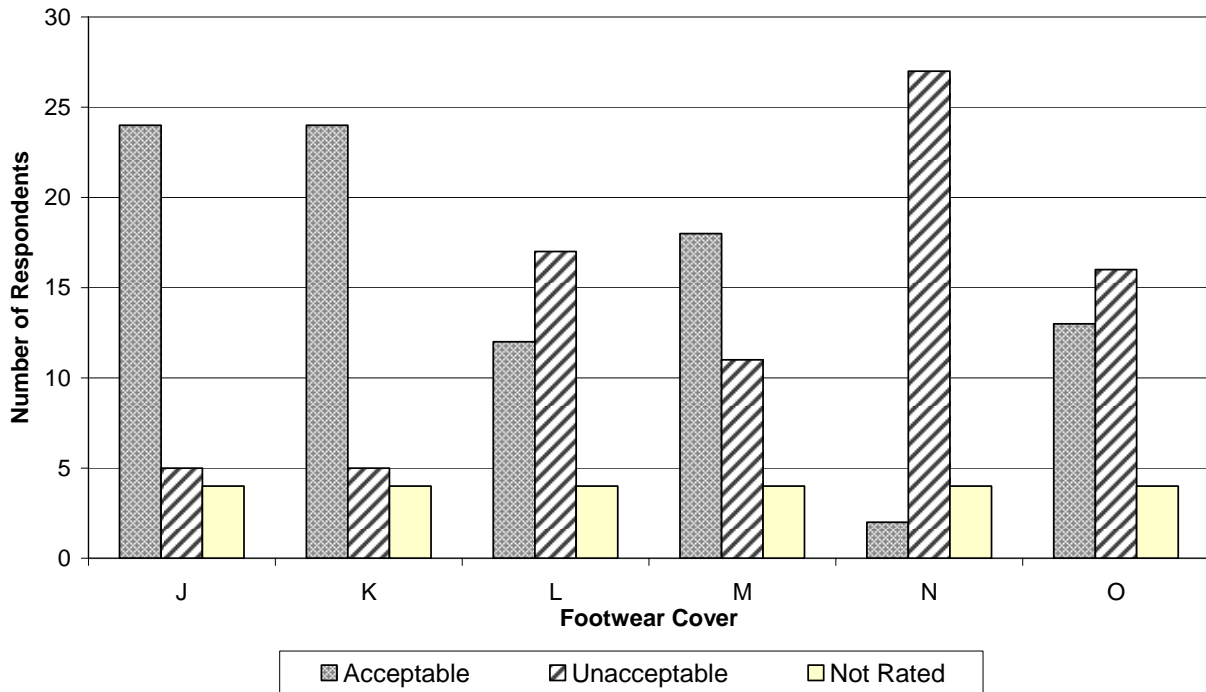
**Figure 52 – Slip Resistance Results for Selected Footwear Cover Wear Surface Materials**

**Determination of Appropriate Physical Performance for Footwear Covers.** As with other investigated areas of EMS protective clothing items, end user feedback was used to help make decisions in setting specific limits for the various criteria under consideration for the particular item. In this case, there was both the benefit of trade show respondent ratings and separate ratings carried out by limited field testing. Of particular interest were ratings for strength, single use durability and traction. Strength was primarily pointed towards the upper material while traction was obviously applicable to the footwear cover wear surface. Single use durability was considered to be applicable to both the upper and wear surface of the footwear cover. The trade show respondent ratings are shown in Figures 53 through 55. These ratings indicated concerns for some of the different types of footwear covers.

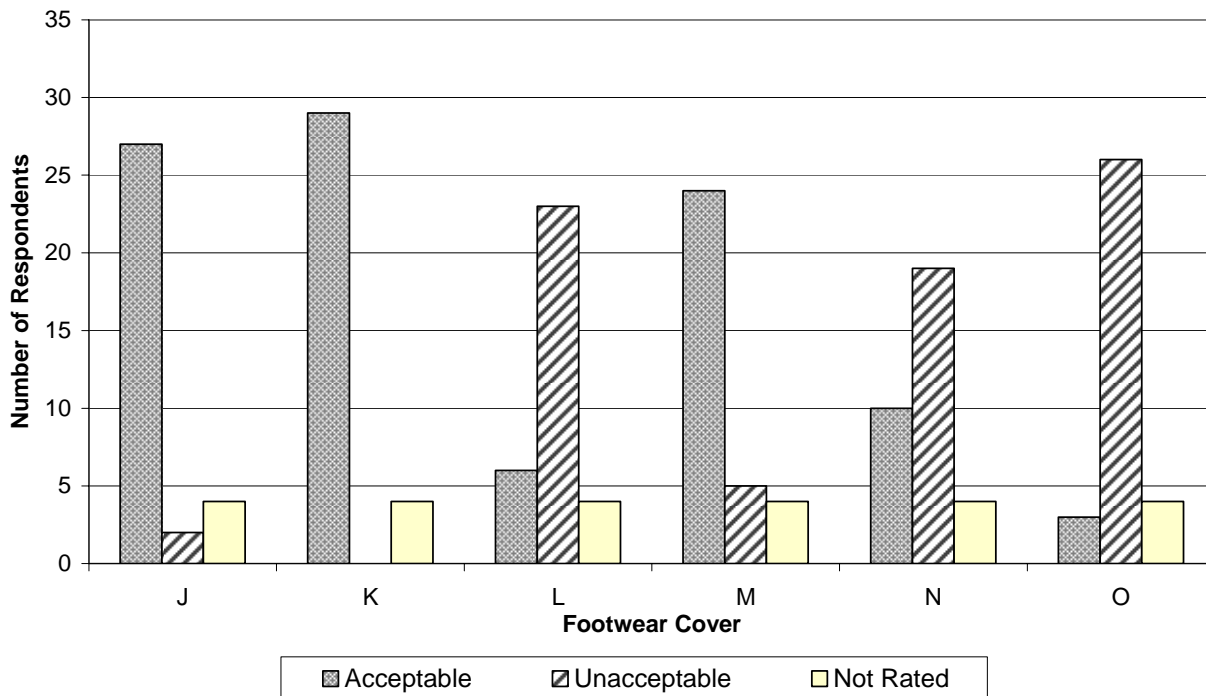
Likewise, limited field testing was conducted by one department to rate the adequacy of footwear cover performance in simulated use trials. In this case, other areas of performance and design issues (height, barrier qualities, and donning ease) were rated, as reported in Table 36.



**Figure 53 – Trade Show Respondent Ratings for Footwear Cover Strength**



**Figure 54 – Trade Show Respondent Ratings for Footwear Cover Single Use Durability**



**Figure 55 – Trade Show Respondent Ratings for Footwear Cover Traction**

**Table 36 – Field Trial Ratings for Disposable Footwear Covers: Percentage Deemed Acceptable or Unacceptable, by Attribute**

Footwear Cover Rating	Quantity Tested	Strength		Single Use Durability		Height		Barrier Qualities		Traction		Donning Ease	
		A	U	A	U	A	U	A	U	A	U	A	U
K – Skid resistant polypropylene shoe cover	4	100%	0%	100%	0%	75%	25%	100%	0%	100%	0%	75%	25%
L – Flashspun polyethylene shoe cover	4	100%	0%	100%	0%	25%	75%	100%	0%	50%	50%	100%	0%
M – Flashspun polyethylene w/PVC sole boot cover	8	100%	0%	100%	0%	75%	25%	100%	0%	63%	37%	100%	0%
N – Polypropylene shoe cover	5	0%	100%	0%	100%	40%	60%	0%	100%	20%	80%	0%	100%
O – Plastic film boot cover	6	17%	83%	50%	50%	83%	17%	50%	50%	50%	50%	17%	83%

A= Acceptable; U = Unacceptable

Certain trends in end user preferences among different footwear cover items were discernable through the overall ratings:

- Footwear Covers J and K were rated higher in strength and single use durability. Footwear Cover J combined a coated polypropylene and PVC sole while Footwear Cover K was a special “skid-resistant” nonwoven material. In some cases, Footwear Cover M had similar ratings to Footwear Cover J, differing only in the type of upper material.
- Footwear Cover L was generally considered unacceptable in terms of strength and durability. Similarly, Footwear Cover N, which was a relatively low end, inexpensive footwear cover, was rated poorly for strength and durability. Likewise, Footwear Cover O, which consisted of a simple plastic film, received low ratings for strength and durability.
- Footwear Covers J, K, and M received a larger number of acceptable ratings for traction while Footwear Covers L, N, and O were most often considered unacceptable.

**Recommended Criteria Changes for Footwear Covers.** More detailed procedures and criteria were developed to better specify footwear cover design; specific changes included:

- Acknowledgement that footwear covers could be provided in a single size
- The increase of the footwear cover height to a minimum of 6 inches from the wear surface
- Incorporation of procedures for measuring footwear cover height by using a standard reusable boot (size 9) inside the footwear cover to determine overall height of barrier coverage
- The addition of a minimum lateral extension requirement beyond the footwear sole for the wear surface with procedures also based on the insertion of a standardized footwear item inside the footwear cover for its measurement.

The performance criteria for footwear covers were significantly revised with several changes made and accepted by the committee:

1. The overall liquid integrity test was removed because the committee considered the testing of footwear cover seams to address issues related to cover leakage.
2. Finalized single-use garment material criteria were applied to upper portion of footwear cover (different criteria were recommended for the wear surface).
3. Cut and puncture resistance for footwear cover upper were not included.
4. A flammability requirement was added for the material consistent with garment and cleaning glove criteria.
5. A seam strength requirement was set consistent with single-use garments.
6. Footwear cover wear surface abrasion resistance testing was changed to the Taber test method and set on best performing materials according to end user trials for durability.
7. Similarly, a different puncture method was applied (ASTM F1342) with ratings consistent with better end user rated materials.
8. The slip resistance coefficient of friction was slightly lowered (to 0.60) but kept above the best performing materials to encourage more attention by manufacturers to traction on footwear cover wear surfaces.

Table 37 summarizes the final accepted performance criteria for footwear covers.

**Table 37 – Final Recommended Criteria for EMS Footwear Covers**

<b>Item</b>	<b>Property</b>	<b>Test Methods</b>	<b>Current Criteria</b>
Footwear cover upper material	Biopenetration	ASTM F1671	Number of plaque forming units = 0/mL
	<b>Tensile strength</b>	<b>ASTM D5034</b>	<b>≥ 50 N</b>
	<b>Burst strength</b>	<b>ASTM D3787</b>	<b>≥ 66 N</b>
	<b>Tear resistance</b>	<b>ASTM D5733</b>	<b>≥ 17 N</b>
	<b>Flammability</b>	<b>ASTM D1230, modified: 1 second edge exposure</b>	<b>Flame spread time ≥ 3.5 seconds</b>
Footwear cover wear surface	<b>Abrasion resistance</b>	<b>ASTM D3884, H-18 abrasant wheel, 1000 gram load</b>	<b>Number of cycles to wear through ≥ 5000</b>
	<b>Puncture resistance</b>	<b>ASTM F1342</b>	<b>&gt; 8 N</b>
Footwear cover seams	Biopenetration	ASTM F1671	Number of plaque forming units = 0/mL
	<b>Strength</b>	<b>ASTM D1683</b>	<b>≥ 50 N</b>

Note – Boldface indicates changes from criteria in NFPA 1999-2003.

### **Revision of Criteria for Eye and Face Protection Devices**

**Key Issues.** Eye and face protection devices are one of three original categories of PPE that have been addressed in NFPA 1999. Despite the widespread use of some form of eye and face protection by different emergency medical end users, certification of these devices to NFPA 1999 has been nearly non-existent. One exception was a combined goggles and faceshield that was marketed specifically for the EMS provider market in the early 2000s (that device is shown as part of the different eye and face protection devices displayed in Figure 56).

Information gathered from interaction with industry and end user shows a variety of eye and face protection devices in use. Most commonly goggles are used, but safety glasses and faceshields are examples of industrial eye protectors that are also used (see Figure 56). The majority of these items are considered reusable, though some disposable faceshields have been marketed for healthcare providers. In addition, a variety of surgical masks styles are used. The most common styles include:

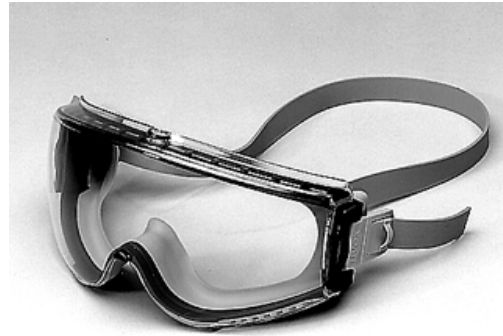
- Pleated
- Cone
- Duckbill

Some styles of medical face masks also incorporate a plastic shield that is attached to the facemask for eye protection. These devices can attach to the head via earloops or ties and include a metal piece inside the nose for adjusting fit. All such devices are considered for one time use only. Several examples of medical face masks are shown in Figure 57.





**(a) Safety glasses with side shields**



**(b) Non-ventilated cover goggle**



**(c) Industrial style faceshield**

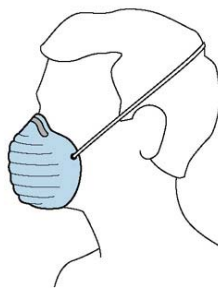


**(d) Combination goggles and faceshield**

**Figure 56 – Examples of Different Reusable Types of Eye and Face Protection Devices**



**(a) Pleated (with faceshield)**



**(b) Cone**



**(c) Duckbill**

**Figure 57 – Examples of Different Surgical Mask Styles Used in EMS Operations**

In addition to the above styles of eye and face protection devices, some EMS workers may wear respirators for potential airborne pathogen protection (particularly against tuberculosis and Asian influenza). The most commonly selected respirators is an N95 particulate filtering facepiece.

Outside the requirements for eye and face protection devices in NFPA 1999, other standards establish different standards for their performance, but not always in the manner appropriate for defining protection against bloodborne pathogens.

- ANSI Z87.1 sets requirements for safety glasses, goggles, and faceshields and particularly focuses on criteria for impact resistance and optical qualities. The standard does not include any test for the barrier properties of any type of device, including goggles. Paragraph 2.4.2 in the standard states:

*This standard, by setting forth its requirements, points out the need to exercise caution in the selection and use of protectors where no performance requirements or standardized testing exist. For example, these protectors may not provide adequate protection against bloodborne pathogens.*

- ASTM F2100 [74] establishes requirements for materials used in medical face masks, and includes requirements on particle filtration efficiency, bacterial filtration efficiency, differential pressure (pressure drop across the material), flammability, biocompatibility and synthetic blood penetration resistance. Facemasks are classified by the level of synthetic blood penetration resistance demonstrated by the respective mask with three categories (low barrier, moderate barrier, and high barrier). There are other differences in criteria as applied to measured mask material properties. However, as the title of the standard applies, the overall construction and performance of these devices are not checked.

Of all the protective clothing items used by EMS personnel, medical face masks are the one item that cannot be required to meet a viral penetration resistance requirement because the mask material must offer a level of breathability that affords respiration. Even though medical face masks are not respirators, they must accommodate the inhalation and expiration of air through the material while maintaining coverage of the face area.

**Existing Criteria and Needs.** The most significant problem in applying criteria is the variety of products that are in use. The 2003 Edition of NFPA 1999 permitted a range of eye and face protection devices that could be declared as single-use or multiple-use without defining areas of eye or face coverage.<sup>27</sup> Performance criteria were limited to:

- A visual acuity test if part of the device covered the eyes
- A liquid tight integrity test based on a synthetic blood penetration resistance test
- Testing of device materials for viral penetration resistance

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<sup>27</sup> Referenced devices included splash-resistant eyewear, hooded visors, and masks.

The application of these criteria was awkward for certain devices, such as faceshields in determining how integrity and material tests should be carried out. Some devices in use, such as medical face masks could not be certified to NFPA 1999 because they could not meet the viral penetration resistance criteria.

There are significant differences between types of eye and face protection devices that require varied criteria. For example, goggles and faceshields have completely different areas of eye and face coverage. Furthermore, medical face masks provide barrier protection in completely different ways as other devices. Moreover, expectations among end user for different device change with the device or its intended service life (single versus multiple-use).

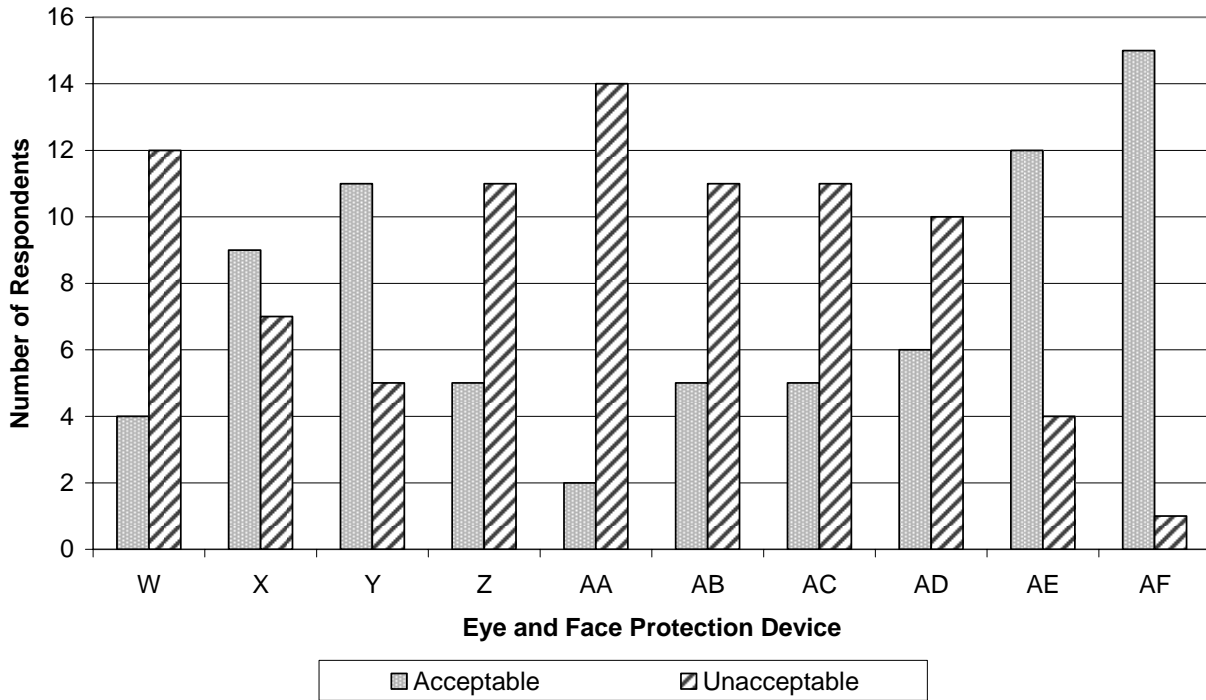
Of the specific criticism regarding use of eye and face protection devices, the largest complaint by far was fogging, particularly for goggles.

**End User Assessments.** Interviews with end users at trade shows and in other forums were important for defining expectations and deciding how to approach the revision of criteria for eye and face protection devices in NFPA 1999. To gather information, end users were shown a range of different types of devices to indicate whether they felt the item was appropriate in EMS operations. The types of devices included those listed in Table 38 below:

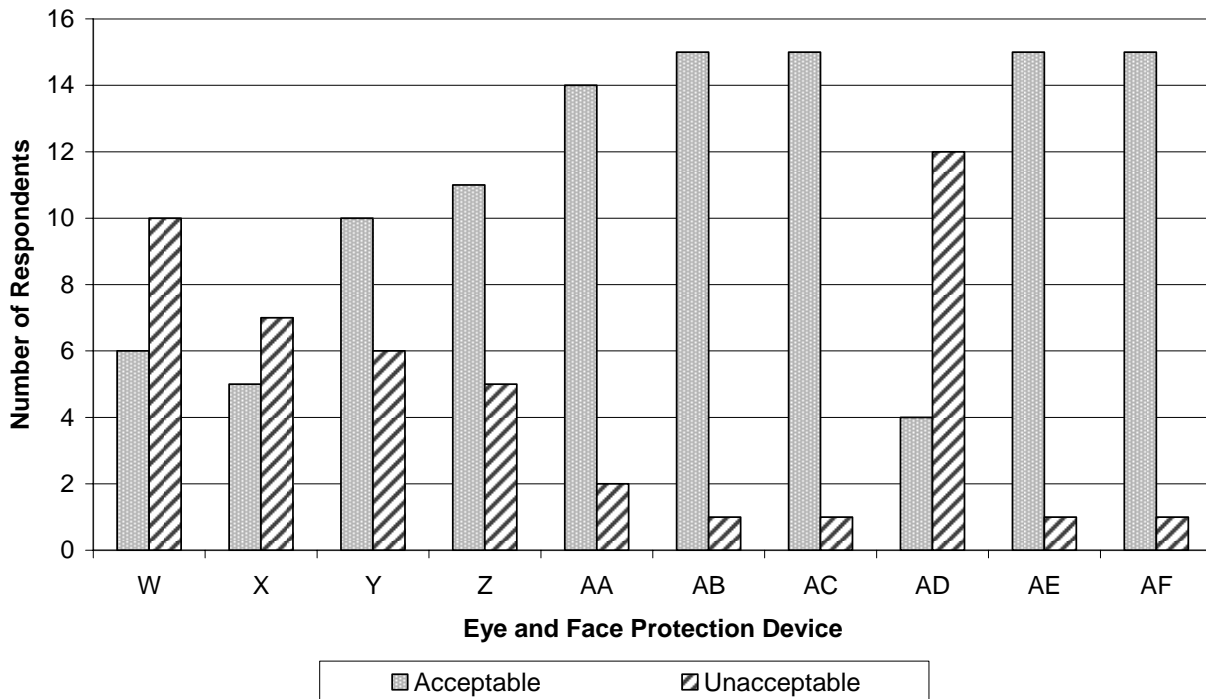
**Table 38 – Types of Eye and Face Protection Devices Considered in Study**

<b>Item Designation</b>	<b>Description</b>	<b>Intended Use</b>
W	Pleated surgical mask	Single use
X	Pleated surgical mask with plastic face shield	Single use
Y	Cone surgical mask with plastic faceshield	Single use
Z	N95 cone respirator	Single use
AA	Safety glasses with side shields	Multiple use
AB	Indirect ventilated cover goggles	Multiple use
AC	Non-ventilated cover goggles	Multiple use
AD	Faceshield with elastic band and foam headpiece	Single use
AE	Industrial faceshield with plastic ratchet suspension	Multiple use
AF	Combined goggles and faceshield device	Multiple use

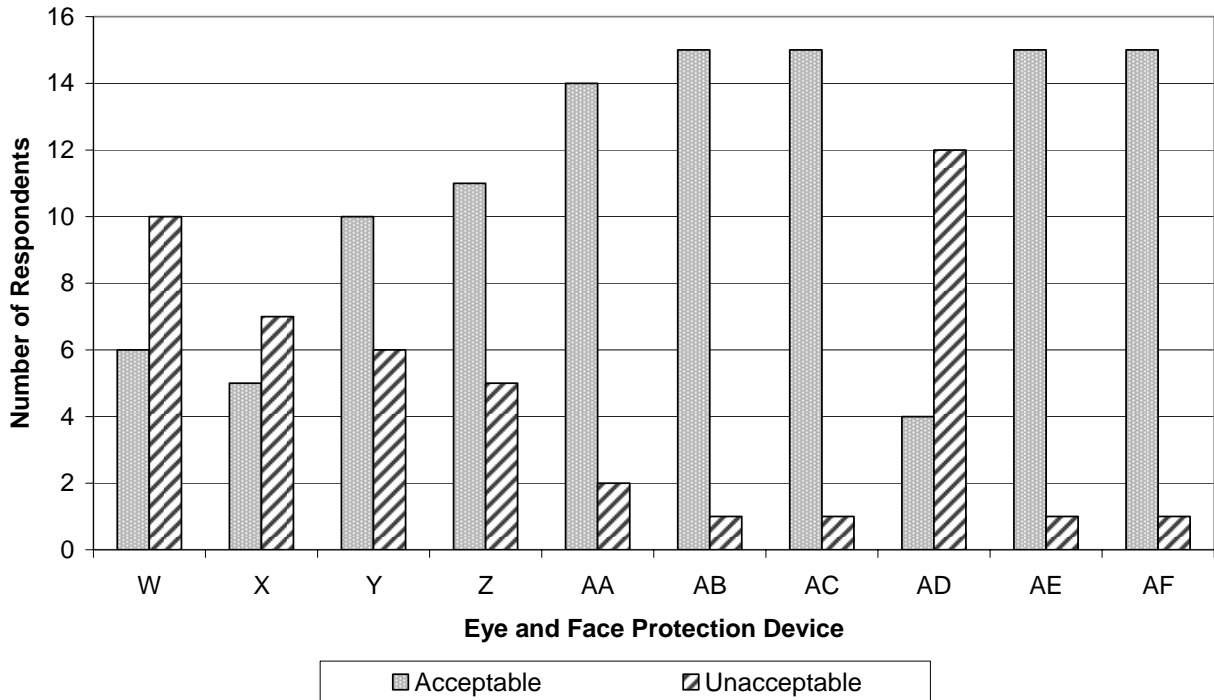
End users were asked to rate devices on the basis of face coverage, single use durability, physical protection, barrier qualities, visibility, and donning ease. Ratings for each of these areas are provided in Figures 58 through 63.



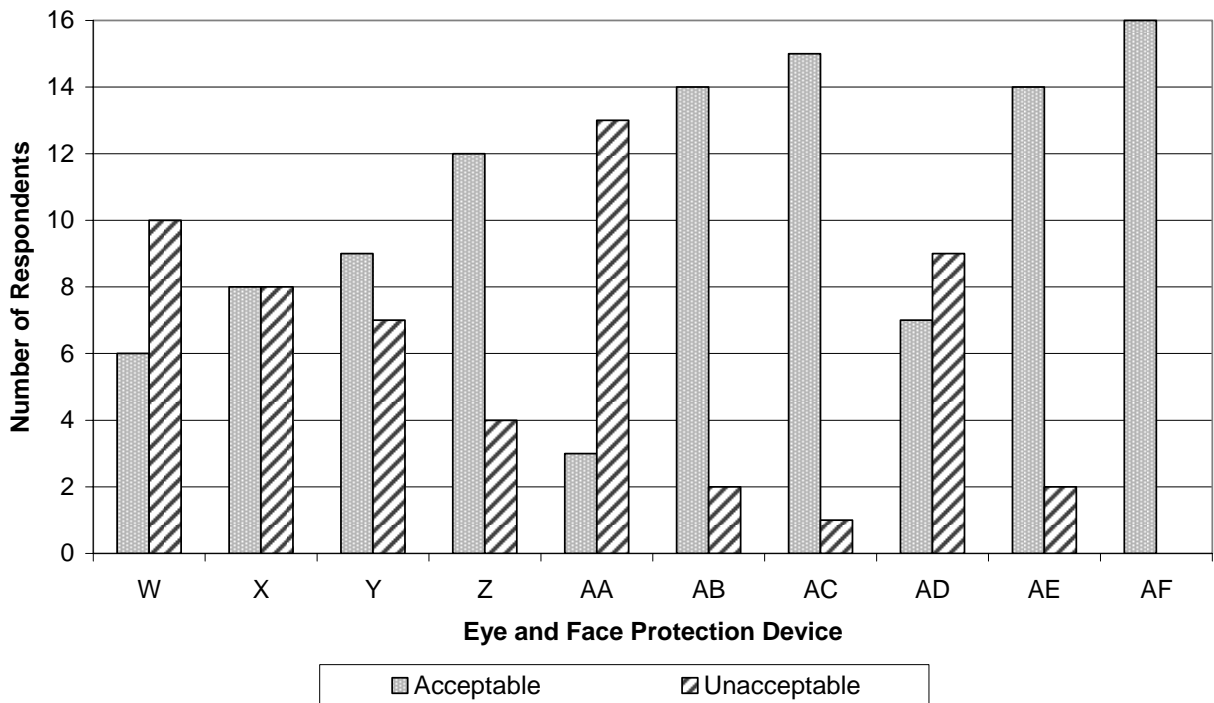
**Figure 58 – Trade Show Respondent Ratings for Eye/Facewear Face Coverage**



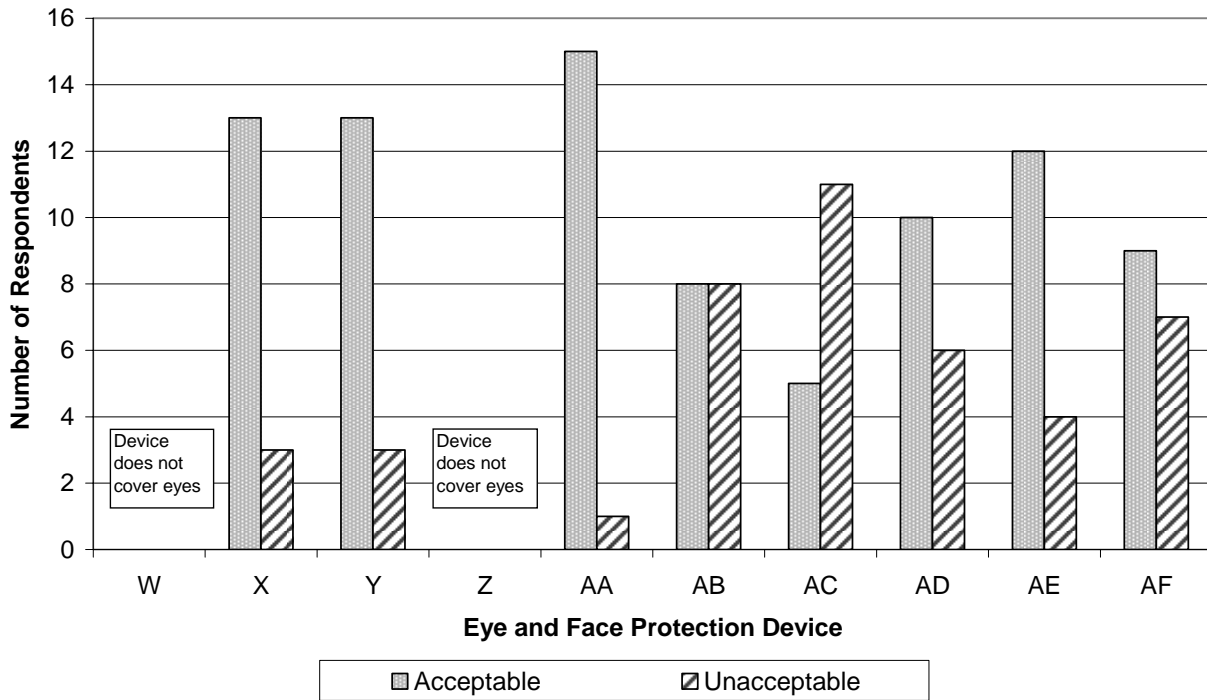
**Figure 59 – Trade Show Respondent Ratings for Eye/Facewear Single Use Durability**



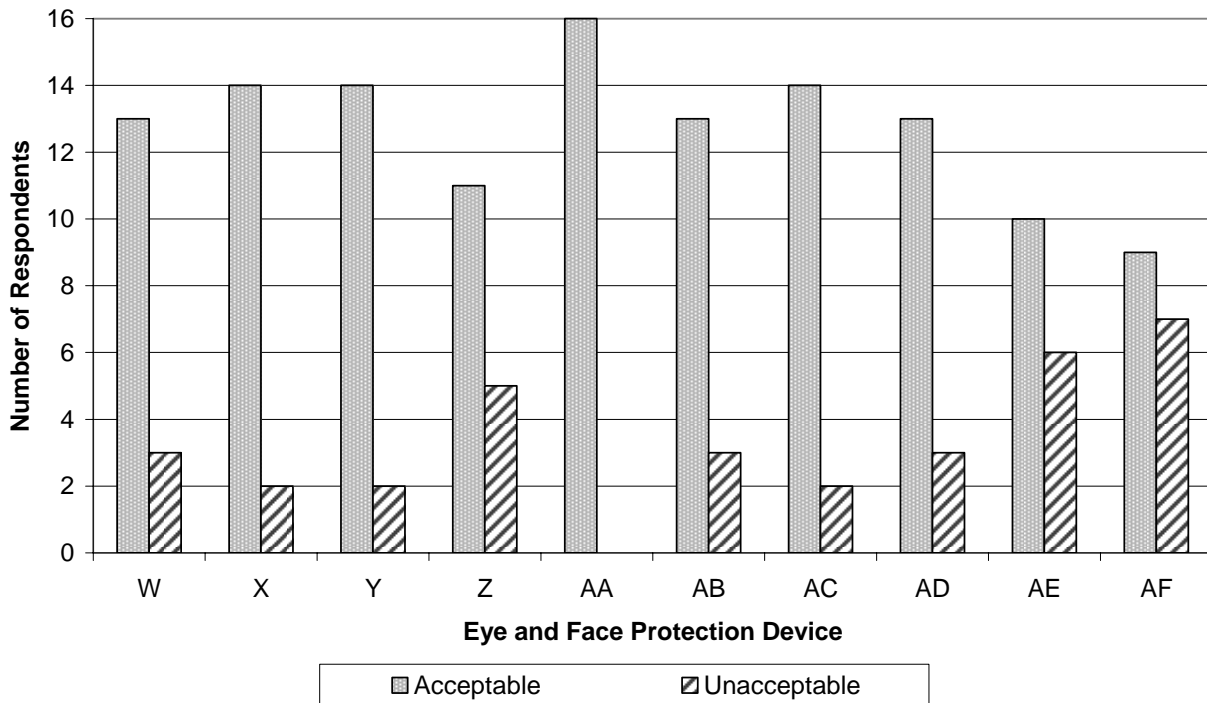
**Figure 60 – Trade Show Respondent Ratings for Eye/Facewear Physical Protection**



**Figure 61 – Trade Show Respondent Ratings for Eye/Facewear Barrier Qualities**



**Figure 62 – Trade Show Respondent Ratings for Eye/Facewear Visibility**



**Figure 63 – Trade Show Respondent Ratings for Eye/Facewear Donning Ease**

The ratings showed that each of the devices had its advantages and disadvantages for certain areas of design or performance:

- Disposable facemasks were considered easy to don and when provided with a faceshield gave good coverage of the face. However, there were some individuals concerned with their barrier properties and it was recognized that these devices provided little physical protection.
- Safety glasses were probably the lowest rated device owing to their lack of face coverage and barrier qualities, but still received high ratings for durability, physical protection, visibility, and ease of donning.
- Goggles received high ratings, particularly for durability, physical protection, and barrier qualities, but were ranked low for visibility because of fogging concerns.
- The industrial faceshield was rated high for face coverage, durability, barrier qualities, and physical protection, but some of the respondents provided low ratings for visibility (which may have been confused with comfort) and donning ease. The disposable faceshield had overall lower ratings, especially for durability and physical protection.
- The combined goggles and faceshield received high ratings in each category, but some respondents felt that the device was cumbersome and did not position well on their face. There were also some concerns for fogging with this device.

**Development of Design and Performance Criteria.** Given the wide range of user preferences, the committee decided to create categories of eye and face protection devices that could accommodate all of the different types of eye and facewear considered in this investigation. As part of this project, the following system for classifying devices was developed to provide appropriate criteria for different types of eye and face protection devices:

- Single-use medical face mask (with and without shields)
- Single-use eye and face protection devices (e.g., a disposable faceshield)
- Multiple use eye and face protection devices (e.g., safety glasses, goggles, faceshields)

Recommendations were made to use existing standards for devices where possible and then provide supplemental criteria to address end user or committee needs. To achieve this objective, the following criteria were implemented:

- Single-use medical face masks were required to conform to the “high barrier” category requirements of ASTM F2100. To supplement these requirements, additional design criteria included:
  - The provision of a means for adjusting the fit of the mask on the wearer’s nose (by metal wire or other device)
  - Prohibition of ties for securing the mask to the wearer’s head (ear loops are preferred)
  - The specification of key dimensions for the faceshield, if attached to the mask

- Single-use eye and face protection devices were required to provide coverage to a specific area of the face based on angles coverage as determined with the device positioned on a specified headform.
- Multiple-use eye and face protection devices were required to meet the respective category requirements (eye protectors, goggles, or faceshields) in ANSI Z87.1.

Additional requirements were developed to address specific areas of performance that were not part of the referenced standard. Table 39 shows the respective proposed performance criteria for each type of eye and face protection device.

**Table 39 – Recommended Performance Criteria for New Categories of Eye and Face Protection Devices**

<b>Performance Requirement</b>	<b>Medical Face Masks</b>	<b>Single-Use Eye/Facewear</b>	<b>Multiple-Use Eye/Facewear</b>
Meet high barrier requirements of ASTM F2100	◆		
Meet respective requirements of ANSI Z87.1			◆
Materials resist viral penetration per ASTM F1671		◆	
Device provides integrity per modified ASTM F1862 method	◆	◆	◆
Device meets new antifogging requirement	◆	◆	◆
Device materials tested for flame spread	Addressed in ASTM F2100	◆	Addressed in ANSI Z87.1

To fully implement these criteria, two test developments were needed:

1. The integrity test had to be adjusted to accommodate and fully evaluate different devices.
2. A test was needed to address end user fogging concerns.

The synthetic blood penetration resistance test that is specified in ASTM F1862 has been the test method of choice for evaluating eye and face protection device integrity. However, the test relies on targeting a specific area on the device. As written, the test is used to assess the blood penetration resistance of medical face masks and the blood stream is directed only towards the center of the mask. For the purposes of the new edition of NFPA 1999, new target areas were selected for single-use medical face masks.

- Next to elastic attachment points
- Near edges of mask
- Underneath visor



Figure 64 shows how the test target locations were modified for evaluating single-use medical face masks.



**Figure 64 – Two Specified New Target Locations on Medical Face Masks for Liquid Integrity Test**

Other locations were chosen for single-use and multiple-use eye and face protection devices. For single-use devices, locations were selected with respect to the device position over the eyes, device edges, and junctures. For multiple-use devices, the test instructions focus on junctures as the materials used in ANSI Z87.1 eye protectors, goggles, and faceshields are already considered impervious. In addition to targeting changes, additional specifications were added to the test method for different headforms and use of blotter materials to permit adaptation of test to different mask styles and positioning.

The solution to the development of a fogging test was to apply existing procedures used for assessing respirator lens fogging and incorporate those procedures into the visual acuity test that had been part of the standard for the 2003 edition. Specifically, specimens of medical face masks incorporating shields or eye and face protection devices are placed in an environment at freezing (0°C) for four hours and brought into an environment of 21°C at 50% relative humidity. The ability of test subjects to read an eye chart is used to assess if fogging of the device interferes with the wearer's vision.

#### **Other Areas of PPE Criteria Recommendations**

A number of specific new areas were raised by the committee and outside reviewers during the revision of NFPA 1999. These included:

- The need for some standardized form of head protection for EMS first responder

- Problems with work glove abrasion test requirements
- The development of footwear criteria for medical first responders
- Creation of a category for reusable ensemble protection against biological particulates

**Head Protection.** As part of the peer review process for the project plan, two organizations identified the need for head protection for EMS emergency responders, citing that vehicular accidents in patient transport had been responsible for a number of EMS personnel fatalities and injuries. An investigation of this hazard showed two principal types of head trauma hazards:

- Accident site protection (standard impact concerns from falling objects)
- Inside vehicle protection (primarily side protection from vehicle motion)

Gathering of data for vehicular accidents showed a range of forces inside a vehicle during movement. The specific data reporting head trauma as part of vehicle accident vary extensively with type of collision and type of passenger restraint or non-restraint system being used [75].

Several different head protection standards were reviewed and compared that included:

- ANSI Z89.1: industrial head protection
- NFPA 1977 [76]: flame/heat protective headwear for wildland firefighting
- ASTM F1447 [77]: bicycle helmets
- EN 12492 [78]: climbing/mountaineering helmets

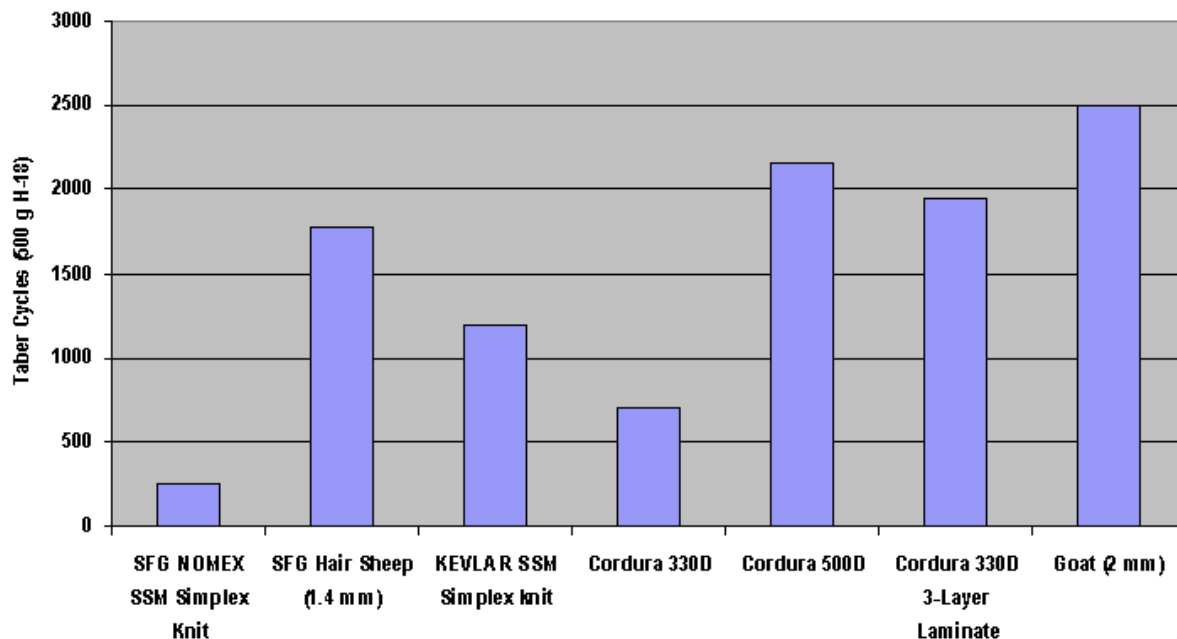
The committee focused on side/top impact criteria that were suitable for vehicle use and also examined weight requirements for EMS helmets. The requirements defined in ANSI Z89.1 appeared to address top impact but were considered inadequate for side protection. The committee also considered restricting the weight of the helmet given potentially long wearing periods.

While the committee considered more research was necessary to properly identify the specific performance features of EMS helmets for both use inside vehicles and at the accident scene, it decided to initially base criteria on NFPA 1977, exempting fire and heat requirements. The committee also decided to add an appendix section that explained alternative head protection strategies (particularly indicating that vehicle interior trauma was not addressed as part of the initial requirements set in the standard).

**Work Gloves.** The category of work gloves was added to the 2003 Edition of NFPA 1999 and prompted some manufacturers to respond with glove products to meet the new standard. Nevertheless, many of the resulting gloves were considered too thick to be effectively used in EMS operations, particularly during extrication of victims from vehicle accidents with the provision of emergency patient care. The principal problem was that shell materials were required to be relatively robust to meet an abrasion requirement. The abrasion criteria based on Taber abrasion testing according to ASTM D3884, specified no wearthrough of the glove following 2,500 abrasion cycles using an H-18 abradant wheel (a 500 gram load was assumed though it was not specified as part of the test method). These criteria forced the use of thick leather shell materials, which when combined with the necessary barrier material, limited the hand function provided by the resulting gloves. The test further focused on just the shell material, thus only one layer was being considered as part of the

test.<sup>28</sup> This direction in glove construction was considered contrary to providing gloves with high levels of dexterity and tactility.

Test results provided by a glove component supplier showed that very few candidate materials could meet the existing criteria as shown in Figure 65.



**Figure 65 – Test Results Comparing Abrasion Resistance of Several Different Work Glove Shell Materials**

A critical review of the application indicated that EMS responders were willing to trade physical protection for hand function. Based on this information, different ways were examined to provide a reasonable level of abrasion protection without limiting hand function. Changes introduced to the work glove abrasion resistance test included:

- Specification of a 500 gram load for testing.
- Testing of only the shell layer; however, the entire composite is placed on the test machine.
- Reduction of the number of abrasion cycles from 2,500 to 1,000.
- Establishment of wear through criteria based on the ability to insert a 6 mm diameter rod through any hole in the material.

The adoption of these criteria thus allowed non-leather alternatives which provided a higher potential for improved hand function. Candidate acceptable materials included those demonstrating acceptable durability in military applications where contact with rough surfaces was a concern.

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<sup>28</sup> These procedures were originally developed as part of the criteria for technical rescue gloves specified in NFPA1951.

**Footwear for Medical First Receivers.** Reusable footwear requirements in NFPA 1999-2003 addressed physical protection to the wearer toe and sole by the meeting certain toe impact/compression criteria and puncture resistance for the sole. These criteria force the incorporation of hardware into the construction of the footwear (steel or composite toe caps and sole puncture plates), which reduce footwear flexibility and make it heavier. These design features are considered undesirable to a large segment of potential NFPA 1999-compliant footwear end users, namely, first receivers at hospitals, where such footwear would be found to be burdensome.

To create a new category of footwear, the committee removed the requirements for toe impact and compression resistance together with the sole puncture resistance requirement. In addition, the committee required that this category of footwear would carry a special label warning the wearer that the footwear provided no physical protection.

**Biological Particulate Protection.** A segment of the end user population was identified as having a need for protection from biological particulates (e.g., anthrax) as may be used during terrorism incidents. Within the NFPA system of standards, NFPA 1994 [79] defines criteria for protective ensembles for first responders to CBRN terrorism incidents.<sup>29</sup> This standard defines three classes of protection as shown in the Table 40.

**Table 40 – NFPA 1994 Classes of Protective Ensembles**

<b>Class</b>	<b>Intended Protection</b>	<b>Type of Environment</b>
2	High levels of chemical and biological agents, and radiological/nuclear particulates requiring use of self-contained breathing apparatus	Gas, vapor, liquid, or particulate environments that are immediately dangerous to life and health (IDLH)
3	Low levels of chemical and biological agents, and radiological/nuclear particulates permitting use of air-purifying respirators	Gas, vapor, liquid, or particulate environments that are below IDLH levels
4	Biological and radiological/nuclear particulates permitting use of air-purifying respirators	Particulate environments that are below IDLH levels; gases, vapors, or liquids are not present

It was pointed out while NFPA 1994 addressed single-use (exposure) ensembles for each class, both Class 2 and Class 3 performance was also addressed in reusable ensemble standards as options (i.e., Class 2 in NFPA 1971 for structural firefighting and Class 2 in NFPA 1951 for technical rescue). Some members of the committee recommended that a reusable Class 4 ensemble should be defined in the new edition of NFPA 1999. Consequently, system requirements based on NFPA 1994 criteria were added to the standard requiring an ensemble consisting of multiple-use garments, eye and face protection, gloves, and footwear. Similar design and durability criteria established in NFPA 1951 were applied to the new BRN ensembles.

<sup>29</sup> CBRN refers to chemical, biological, radiological, and nuclear agents that can be used during terrorism incidents. Both radiological and nuclear agents are considered to be particulates only and not include high energy radiation.

## OVERALL CONCLUSIONS

An extensive study was undertaken to characterize the specific patterns of emergency medical service (EMS) personal protective equipment (PPE) use and problems associated with its selection based on available products and existing criteria in NFPA 1999. This study focused on items of protective clothing in NFPA 1999 where certification submittals had been lacking and included single-use garments, cleaning gloves, footwear covers, and eye and face protection devices.

A systematic approach was used for gathering information to support the determination of end user needs; trade show participants provided responses, and interviews were undertaken with representatives of selected organizations providing EMS services. This information was invaluable to the decision-making process for prioritizing specific design and performance issues and forestablishing criteria to reflect end user expectations and protection needs. In some cases, end user ratings together with limited field trials of a range of clothing items from the particular PPE category were used to help determine whether gear with certain design and performance characteristics would be considered acceptable or unacceptable for use during EMS. This method of delineating design and performance differences was then applied to test data or other product findings that could help establish specific criteria.

This work was undertaken to provide technical support to the National Fire Protection Association (NFPA) Technical Committee on Emergency Medical Operations Protective Clothing and Equipment in their revision of NFPA 1999, *Standard on Protective Clothing for Emergency Medical Operations*. The study was undertaken in a timely fashion to provide input to the committee at critical junctures of the standards development process with specific aims to resolve test method issues and to help set appropriate design and performance criteria to address changing EMS responder needs.

The project was successful in several areas by accomplishing the following:

1. Specific design criteria were created to define partial body protective garments.
2. Test results were obtained to help the committee make decisions on the more appropriate test methods in several different performance areas.
3. Discriminating data were used to establish separate test methods (in some cases) and criteria for single-use garments as compared to multiple-use garments.
4. An approach was developed to address high visibility concerns for EMS garments, when needed.
5. Criteria discrepancies in cleaning glove criteria were identified and resolved through modification of test methods and performance criteria.
6. Appropriate criteria were developed for footwear covers.
7. A system of classification together with specific design and performance criteria was assembled to address the range of eye and face protection devices used by EMS responders in a manner consistent with their use.

These changes are expected to result in the increased certification of PPE to NFPA 1999 and the consequent availability of certified products to EMS responders for their increased safety.

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- [63] ASTM F 1868, "Standard Test Method for Thermal and Evaporative Resistance of Clothing Materials Using a Sweating Hot Plate," *Volume 11.03 Book of Standards*, ASTM International, West Conshocken, PA, 2002.
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- [74] ASTM F 2100, "Standard Specification for Performance of Materials Used in Medical Face Masks," *Volume 11.03 Book of Standards*, ASTM International, West Conshocken, PA, 2007.
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**APPENDIX A**  
**NFPA 1999 PUBLIC PROPOSALS**  
**SUBMITTED AS PART OF PROJECT**

## APPENDIX A

### NFPA 1999 PUBLIC PROPOSALS SUBMITTED AS PART OF PROJECT

#### Page 3, Log #1 – Accept in Principle

**Committee Statement:** The committee finds that the provision of multiple use [C]BRN ensembles is not addressed in any other standards and its implementation in NFPA 1999 fills a gap in industry PPE needs for this type of protection. The proposed criteria, while consistent with Class 4 of NFPA 1994, establish minimum preconditioning requirements intended to demonstrate the continued service of protective clothing in providing protection against [C]BRN agents.

#### Page 10, Log #146 – Accept

*Recommendation should read:*

**1.3.7** This standard shall not apply to the use or conditions of use for emergency medical protective clothing and ensembles by emergency medical responders and medical first receivers.

#### Page 17, Log #96 – Accept

*Recommendations should read:*

**3.3.XX Emergency Medical Facemask.** An item of emergency medical protective clothing that is designed and configured to provide protection to the wearer's face including the mucous membrane areas of the wearer's nose and mouth.

**A.3.3.XX Emergency Medical Facemask.** Emergency medical facemasks include surgical and procedure masks, which may or may not have shields. These items of protective clothing include materials that are resistant to the penetration of blood and body fluids while allowing the wearer to breathe through the facemask material. NFPA 1999 references that emergency medical facemasks comply with the "high barrier performance" of requirements of ASTM F2100, *Standard Specification for Performance of Materials Used in Medical Face Masks*. Nevertheless, these items do not afford the same level of barrier protection consistent with other items of emergency medical protective clothing since they are not tested for and cannot pass viral penetration resistance testing.

Emergency medical facemasks, unless certified by NIOSH under Code of Federal Regulations Title 42 Code of Federal Regulations Part 84, *Approval of Respiratory Protective Devices*, are not respirators and do not provide respiratory protection against airborne hazards. Also see A.1.3.4.

*{ensure that 42 CFR Part 84 is referenced in Appendix B}*

#### Page 18, Log #94 – Accept

*Recommendations should read:*

**3.3.16\* Emergency Medical Cleaning/Utility Glove.** Multipurpose glove, not for emergency patient care, that provides a barrier against body fluids, cleaning fluids, and disinfectants and limited physical protection to the wearer.

**A.3.3.16 Emergency Medical Cleaning/Utility Glove.** Emergency medical cleaning/utility gloves are *not* intended to be used as emergency medical examination gloves or emergency medical work gloves. Emergency medical cleaning/utility gloves are not intended and should not

be used for emergency patient care because these gloves may not provide adequate hand function in terms of dexterity and tactility for some medical tasks. Emergency medical cleaning/utility gloves also do not provide the necessary levels of physical protection that are met by emergency medical work gloves, which are suitable for extrication and other emergency medical operations where significant physical hazards may be faced. However, emergency medical cleaning/utility gloves are more robust and provide greater resistance to physical hazards compared to emergency medical examination gloves and can be suitable for body recovery and other medical functions where blood and other body fluids may be encountered outside the provision of emergency patient care.

*{ensure that everywhere cleaning gloves appears, changes are made to “cleaning/utility” gloves}*

Page 19, Log #95 – Accept

*Recommendations should read:*

**3.3.25\* Emergency Medical Eye and Face Protection Device.** An item of emergency medical protective clothing that is designed and configured to provide protection to the wearer's eyes, face or both eyes and face.

**A.3.3.25 Emergency Medical Eye and Face Protection Device.** These devices include spectacles, goggles, faceshields, and combination devices, but do not include emergency medical face masks, which are separately defined and to which different criteria are applied. These devices differ from emergency medical facemasks by being continuous in their barrier protection to the eyes or portions of the face that are protected. These devices further provide physical protection to the eyes and portions of the face.

Page 21, Log #93 – Accept

*Recommendations should read:*

**3.3.30\* Emergency Medical Operations.** Provision of emergency patient care and transportation prior to arrival at a medical care facility by emergency medical responders, emergency patient care by medical first receivers at a medical care facility, and body recovery by emergency medical responders.

**A.3.3.30 Emergency Medical Operations.** Emergency medical operations include the provision of emergency patient care by emergency medical responders and medical first receivers. For emergency medical responders, this care may be provided at the scene of accident or in the transport of patients to a medical facility. For medical first receivers, care is generally provided at a medical facility, though medical first receivers may also provide emergency patient care at various temporary emergency medical facilities. Body recovery is included as emergency medical operations because some patients may die in the course of treatment and some events, including large scale disasters, may require body removal, which significant blood borne pathogen hazards exist.

*{appendix item added based on committee discussion}*

Page 22, Log #97 – Accept

*Recommendation should read:*

**3.3.31 Emergency Medical Protective Clothing.** Multiple items of protective clothing, including single-use and multiple-use garments, single-use examination gloves, single-use cleaning/utility gloves, multiple-use work gloves, single-use footwear covers, multiple-use

footwear, single-use masks, single-use eye and face protection devices, multiple-use eye and face protection devices, and multiple-use helmets designed and configured to provide limited physical protection and barrier protection against body fluid-borne pathogens contact with the wearer's body during delivery of emergency patient care and other emergency medical functions. *(See also Emergency Medical Cleaning/Utility Glove, Emergency Medical Examination Glove, Emergency Medical Eye and Face Protection Device, Emergency Medical Facemask, Emergency Medical Footwear, Emergency Medical Footwear Cover, Emergency Medical Garment, Emergency Medical Helmet, and Emergency Medical Work Glove.)*

Page 24, Log #92 – Accept in Principle

**Committee Statement:** See action taken on Log 45, Page 23

Page 31, Log #112 - Accept

*Recommendations should read:*

**5.1 Product Label Requirements for Emergency Medical Protective Clothing Items.**

**5.1.1 General Product and Package Label Requirements.**

**5.1.1.1** All worded portions of the required product and package labels shall be at least in English.

**5.1.1.2** All letters and numbers on product labels and product package labels shall be at least 2 mm (1/16 in.) high.

**5.1.1.3** Symbols and other pictorial graphic representations shall be permitted to be used to supplement worded statements on the product label(s).

**5.1.1.4** Configuration of the product label and attachment of the product label shall not interfere with the legibility of any printed portion of the product label.

**5.1.1.5** Where applicable, multiple label pieces shall be permitted in order to carry all statements and information required to be on the product label; however, all label pieces comprising the entire product label shall be located adjacent to each other.

**5.1.1.6** Where package labels are required, the package product label shall be permanently and conspicuously located on the outside of the package or printed on the package and shall not be removed, obscured, or otherwise mutilated by the opening of the package when the package is opened as intended.

**5.1.2 Single-Use Emergency Medical Garment Product Label Requirements.**

**5.1.2.1** Each garment shall have a product label or labels permanently and conspicuously located inside each garment when the garment is properly assembled with all layers and components in place.

**5.1.2.2** The product label shall have the certification organization's label, symbol, or identifying mark and at least the following statement legibly printed on the product label.

**“THIS GARMENT IS FOR SINGLE USE ONLY!**

**THIS GARMENT MEETS THE SINGLE-USE EMERGENCY MEDICAL GARMENT REQUIREMENTS OF NFPA 1999, STANDARD ON PROTECTIVE CLOTHING FOR EMERGENCY MEDICAL OPERATIONS, 2008 EDITION.**

**DO NOT REMOVE THIS LABEL!”**

**5.1.2.3** The following information shall also be printed legibly on the product label.

- (1) Manufacturer's name, identification, or designation
- (2) Manufacturer's address
- (3) Country of manufacture



- (4) Garment model or style
- (5) Trace number
- (6) Materials of construction
- (7) Month and year of manufacture, not coded
- (8) Size

### **5.1.3 Multiple-Use Emergency Medical Garment Product Label Requirements.**

**5.1.3.1** Each garment shall have a product label or labels permanently and conspicuously located inside each garment when the garment is properly assembled with all layers and components in place.

**5.1.3.2** The product label shall have the certification organization's label, symbol, or identifying mark and at least the following statement legibly printed on the product label.

**“THIS GARMENT MEETS THE MULTIPLE-USE EMERGENCY MEDICAL GARMENT REQUIREMENTS OF NFPA 1999, STANDARD ON PROTECTIVE CLOTHING FOR EMERGENCY MEDICAL OPERATIONS, 2008 EDITION. DO NOT REMOVE THIS LABEL!”**

**5.1.3.3** The following information shall also be printed legibly on the product label.

- (1) Manufacturer's name, identification, or designation
- (2) Manufacturer's address
- (3) Country of manufacture
- (4) Garment model or style
- (5) Trace number
- (6) Materials of construction
- (7) Cleaning precautions
- (8) Month and year of manufacture, not coded
- (9) Size

**5.1.3.4** Where visibility materials are used on garments and the garment meets the requirements of ANSI/ISEA 107, *American National Standard for High-Visibility Safety Apparel and Headwear*, the product label shall also meet the marking information required by ANSI/ISEA 107.

**5.1.3.5** Where visibility materials are used on garments and are not intended to meet the requirements in ANSI/ISEA 107, *American National Standard for High-Visibility Safety Apparel and Headwear*, the product label shall include the following warning:

**“WEARING OF THIS GARMENT ALONG ROADSIDES OR OTHER AREAS WITH VEHICULAR TRAFFIC REQUIRES ADDITIONAL HIGH VISIBILITY SAFETY APPAREL, COMPLIANT WITH AT LEAST THE CLASS 2 REQUIREMENTS OF ANSI / ISEA 107.”**

### **5.1.4 Single-Use Emergency Medical Examination Gloves Product Label Requirements.**

**5.1.4.1** The package containing the smallest number of glove items from which the user withdraws the product for use shall have a package product label.

**5.1.4.2** The certification organization's label, symbol, or identifying mark and at least the following statement shall be legibly printed on the package product label.

**“THIS GLOVE IS FOR SINGLE USE ONLY!**

**THIS GLOVE MEETS THE SINGLE-USE EMERGENCY MEDICAL EXAMINATION GLOVE REQUIREMENTS OF NFPA 1999, STANDARD ON PROTECTIVE CLOTHING FOR EMERGENCY MEDICAL OPERATIONS, 2008 EDITION. DO NOT REMOVE THIS LABEL!”**

**5.1.4.3** The following information shall also be printed legibly on the package product label.

- (1) Manufacturer's name, identification, or designation
- (2) Manufacturer's address
- (3) Country of manufacture
- (4) Glove model or style
- (5) Trace number
- (6) Materials of construction
- (7) Month and year of manufacture, not coded
- (8) Size

**5.1.4.4** In addition to the required package product label, each glove shall be permitted to have a product label on the outside of the glove.

**5.1.4.5** Where each glove has a product label, the certification organization's label, symbol, or identifying mark and at least the following statement shall be legibly printed as the product label on each glove.

**“MEETS NFPA 1999, 2008 ED.”**

**5.1.5 Single-Use Emergency Medical Cleaning/Utility Glove Product Label Requirements.**

**5.1.5.1** The package containing the smallest number of glove items from which the user withdraws the product for use shall be permitted to have a package product label in place of the package label.

**5.1.5.2** The certification organization's label, symbol, or identifying mark and at least the following statement shall be legibly printed on the package product label.

**“THIS GLOVE IS FOR SINGLE USE ONLY!**

**THIS GLOVE MEETS THE SINGLE-USE EMERGENCY MEDICAL CLEANING/  
UTILITY GLOVE REQUIREMENTS OF NFPA 1999, STANDARD ON PROTECTIVE  
CLOTHING FOR EMERGENCY MEDICAL OPERATIONS, 2008 EDITION.**

**DO NOT REMOVE THIS LABEL!”**

**5.1.5.3** The following information shall also be printed legibly on the package product label.

- (1) Manufacturer's name, identification, or designation
- (2) Manufacturer's address
- (3) Country of manufacture
- (4) Glove model or style
- (5) Trace number
- (6) Materials of construction
- (7) Month and year of manufacture, not coded
- (8) Size

**5.1.5.4** In addition to the required package product label, each cleaning glove shall be permitted to have a product label on the outside of the glove.

**5.1.5.5** Where each cleaning glove has a product label, the certification organization's label, symbol, or identifying mark and at least the following statement shall be legibly printed as the product label on each glove.

**“MEETS NFPA 1999, 2008 ED.”**

**5.1.6 Multiple-Use Emergency Medical Work Glove Product Label Requirements.**

**5.1.6.1** Each work glove shall have a product label(s) permanently and conspicuously attached inside each glove.

**5.1.6.2** The certification organization's label, symbol, or identifying mark and at least the following statement shall be legibly printed on the product label.

**“THIS GLOVE MEETS THE MULTIPLE-USE EMERGENCY MEDICAL WORK GLOVE REQUIREMENTS OF NFPA 1999, STANDARD ON PROTECTIVE CLOTHING FOR EMERGENCY MEDICAL OPERATIONS, 2008 EDITION. DO NOT REMOVE THIS LABEL.”**

**5.1.6.3** The following information shall also be printed legibly on the product label.

- (1) Manufacturer's name, identification, or designation
- (2) Manufacturer's address
- (3) Country of manufacture
- (4) Glove model or style
- (5) Trace number
- (6) Materials of construction
- (7) Cleaning instructions
- (8) Month and year of manufacture, not coded
- (9) Size

**5.1.7 Single-Use Emergency Medical Facemask Product Label Requirements.**

**5.1.7.1** The package containing the smallest number of facemask items from which the user withdraws the product for use shall have a package product label.

**5.1.7.2** The certification organization's label, symbol, or identifying mark and at least the following statement shall be legibly printed on the package product label.

**“THIS FACEMASK IS FOR SINGLE USE ONLY!**

**THIS MASK MEETS THE SINGLE-USE EMERGENCY MEDICAL FACEMASK REQUIREMENTS OF NFPA 1999, STANDARD ON PROTECTIVE CLOTHING FOR EMERGENCY MEDICAL OPERATIONS, 2008 EDITION. DO NOT REMOVE THIS LABEL!”**

**5.1.7.3** The following information shall also be printed legibly on the package product label.

- (1) Manufacturer's name, identification, or designation
- (2) Manufacturer's address
- (3) Country of manufacture
- (4) Facemask model or style
- (5) Trace number
- (6) Materials of construction
- (7) Month and year of manufacture, not coded
- (8) Size, where applicable

**5.1.7.4** In addition to the required package product label, each mask shall be permitted to have a product label in an area of the facemask that does not affect its function.

**5.1.7.5** Where each facemask has a product label, the certification organization's label, symbol, or identifying mark and at least the following statement shall be legibly printed as the product label on each facemask.

**“MEETS NFPA 1999, 2008 ED.”**

**5.1.7.6** Where the medical facemask is not certified by National Institute for Occupational Safety and Health (NIOSH) as a respirator to Title 42 Code of Federal Regulations Part 84, *Approval of Respiratory Protective Devices*, the package product label shall include the following additional warning:

**THIS FACEMASK IS NOT A RESPIRATOR AND WILL NOT PROVIDE RESPIRATORY PROTECTION AGAINST AIRBORNE BIOLOGICAL HAZARDS.**

### **5.1.8 Single-Use Emergency Medical Eye and Face Protection Device Product Label Requirements.**

**5.1.8.1** The package containing the smallest number of eye and face protection device items from which the user withdraws the product for use shall have a package product label.

**5.1.8.2** The certification organization's label, symbol, or identifying mark and at least the following statement shall be legibly printed on the package product label.

**“THIS {insert name of item} IS FOR SINGLE USE ONLY!**

**THIS {insert name of item} MEETS THE SINGLE-USE EMERGENCY EYE AND FACE PROTECTION DEVICE REQUIREMENTS OF NFPA 1999, STANDARD ON PROTECTIVE CLOTHING FOR EMERGENCY MEDICAL OPERATIONS, 2008 EDITION.**

**DO NOT REMOVE THIS LABEL!”**

**5.1.8.3** The following information shall also be printed legibly on the package product label.

- (1) Manufacturer's name, identification, or designation
- (2) Manufacturer's address
- (3) Country of manufacture
- (4) Eye and face protection device model or style
- (5) Trace number
- (6) Materials of construction
- (7) Month and year of manufacture, not coded
- (8) Size, where applicable

**5.1.8.4** In addition to the required package product label, each eye and face protection device shall be permitted to have a product label in a location of the eye and face protection device that does not interfere with the wearer's vision or device's function.

**5.1.8.5** Where each eye and face protection device has a product label, the certification organization's label, symbol, or identifying mark and at least the following statement shall be legibly printed as the product label on each eye and face protection device.

**“MEETS NFPA 1999, 2008 ED.”**

### **5.1.9 Multiple-Use Emergency Medical Eye and Face Protection Devices Product Label Requirements.**

**5.1.9.1** The package containing the smallest number of eye and face protection device items from which the user withdraws the product for use shall have a package product label.

**5.1.9.2** The certification organization's label, symbol, or identifying mark and at least the following statement shall be printed on the package product label:

**“THIS DEVICE MEETS THE MULTIPLE-USE EMERGENCY MEDICAL EYE AND FACE PROTECTION REQUIREMENTS OF NFPA 1999, STANDARD ON PROTECTIVE CLOTHING FOR EMERGENCY MEDICAL OPERATIONS, 2008 EDITION.**

**DO NOT REMOVE THIS LABEL!”**

**5.1.9.3** The following information also shall be printed legibly on the package product label.

- (1) Manufacturer's name, identification, or designation
- (2) Manufacturer's address
- (3) Country of manufacture
- (4) Eye and face protection device model or style
- (5) Trace number
- (6) Materials of construction

- (7) Cleaning precautions
- (8) Month and year of manufacture, not coded
- (9) Size

**5.1.9.4** Each face protection device shall have a product label, in addition to the required package product label, placed in a conspicuous location on the device that shall not interfere with the wearer's vision.

**5.1.9.5** The certification organization's label, symbol, or identifying mark and at least the following statement shall be legibly printed on the product label of each multiple-use face protection device.

**“MEETS NFPA 1999, 2008 ED.”**

**5.1.10 Single-Use Emergency Medical Footwear Cover Product Label Requirements.**

**5.1.10.1** The package containing the smallest number of footwear cover items from which the user withdraws the product for use shall have a package product label.

**5.1.10.2** The certification organization's label, symbol, or identifying mark and at least the following statement shall be legibly printed on the package product label.

**“THIS FOOTWEAR COVER IS FOR SINGLE USE ONLY!**

**THIS FOOTWEAR COVER MEETS THE SINGLE-USE EMERGENCY MEDICAL FOOTWEAR COVER REQUIREMENTS OF NFPA 1999, STANDARD ON PROTECTIVE CLOTHING FOR EMERGENCY MEDICAL OPERATIONS, 2008 EDITION.**

**DO NOT REMOVE THIS LABEL!”**

**5.1.10.3** The following information shall also be printed legibly on the package product label.

- (1) Manufacturer's name, identification, or designation
- (2) Manufacturer's address
- (3) Country of manufacture
- (4) Footwear cover model or style
- (5) Trace number
- (6) Materials of construction
- (7) Month and year of manufacture, not coded
- (8) Size, where applicable

**5.1.10.4** In addition to the required package product label, each footwear cover shall be permitted to have a product label in area of the footwear cover that does not affect the comfort of the wearer.

**5.1.10.5** Where each footwear cover has a product label, the certification organization's label, symbol, or identifying mark and at least the following statement shall be legibly printed as the product label on each footwear cover.

**“MEETS NFPA 1999, 2008 ED.”**

**5.1.11 Multiple-Use Emergency Medical Footwear Product Label Requirements.**

**5.1.11.1** Each footwear item shall have a product label or labels permanently and conspicuously attached inside each footwear item when the footwear is properly donned.

**5.1.11.2** The certification organization's label, symbol, or identifying mark and at least the following statement shall be legibly printed on the product label.

**“THIS FOOTWEAR MEETS THE MULTIPLE-USE EMERGENCY MEDICAL FOOTWEAR REQUIREMENTS OF NFPA 1999, STANDARD ON PROTECTIVE CLOTHING FOR EMERGENCY MEDICAL OPERATIONS, 2008 EDITION.**

**DO NOT REMOVE THIS LABEL!”**

**5.1.11.3** The following information shall also be printed legibly on the product label.

- (1) Manufacturer's name, identification, or designation
- (2) Manufacturer's address
- (3) Country of manufacture
- (4) Footwear model or style
- (5) Trace number
- (6) Materials of construction
- (7) Cleaning precautions
- (8) Month and year of manufacture, not coded
- (9) Size

**5.1.12 Multiple-Use Emergency Medical Helmet Product Labeling Requirements.**

**5.1.12.1** Each helmet shall have a product label or labels permanently and conspicuously attached. At least one product label shall be conspicuously located on or inside each helmet when the helmet is properly assembled with all components in place.

**5.1.12.2** The certification organization's label, symbol, or identifying mark and at least the following statement shall be legibly printed on the product label.

**“THIS HELMET MEETS THE EMERGENCY MEDICAL HELMET REQUIREMENTS OF NFPA 1999, STANDARD ON PROTECTIVE CLOTHING FOR EMERGENCY MEDICAL OPERATIONS, 2008 EDITION. DO NOT REMOVE THIS LABEL!”**

**5.1.12.3** The following information shall also be printed legibly on the product label.

- (1) Manufacturer's name, identification, or designation
- (2) Manufacturer's address
- (3) Country of manufacture
- (4) Helmet model or style
- (5) Trace number
- (6) Helmet size or size range
- (7) Nominal weight of helmet
- (8) Month and year of manufacture, not coded
- (9) Cleaning precautions

**5.1.12.4** Where visibility materials are used on helmets and the helmet meets the requirements of ANSI/ISEA 107, *American National Standard for High-Visibility Safety Apparel and Headwear*, the product label shall also meet the marking information in ANSI/ISEA 107.

**5.1.13 Multiple-Use Emergency Medical [C]BRN Protective Ensembles Product Labeling Requirements.**

**5.1.13.1** Where an entire ensemble is certified as compliant to the requirements for an Emergency Medical [C]BRN Protective Ensemble for protection against [C]BRN terrorism agents, each element of the entire ensemble shall have at least the additional compliance statement as specified in 5.1.13.3 on the product label in place of the appropriate compliance statement specified for the item in this section.

**5.1.13.2** The appropriate term for the element type — garment, glove, footwear, or another item — shall be inserted in the compliance statement text where indicated in this section.

**5.1.13.3** Other than the term “[C]BRN Protective Ensemble” all product label letters and figures shall be at least 2.5 mm (3/32 in.) in height. The term “[C]BRN Protective Ensemble” letters shall be at least 10 mm (3/8 in.) in height.

**“[C]BRN PROTECTIVE ENSEMBLE**

**THIS ELEMENT IS NOT PART OF A HAZARDOUS MATERIALS PROTECTIVE ENSEMBLE!**

**THIS EMERGENCY MEDICAL PROTECTIVE (insert appropriate element term here) ELEMENT MEETS THE REQUIREMENTS OF NFPA 1999, STANDARD ON PROTECTIVE CLOTHING FOR EMERGENCY MEDICAL OPERATIONS, 2008 EDITION, AND THE OPTIONAL REQUIREMENTS FOR [C]BRN PROTECTION WHEN WORN TOGETHER WITH THE OTHER SPECIFIED ELEMENTS AND INTERFACE COMPONENTS OF THE ENSEMBLE.**

**DO NOT REMOVE THIS LABEL!”**

**5.1.13.4** The garment element portion of the ensemble meeting the requirements for protection against [C]BRN terrorism agents shall list those items of the certified ensemble by manufacturer name and model number on the product label.

*{delete paragraph A.5.3.1}*

*{renumber section 5.3 as 5.2}*

Pages 32 through

Page 64, Log #91 – Accept

*Recommendations should read:*

**6.1 Emergency Medical Garment Design Requirements.**

**6.1.1 Single-Use Emergency Medical Garment Design Requirements.**

[new section]

**6.1.2 Multiple-Use Emergency Medical Garment Design Requirements.**

[current 6.1.1 through 6.1.10]

**6.2 Emergency Medical Glove Design Requirements.**

**6.2.1 Single-Use Emergency Medical Examination Glove Design Requirements.**

[current 6.2.1 through 6.2.4]

**6.2.2 Single-Use Emergency Medical Cleaning Glove Design Requirements.**

[current 6.6.1 through 6.6.5]

**6.2.3 Multiple-Use Emergency Medical Work Glove Design Requirements.**

[current 6.7.1 through 6.7.6]

**6.3 Emergency Medical Eye and Face Protection Device Design Requirements.**

**6.3.1 Single-Use Emergency Medical Facemask Design Requirements.**

[new section]

**6.3.2 Single-Use Emergency Medical Eye and Face Protection Device Design Requirements.**

[new section]

**6.3.3 Multiple-Use Emergency Medical Eye and Face Protection Device Requirements.**

[current 6.3.1 through 6.3.6, to be revised]

**6.4 Emergency Medical Footwear Design Requirements.**

**6.4.1 Single-Use Emergency Medical Footwear Cover Item Design Requirements.**

[current 6.5.1 through 6.5.4]

**6.4.2 Multiple-Use Emergency Medical Footwear Design Requirements.**

[current 6.4.1 through 6.4.4.2]

**6.5 Multiple-Use Emergency Medical Helmet Design Requirements.**

[current 6.8.1 through 6.8.12]

**6.6 Multiple-Use Emergency Medical [C]BRN Protective Ensemble Design Requirements.**

[current 6.9.1 through 6.9.9]

Page 65, Log #142 – Accept

*Wrong language appears in this log*

*Recommendations should read:*

## **6.1 Emergency Medical Protective Garment Design Requirements.**

### **6.1.1 Single-Use Emergency Medical Garment Design Requirements.**

**6.1.1.1** Garments shall be designed to cover any part of the upper and lower torso, excluding hands, face, and feet.

**6.1.1.2\*** Garments shall be permitted to be configured as full body clothing such as jackets and pants or coveralls; and non-full body clothing such as aprons, sleeve protectors, and sleeved aprons or smocks.

**6.1.1.2.1** Where garments are configured as aprons, garments shall be designed to protect the front torso of the wearer from the neck to below the knees.

**6.1.1.2.2** Where garments are configured as sleeve protectors, garments shall be designed to protect the arm of the wearer from the wrist crease to a distance of no less than 405 mm (16 in.) from the wrist crease.

**6.1.1.2.3** Where garments are configured as sleeved aprons, garments shall be designed to protect the front torso of the wearer from the neck to below the knees and arm of the wearer to the wrist crease.

**6.1.1.3** Garments shall be permitted to include integrated booties to protect the wearer's feet in conjunction with outer footwear.

**6.1.1.3.1** Where garments incorporate booties, the booties shall be designed as an extension of the garment leg and shall cover the entire foot and ankle.

**6.1.1.4** Garments shall be permitted to include integrated hoods to protect portions of the wearer's head and face in conjunction with eye and face protection devices and appropriate respirators.

**6.1.1.4.1** Where garments incorporate hoods, the hood shall cover at least the back and sides of the head.

**6.1.1.5\*** All portions of the body covered by the garment item shall be provided with barrier protection.

*{renumber current A.6.1.4 as A.6.1.1.5}*

**6.1.1.6\*** The barrier layer used in the construction of the garment shall be a single, nonseparable layer.

*{renumber current A.6.1.5 as A.6.1.1.6}*

**6.1.1.7** All external fittings including, but not limited to, zippers, snaps, or other fasteners of specimen garments shall be examined and shall be free of rough spots, burrs, or sharp edges that could tear the garment or glove materials.

### **6.1.2 Multiple-Use Emergency Medical Garment Design Requirements.**

**6.1.2.1** Garments shall be designed to cover any part of the upper and lower torso, excluding hands, face, and feet.

**6.1.2.2\*** Garments shall be permitted to be configured as full body clothing such as jackets and pants or coveralls; and non-full body clothing such as aprons, sleeve protectors, sleeve aprons or smocks.

**6.1.2.2.1** Where garments are configured as aprons, garments shall be designed to protect the front torso of the wearer from the neck to below the knees.



**6.1.2.2.2** Where garments are configured as sleeve protectors, garments shall be designed to protect the arm of the wearer from the wrist crease to a distance of no less than 405 mm (16 in.) from the wrist crease.

**6.1.2.2.3** Where garments are configured as sleeved aprons, garments shall be designed to protect the front torso of the wearer from the neck to below the knees and arm of the wearer to the wrist crease.

**6.1.2.3** Garments shall be permitted to include integrated booties to protect the wearer's feet in conjunction with outer footwear.

**6.1.2.3.1** Where garments incorporate booties, the booties shall be designed as an extension of the garment leg and shall cover the entire foot and ankle.

**6.1.2.4** Garments shall be permitted to include integrated hoods to protect portions of the wearer's head and face in conjunction with eye and face protection devices and appropriate respirators.

**6.1.2.4.1** Where garments incorporate hoods, the hood shall cover at least the back and sides of the head.

**6.1.2.5\*** All portions of the body covered by the garment item shall be provided with barrier protection.

{renumber current A.6.1.4 as A.6.1.2.5}

**6.1.2.6\*** The barrier layer used in the construction of the garment shall be a single, nonseparable layer.

{renumber current A.6.1.5 as A.6.1.2.6}

**6.1.2.7** Fastener tape shall meet the requirements of A-A-55126, *Commercial Item Description, Fastener Tapes, Hook and Pile, Synthetic*.

**6.1.2.8** Snaps shall be Style 2 and shall comply with the design and construction requirements of MIL-F-10994G, *Fasteners, Snap*. The construction of the snap shall be permitted to vary from the MIL-F-10994G drawings with regard to the attachment means and the use of logos on the caps.

**6.1.2.9** Zippers shall meet the physical performance requirements of A-A-55634, *Commercial Item Description, Zippers (Fasteners, Slide, Interlocking)*.

**6.1.2.10** All external fittings including, but not limited to, zippers, snaps, or other fasteners of specimen garments shall be examined and shall be free of rough spots, burrs, or sharp edges that could tear the garment or glove materials.

**6.1.2.11\*** Where visibility materials are used on garments, and the garments are intended to be used as high visibility safety apparel, garments shall meet the respective requirements for Performance Class 1, 2, or 3 in accordance with ANSI/ISEA 107, *American National Standard for High-Visibility Safety Apparel and Headwear*.

{renumber current A.6.1.10 as A.6.1.2.11}

**A.6.1.1.2** In specifying full body emergency medical protective garments, garments should include the combination of both jacket or coat and pants in order to provide protection to the whole body. Exclusion of the protective pants permits exposure of individuals to hazards associated with emergency medical operations.

**A.6.1.2.2** See A.6.1.1.2

{Add references}

**2.3.10 U.S. Department of Defense Publications.** Standardization Document Order Desk, Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

A-A-55126, *Commercial Item Description, Fastener Tapes, Hook and Pile, Synthetic*, 1999.

A-A-55634, *Commercial Item Description, Zippers (Fasteners, Slide, Interlocking)*, 2004.  
MIL-F-10994G, *Fasteners, Snap*, 16 June 1995.

Page 71, Log #143 – Accept

*Recommendations should read:*

### **6.3 Emergency Medical Face Protection Device Design Requirements.**

#### **6.3.1 Single-Use Emergency Medical Facemask Design Requirements.**

**6.3.1.1** Facemasks shall incorporate a wire or other device that allows the portion of the facemask that covers the top of the nose to be shaped over the wearer's nose.

**6.3.1.2** Facemasks shall have a means for securing the face mask to the wearer's head that do not require tying.

**6.3.1.3** Where facemasks include plastic shields, the plastic shield shall overlap the top of the face mask by at least 19 mm (3/4 in.) over the entire top between points of attachment for the plastic shield.

**6.3.1.4** Where facemasks include plastic shields, the plastic shield shall have a height of at least 50 mm (2 in.) above the top of the face mask.

**6.3.1.5** Where facemasks include plastic shields, the sides of the plastic shield shall extend at least 19 mm (3/4 in.) beyond the points of attachment for the plastic shield.

#### **6.3.2 Single-Use Emergency Medical Eye and Face Protection Device Design Requirements.**

**6.3.2.1** Eye and face protection devices shall be designed to cover part or all of the face including the eyes.

**6.3.2.2** Where the eye and face protection device is configured as a faceshield, the faceshield shall provide at least the following field of vision:

- (1) Dihedral angle of at least 85 degrees
- (2) Upper dihedral angle of at least 10 degrees
- (3) Lower dihedral angle of at least 40 degrees

**6.3.2.3** The field of vision shall be measured from the center of the surface of the eye.

**6.3.2.4** The faceshield shall be positioned on an Alderson 50th percentile male headform specified in Figure 6.3.2.4.

*{Figure 8.17.4.1.1 from NFPA 1971-2007}*

**6.3.2.5** Face protection devices and related hardware shall be examined for, and shall be free of rough spots, burrs, or sharp edges that could tear garment or glove materials.

#### **6.3.3 Multiple-Use Emergency Medical Eye and Face Protection Device Design Requirements.**

**6.3.3.1** Eye and face protection devices shall be designed to cover part or all of the face or head. Face protection devices shall be permitted to be configured as but are not limited to splash-resistant eyewear, goggles, faceshields, and hooded visors, and combinations of these items.

**6.3.3.2** Eye and face protection devices to be certified as compliant with this standard need not be primary eye protection but shall be permitted to be primary eye protection.

**6.3.3.3** Where the eye and face protection device is configured as safety glasses, the safety glasses shall meet the design requirements for Spectacles in Section 7 of ANSI/ASSE Z87.1, *Occupational and Educational Personal Eye and Face Protection Devices*, including basic impact.

**6.3.3.4** Where the eye and face protection device is configured as goggles, the goggles shall meet the design requirements for Goggles in Section 8 of ANSI/ASSE Z87.1, *Occupational and Educational Personal Eye and Face Protection Devices*, including basic impact.

**6.3.3.5** Where the eye and face protection device is configured as a faceshield, the faceshield shall meet the design requirements for Faceshields in Section 9 of ANSI/ASSE Z87.1, Occupational and Educational Personal Eye and Face Protection Devices, including basic impact.

**6.3.3.6** Face protection devices and related hardware shall be examined for, and shall be free of rough spots, burrs, or sharp edges that could tear garment or glove materials.

Page 75, Log #130 – Accept

*Recommendations should read:*

**6.5 Single-Use Emergency Medical Footwear Cover Design Requirements.**

**6.5.1** Footwear covers shall be permitted to be offered in only one size.

**6.5.2** The footwear cover height shall be a minimum of 150 mm (6 in.) when measured as specified in 6.5.2.1 and 6.5.2.2.

**6.5.2.1** An NFPA 1999-compliant footwear item in size 9, D width shall be used to determine the height of the footwear cover when placed over the footwear.

**6.5.2.2** The footwear cover height shall be determined by measuring lowest point of the footwear cover that extends up over the ankle area of the NFPA 1999-compliant footwear.

**6.5.3** The wear surface of the footwear cover shall extend 25 mm (1-in.) laterally in all directions from the wear surface of standard footwear when measured as specified in 6.5.3.1.

**6.5.3.1** An NFPA 1999-compliant footwear item in size 9, D width shall be used to determine the lateral extension of the footwear cover wear surface.

**6.5.3.2** The NFPA 1999-compliant footwear item shall be centered inside the footwear cover for determining lateral extension of the footwear cover wear surface.

**6.5.4** The footwear cover shall have some means to allow the top of the footwear cover to fit snugly around the wearer's bottom leg.

Page 80, Log #124 – Accept

*Recommendations should read:*

**6.6 Single-Use Cleaning/Utility Glove Design Requirements.**

**6.6.1** In order to label or otherwise represent cleaning/utility gloves as being compliant with the requirements of this standard, the manufacturer shall provide gloves in not less than four separate and distinct sizes.

**6.6.2** Cleaning/utility glove hand circumference shall be in accordance with Clause 5.1 of EN 420, *General requirements for gloves*.

**6.6.3** When measured on the palm side, gloves shall have a length of at least 305 mm (12 in.) as measured from the tip of the middle finger to the end of the cuff.

Page 81, Log #109 – Change action from Hold to Accept in Principle

**Committee Action:** Add new appendix sections

Add asterisk to Section 6.6.

**A.6.6** Helmet design and performance criteria are provided for emergency medical helmets for use in environments where impact hazards may be present. These helmets can also be used to help prevent head injuries to emergency medical responders in vehicles during transport of patients. Alternative types of helmets may provide similar protection for side and top impact for use in emergency vehicles but are not addressed by this standard. It is important that any head

protection that is used inside emergency vehicles provide side and top impact protection and remain secure on the wearer's head.

Add asterisk to Section 7.8.

**A.7.8** See A.6.6

**Committee Statement:** No specific alternative criteria have been provided, but the committee recognizes the need for consideration of other types of helmets that may be suitable in reducing head injuries for emergency medical providers during transport of patients inside emergency vehicles. The committee has proposed language for the appendix to discuss the need for head protection during emergency medical operations and the types of helmet characteristics that are appropriate for this type of protection.

Page 90, Log #90 – Accept

*Recommendations should read:*

**7.1 Emergency Medical Garment Performance Requirements.**

**7.1.1 Single-Use Emergency Medical Garment Performance Requirements.**

[current 7.1.1.1 through 7.1.1.10]

**7.1.2 Multiple-Use Emergency Medical Garment Performance Requirements.**

[current 7.1.2.1 through 7.1.2.16]

**7.2 Emergency Medical Glove Performance Requirements.**

**7.2.1 Single-Use Emergency Medical Examination Glove Performance Requirements.**

[current 7.2.1 through 7.2.7]

**7.2.2 Single-Use Emergency Medical Cleaning/Utility Glove Performance Requirements.**

[current 7.6.1 through 7.6.11]

**7.2.3 Multiple-Use Emergency Medical Work Glove Performance Requirements.**

[current 7.7.1 through 7.7.12]

**7.3 Emergency Medical Eye and Face Protection Device Performance Requirements.**

**7.3.1 Single-Use Emergency Medical Facemask Performance Requirements.**

[new section]

**7.3.2 Single-Use Emergency Medical Eye and Face Protection Device Performance Requirements.**

[new section]

**7.3.3 Multiple-Use Emergency Medical Eye and Face Protection Device Requirements.**

[current 7.3.1 through 7.3.8, to be revised]

**7.4 Emergency Medical Footwear Performance Requirements.**

**7.4.1 Single-Use Emergency Medical Footwear Cover Performance Requirements.**

[current 7.5.1 through 7.5.11]

**7.4.2 Multiple-Use Emergency Medical Footwear Performance Requirements.**

[current 7.4.1 through 7.4.13]

**7.5 Multiple-Use Emergency Medical Helmet Performance Requirements.**

[current 7.8.1 through 7.8.3]

**7.6 Multiple-Use Emergency Medical [C]BRN Protective Ensemble Performance Requirements.**

[current 7.9.1 through 7.9.6]

Page 92, Log #113

*Recommendations should read:*

### **7.1.1\* Single-Use Garment Item Performance Requirements**

**7.1.1.1** Full body or full torso garments, including but not limited to coveralls, coats, jackets, pants, and overalls, shall be tested for liquidtight integrity as specified in Section 8.2, Liquidtight Integrity Test One, and shall allow no water penetration.

**7.1.1.2** Garment barrier layer material and barrier layer seams shall be tested for body fluid-borne pathogen resistance as specified in Section 8.3, Biopenetration Test One, and shall exhibit no penetration of the Phi-X174 bacteriophage.

**7.1.1.3** Garment materials shall be tested for tensile strength as specified in Section 8.4, Tensile Strength Test, and shall have a tensile strength of not less than 50 N (11.2 lbf).

**7.1.1.4** Garment materials shall be tested for bursting strength as specified in Section 8.5, Burst Strength Test Two, and shall have a bursting strength of not less than 66 N (14.9 lbf).

**7.1.1.5** Garment materials shall be tested for tear strength as specified in Section 8.43, Tear Resistance Test Two, and shall have a tear strength of not less than 17 N (3.8 lbf).

**7.1.1.6** Garment material seams shall be tested for breaking strength as specified in Section 8.8, Seam Breaking Strength Test, and shall have a breaking strength of not less than 50 N (11.2 lbf).

**7.1.1.7** Garment materials for full body garments including, but not limited to coveralls and full torso and limb encapsulating garments, shall be tested for total heat loss as specified in Section 8.35, Total Heat Loss Test, and shall have a total heat loss value of 450 W/m<sup>2</sup> or greater.

**7.1.1.8** Garment materials shall be tested for flammability as specified in Section 8.44, Flammability Test, and shall have a flame spread time of 3.5 seconds or more.

Page 97, Log #104 – Accept

*Recommendations for performance requirement should read:*

**7.1.1.10** Garment materials shall be tested for flammability as specified in Section 8.44, Flammability Test, and shall have a flame spread time of 3.5 seconds or more.

**7.1.2.16** Each separable layer of garment material shall be tested for flammability as specified in Section 8.44, Flammability Test, and shall have a flame spread time of 3.5 seconds or more.

~~**7.4.13** Footwear shall be tested for flammability as specified in Section 8.44, Flammability Test, and shall have an afterflame time of 2.0 seconds or less.~~

**7.5.11** Footwear cover materials shall be tested for flammability as specified in Section 8.44, Flammability Test, and shall have a flame spread time of 3.5 seconds or more.

**7.6.11** Cleaning/utility glove materials shall be tested for flammability as specified in Section 8.44, Flammability Test, and shall have a flame spread time of 3.5 seconds or more.

~~**7.7.12** Glove materials shall be tested for flammability as specified in Section 8.44, Flammability Test, and shall have an afterflame time of 2.0 seconds or less.~~

*Recommendations for test method should read:*

### **8.44 Flammability Test.**

#### **8.44.1 Application.**

**8.44.1.1** This test shall apply to materials used in garments, cleaning/utility gloves, single-use eye and face protection devices, and footwear covers.

**8.44.1.2** Modifications to this test method for testing multiple-use garments shall be as specified in 8.44.7

**8.44.1.3** Modifications to this test method for testing footwear covers and single-use garments shall be as specified in 8.44.8.

**8.44.1.4** Modifications to this test method for testing cleaning/utility gloves shall be as specified in 8.44.9.

**8.44.1.5** Modifications to this test method for testing single-use eye and face protection devices shall be as specified in 8.44.10.

**8.44.2 Specimens.** A minimum of five specimens shall be tested.

**8.44.3 Sample Preparation.** Samples shall be conditioned as specified in 8.1.2.

**8.44.4 Procedure.** Specimens shall be tested in accordance with ASTM D 1230, *Standard Test Method for Flammability of Apparel Textiles*, with the following modifications:

- (1) Sample preparation and conditioning shall be as specified in this section.
- (2) The specimens shall be positioned in the flammability tester specimen holder so that the tip of the flame contacts the bottom edge of the specimen.
- (3) The time of flame application shall be 1-second.

**8.44.5 Report.**

**8.44.5.1** The flame spread time for each specimen shall be reported to the nearest 0.1 second.

**8.44.5.2** The average flame spread time for all specimens shall be reported.

**8.44.5.3** Specimens that do not ignite shall be recorded as “Did not ignite” and shall not be included in the average flame spread time.

**8.44.5.4** Specimens that ignite but where the flame extinguished before reaching the stop cord, shall be recorded as “Ignited but extinguished” and shall not be included in the average flame spread time.

**8.44.6 Interpretation.**

**8.44.6.1** Pass/fail performance shall be based on the average flame spread time.

**8.44.6.2** If no specimens have a recorded flame spread time because the specimens did not ignite or ignited but extinguished, the material performance shall be interpreted as passing.

**8.44.7 Specific Requirements for Multiple Use Garments.**

**8.44.7.1** Where the garment is constructed of several separable layers, each separable layer of garment material shall be tested.

**8.44.7.2** Five specimens in each of the warp and fill directions shall be tested from each sample unit.

**8.44.7.3** Samples for conditioning shall be the entire complete garment.

**8.44.7.4** Garment samples shall be conditioned as specified in 8.1.3 and then conditioned as specified in 8.1.2.

**8.44.7.5** Pass/fail performance shall be based on the average flame spread time in the warp and fill directions.

**8.44.7.6** Failure in any one direction constitutes failure for the material.

**8.44.8 Specific Requirements for Footwear Covers and Single Use Garments.**

**8.44.8.1** Where the footwear cover or garment is constructed of several separable layers, each separable layer of garment material shall be tested.

**8.44.8.2** Five specimens in each of the warp and fill directions shall be tested from each sample unit.

**8.44.8.3** Samples for conditioning shall be the entire complete footwear cover or garment.

**8.44.8.4** Pass/fail performance shall be based on the average flame spread time in the warp and fill directions.

**8.44.8.5** Failure in any one direction constitutes failure for the material.

**8.44.9 Specific Requirements for Cleaning/Utility Gloves.** Samples for testing shall be taken from the palm and back portions of the gloves in the gauntlet area.

**8.44.10 Specific Requirements for Single-Use Eye and Face Protection Devices.**

**8.44.10.1** Samples for testing shall only be taken from the textile portions of the eye and face protection device, where applicable.

**8.44.10.2** If specimens do not meet the size requirements as specified in ASTM D 1230, *Standard Test Method for Flammability of Apparel Textiles*, then sections of inherently flame resistant material shall be attached to the sides of specimens to meet the specimen width of 50 mm (2 in.).

Page 101, Log #118 – Accept

*Recommendation should read:*

**7.1.2.4** Each separable layer of garment material shall be tested for bursting strength as specified in Section 8.5, Burst Strength Test, and shall have a bursting strength of not less than 222.5 N (50 lbf).

Page 105, Log #49 (Dan Gohlke) – Accept

*Recommendations should read:*

Replace paragraph 7.1.2.9 with paragraph 7.1.2.15 and section 8.34 with Section 8.42.

**7.1.2.9** Garment outer shell fabric shall be tested for water absorption resistance as specified in Section 8.42, Water Absorption Resistance Test, and shall have a percent water absorption of 30% or less.

#### **8.34 Water Absorption Resistance Test.**

**8.34 Application.** This test method shall apply to the multiple-use garment materials.

##### **8.34.2 Sample Preparation.**

**8.34.2.1** Samples for conditioning shall be at least 1-m (1-yd) square of each material.

**8.34.3.2** Specimens shall be conditioned as specified in 8.1.3 followed by conditioning as specified in 8.1.2.

##### **8.34.3 Specimens.**

**8.34.3.1** Specimens shall be 200 mm x 200 mm (8 in. x 8 in.).

**8.34.3.2** At least 3 specimens shall be tested.

**8.34.4 Apparatus.** The test apparatus shall be as specified in AATCC 42, *Water Resistance: Impact Penetration Test*, with the following modifications:

(a) A metal roller 113 mm,  $\pm 6$  mm (4 1/2 in.  $\pm 1/4$  in.) long and weighing 1 kg (2 1/4 lbs) shall be used.

(b) Embroidery hoops, measuring 150 to 180 mm (6 to 7 in.) in diameter shall be used for mounting the specimen.

##### **8.34.5 Procedure.**

**8.34.5.1** The conditioned specimen shall be securely mounted in the embroidery hoops with sufficient tension to ensure a uniformly smooth surface.

**8.34.5.2** The direction of the flow of water down the specimen shall coincide with the warpwise direction of the specimen as placed on the stand.

**8.34.5.3** The mounted specimen shall be placed on the block with the center of the specimen directly beneath the center of the nozzle and the plane of the surface of the specimen at a 45 angle with the horizontal.

**8.34.5.4** A 500 ml volume of distilled water at a temperature of  $27^{\circ}\text{C} \pm 1^{\circ}\text{C}$  ( $80^{\circ}\text{F} \pm 2^{\circ}\text{F}$ ) shall be poured quickly into the funnel and allowed to spray onto the specimen.

**8.34.5.5** The following operations shall then be executed as rapidly as possible:

(a) The specimen shall be removed from the hoops and placed between sheets of blotting paper on a flat horizontal surface. The metal roller shall be rolled quickly forward and back one time over the paper without application of any pressure other than the weight of the roller.

(b) A square 100 by 100 mm (4 in. by 4 in.) shall be cut out of the center of the wet portion of the specimen and weighed to the nearest 0.05 g. This weight shall be designated the “wet weight”. Not more than 30 seconds shall elapse between the time the water has ceased flowing through the spray nozzle and the start of the weighing.

(c) The same 100 mm (4-in.) square shall be conditioned as specified in 8.1.2 until it has dried and reached moisture equilibrium with the surrounding standard atmosphere for textiles. Following this conditioning it shall be reweighed. This weight shall be designated the “dry weight”.

**8.34.5.6** The percent water absorption shall be calculated using the following equation:

Percent water absorption = [(Wet Weight – Dry Weight)/(Dry Weight)] x 100

**8.34.6 Report.** The percent water absorption for each specimen shall be reported. The average percent water absorption for all tested specimens shall be calculated and reported.

**8.34.7 Interpretation.** The average percent water absorption shall be used to determine pass/fail performance.

Delete Paragraph 7.1.2.9 and Section 8.42.

Page 108, Log #123 – Accept

*Recommendations should read:*

**7.1.2.13** Where visibility materials are used on garments and the garment is intended to provide high visibility of the wearer in accordance with the requirement in 6.1.2.11, the background, retroreflective, and combined performance materials shall meet the requirements of ANSI/ISEA 107, *American National Standard for High-Visibility Safety Apparel and Headwear*.

**7.1.2.14** Where visibility materials are used on garments and the garment is intended to provide high visibility of the wearer in accordance with the requirement in 6.1.2.11, garments shall be tested for retroreflectivity and fluorescence as specified in Section 8.40, Retroreflectivity and Fluorescence Test Following Laundering.

Page 110, Log #105 - Accept

*Recommendations should read:*

**7.3 Emergency Medical Eye and Face Protection Device Performance Requirements.**

**7.3.1 Single-Use Emergency Medical Facemask Performance Requirements**

**7.3.1.1** Medical facemasks shall meet the requirements for high barrier performance class medical face masks in accordance with Table 1 and Section 6 of ASTM F 2100, *Standard Specification for Performance of Materials Used in Medical Face Masks*.

**7.3.1.2** Medical facemasks shall be tested for liquidtight integrity as specified in Section 8.17, Liquidtight Integrity Test Three, and shall allow no liquid penetration.

**7.3.1.3** Medical facemasks that include visors that cover the eyes or affect the vision of the wearer shall be tested for visual acuity as specified in Section 8.16, Visual Acuity/Fogging Resistance Test, and shall permit test subjects to read at least the 20/20 visual acuity line or better and shall have the facemask be able to be donned and adjusted in accordance with manufacturer’s instructions.

**7.3.2 Single-Use Emergency Medical Eye and Face Protection Device Performance Requirements.**



**7.3.2.1** These requirements shall apply to eye and face protection devices that are not medical facemasks or eye and face protection devices that incorporate medical facemask like designs, which are intended for single use only.

**7.3.2.2** If the portion of the eye and face protection device covering the eyes and face is not a continuous plastic or solid film, materials used in the construction of eye and face protection devices shall be tested for body fluid-borne pathogen resistance as specified in Section 8.3, Biopenetration Test One, and shall exhibit no penetration of the Phi-X174 bacteriophage.

**7.3.2.3** Eye and face protection devices shall be tested for liquidtight integrity as specified in Section 8.17, Liquidtight Integrity Test Three, and shall allow no liquid penetration.

**7.3.2.4** Where present, materials used in the construction of hoods that also provide protection to the face and eyes shall meet the requirements for single-use emergency medical garments specified in 7.1.1.

**7.3.2.5** Eye and face protection devices that cover the eyes or affect the vision of the wearer shall be tested for visual acuity as specified in Section 8.16, Visual Acuity/Fogging Resistance Test, and shall permit test subjects to read at least the 20/20 visual acuity line or better and shall have the eye and face protection device be able to be donned and adjusted in accordance with manufacturer's instructions.

**7.3.2.6** Each textile layer used in the construction of the eye and face protection device shall be tested for flammability as specified in Section 8.44, Flammability Test, and shall have a flame spread time of 3.5 seconds or more.

**7.3.3 Multiple-Use Emergency Medical Eye and Face Protection Device Item and Element Performance Requirements.**

**7.3.3.1** Eye and face protection devices that are spectacle or eye and face protection devices that incorporate designs similar to spectacles shall meet the requirements for spectacles in accordance with Section 7 of ANSI Z87.1, *American National Standard for Occupational and Educational Eye and Face Protection Devices*, including requirements for basic impact resistance.

**7.3.3.2** Eye and face protection devices that are goggles or eye and face protection devices that incorporate designs similar to goggles shall meet the requirements for goggles in accordance with Section 8 of ANSI Z87.1, *American National Standard for Occupational and Educational Eye and Face Protection Devices*, including requirements for basic impact resistance.

**7.3.3.3** Eye and face protective devices that are faceshields or eye and face protection devices that incorporate designs similar to faceshields shall meet the requirements for faceshields in accordance with Section 9 of ANSI Z87.1, *American National Standard for Occupational and Educational Eye and Face Protection Devices*, including requirements for basic impact resistance.

**7.3.3.4** Eye and face protection devices that involve junctures or interfaces between different items that are not continuous in their design shall be tested for liquidtight integrity as specified in Section 8.17, Liquidtight Integrity Test Three, and shall allow no liquid penetration.

**7.3.3.5** Eye and face protection devices that cover the eyes or affect the vision of the wearer shall be tested for visual acuity as specified in Section 8.16, Visual Acuity/Fogging Resistance Test, and shall permit test subjects to read at least the 20/20 visual acuity line or better and shall have the eye and face protection device be able to be donned and adjusted in accordance with manufacturer's instructions.

**7.3.3.6** Unless corrosion resistance is already evaluated in another requirement, all eye and face protection device hardware and specimens of all face protection device hardware that include metal parts shall be individually tested for resistance to corrosion as specified in Section 8.25,

and shall have metals that are inherently resistant to corrosion including but not limited to stainless steel, brass, copper, aluminum, and zinc show no more than light surface-type corrosion or oxidation, shall have ferrous metals show no corrosion of the base metal, and shall have all hardware remain functional.

Page 120, Log #131 – Accept

*Recommendations should read:*

**7.5 Single-Use Emergency Medical Footwear Cover Performance Requirements.**

**7.5.1** Footwear cover materials and seams shall be tested for body fluid-borne pathogen resistance as specified in Section 8.3, Biopenetration Test One, and shall show no penetration of the Phi-X174 bacteriophage.

**7.5.2** Footwear cover upper materials shall be tested for tensile strength as specified in Section 8.4, Tensile Strength Test, and shall have a tensile strength of not less than 50 N (11.2 lbf).

**7.5.3** Footwear cover upper materials shall be tested for bursting strength as specified in Section 8.41, Burst Strength Test Two, and shall have a bursting strength of not less than 66 N (14.9 lbf).

**7.5.4** Footwear cover materials shall be tested for tear strength as specified in Section 8.43, Tear Resistance Test Two, and shall have a tear strength of not less than 17 N (3.8 lbf).

**7.5.5** Footwear cover material seams shall be tested for breaking strength as specified in Section 8.8, Seam Breaking Strength Test, and shall have a breaking strength of not less than 50 N (11.2 lbf).

**7.5.6** Footwear cover wear surface materials shall be tested for abrasion resistance as specified in Section 8.28, Abrasion Resistance Test Two, and shall show no wear-through.

**7.5.7** The footwear cover wear surface materials shall be tested for puncture resistance as specified in Section 8.13, Puncture Resistance Test One, and shall have a puncture force greater than 8.0 N (1.8 lbf).

**7.5.8** The footwear cover wear surface materials shall be tested for slip resistance as specified in Section 8.22, Slip Resistance Test, and shall show a friction coefficient of greater than 0.60 under dry conditions.

**7.5.9** Footwear cover materials shall be tested for flammability as specified in Section 8.44, Flammability Test, and shall have a flame spread time of 3.5 seconds or more.

Page 125, Log #125 – Accept

*Recommendations should read:*

**7.6 Emergency Medical Cleaning/Utility Glove Performance Requirements.**

**7.6.1** Cleaning/utility gloves shall be tested for liquidtight integrity as specified in Section 8.9, Liquidtight Integrity Test Two, and shall show no leakage.

**7.6.2** Cleaning/utility gloves shall be tested for body fluid-borne pathogen resistance as specified in Section 8.10, Biopenetration Test Two, and shall exhibit no penetration of Phi-X174 bacteriophage.

**7.6.3** Cleaning/utility glove materials shall be tested for permeation resistance as specified in Section 8.27, Chemical Permeation Resistance Test, and shall not have a cumulative permeation of greater than  $6 \mu\text{g}/\text{cm}^2$  for each chemical tested.

**7.6.4** Cleaning/utility glove materials shall be tested for tensile strength as specified in Section 8.11, Ultimate Tensile Strength Test, and shall have an ultimate tensile strength of greater than 12.5 MPa (1813 psi).

**7.6.5** Cleaning/utility glove materials shall be tested for puncture resistance as specified in Section 8.13, Puncture Resistance Test One, and shall have a puncture resistance of greater than 10 N (2.3 lbf).

**7.6.6** Cleaning/utility gloves shall be tested for resistance to cut as specified in Section 8.18, Cut Resistance Test, and shall have a cut distance resistance of greater than 25 mm (1 in.).

**7.6.7** Cleaning/utility glove materials shall be tested for abrasion resistance as specified in Section 8.28, Abrasion Resistance Test Two, and shall not show wear-through after 1000 cycles.

**7.6.8** Cleaning/utility gloves shall be tested for dexterity as specified in Section 8.14, Dexterity Test Two, and shall not have an average percent of barehanded control exceeding 200 percent.

**7.6.9** Cleaning/utility gloves shall be tested for tactility as specified in Section 8.33, Tactility Test, and shall permit pick up of pins having a diameter of 2.5 mm (0.098 in.) or greater.

**7.6.10** Cleaning/utility glove materials shall be tested for flammability as specified in Section 8.44, Flammability Test, and shall have a flame spread time of 3.5 seconds or more.

Page 127, Log #125 – Accept

*Recommendations should read:*

**7.6.9** Cleaning/utility glove materials shall be tested for permeation resistance as specified in Section 8.27, Chemical Permeation Resistance Test, and shall not have a cumulative permeation of greater than  $6 \mu\text{g}/\text{cm}^2$  for each chemical tested.

**8.27 Chemical Permeation Resistance Test.**

**8.27.1 Application.** This test method shall apply to cleaning/utility glove materials.

**8.27.2 Specimens.** A minimum of three specimens shall be tested.

**8.27.3 Sample Preparation.** Specimens shall be conditioned as specified in 8.1.2.

**8.27.4 Procedure.**

**8.27.4.1** Permeation resistance shall be measured in accordance with ASTM F 739a, *Standard Test Method for Resistance of Protective Clothing Materials to Permeation by Liquids or Gases Under Conditions of Continuous Contact*, at  $25^\circ\text{C}$ ,  $\pm 2^\circ\text{C}$  ( $77^\circ\text{F}$ ,  $\pm 3^\circ\text{F}$ ), using the following test parameters and modifications:

(1) A test duration of 1-hour shall be used.

(2) The test shall be done in the closed loop configuration, using distilled water as the collection medium.

(3) The selected method of detection shall have a sensitivity for measuring a cumulative permeation of  $0.1 \mu\text{g}/\text{cm}^2$  over the 1-hour test period. The actual sensitivity of the selected method of detection shall be determined.

(4) The total cumulative permeation over one hour shall be measured in lieu of breakthrough time and permeation rate.

**8.27.4.2** Permeation resistance shall be separately evaluated against the following chemicals:

(1) 40 percent weight-for-weight (w/w) solution of glutaraldehyde

(2) 70 percent w/w isopropanol

(3) 5 percent solution of sodium hypochlorite

(4) 30 percent w/w hydrogen peroxide

**8.27.5 Report.**

**8.27.5.1** The following information and results shall be recorded and reported:

(1) Material type or name

(2) Chemical or chemical mixture (volume composition of mixture)

(3) The measured cumulative permeation mass for each specimen in  $\mu\text{g}/\text{cm}^2$  reported to the nearest 0.1  $\mu\text{g}/\text{cm}^2$

(4) Type of test cell

(5) Detection method

(6) Minimum detectable mass for detection system ( $\mu\text{g}/\text{cm}^2$ )

(7) Date of test

(8) Testing laboratory

**8.27.5.2** If no chemical is detected at the end of the 1-hour test period, the cumulative permeation shall be reported as less than the minimum detectable mass per unit area for the specific chemical being tested.

**8.27.5.3** The average cumulative permeation shall be calculated for all specimens.

**8.27.5.3.1** If no chemical is detected for one or two specimens, the average cumulative permeation shall be the average of all specimens where cumulative permeation is measured.

**8.27.5.3.2** If no chemical is detected in all of the specimens tested, the average cumulative permeation shall be the minimum detectable mass per unit area for the specific chemical being tested.

**8.27.6 Interpretation.** The average cumulative permeation shall be used in determining compliance for the particular material/chemical combination.

Page 150, Log #134 – Accept

*Change referenced section to 8.6*

*Recommendations should read:*

## **8.6 Puncture Propagation Tear Resistance Test.**

**8.6.1 Application.** This test shall apply to materials used in the construction of multiple-use garments. Where the garment is constructed of several separable layers, each separable layer of garment material shall be tested.

**8.6.2 Specimens.** Five specimens in each of the warp and fill directions shall be tested from each sample unit.

### **8.6.3 Sample Preparation.**

**8.6.3.1** Samples for conditioning shall be complete garments.

**8.6.3.2** Samples shall be conditioned as specified in 8.1.3 and then conditioned as specified in 8.1.2.

**8.6.4 Procedure.** Specimens shall be tested in accordance with ASTM D 2582, *Standard Test Method for Puncture-Propagation Tear Resistance of Plastic Film and Thin Sheeting*.

### **8.6.5 Report.**

**8.6.5.1** The puncture propagation tear resistance of each specimen shall be recorded and reported to the nearest 0.5 N (0.1 lbf) of force.

**8.6.5.2** An average puncture propagation tear resistance shall be calculated and reported for warp and fill directions.

### **8.6.6 Interpretation.**

**8.6.6.1** Pass/fail performance shall be based on the average puncture propagation tear resistance in the warp and fill directions.

**8.6.6.2** Failure in any one direction shall constitute failure for the material.

Page 152, Log #115 – Accept

*Recommendations should read:*

## **8.8 Seam Breaking Strength Test.**

### **8.8.1 Application.**

**8.8.1.1** This test shall be applied to seams used in the construction of garments.

**8.8.1.2** Where garments consist of multiple separable layers, the test shall be applied to the seams of each separable layer.

### **8.8.2 Specimens.**

**8.8.2.1** A minimum of five seam specimens representative of the garment shall be tested for each seam type.

**8.8.2.2** Straight-seam specimens shall be cut from conditioned samples.

**8.8.2.3** Specimens for testing shall include at least 100 mm (4 in.) of material on either side of the seam.

### **8.8.3 Sample Preparation.**

**8.8.3.1** Samples for conditioning shall be complete garments.

**8.8.3.2** Single-use garment samples shall be conditioned as specified in 8.1.2.

**8.8.3.3** Multiple-use garment samples shall be conditioned as specified in 8.1.3 and then conditioned as specified in 8.1.2.

**8.8.4 Procedure.** All seams shall be tested in accordance with ASTM D 1683, *Standard Test Method for Failure in Sewn Seams of Woven Apparel Fabrics*.

### **8.8.5 Report.**

**8.8.5.1** The breaking strength for each seam specimen shall be recorded and reported to the nearest 0.5 N (0.1 lbf) of force.

**8.8.5.2** The average breaking strength for each seam type shall also be recorded and reported.

**8.8.6 Interpretation.** The average breaking strength for each seam or closure assembly type shall be used to determine pass/fail performance.

*Add Reference to Section 2.3.3:*

ASTM D 1683, *Standard Test Method for Failure in Sewn Seams of Woven Apparel Fabrics*, 2004.

Page 153, Log #135 – Accept in Principle

**Committee Statement:** See action taken on Log 115, Page 152

Page 155, Log #127 – Accept

*Recommendations should read:*

## **8.9 Liquidtight Integrity Test Two.**

### **8.9.1 Application.**

**8.9.1.1** This test shall be applied to whole examination gloves, cleaning/utility gloves, and footwear covers.

**8.9.1.2** Modifications to this test method for testing examination gloves shall be as specified in 8.9.7.

**8.9.1.3** Modifications to this test method for testing cleaning/utility gloves shall be as specified in 8.9.8.

**8.9.2 Specimens.** Specimens shall be whole examination gloves or cleaning/utility gloves.

**8.9.3 Sample Preparation.** Samples shall be conditioned as specified in 8.1.2.

**8.9.4\* Procedure.** Liquidtight integrity testing shall be conducted in accordance with ASTM D 5151, *Standard Test Method for Detection of Holes in Medical Gloves*, with the modification

that the water shall be replaced with water treated with a surfactant to achieve a surface tension of 35 dynes/cm,  $\pm 2$  dynes/cm.

**8.9.5 Report.** The pass/fail result for each specimen shall be recorded and reported.

**8.9.6 Interpretation.** Passing performance shall be based on the number of passing and failing specimens.

**8.9.7 Specific Requirements for Testing Examination Gloves.**

**8.9.7.1** The number of specimens shall be determined in accordance with ISO 2859-1, *Sampling procedures for inspection by attributes. Part 1: Sampling plans indexed by acceptable quality level (AQL) for lot-by-lot inspection*.

**8.9.7.2** A minimum of 32 specimens shall be tested.

**8.9.7.3** Passing performance shall be consistent with a set of specimens that meets an Acceptable Quality Level of 1.5 or better, in accordance with ISO 2859-1, *Sampling procedures for inspection by attributes. Part 1: Sampling plans indexed by acceptable quality level (AQL) for lot-by-lot inspection*.

**8.9.8 Specific Requirements for Testing Cleaning/Utility Gloves.**

**8.9.8.1** A total of 10 different specimens shall be tested.

**8.9.8.2** The cleaning/utility glove shall be filled with the surfactant-treated water to a height 25 mm (1 in.) above the top of the thumb crotch, when the glove is oriented in the fingers down position.

**8.9.8.3** If one of the 10 specimens fail, a second set of 10 specimens shall be tested and the results of the second specimen set used to determine pass/fail performance.

Page 164, Lot #139 – Accept  
*Recommendation should read:*

**8.13.9 Specific Requirements for Testing Footwear Cover Materials.** Specimens shall be taken from the footwear wear surface and shall include all layers used in the construction of the footwear cover from wear surface exterior to interior of the footwear cover.

Page 166, Log #194 (Karen Lehtonen) – Accept in Principle  
**Committee Statement:** See action taken on Log #58, Page 157

Page 167, Log #108 – Accept  
*Recommendations should read:*

**8.17 Liquidtight Integrity Test Three.**

**8.17.1 Application.**

**8.17.1.1** This test shall apply to medical facemasks and eye and face protection devices.

**8.17.1.2** Modifications to this test method for evaluating medical facemasks shall be as specified in 8.17.8.

**8.17.1.3** Modifications to this test method for evaluating single-use eye and face protection devices shall be as specified in 8.17.9.

**8.17.1.4** Modifications to this test method for evaluating single-use eye and face protection devices shall be as specified in 8.17.10.

**8.17.2 Specimens.**

**8.17.2.1** A minimum of three specimens shall be tested for each target area.

**8.17.2.2** Specimens shall be complete medical facemasks or eye and face protection devices.

**8.17.3 Sample Preparation.**

**8.17.3.1** Samples for conditioning shall be complete medical facemasks or eye and face protection devices.

**8.17.3.2** Samples shall be conditioned as specified in 8.1.2.

**8.17.4 Apparatus.**

**8.17.4.1** The test apparatus shall be as specified in ASTM F 1862, *Standard Test Method for Resistance of Medical Face Masks to Penetration by Synthetic Blood (Horizontal Projection of Fixed Volume at a Known Velocity)*.

**8.17.4.2** Where needed to support the specimen, a headform shall be used. The headform shall be permitted to be a human-shape headform such as the Alderson Headform, shown in Figure 8.17.4.2.

\*\*\* Insert Figure 8.17.4.1.1 from NFPA 1971-2007, page 1971-61\*\*\*

**8.17.5 Procedures.** Medical facemasks and eye and face protection devices shall be tested as specified in ASTM F 1862, *Standard Test Method for Resistance of Medical Face Masks to Penetration by Synthetic Blood (Horizontal Projection of Fixed Volume at a Known Velocity)*, with the modifications specified below:

(1) The medical facemask or eye and face protection device shall be positioned on an appropriate holder or headform such that the distance from the tip of pneumatic valve canula to the target area on the face protection device is 305 mm (12 in.) and the target area of the medical facemask or eye and face protection device is perpendicular to the path of the synthetic blood.

(2) Testing shall be conducted at a blood velocity equivalent to a blood pressure of 21.3 kPa (160 mm Hg).

(3) An absorptive blotting paper or similar absorptive material shall be permitted to be placed on the interior side of the medical facemask or eye and face protection device to provide an aid in determining the occurrence of synthetic blood strikethrough.

(4) Pass/fail results shall be reported only. An acceptable quality limit shall not be applied in testing.

**8.17.5.3** Straps, ear loops, and temple portions of face protection devices shall not be evaluated.

**8.17.6 Report.** The pass/fail result for each target for each face protection device evaluated shall be recorded and reported.

**8.17.7 Interpretation.** Failure of any one target area for any tested face protection device shall constitute failing performance for the face protection device.

**8.17.8 Specific Requirements for Testing Medical Facemasks.**

**8.17.8.1** Where medical facemasks do not incorporate visors or faceshields, target areas shall include locations 13 mm (½ in.) from each side of the medical facemask and 13 mm (½ in.) from the top and bottom of the medical facemask, centered on the horizontal height or span of the medical facemask, respectively.

**8.17.8.2** Where medical facemasks do incorporate visors or faceshields, target areas shall include locations 13 mm (½ in.) from each side of the medical facemask, 13 mm (½ in.) from the bottom of the medical facemask, and 13 mm (½ in.) from the bottom center of the visor or faceshield centered on the horizontal height or span of the medical facemask, respectively.

**8.17.8.3** Target areas shall not coincide with attachment points for ear loops or other attachment or hardware provided on the medical facemask.

**8.17.9 Specific Requirements for Testing Single-Use Eye and Face Protection Devices.**

**8.17.9.1** Specific target areas on each eye and face protection device that shall be evaluated include the portions of the eye and face protection device that directly cover the center of each of the wearer's eyes, two locations 13 mm (½ in.) from the edge of the protective area provided by

the eye and face protection device, and at least one location at every representative seam or junction of the eye and face protection device.

**8.17.9.2** Target areas shall not coincide with attachment points for ear loops or other attachment or hardware provided on the eye and face protection device.

**8.17.10 Specific Requirements for Testing Multiple-Use Eye and Face Protection Devices.**

Specific target areas shall include at least one location at every representative junctures or interfaces between different items that are not continuous for the eye and face protection device.

Page 168, Log #136 – Accept

*Recommendations should read:*

**8.18 Cut Resistance Test.**

**8.18.1 Application.**

**8.18.1.1** This test method shall apply to cleaning/utility gloves, work gloves, and footwear upper materials.

**8.18.1.3** Modifications to this test method for evaluation of cleaning/utility gloves shall be as specified in 8.18.7.

**8.18.1.2** Modifications to this test method for evaluation of work gloves shall be as specified in 8.18.8.

**8.18.1.4** Modifications to this test method for evaluation of footwear upper materials shall be as specified in 8.18.9.

**8.18.2 Specimens.** A minimum of three specimens shall be tested.

**8.18.3 Sample Preparation.**

**8.18.3.1** Samples for conditioning shall be whole gloves or footwear uppers.

**8.18.3.2** Specimens shall be conditioned as specified in 8.1.2.

**8.18.4 Procedure.** Specimens shall be evaluated in accordance with ASTM F 1790, *Test Methods for Measuring Cut Resistance of Materials Used in Protective Clothing*, with the modification that specimens shall be tested to a specific load with the measurement of cut distance.

**8.18.5 Report.**

**8.18.5.1** The cut distance shall be recorded and reported to the nearest 1 mm (1/32 in.) for each specimen.

**8.18.5.2** The average cut distance in mm (in.) shall be calculated and reported for all specimens tested.

**8.18.6 Interpretation.** The average cut distance shall be used to determine pass/fail performance.

**8.18.7 Specific Requirements for Testing Cleaning/Utility Gloves.**

**8.18.7.1** Specimens shall be taken from the back and palm of the glove and shall not include seams.

**8.18.7.2** Cut resistance testing shall be performed under a load of 50 grams (1.8 oz).

**8.18.8 Specific Requirements for Testing Work Gloves.**

**8.18.8.1** Specimens shall be taken from the back and palm of the glove and shall not include seams.

**8.18.8.2** Cut resistance testing shall be performed under a load of 200 grams (7 oz).

**8.18.9 Specific Requirements for Testing Footwear Upper Materials.**



**8.18.9.1** Specimens shall consist of each composite of the footwear item used in the actual footwear configuration with layers arranged in proper order. Specimens shall be taken from the thinnest portion of the footwear upper.

**8.18.9.2** Cut resistance testing shall be performed under a load of 400 grams (14 oz).

Page 172, Log #141 – Accept

*Recommendations should read:*

**8.22 Slip Resistance Test.**

**8.22.1 Application.**

**8.22.1.1** This test method shall apply to footwear soles and the wear surface of footwear covers.

**8.22.1.2** Modifications to this test method for evaluation of footwear soles shall be as specified in 8.22.7.

**8.22.1.3** Modifications to this test for this test method for evaluation of footwear cover wear surface materials shall be as specified in 8.22.8.

**8.22.2 Sample Preparation.** Samples for conditioning shall be footwear or whole footwear covers.

**8.22.3 Specimens.**

**8.22.3.1** A minimum of three footwear soles or footwear cover wear surfaces shall be tested.

**8.22.3.2** Specimens shall be conditioned as specified in 8.1.2.

**8.22.4 Procedure.** Slip resistance shall be performed in accordance with ASTM F 489, *Standard Test Method for Static Coefficient of Friction of Shoe Sole and Heel Materials as Measured by the James Machine*, in a dry condition.

**8.22.5 Report.** The static coefficient of friction under dry conditions of each specimen shall be recorded and reported.

**8.22.6 Interpretation.** One or more footwear or footwear cover specimens failing this test shall constitute failing performance.

**8.22.7 Specific Requirements for Testing Footwear Soles.**

**8.22.7.1** Specimens shall be taken from representative outer sole and heel samples of the footwear.

**8.22.7.2** Where the outer sole and heel use the same material and tread pattern, specimens shall be permitted to be taken from either outer sole or heel samples.

**8.22.7.3** Specimens shall be prepared as specified in Section 7 of ASTM F 489, *Standard Test Method for Static Coefficient of Friction of Shoe Sole and Heel Materials as Measured by the James Machine*.

**8.22.8 Specific Requirements for Testing Footwear Cover Wear Surface Materials.**

**8.22.8.1** Specimens shall include outer most layer of the footwear cover wear surface.

**8.22.8.2** Specimens shall not be prepared as specified in Section 7 of ASTM F 489, *Standard Test Method for Static Coefficient of Friction of Shoe Sole and Heel Materials as Measured by the James Machine*.

**8.22.8.3** Specimens shall be attached to the leather test reference shoe by wrapping the specimen tightly around the leather and taping the specimen securely to the front and rear of the shoe.

Page 177, Log #140 – Accept

*Recommendations should read:*

**8.28 Abrasion Resistance Test Two.**

**8.28.1 Application.**

**8.28.1.1** This test shall apply to cleaning/utility glove, work glove, and footwear cover materials.

**8.28.1.2** Modifications to this test method for testing cleaning/utility glove materials shall be as specified in 8.28.7.

**8.28.1.3** Modifications to this test method for testing work glove materials shall be as specified in 8.28.8.

**8.28.1.4** Modifications to this test method for testing work footwear cover wear surface materials shall be as specified in 8.28.9.

**8.28.2 Specimens.** A minimum of five specimens shall be tested.

**8.28.3 Sample Preparation.** Specimens shall be conditioned as specified in 8.1.2.

**8.28.4 Procedure.**

**8.28.4.1** Specimens shall be tested in accordance with ASTM D 3884, *Standard Test Method for Abrasion Resistance of Textile Fabrics (Rotary Platform, Double-Head Method)*, using a Calibrase H-18 wheel.

**8.28.4.2** At the end of each abrasion exposure, the specimen shall be examined for evidence of wear-through.

**8.28.5 Report.** The wear-through determination shall be recorded and reported for each specimen tested.

**8.28.6 Interpretation.** Any specimen showing wear-through shall constitute failure of this test.

**8.28.7 Specific Requirements for Testing Cleaning/Utility Gloves.** Testing shall be conducted under a load of 500 g and specimens shall be examined after 1000 cycles.

**8.28.8 Specific Requirements for Testing Work Gloves.** Testing shall be conducted under a load of 500 g and examined after 2500 cycles.

**8.28.9 Specific Requirements for Testing Footwear Cover Wear Surface Materials.** Testing shall be conducted under a load of 1000 g and specimens shall be examined after 5000 cycles.

Page 189, Log #129 – Accept  
*Recommendations should read:*

**8.33 Tactility Test.**

**8.33.1 Application.**

**8.33.1.1** This test shall apply to cleaning/utility gloves and work gloves.

**8.33.1.2** Modifications to this test method for testing cleaning gloves shall be as specified in 8.33.7.

**8.33.1.3** Modifications to this test method for testing work gloves shall be as specified in 8.33.8.

**8.33.2 Specimens.**

**8.33.2.1** A minimum of three glove pairs each for two different sizes shall be used for testing.

**8.33.2.2** Each glove pair shall be tested as a complete set of gloves in new, as-distributed, condition.

**8.33.2.3** Glove pair specimens shall not receive special softening treatments prior to tests.

**8.33.3 Sample Preparation.**

**8.33.3.1** Samples for conditioning shall be whole glove pairs.

**8.33.3.2** Glove pair specimens shall be conditioned as specified in 8.1.2.

**8.33.4 Procedures.**

**8.33.4.1** A separate test subject shall be used for each size of gloves to be evaluated.

**8.33.4.2** Test subjects shall be selected such that their hand dimensions conform to the offered respective sizes for each glove.

**8.33.4.3** Ten metal pins having diameters of 11 mm (0.430 in.), 9.5 mm (0.370 in.), 8 mm (0.310 in.), 6.5 mm (0.260 in.), 5 mm (0.200 in.), 3.5 mm (0.138 in.), 2.5 mm (0.098 in.), 1.5 mm (0.058 in.), 0.5 mm (0.018 in.), and 0.2 mm (0.008 in.), which have a length of 50 mm,  $\pm 10$  mm (2 in.,  $\pm 0.4$  in.), shall be used.

**8.33.4.4** With each of the metal pins lying on a flat, smooth surface at a spacing of 100 mm,  $\pm 20$  mm (4 in.,  $\pm 0.8$  in.), the test subject shall attempt to pick up each pin starting with the largest diameter pin. The test subject shall be provided a period of 10 seconds to complete picking up each pin and then shall hold the pin for a minimum of 10 seconds. The test subject shall not pick up the pins by their ends.

**8.33.5 Report.**

**8.33.5.1** The diameter of the smallest pin that can be successfully picked up shall be recorded and reported for each test subject.

**8.33.5.2** The average diameter that can be successfully picked up by all test subjects shall be calculated and reported.

**8.33.6 Interpretation.** The average diameter of the smallest pin that can be picked up shall be used to determine pass/fail performance.

**8.33.7 Specific Requirements for Testing Cleaning/Utility Gloves.** The sizes selected for testing shall represent the smallest and largest sized gloves that available for the specific style of glove being evaluated.

**8.33.8 Specific Requirements for Testing Work Gloves.**

**8.33.8.1** Size small and size large shall be evaluated.

**8.33.8.2** Glove pair specimens shall be preconditioned as specified in 8.1.9 and then conditioned as specified in 8.1.2 prior to testing.

Page 201, Log #119 – Accept

*Current section 8.5 is deleted and replaced with the following:*

**8.5 Burst Strength Test.**

**8.5.1 Application.** This test shall apply to materials used in the construction of garments. Where the garment is constructed of several separable layers, each separable layer of garment material shall be tested.

**8.5.2 Specimens.** A total of 10 specimens shall be tested.

**8.5.3 Sample Preparation.**

**8.5.3.1** Samples for conditioning shall be complete garments.

**8.5.3.2** Single-use garment samples shall be conditioned as specified in 8.1.2.

**8.5.3.3** Multiple-use garment samples shall be conditioned as specified in 8.1.3 and then conditioned as specified in 8.1.2.

**8.5.4 Procedure.** Specimens shall be tested in accordance with ASTM D 3787, *Method for Bursting Strength of Textiles-Constant-Rate-of-Traverse (CRT) Ball Burst Test*.

**8.5.5 Report.** The burst strength of each specimen shall be recorded and reported to the nearest 0.5 N (0.1 lbf). The average burst strength of all specimens shall be calculated and reported.

**8.5.6 Interpretation.** The average burst strength shall be used to determine pass/fail performance.

*Section 8.41 should be deleted*

Page 216, Log #147 – Accept

*Recommendation should read:*

**A.1.3.6** NFPA 1994, *Standard on Protective Ensemble for First Responders to CBRN Terrorism Incidents*, establishes two different classes of ensembles addressing the hazards present during chemical terrorism incidents. These ensembles consist of full body one- or multi-piece suit, gloves, and footwear.

The Class 2 ensemble may be designed with the CBRN SCBA worn inside or outside of the ensemble and is intended for wearer protection in an immediately dangerous to life and health (IDLH) environment. Ensembles are tested for their integrity to both vapors and liquids. Materials are tested for permeation resistance to selected chemical agent and toxic industrial chemicals at concentrations consistent with the same levels used for evaluating CBRN SCBA; materials are also tested for viral penetration resistance, and various physical properties to demonstrate adequate physical hazard resistance and durability for a single use. Ensembles are tested for functionality.

Class 3 ensembles may be designed for use with CBRN SCBA, CBRN APR, or CBRN PAPR, though CBRN APR and CBRN PAPR are consistent with the use of this ensemble. The Class 3 ensemble is designed for protection against lower exposure levels of gases, vapors, liquids, and particulates as compared to Class 2 ensembles and are intended for exposure levels below immediately dangerous to life and health (IDLH) levels. Ensembles are evaluated for vapor and liquid integrity but with less stringent criteria as compared to Class 2 ensembles. Materials are tested for permeation resistance to selected chemical agent and toxic industrial chemicals at low concentrations consistent with the same levels used for evaluating CBRN APR; materials are also tested for viral penetration resistance, and various physical properties to demonstrate adequate physical hazard resistance and durability for a single use. Ensembles are tested for functionality.

In addition to NFPA 1994, CBRN protection for chemical terrorism incidents is addressed in optional performance criteria established by NFPA 1971, *Standard on Protective Ensemble for Structural and Proximity Fire Fighting*. The levels of protection established for the CBRN option are consistent with those provided for Class 2 in NFPA 1994, *Standard on Protective Ensemble for First Responders to CBRN Terrorism Incidents*; however, ensembles and materials are tested against representative CBRN agents or simulants after rigorous conditioning to help ensure that the protection will remain in place over the expected service life of the ensemble. Specific design and performance criteria are established in this standard to demonstrate limited protection against CBRN terrorism agents to permit fire fighters to escape and provide limited rescue while escaping the contaminated environment when encountering terrorism incidents. The criteria are not intended to provide for reentry of fire fighters into the contaminated environment. This standard does not establish criteria for protection from all chemical warfare agents, protection from all biological agents, protection from all weapons of mass destruction, or protection from all toxic industrial chemicals.

Similarly, NFPA 1951, *Standard on Protective Ensembles for Technical Rescue Incidents*, establishes requirements for a CBRN protective ensemble that can be used for protection during chemical terrorism incidents. The criteria and levels of protection established for the CBRN protective ensemble for technical rescue incidents are based on Class 3 in NFPA 1994, *Standard on Protective Ensemble for First Responders to CBRN Terrorism Incident*. Like NFPA 1971, assessment of ensemble and material performance are made after rigorous conditioning to help ensure that the protection will remain in place over the expected service life of the ensemble. The standard is also similar in indicating that the design and performance criteria established in this standard demonstrate limited protection against CBRN terrorism agents to permit rescuers to

escape and provide limited rescue while escaping the contaminated environment when encountering terrorism incidents. The standard also does not establish criteria for protection from all chemical warfare agents, protection from all biological agents, protection from all weapons of mass destruction, or protection from all toxic industrial chemicals.

Committee Comment to Address Antifogging Requirement – Accept  
*Modifications to Section 8.16*

**Committee Action:**

**8.1.12 Cold Temperature Conditioning for Medical Facemasks and Eye and Face Protection Devices.** Specimens shall be exposed to in an environmental chamber at a temperature of 0°C,  $\pm 2^\circ\text{C}$ , for a period of not less than 4 hours.

**8.16 Visual Acuity/Fogging Resistance Test.**

**8.16.1 Application.** This test method shall apply to the portion of medical facemasks and eye and face protection device that cover the wearer's eyes.

**8.16.2 Specimens.**

**8.16.2.1** A minimum of three specimens shall be tested.

**8.16.2.2** Specimens shall be complete medical facemasks or eye and face protection devices.

**8.16.2.3** Specimens shall be selected to fit each test subject in accordance with the manufacturer's sizing guidelines.

**8.16.3 Sample Preparation.**

**8.16.3.1** Samples for conditioning shall be complete medical facemasks or eye and face protection devices.

**8.16.3.2** Samples shall be conditioned as specified in 8.1.12.

**8.16.4 Procedure.**

**8.16.4.1** Testing shall be conducted in an atmosphere with a temperature of 21°C,  $\pm 3^\circ\text{C}$ , and a relative humidity of 50 percent,  $\pm 5$  percent.

**8.16.4.2** Testing shall be conducted using a minimum of three different test subjects.

**8.16.4.3** The test subjects shall have a minimum visual acuity of 20/20 in each eye uncorrected, or corrected with contact lenses, as determined by a visual acuity test or doctor's examination.

**8.16.4.4** Prior to evaluation for visual acuity, the medical facemask or eye and face protection device shall be inspected for functionality and the ability to be donned and adjusted in accordance with the manufacturer's instructions.

**8.16.4.5** To evaluate visual acuity, the medical facemask or eye and face protection device shall be donned and adjusted in accordance with the manufacturer's instructions.

**8.16.4.6** The test subject shall wear the medical facemask or eye and face protection device for a period of 3 minutes,  $\pm 30$  seconds, before reading the eye chart. The three minute period shall commence when the face mask is fully donned and adjusted by the subject.

**8.16.4.7** The test shall be conducted using a standard 6.1-m (20-ft) eye chart with a normal lighting range of 100 to 150 foot-candles at the chart and with test subjects positioned at a distance of 6.1 m (20 ft) from the chart.

**8.16.4.8** Test subjects shall then read the standard eye chart through the medical facemask or eye and face protection device and the visual acuity of each subject shall be determined.

**8.16.5 Report.**

**8.16.5.1** The visual acuity of each test subject through the medical facemask or eye and face protection device shall be recorded and reported.

**8.16.5.2** The ability of the test subject to don and doff the medical facemask or eye and face protection device without difficulty or without damage to the medical facemask or eye and face protection device shall be noted.

**8.16.6 Interpretation.**

**8.16.6.1** Failure of any one test subject to achieve the required visual acuity while wearing the medical facemask or eye and face protection device shall constitute failure of the test.

**8.16.6.2** If any medical facemask or eye and face protection device cannot be properly donned or doffed, or sustains any damage during the testing, the medical facemask or eye and face protection device shall be considered to have failed the test.

**Committee Statement:** Fogging of eye and facewear has been identified as a significant concern for their use. The committee proposes an adaptation of the current visual acuity test method for assessing this eye and facewear performance concern. The employed approach is based on procedures used by NIOSH in their assessment of fogging for respirators as part of procedures established in 42 CFR Part 84.

**APPENDIX B**  
**EMS PPE INTERVIEW QUESTIONS**

## **Appendix B**

### **EMS PPE INTERVIEW QUESTIONS**

Department:  
Contact:  
Title:  
Telephone:  
E-Mail:  
Date of Interview:

#### **DEPARTMENT DEMOGRAPHICS:**

Type of Department:  
Number of Personnel:  
Area Served:  
Call Volume (per year):  
Number of calls:                      %EMS:                      %Fire                      %Other

Delivery of EMS SERVICES:  
By FF/EMT –1 (BLS)      or FF/ Paramedic  
Procedures for researching and selecting EMS PPE:  
What are the tiers of EMS PPE used and how does the responder decide what level of protection is necessary? Is there a “decision tree”?

#### **GARMENTS**

##### **Disposable Garments**

Brand/model:  
Material:  
Sizes:  
Problems/concerns/comments:

##### **Reusable Garments (besides stationwear and bunker gear)**

Brand/model:  
Material:  
Sizes:  
Problems/concerns/comments:

#### **GLOVES**

##### **Examination Gloves**

Brand/model:  
Material:  
Sizes:  
Problems/concerns/comments:

##### **Other Gloves**

Brand/model:



Material:

Sizes:

Problems/concerns/comments:

### **FOOT PROTECTION**

Is footwear other than fire fighter boots specified?

Are steel-toed shoes/boots mandatory?

Are footwear covers available, and if so, are they commonly used?

Problems/Concerns/Comments:

### **EYE/FACE PROTECTION**

#### **Safety Glasses**

Brand/model:

Material/construction details:

Problems/concerns/comments:

#### **Goggles**

Brand/model:

Material/construction details:

Problems/concerns/comments:

#### **Surgical Masks**

Brand/model:

Material/construction details:

Problems/concerns/comments:

### **PARTICULATE RESPIRATORS**

Brand/model:

Material/construction details:

Problems/concerns/comments:

### **HEAD PROTECTION**

Besides fire fighter helmets, are helmets or other head protection used (while transporting patient)? What kind?

Is head protection in situations such as transport an area of concern?

### **VISIBILITY OF PERSONNEL**

Are reflective vests used?

How is visibility of personnel being addressed?

**APPENDIX C**  
**Sample Rating Forms for Sample Reviews and**  
**Field Trials**