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NFPA 1999 Protective Clothing for Emergency Medical Operations 1992 Edition

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The Board of Directors reaffirms that the National Fire Protection Association recognizes that the toxicity of the products of combustion is an important factor in the loss of life from fire. NFPA has dealt with that subject in its technical committee documents for many years.

There is a concern that the growing use of synthetic materials may produce more or additional toxic products of combustion in a fire environment. The Board has, therefore, asked all NFPA technical committees to review the documents for which they are responsible to be sure that the documents respond to this current concern. To assist the committees in meeting this request, the Board has appointed an advisory committee to provide specific guidance to the technical committees on questions relating to assessing the hazards of the products of combustion.

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NFPA 1999

Standard on

Protective Clothing for Emergency Medical Operations

1992 Edition

This edition of NFPA 1999, *Standard on Protective Clothing for Emergency Medical Operations*, was prepared by the Technical Committee on Fire Service Protective Clothing and Equipment and acted on by the National Fire Protection Association, Inc. at its Annual Meeting held May 18-21, 1992 in New Orleans, LA. It was issued by the Standards Council on July 17, 1992, with an effective date of August 14, 1992.

The 1992 edition of this document has been approved by the American National Standards Institute.

Origin and Development of NFPA 1999

This new standard was 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 defines minimum performance for protective clothing as required by the Occupational Safety and Health Administration (OSHA) Final Rule (29 CFR 1910.1030) on *Protective Health Care Workers from Occupational Exposure to Bloodborne Pathogens*. 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 employees 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 offers specific performance criteria that involves exposing protective clothing materials to surrogate virus challenge utilizing a specific time and pressure protocol. This procedure has been documented to discriminate between current protective clothing materials and correlate with visual penetration results that are obtained with a human factors evaluation. Each type of clothing must resist penetration to blood-borne pathogens as determined by this test.

Additional garments requirements cover overall liquid-tight integrity, material strength, physical hazard resistance, seam strength, and closure strength.

Additional requirements for gloves cover minimum performance for tensile and elongation properties in an "as received" condition as well as following heat aging and isopropyl alcohol immersion, minimum sizing, and liquid-tight integrity for intended areas of penetration.

Additional requirements for facewear or face protective devices cover adequate visibility and integrity, in addition to resisting penetration of blood-borne pathogens.

The selection of test methods and performance requirements was based on surveys of EMS personnel and a technical study supported by the U.S. Fire Administration.

The Subcommittee on Hazardous Chemicals Protective Clothing began its work in 1990 and passed its work on to the Technical Committee in January, 1991. This first edition was presented to the Association at the 1992 Annual Meeting in New Orleans, Louisiana.

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Standard on

Protective Clothing for Emergency Medical Operations

1992 Edition

NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates explanatory material on that paragraph in Appendix A.

Information on referenced publications can be found in Chapter 6 and Appendix C.

Chapter 1 Administration

1-1 Scope.

1-1.1* This standard specifies minimum documentation, design criteria, performance criteria, and test methods for emergency medical clothing, including garments, gloves, and face protection devices, designed to protect emergency medical service personnel or victims and patients from exposure to liquid-borne pathogens during emergency medical operations.

1-1.2* This standard does not apply to protective clothing for any fire fighting application.

1-1.3* This standard does not provide criteria for protection from radiological or cryogenic agents, hazardous chemicals, or flammable or explosive atmospheres.

1-1.4* This standard is not intended to be utilized as a detailed manufacturing or purchase specification, but can be referenced in purchase specifications as minimum requirements.

1-2 Purpose.

1-2.1 The purpose of this standard is to provide minimum requirements for emergency medical garments, gloves, and face protection devices designed to minimize skin exposure to liquid-borne pathogens under the various conditions that might exist at the scene of an emergency.

1-2.2* It is not the purpose of this standard to provide criteria for protection from biological agents that are not liquid borne.

1-2.3 Controlled laboratory tests used to determine compliance with the performance requirements of this standard shall not be deemed as establishing performance levels for all situations to which personnel may be exposed.

1-3 Definitions.

Approved.* Acceptable to the "authority having jurisdiction."

Authority Having Jurisdiction.* The "authority having jurisdiction" is the organization, office or individual responsible for "approving" equipment, an installation or a procedure.

Biological Agents. Biological materials that are capable of causing a disease or long term damage to the human body.

Body Fluids. Fluids that the body makes including, but not limited to, blood, semen, mucus, feces, urine, vaginal secretions, breast milk, amniotic fluid, cerebrospinal fluid, synovial fluid, and pericardial fluid.

Boot. A protective clothing item designed to protect the wearer's feet.

Bootie. A sock-like extension of the garment leg designed to protect the wearer's feet when worn in conjunction with an outer boot.

Certification/Certified. A system whereby a certification organization determines that a manufacturer has demonstrated the ability to produce a product that complies with the requirements of the standard, authorizes the manufacturer to use a label on listed products that comply with the requirements of this standard and establishes a follow-up program conducted by the certification organization as a check on the methods the manufacturer uses to determine compliance with the requirements of this standard.

Certification Organization. An independent, third party organization that determines product compliance with the requirements of this standard with a labeling/listing/follow-up program.

Compliant. Meeting or exceeding all applicable requirements of this standard.

Cryogenic Agents. Low temperature materials that are capable of causing acute or long term freeze burn damage to the human body.

Emergency Medical Clothing. A single garment or an assembly of multiple garments constructed of protective clothing material, designed and configured to cover any part of the wearer's skin, and that meets all applicable requirements of this standard.

Emergency Medical Face Protection Device. A face protection device that meets all applicable requirements of this standard.

Emergency Medical Glove. A glove constructed of protective clothing materials, designed and configured to cover the wearer's hand to at least the wrist, and meeting all applicable requirements of this standard.

Emergency Medical Operations. Delivery of emergency patient care and transportation prior to arrival at a hospital or other health care facility.

Emergency Patient Care. The provision of treatment to patients, including first aid, cardiopulmonary resuscitation, basic life support (EMT level), advanced life support

(Paramedic level), and other medical procedures that occur prior to arrival at a hospital or other health care facility.

Exposure. Contact with an infectious agent, such as body fluids, through inhalation, percutaneous inoculation, or contact with an open wound, nonintact skin, or mucous membrane.

Face Protection Device Product Label. A tag, symbol, or other identifying mark affixed to or imprinted on the face protection device by the manufacturer indicating compliance with this standard.

Face Protection Devices. Devices constructed of protective clothing materials, designed and configured to cover part or all of the wearer's entire face or head. Face protection devices may include splash resistant eyewear, hooded visors, or respirators.

Flammable or Explosive Atmospheres. Atmospheres containing substances or gases at concentrations that will burn or explode if ignited.

Follow-Up Program. The sampling, inspections, tests, or other measures conducted by the certification organization on a periodic basis to determine the continued compliance of labeled and listed products that are being produced by the manufacturer to the requirements of this standard.

Garment. An item of clothing that covers any part of the wearer's skin, excluding accessory items like gloves or face protection devices, including but not limited to full body clothing such as suits, coveralls, and patient/victim isolation bag and non-full body clothing such as aprons, sleeve protectors, and shoe covers.

Garment Closure. The garment component designed and configured to allow the wearer to enter (don) and exit (doff) the emergency medical garment.

Garment Closure Assembly. The combination of the garment closure and the seam attaching the garment closure to the garment, excluding any protective flap or cover.

Garment Material. The primary protective clothing material(s) used in the construction of emergency medical garments.

Garment Product Label. A tag, symbol, or other identifying mark affixed to the garment by the manufacturer containing general information, warnings, care, maintenance, or similar data.

Glove. A protective clothing item designed to protect the wearer's hands.

Glove Material. The primary protective clothing material(s) used in the construction of emergency medical gloves.

Glove Product Label. A tag, symbol, or other identifying mark affixed to or imprinted on the glove by the manufacturer indicating compliance with this standard.

Hazardous Chemical. Any solid, liquid, gas, or mixture thereof that can potentially cause harm to the human body through respiration, ingestion, skin absorption, or contact.

Labeled. Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization acceptable to the "authority having jurisdiction" and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

Liquid-Borne Pathogen. An infectious bacteria or virus carried in human, animal, or clinical body fluids, organs, or tissues.

Listed.* Equipment or materials included in a list published by an organization acceptable to the "authority having jurisdiction" and concerned with product evaluation, that maintains periodic inspection of production of listed equipment or materials and whose listing states either that the equipment or material meets appropriate standards or has been tested and found suitable for use in a specified manner.

Package. The wrapping or enclosure directly containing the emergency medical glove or face protection device.

Protective Clothing Material. Any material or combination of materials used in garments, gloves, or face protection devices for the purpose of isolating parts of the wearer's body from contact with liquid-borne pathogens or physical hazards.

Radiological Agents. Radiation associated with X-rays, alpha and gamma emissions from radioactive isotopes, or other material in excess of normal radiation background levels.

Seam. Any permanent attachment of two or more garment or glove materials, excluding external fittings, gaskets, and garment closure assemblies, in a line formed by joining the separate material pieces.

Shall. This term indicates a mandatory requirement.

Should. This term, as used in the Appendix, indicates a recommendation or that which is advised but not required.

Splash Resistant Eyewear. Safety glasses, prescription eyewear, goggles, or chin-length face shields that when properly worn provide limited protection against splashes, spray, spatters, droplets, or aerosols of body fluids or other potentially infectious material.

Trace Number. A code that can be used to retrieve the production history of a product, for example a lot or serial number.

1-4 Units.

1-4.1* In this standard, values for measurement are followed by an equivalent in parentheses, but only the first stated value shall be regarded as the requirement. Equivalent values in parentheses shall not be considered as the requirement as these values might be approximate.

Chapter 2 Certification

2-1 General.

2-1.1 Emergency medical garments, gloves, and face protection devices that are labeled as being compliant with this standard shall meet or exceed all applicable requirements specified in this standard and shall be certified.

2-1.2 All certifications shall be performed by an approved certification organization.

2-1.3 Compliant emergency medical garments shall be labeled and listed. Such garments shall also have a garment product label that meets the requirements specified in Section 2-5 of this chapter.

2-1.4 Compliant emergency medical gloves shall be labeled and listed. Such gloves shall also have product labels that meets the requirements specified in Section 2-6 of this chapter.

2-1.5 Compliant emergency medical face protection devices shall be labeled and listed. Such face protection devices shall also have product labels that meet the requirements specified on Section 2-7 of this chapter.

2-2 Certification Program.

2-2.1* The certification organization shall not be owned or controlled by manufacturers or vendors of the product being certified. The certification organization shall be primarily engaged in certification work and shall not have a monetary interest in the product's ultimate profitability.

2-2.2 The certification organization shall refuse to certify products to this standard that do not comply with all applicable requirements of this standard.

2-2.3* The contractual provisions between the certification organization and the manufacturer shall specify that certification is contingent on compliance with all applicable requirements of this standard. There shall be no conditional, temporary, or partial certifications.

2-2.4* For certification, laboratory facilities and equipment for conducting proper tests shall be available, a program for calibration of all instruments shall be in place and operating, and procedures shall be in use to ensure proper control of all testing. Good practice shall be followed regarding the use of laboratory manuals, form data sheets, documented calibration and calibration routines, performance verification, proficiency testing, and staff qualification and training programs.

2-2.5 Manufacturers shall be required to establish and maintain a program of production inspection and testing that meets the requirements of Section 2-4 of this chapter.

2-2.6 The manufacturer and the certification organization shall evaluate any changes affecting the form, fit, or function of the certified product to determine its continued certification to this standard.

2-2.7* Product certifications shall include a follow-up inspection program, with at least 2 random and unannounced visits per 12-month period.

2-2.8 The certification organization shall have a program for investigating field reports alleging malperformance or failure of listed products.

2-2.9 The operating procedures of the certification organization shall provide a mechanism for the manufacturer to appeal decisions. The procedures shall include the presentation of information from both sides of a controversy to a designated appeals panel.

2-2.10 The certification organization shall be in a position to use legal means to protect the integrity of its name and label. The name and label shall be registered and legally defended.

2-3 Inspection and Testing.

2-3.1 Sampling levels for testing and inspection shall be established by the certification organization and the manufacturer to assure a reasonable and acceptable reliability at a reasonable and acceptable confidence level that products certified to this standard are compliant. This information shall be included in the manufacturer's technical data package.

2-3.2 Testing for determining material and component compliance with the requirements specified in Chapter 4 of this standard shall be performed on samples representative of materials and components used in the actual construction of the emergency medical garments, gloves, or face protection devices. The certification organization shall also be permitted to use sample materials cut from representative emergency medical clothing.

2-3.3 Any combination of materials used in emergency medical clothing that is needed to meet any of the performance requirements specified in Chapter 4 of this standard shall also be required to meet all of the requirements for that particular segment of the emergency medical clothing.

2-4 Manufacturer's Quality Assurance Program.

2-4.1 The manufacturer shall provide and maintain a quality assurance program that includes a documented inspection and product recall system. The manufacturer shall have an inspection system to substantiate conformance to this standard.

2-4.2 The manufacturer shall maintain written inspection and testing instructions. The instructions shall prescribe inspection and test of materials, work in process, and completed articles. Criteria for acceptance and rejection of materials, processes, and final product shall be part of the instructions.

2-4.3 The manufacturer shall maintain records of all pass/fail tests. Pass/fail records shall indicate the disposition of the failed material or product.

2-4.4 The manufacturer's inspection system shall provide for procedures that assure the latest applicable drawings, specifications, and instructions are used for fabrication, inspection, and testing.

2-4.5 The manufacturer shall, as part of the quality assurance program, maintain a calibration program of all instruments used to ensure proper control of testing. The calibration program shall be documented as to the date of calibration and performance verification.

2-4.6 The manufacturer shall maintain a system for identifying the appropriate inspection status of component materials, work in process, and finished goods.

2-4.7 The manufacturer shall establish and maintain a system for controlling nonconforming material, including procedures for the identification, segregation, and disposition of rejected material. All nonconforming materials or products shall be identified to prevent use, shipment, and intermingling with conforming materials or products.

2-4.8 The manufacturer's quality assurance program shall be audited by the third party certification agency to determine that the program is sufficient to ensure continued product compliance with this standard.

2-5 Garment Product Labeling.

2-5.1 The emergency medical garment shall have a garment product label permanently and conspicuously attached to the inside of the garment upon which at least the following warnings and information are printed in at least 1/16 in. (1.5 mm) high letters.

"THIS EMERGENCY MEDICAL GARMENT (insert name of garment type, e.g., coveralls, sleeve protector) MEETS THE REQUIREMENTS OF NFPA 1999, STANDARD ON PROTECTIVE CLOTHING FOR EMERGENCY MEDICAL OPERATIONS, 1992 EDITION.

WARNING

THIS GARMENT MAY BURN. IT HAS NOT BEEN REQUIRED TO MEET A FLAMMABLE PERFORMANCE TEST. USE THIS GARMENT FOR EMERGENCY MEDICAL RESPONSE ONLY. DO NOT USE FOR PROTECTION FROM ANY HAZARDOUS CHEMICAL EMERGENCIES, FIRE FIGHTING APPLICATIONS, CRYOGENIC AGENTS, OR IN FLAMMABLE OR EXPLOSIVE ATMOSPHERES. CONTAMINATION OF THIS GARMENT MAY WARRANT ITS DISPOSAL. MAINTAIN ONLY IN ACCORDANCE WITH MANUFACTURER'S INSTRUCTIONS. NO PROTECTIVE GARMENT CAN PROVIDE PROTECTION FROM ALL CONDITIONS. FAILURE TO COMPLY WITH THESE INSTRUCTIONS MAY RESULT IN SERIOUS INJURY OR DEATH."

Manufacturer's name
Manufacturer's address
Country of manufacture
Garment model and style
Trace number
Date of manufacture
Size

"DO NOT REMOVE THIS LABEL"

2-5.2 All portions of this required garment product label shall be printed at least in English. The label shall be clearly legible to the eye.

2-5.3 The garment product label shall bear the certification label, symbol, or identifying mark of the certification organization denoting compliance. The label, symbol, or identifying mark printing shall be in at least 1/4 in. (6.0 mm) high letters.

2-6 Glove Product Labeling.

2-6.1 The emergency medical glove shall have at least a glove product label on the outside of the gauntlet that includes the following statement printed in at least 1/4 in. (6.0 mm) high letters.

"MEETS NFPA 1999 (1992 EDITION)"

2-6.2 Each package containing one or more emergency medical gloves shall have a package product label permanently and conspicuously attached to the outside or printed on the package upon which at least the following warnings and information are printed in at least 1/16 in. (1.5 mm) high letters.

"THIS EMERGENCY MEDICAL GLOVE MEETS THE REQUIREMENTS OF NFPA 1999, STANDARD ON PROTECTIVE CLOTHING FOR EMERGENCY MEDICAL OPERATIONS, 1992 EDITION.

WARNING

THIS GLOVE MAY BURN. IT HAS NOT BEEN REQUIRED TO MEET A FLAMMABLE PERFORMANCE TEST. USE THIS GLOVE FOR EMERGENCY MEDICAL OPERATIONS ONLY. DO NOT USE FOR PROTECTION FROM ANY HAZARDOUS CHEMICAL EMERGENCIES, FIRE FIGHTING APPLICATIONS, CRYOGENIC AGENTS, OR IN FLAMMABLE OR EXPLOSIVE ATMOSPHERES. CONTAMINATION OF THIS GLOVE MAY WARRANT ITS DISPOSAL. MAINTAIN ONLY IN ACCORDANCE WITH MANUFACTURER'S INSTRUCTIONS. NO PROTECTIVE CLOTHING CAN PROVIDE PROTECTION FROM ALL CONDITIONS. FAILURE TO COMPLY WITH THESE INSTRUCTIONS MAY RESULT IN SERIOUS INJURY OR DEATH."

Manufacturer's name
Manufacturer's address
Country of manufacture
Glove model and style
Trace number
Date of manufacture
Size

"DO NOT REMOVE THIS LABEL"

2-6.3 All portions of the required glove and package product labels shall be printed at least in English. All labels shall be clearly legible to the eye.

2-6.4 The glove and package product labels shall bear the certification label, symbol, or identifying mark of the certification organization denoting compliance. The label, symbol, or identifying mark printing shall be in at least 1/4 in. (6.0 mm) high letters.

2-7 Face Protection Device Product Labeling.

2-7.1 The emergency medical face protection device shall have a face protection device product label in a conspicuous location not interfering with vision that includes the following statement printed in at least 1/4 in. (6.0 mm) high letters.

"MEETS NFPA 1999 (1992 EDITION)"

2-7.2 Each package containing one or more emergency medical face protection devices shall have a package product label permanently and conspicuously attached to the outside of the package upon which at least the following warnings and information are printed in at least 1/16 in. (1.5 mm) high letters.

"THIS EMERGENCY MEDICAL FACE PROTECTION DEVICE MEETS THE REQUIREMENTS OF NFPA 1999, STANDARD ON PROTECTIVE CLOTHING FOR EMERGENCY MEDICAL OPERATIONS, 1992 EDITION.

WARNING

THIS FACE PROTECTION DEVICE MAY BURN. IT HAS NOT BEEN REQUIRED TO MEET A FLAMMABLE PERFORMANCE TEST. USE THIS FACE PROTECTION DEVICE FOR EMERGENCY MEDICAL OPERATIONS ONLY. DO NOT USE FOR PROTECTION FROM ANY HAZARDOUS CHEMICAL EMERGENCIES, FIRE FIGHTING APPLICATIONS, CRYOGENIC AGENTS, OR IN FLAMMABLE OR EXPLOSIVE ATMOSPHERES. CONTAMINATION OF THIS FACE PROTECTION DEVICE MAY WARRANT ITS DISPOSAL. MAINTAIN ONLY IN ACCORDANCE WITH MANUFACTURER'S INSTRUCTIONS. NO PROTECTIVE DEVICE CAN PROVIDE PROTECTION FROM ALL CONDITIONS. FAILURE TO COMPLY WITH THESE INSTRUCTIONS MAY RESULT IN SERIOUS INJURY OR DEATH."

Manufacturer's name
Manufacturer's address
Country of manufacture
Device model and style
Trace number
Date of manufacture
Size

"DO NOT REMOVE THIS LABEL"

2-7.3 All portions of the required face protection device and package product labels shall be printed at least in English. All labels shall be clearly legible to the eye.

2-7.4 The face protection device and package product labels shall bear the certification label, symbol, or identifying mark of the certification organization denoting compliance. The label, symbol, or identifying mark printing shall be in at least 1/4 in. (6.0 mm) high letters.

2-8 Garment User Information.

2-8.1 The manufacturer of emergency medical garments certified as being compliant with this standard shall provide the following instructions and information with each garment:

(a) Cleaning instructions;

(b) Marking and storage instructions;

(c) Frequency and details of inspections;

(d) Maintenance criteria;

(e) How to use test equipment, where applicable;

(f) Method of repair, if recommended by manufacturer;

(g) Warranty information.

2-8.2 The manufacturer of emergency medical garments shall also furnish training materials that address, but are not limited to:

(a) Donning procedures;

(b) Doffing procedures;

(c) Safety considerations;

(d) Optimum storage conditions;

(e) Recommended storage life;

(f) Decontamination recommendations and considerations;

(g) Retirement considerations;

(h) Disposal considerations;

(i) Closure lubricants, if applicable.

2-9 Glove User Information.

2-9.1 The manufacturer of emergency medical gloves certified as being compliant with this standard shall provide the following instructions and information with each package of gloves:

(a) Donning procedures;

(b) Doffing procedures;

(c) Safety considerations;

(d) Optimum storage conditions;

(e) Recommended storage life;

(f) Decontamination recommendations and considerations;

(g) Retirement considerations;

(h) Disposal considerations.

2-10 Face Protection Device User Information.

2-10.1 The manufacturer of emergency medical face protection devices certified as being compliant with this standard shall provide the following instructions and information with each package of face protection devices:

(a) Donning procedures;

(b) Doffing procedures;

(c) Safety considerations;

(d) Optimum storage conditions;

(e) Recommended storage life;

(f) Decontamination recommendations and considerations;

(g) Retirement considerations;

(h) Disposal considerations;

(i) Visor/faceshield antifog agents or procedures, if applicable.

Chapter 3 Documentation Requirements

3-1 Technical Data Package.

3-1.1* Upon the request of the purchaser or end user, the manufacturer shall furnish a technical data package with each type of clothing.

3-1.2 The technical data package shall contain all documentation required by this standard and the data showing compliance with this standard.

3-2 Emergency Medical Garment Information.

3-2.1 In the technical data package, the manufacturer shall describe the emergency medical garment in terms of manufacturer trade name and model number, manufacturer replaceable components and available options, accessories such as repair kits, and sizes.

3-2.2 The manufacturer shall provide, in the technical package, the list and descriptions of the following garment materials and components, if applicable:

(a) Garment material;

(b) Boot or bootie material;

(c) Zipper/closure type and materials;

(d) Material seam types and composition;

(e) External fitting types and material(s);

(f) External gasket types and material(s).

3-2.2.1 All descriptions of material composition shall specify either the generic material names or the trade names if the composition of the material is proprietary. The manufacturer shall identify those portions of the garment or materials intended to act as a barrier to liquid-borne pathogens.

3-2.2.2 Descriptions of respective suit materials and components shall include the following information, if applicable:

(a) Boots or booties.

1. Type of linings or surface treatments;
2. Type of soles or special toe reinforcements;
3. Available boot sizes.

(b) Garment zipper or closure.

1. The material(s) of construction for the closure (including chain, slide, pull, and tape for zippers);
2. The location and the length of the completed closure assembly;
3. A description of any protective covers or flaps.

3-2.3 The manufacturer shall describe, in the technical data package, the type of seams or methods of attachment for the following garment material and component combinations, if applicable:

(a) Garment material-garment material;

(b) Garment material-visor;

(c) Garment material-glove;

(d) Garment material-boot;

(e) Garment material-garment closure.

3-2.4* The manufacturer shall document, in the technical data package, the flame resistance of the garment material when tested in accordance with ASTM F 1358, *Standard Test Method for Resistance of Protective Clothing Materials to Flame Impingement.*

3-2.5* This manufacturer shall document, in the technical data package, penetration resistance to liquid-borne pathogens after abrasion of the garment material for one hour, when tested as specified in Section 5-1 of this standard.

3-2.6* The manufacturer shall document, in the technical data package, penetration resistance to liquid-borne pathogens after flexing of the garment material for one hour, when tested as specified in Section 5-2 of this standard.

3-3 Emergency Medical Glove Information.

3-3.1 In the technical data package, the manufacturer shall provide the following information, if applicable:

(a) Name or designation of manufacturer;

(b) Model number or design;

(c) Material composition;

(d) Description of material seams;

(e) Type of linings or surface treatments;

(f) Available glove sizes.

3-3.2 Description of the material composition shall specify either the generic material name or the trade name if the composition of the material is proprietary.

3-4 Emergency Medical Face Protection Device Information.

3-4.1 In the technical data package, the manufacturer shall provide the following information, if applicable:

(a) Name or designation of manufacturer;

(b) Model number or design;

(c) Material composition;

(d) Description of any hardware;

(e) Replaceable items;

(f) Available sizes.

3-4.2 Description of the material composition shall specify either the generic material name or the trade name if the composition of the material is proprietary.

Chapter 4 Design and Performance Requirements

4-1* Emergency Medical Garment Requirements.

4-1.1 Only those portions of the garment or garment materials that are intended to act as a barrier to liquid-borne pathogens shall be tested to the requirements specified in this section. Garment material samples shall refer to those materials intended to provide barrier protection.

4-1.2 All external fittings including, but not limited to, zippers, snaps, or other fasteners shall be free of rough spots, burrs, or sharp edges that could tear the garment or glove materials.

4-1.3 Sample garments shall be tested for watertight integrity and shall allow no water penetration when tested as specified by Section 5-3 of this standard.

4-1.4 Garment material samples shall exhibit no penetration of Phi-X-174 Bacteriophage for at least one hour when tested as specified by Section 5-4 of this standard.

4-1.5 Garment material samples shall be tested for tensile strength and have a tensile strength of not less than 30 lb (13.6 kg) when tested in accordance with Section 9, Breaking Strength, A — Grab Method, of ASTM D 751, *Standard Test Methods for Coated Fabrics*.

4-1.6 Garment material samples shall be tested for bursting strength and have a bursting strength of not less than 50 psi (3.5 kg/cm^2) in accordance with Section 15.3, Bursting Strength, using the Diaphragm Bursting Testing, of ASTM D 751, *Standard Test Methods for Coated Fabrics*.

4-1.7 Garment material samples shall be tested for puncture resistance and shall have a puncture resistance of not less than 5.5 lb (2.5 kg) when tested in accordance with ASTM D 2582, *Standard Test Method for Puncture Propagation Tear Resistance of Plastic Film and Thin Sheeting*.

4-1.8 Garment material samples shall be tested for tear strength and shall have a tear strength of not less than 8.0 lb (35.6 N) when tested as specified in Section 5-5 of this standard.

4-1.9 All garment seams shall possess a breaking strength of not less than 15 lbf/2 in. (66.7 N/5.0 cm) when tested in accordance with Section 50-55, Seam Strength, of ASTM D 751, *Standard Test Methods for Coated Fabrics*.

4-1.10 The garment closure assembly shall possess a breaking strength of not less than 15 lbf/2 in. (66.7 N/5.0 cm) when tested in accordance with Section 50-55, Seam Strength, of ASTM D 751, *Standard Test Methods for Coated Fabrics*.

4-2* Emergency Medical Glove Requirements.

4-2.1 Sample gloves and related hardware shall be free of rough spots, burrs, or sharp edges that could tear the garment or glove material.

4-2.2 Sample gloves shall be tested for watertight integrity and meet the "pass" requirements when tested in accordance with ASTM D 5151, *Standard Test Method for Detection of Holes in Medical Gloves*.

4-2.3 Sample gloves shall be measured for physical dimensions and shall meet the length and width dimension requirements when tested in accordance with ASTM D 3577, *Standard Specification for Rubber Surgical Gloves*.

4-2.4 Glove material and seam samples shall exhibit no penetration of Phi-X-174 Bacteriophage for at least one hour when tested as specified in Section 5-4 of this standard.

4-2.5 Glove material samples shall have an ultimate tensile strength elongation of not less than 2000 psi (13.7 MPa) and a 300 percent modulus of not more than 300 psi (2.07 MPa) when tested in accordance with ASTM D 412, *Standard Test Methods for Rubber Properties in Tension, Method A, Dumbbell Specimens*.

4-2.6 Glove material samples shall be tested for ultimate elongation following whole glove immersion in isopropanol and shall have an ultimate elongation of not less than 500 percent when tested as specified in Section 5-6 of this standard.

4-2.7 Glove material samples shall be tested for ultimate elongation following heat aging and shall have an ultimate elongation of not less than 500 percent when tested as specified in Section 5-7 of this standard.

4-2.8 Glove material samples shall be tested for puncture resistance and shall have a puncture resistance of not less than 1.0 lb (0.45 kg) when tested in accordance with ASTM F 1342, *Standard Test Method for Resistance of Protective Clothing Materials to Puncture*.

4-2.9 Sample gloves shall be tested for small parts dexterity, and test times shall be no greater than 106 percent of baseline test measurements when tested in accordance with Section 5-6 of this standard.

4-3* Emergency Medical Face Protection Device Requirements.

4-3.1 Sample face protection devices and related hardware shall be free of rough spots, burrs, or sharp edges that could tear garment or glove materials.

4-3.2 Visor or faceshield material samples shall be tested for total visible luminous transmittance and percentage haze as specified in Section 5-9 of this standard. Visor

material samples shall transmit not less than 95 percent of the incident visible radiation. The percentage haze of visor material samples shall not exceed 3 percent.

4-3.3 Sample face protection devices shall be tested for watertight integrity and shall allow no water penetration when tested as specified in Section 5-3 of this standard.

4-3.4 Samples representing protective clothing materials used in construction of the face protection device shall exhibit no penetration of Phi-X-174 Bacteriophage for at least one hour when tested as specified by Section 5-4 of this standard.

Chapter 5 Test Methods

5-1 Abrasion Resistance Test.

5-1.1 Abrasion resistance testing shall be conducted in accordance with ASTM D 4157, *Standard Test Method for Abrasion Resistance of Textile Fabrics (Oscillatory Cylinder Method)*, with the following conditions:

(a) A 5 lb (2.27 kg) tension weight shall be used.

(b) A 3½ lb (1.6 kg) head weight shall be used.

(c) An 80 grit abradant trimite D-weight open coat #1A4180, or equivalent, shall be used.

(d) The specimen shall be abraded for 25 continuous cycles.

(e) Penetration resistance to Phi-X-174 Bacteriophage testing as specified in Section 5-4 of this chapter shall be substituted for abrasion to rupture and percentage loss in breaking load for interpreting abrasion resistance test results.

5-1.2 Only one specimen for bacteriophage penetration resistance testing shall be taken from each sample subjected to abrasion. The test specimen shall be taken from the exact center of the abraded sample so that the center of the bacteriophage exposure test and the center of the abraded sample coincide.

5-1.3 The pass/fail determination shall be reported.

5-1.4 Any visual observations, such as sample rupture, loss of luster, or deformation of the outside coating of tested specimens, shall be reported.

5-2 Flexural Fatigue Test.

5-2.1 Flexural fatigue testing shall be conducted in accordance with ASTM F 392, *Standard Test Method for Flex Durability of Flexible Barrier Materials*, with the following modifications:

(a) In lieu of Flexing Conditions A, B, C, D, or E, test specimens shall have a flex period of 100 cycles at 45 cycles per minute. A cycle shall be full flex and twisting action.

(b) Penetration resistance to Phi-X-174 Bacteriophage testing as specified in Section 5-4 of this chapter shall be substituted for pinhole counting.

(c) Anisotropic materials shall be tested in both machine and transverse directions.

5-2.2 Only one specimen for bacteriophage penetration testing shall be taken from each sample subjected to flexing conditions. The test specimen shall be taken from the exact center of the flexed sample so that the center of the bacteriophage exposure and the center of the flexed sample coincide.

5-2.3 The pass/fail determination shall be reported.

5-2.4 Any unusual observations for test specimens, such as delamination or tears, shall be reported.

5-3 Clothing Watertight Integrity Test.

5-3.1 Garment and face protection device watertight integrity testing shall be conducted in accordance with ASTM F 1359, *Standard Practice for Determining Liquid-Tight Integrity of Chemical Protective Suits or Ensembles under Static Conditions*, using the following modifications:

(a) Water shall be sprayed at the mannequin for a duration of 5 minutes for each of the specified suit orientations.

(b) When non-full body garments are tested, those portions of the body for which protection is not intended shall be blocked off and shall not be evaluated for watertight integrity.

5-4 Bacteriophage Penetration Resistance Test.

5-4.1 A thickness gauge, suitable for measuring thickness to the nearest 0.001 in. (0.01 mm), as specified in Method 5030.2, "Thickness of Textile Materials," of Federal Test Method Standard 191A, *Textile Test Methods*, shall be used to determine the thickness of each emergency medical clothing material specimen tested.

5-4.2* A test cell shall be used to restrain the specimen during contact with the pressurized test liquid. It shall consist of a chamber that will contain at least 60 ml (2.0 oz) of the challenge liquid in contact with the specimen's normal outside surface and a restraining ring with a viewing port that will allow observation of the specimen's normal inside surface during the test. Specifications for the test cell shall be as specified in ASTM F 903, *Standard Test Method for Resistance of Protective Clothing Materials to Penetration by Liquids*.

5-4.3 The following other equipment shall be used in this test:

(a) Air pressure source.

(b) Cell incubator capable of 35° to 37°C (95° to 99°F).

(c) Waterbath capable of 45°C ± 2°C (113°F ± 4°F).

(d) Analytical balance capable of 0.001 g.

(e) Vortex mixer.

(f) Refrigerator capable of 2° to 8°C (36° to 46°F).

(g) Autoclave capable of 121°C (250°F); 15 psi (105 kPa) pressure.

(h) Electronic timer.

(i) Orbital shaker.

(j) pH meter sensitive to 0.1 pH units.

(k) Inoculating loop.

(l) Torque wrench capable of 120 in.-lb (13 J).

5-4.4* The following supplies shall be used in this test:

(a) Sterile petri dishes, 15 × 100 mm.

(b) Sterile 1, 5, 10 ml pipettes.

(c) 13 × 100 mm test tubes.

(d) Stainless steel test tube rack.

(e) 0.22 μm sterile membrane filters.

(f) Sterile glass bottles, 100 ml - 500 ml.

(g) Micropipette capable of delivering 2 μl accurately and consistently.

(h) Phi-X-174 ATCC 13706-B1.

(i) *E. coli* C ATCC 13706.

5-4.5* The following reagent shall be used in this test:

(a) *Tween 80.* Sterilize by filtering through sterile 0.22 μm membrane filter.

5-4.6* Test media shall be prepared as follows:

(a) *Bacteriophage Nutrient Broth* (Phi-X):

Nutrient Broth	8.0 g
Potassium Chloride	5.0 g
Calcium Chloride	0.20 g
Purified Water, Q.S. to	1000 ml

Adjust pH to 7.2 to 7.4 with 2.5 N Sodium Hydroxide; Sterilize by autoclaving.

(b) *Bottom Agar* (Phi-X):

Bacto-Agar	15.0 g
Nutrient Broth	8.0 g
Calcium Chloride	0.2 g
Potassium Chloride	5.0 g
Purified Water, Q.S. to	1000 ml

Adjust pH to 7.2 to 7.4 with 2.5 N Sodium Hydroxide; Sterilize by autoclaving.

(c) *Top Agar* (Phi-X):

Bacto Agar	7.0 g
Nutrient Broth	8.0 g
Calcium Chloride	0.2 g
Potassium Chloride	5.0 g
Purified Water, Q.S. to	1000 ml

Adjust pH to 7.2 to 7.4 with 2. 5 N Sodium Hydroxide; Sterilize by autoclaving.

5-4.7* Material specimens shall be tested separately in both directions to challenge both normal exterior and interior surfaces of the material. A minimum of three random specimens shall be tested for each material or each of the product areas to be evaluated, including but not limited to seams versus flat material, in each direction.

5-4.8 The bacteriophage suspension shall be prepared as follows:

(a) Using an inoculating loop, 100 ml of nutrient broth shall be inoculated with *E. coli* C and incubated overnight at 35° to 37°C (95° to 99°F) with shaking at 200 rpm.

(b) A 1:100 dilution of the culture shall be prepared in bacteriophage nutrient broth and incubated at 35° to 37°C (95° to 99°F) with shaking at 200 rpm for 90 minutes, ± 5 minutes.

(c) The 90 minute culture shall be inoculated with 0.5 ml of the Phi-X-174 Bacteriophage stock.

(d) The culture shall be incubated at 35° to 37°C (95° to 99°F) with rapid shaking for 3 hours ±2 hours or until lysis is complete. Complete lysis of the host bacteria shall be noted when the broth is clear.

(e) The bacteriophage suspension shall be filtered through a sterile 0.22 μm microporous membrane filter to remove the host cell debris.

(f) The bacteriophage suspension shall be refrigerated at 5°C ±3°C.

(g) Sterile 0.1 percent Tween 80 in nutrient broth shall be made and diluted 1 volume to 9 volumes of the bacteriophage suspension.

(h) The titer of the bacteriophage suspension shall be adjusted to at least 1.0×10^8 PFU/ml with 0.01 percent Tween 80. The titer shall be verified using the procedure specified in 5-4.10 of this section.

5-4.9 The test cell shall be prepared as follows:

(a) The penetration test cell shall be autoclaved at 121°C ± 5°C at 15 psig (105 kPa) for 15 minutes. The test cell shall be allowed to cool to room temperature.

(b) The material sample shall be aseptically inserted in the cell with the normal outside surface oriented away from the challenge.

5-4.9.1* A retaining screen shall be placed outside the material in the test cell, away from the bacteriophage suspension. The retaining screen shall be inert material with a minimum mesh per in. of 20 and open area of 45 percent. Gaskets shall be placed between the test cell and material, between the material and retaining screen, and between the retaining screen and the top flange.

(a) The bolts in the test cell shall be torqued to 120 in.-lb (13 J) each.

(b) The test cell shall be placed in test apparatus but not connected in the air line.

(c) The drain valve shall be closed.

(d) With the test cell in a vertical orientation the chamber shall be carefully filled with approximately 60 ml of challenge.

(e) The material shall be observed for five minutes.

(f) The air line shall be connected to the cell.

(g) The test cell valve to the pressure source shall be opened to pressure and brought to 2 psig (0.14 kg/cm^2) at a rate no faster than 0.5 psig/sec.

(h) The test pressure shall be held constant for one minute. The surface of the sample shall be monitored for the appearance of liquid. The test shall be terminated if liquid appears.

(i) The cell valve shall be turned to the vent position.

(j) The surface of the sample shall be observed for 54 minutes.

(k) The drain valve shall be opened, and the test cell drained of the bacteriophage suspension. The titer of the drained bacteriophage suspension shall be quantified using the procedures specified in 5-4.10 of this section.

(l) The test cell shall be removed from the apparatus.

(m) With the test cell in a horizontal position, 5 ml sterile nutrient broth shall be added with 0.01 percent Tween 80 onto the inner surface of the sample. The test cell shall be swirled for 1 minute, ±0.15 min., to ensure contact with the entire viewing surface of the test specimen. The nutrient broth shall be removed as soon as possible. This removed nutrient broth shall become the assay fluid.

(n) The assay fluid shall be quantified immediately following its removal from the test cell.

(o) The material sample shall be removed from the test cell.

(p) The test apparatus shall be disassembled. The cover plate and retaining screen shall be removed.

5-4.10 The assay fluid shall be quantified as follows:

(a) 2.5 ml of sterile molten top agar shall be dispensed into sterile test tubes containing top agar under heat at 45°C ±2°C (113°F ±4°F).

(b) Immediately after removing the test tube from the heat, 0.5 ml of the assay fluid shall be added to three top agar tubes. This procedure shall be repeated three times for each replicate.

(c) One to two drops of an overnight culture of *E. coli* C shall be added to each of the inoculate tubes.

(d) The tubes shall be mixed well and poured over the surface of the bottom agar plates.

(e) The agar shall be allowed to solidify and incubated at 35° to 37°C (95° to 99°F) for 4 to 18 hours.

(f) The plaques shall be counted and the bacteriophage titer calculated.

(g) If necessary, serial 1 to 10 dilutions shall be prepared in nutrient broth of the assay fluid and assayed for bacteriophage as above.

5-4.11 All tests shall be run with a "blank" that uses nutrient broth without bacteriophage, which shall be tested and titered using the procedure specified in 5-4.10 of this section.

5-4.12 Background aerosol/airborne counts of the Phi-X-174 Bacteriophage shall be made utilizing settling plates. Settling plates shall be placed in strategic locations during the aseptic test sample insertion, filling, testing, draining, and assay operations. If settle plate counts are found, then the results of the test shall be considered invalid.

5-4.13* Negative test sample controls shall be selected at random and introduced into the test program. Mylar film shall be used as the test sample controls.

5-4.14 The possibility of false positives resulting from contamination not affecting the "blank" cell shall be minimized by repeating the test. Tests shall be repeated if bacteriophage is found in only one cell and the number of counts is less than ten. Less than ten bacteriophage particles in one out of six replicates with no contamination of two blanks shall be considered passing results.

5-4.15 The bacteriophage suspension shall be quantified before and after contact with the material. If the titer falls below 10^8 PFU/ml, the test shall be repeated with a sufficient titer to achieve 10^8 PFU/ml after one hour.

5-4.16 If the material contains substances that inactivate the bacteriophage, the compatibility of the test material with the bacteriophage shall be assessed.

5-4.17 Material specimens that show any bacteriophage penetration shall be classified as failing this test.

5-5 Tear Resistance Testing.

5-5.1 The specimen shall be a 3 × 6 in . (76.2 × 152.4 mm) rectangle. The long dimension shall be parallel to the warp for the warp tests and parallel to the filling for filling tests. No two specimens for warp tests shall contain the same warp yarns, nor shall any two specimens for filling tests contain the same filling yarns. The specimen shall be taken no nearer to salvage than one-tenth of the width of the cloth. An isosceles trapezoid having an altitude of 3 in. (76.2 mm) and bases of 1 and 4 in. (25.4 and 101.6 mm) in length, respectively, shall be marked on each specimen, with the aid of a template. A cut $\frac{3}{8}$ in. (9.5 mm) in length shall then be made in the center of a line perpendicular to the 1 in. (25.4 mm) edge.

5-5.2 Apparatus shall consist of a straining mechanism, two clamps for holding specimens, and load and elongation recording mechanisms, wherein the specimen is held between two clamps and strained by a uniform movement of the pulling clamp.

5-5.2.1 Straining mechanism shall be of such capacity that the maximum load required to break the specimen shall be not greater than 85 percent or less than 15 percent of the manufacturer's rated capacity.

5-5.2.2 Clamps shall be designed such that the 6 oz (170 g) of weight are distributed evenly across the complete width of the sample. The clamps shall have two jaws on each clamp. The design of the clamps shall be such that one gripping surface or jaw shall be permitted to be an integral part of the rigid frame of the clamp or be fastened to allow a slight vertical movement, while the other gripping surface or jaw shall be completely moveable.

The dimensions of the immovable jaw of each clamp parallel to the application of the load shall measure 1 in. (25.4 mm) and the dimension of the jaw perpendicular to this direction shall measure 3 in. (76.2 mm) or more. The face of the moveable jaw of each clamp shall measure 1 in. × 3 in. (25.4 mm × 76.2 mm). Each jaw face shall have a flat, smooth gripping surface. All edges that might cause a cutting action shall be rounded to a radius of not more than $\frac{1}{64}$ in. (0.4 mm).

In cases where a cloth tends to slip when being tested, the jaws shall be faced with rubber or other material to prevent slippage. The distance between the jaws shall be 1 in. (25.4 mm) at the start of the test.

5-5.2.3 Recorder shall consist of calibrated dial, scale, or chart used to indicate applied load and elongation. Error shall not exceed 2 percent up to and including a 50 lb (22.7 kg) load and 1 percent over a 50 lb (22.7 kg) load at any reading within its loading range. All machine attachments for determining maximum loads shall be disengaged during test.

5-5.3 The specimen shall be clamped along the nonparallel sides of the trapezoid so that these sides lie along the lower edge of the upper clamp and the upper edge of the lower clamp with the cut halfway between the clamps. The short trapezoid base shall be held taut, and the long trapezoid base shall lie in the folds.

The strain mechanism shall be started, and the force necessary to tear the clothing shall be observed by means of the recording device. Five specimens in each of the warp and filling directions shall be tested from each sample unit. If a specimen individual measurement falls markedly below the average test results for the sample unit, such result shall be discarded and another specimen shall be tested.

5-5.4 The tear strength shall be the average of the five highest peak loads of resistance registered in inches of separation of the tear. The tear strength shall be reported to the nearest 0.1 lb (45.4 g).

5-6 Isopropanol Degradation Test.

5-6.1 Isopropanol degradation shall be measured in accordance with ASTM D 412, *Standard Test Methods for Rubber Properties in Tension, Method A, Dumbbell Specimen*, with the following modifications:

(a) Test specimens shall be conditioned by total immersion in 100 percent isopropanol at room temperature for a period of 2 hours.

(b) The test specimens shall be blotted dry and tested within 5 minutes following removal from the isopropanol.

5-6.2 Ultimate elongation (percentage) shall be measured and reported.

5-7 Heat Aging Degradation Test.

5-7.1 Specimen degradation shall be measured in accordance with ASTM D 412, *Standard Test Methods for Rubber Properties in Tension, Method A, Dumbbell Specimen*, following heat aging conducted in accordance with ASTM D 573, *Test Method for Rubber — Deterioration in an Air Oven*.

5-7.2 Specimens shall be subjected to a temperature of 100°C ±2°C (212°F ±4°F) for 22 hours ±0.3 hours.

5-7.3 Ultimate elongation (percentage) shall be measured and reported.

5-8 Dexterity Testing.

5-8.1 Dexterity shall be evaluated using the *Crawford Small Parts Dexterity Test, Screws Technique*.

5-8.2 Each sample glove shall be tested as a complete glove in new, as-distributed condition. The size most comfortably fitting the test subject shall be selected.

5-8.3 Sample gloves shall not receive special softening treatments prior to tests.

5-8.4 For each glove style or type to be certified the test shall be repeated three times using three separate test subjects and glove specimens for each material and construction combination.

5-8.5 Each test subject shall practice without wearing any glove until the baseline times of that person's last three repetitions vary no more than 6 percent.

5-8.6 Each test subject's first time wearing gloves shall be compared with the average time from the three last practice trials to determine percentage of baseline test time required to perform the exercise while wearing gloves.

5-9 Luminous (Visible) Transmittance Testing.

5-9.1 Luminous (visible) transmittance shall be measured in accordance with ASTM D 1003, *Test Method for Haze and Luminous Transmittance of Transparent Plastics*, Method A, with the following modifications:

(a) The standard source of radiant energy used in the measurement of luminous transmittance of filter lenses shall be a projection-type lamp T-8, or other high-powered, gas-filled, tungsten-filament incandescent lamp, operated at the color temperature corresponding to Commission Internationale de l'Eclairage (CIE) Source A.

(b) Luminous transmittance shall be determined by measuring the spectral transmittance and calculating the luminous transmittance through the use of published data on the special radiant energy of CIE Source A and the relative luminous efficiency of the average eye. The standards of luminous transmittance maintained by the National Bureau of Standards shall be tested.

Chapter 6 Referenced Publications

6-1 The following documents or portions thereof are referenced within this standard and shall be considered part of the requirements of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

6-1.1* ASTM Publications.

ASTM D 412, *Standard Test Methods for Rubber Properties in Tension*, 1987

ASTM D 573, *Standard Test Method for Rubber—Deterioration in an Air Oven*, 1988

ASTM D 751, *Standard Test Methods for Coated Fabrics*, 1989

ASTM D 1003, *Standard Test Method for Haze and Luminous Transmittance of Transparent Plastics*, 1988

ASTM D 2582, *Standard Test Method for Puncture Propagation Tear Resistance of Plastic Film and Thin Sheeting*, 1990

ASTM D 3577, *Standard Specification for Rubber Surgical Gloves*, 1991

ASTM D 4157, *Standard Test Method for Abrasion Resistance of Textile Fabrics (Oscillatory Cylinder Methods)*, 1982

ASTM D 5151, *Standard Test Method for Detection of Holes in Medical Gloves*, 1991

ASTM F 392, *Standard Test Method for Flex Durability of Flexible Barrier Materials*, 1987

ASTM F 903, *Standard Test Method for Resistance of Protective Clothing Materials to Penetration by Liquids*, 1990

ASTM F 1342, *Standard Test Method for Resistance of Protective Clothing Materials to Puncture*, 1991

ASTM F 1358, *Standard Test Method for Resistance of Protective Clothing Methods to Flame Impingement*, 1992

ASTM F 1359, *Standard Practice for Determining Liquid-Tight Integrity of Chemical Protective Suits or Ensemblies under Static Conditions*, 1991

6-1.2* GSA Publications.

Federal Test Method Standard 191A, *Textile Test Methods*, 20 July 1978

Military Standard MIL-STD-105D, *Sampling Procedures and Tables for Inspection by Attributes*, 29 April 1983

6-1.3* Psychological Corporation Publication.

Crawford Small Parts Dexterity Test, 1981

Appendix A

This Appendix is not a part of the requirements of this NFPA document, but it is included for information purposes only.

A-1-1.1 Use of emergency medical clothing is addressed in NFPA 1581, *Standard on Fire Department Infection Control Program*. Particularly relevant sections are:

2-2 Training and Education

2-5 Exposures

4-2 Infection Control Garments and Equipment

5-1 Skin Washing

5-2 Disinfectants

5-3 Emergency Medical Equipment

5-4 Clothing

A-1-1.2 Organizations responsible for fire fighting applications should use protective clothing and equipment specifically designed for those activities.

A-1-1.3 Organizations responsible for chemical response functions and other hazard protection including radiological, cryogenic, or hazardous chemical should use protective clothing and equipment specifically designed for those activities. Criteria for protection from hazardous chemicals are provided in the following standards:

(a) NFPA 1991, *Standard on Vapor-Protective Suits for Hazardous Chemical Emergencies*

(b) NFPA 1992, *Standard on Liquid Splash-Protective Suits for Hazardous Chemical Emergencies*

(c) NFPA 1993, *Standard on Support Function Protective Garments for Hazardous Chemical Operations*

A-1-1.4 Purchasers should specify desired features that are not in conflict with the design requirements of this standard. It is recommended that purchasers of emergency medical garments should consider the following:

(a) Personnel may be wearing many items of protective clothing and equipment. Any interference by one item of another's use might result in inefficient operations or unsafe situations.

(b) Different breathing apparatus, communications systems, cooling devices, and other protective equipment may not be accommodated by the emergency medical garments equally.

(c) Specifications of additional reinforcement in high-wear or load-bearing areas such as the knees, elbows, shoulders, and back may be necessary. Reinforcing materials should be the same as the garment material. Purchasers are cautioned that additional weight caused by excessive reinforcement could lead to fatigue or injury.

A-1-2.2 Biological agents may also be transmitted via aerosols.

A-1-3 Approved. The National Fire Protection Association does not approve, inspect or certify any installations, procedures, equipment, or materials nor does it approve or evaluate testing laboratories. In determining the acceptability of installations or procedures, equipment or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization concerned with product evaluations which is in a position to determine compliance with appropriate standards for the current production of listed items.

A-1-3 Authority Having Jurisdiction. The phrase "authority having jurisdiction" is used in NFPA documents in a broad manner since jurisdictions and "approval" agencies vary as do their responsibilities. Where public safety is primary, the "authority having jurisdiction" may be a federal, state, local or other regional department or individual such as a fire chief, fire marshal, chief of a fire prevention bureau, labor department, health department, building official, electrical inspector, or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the "authority having jurisdiction."

In many circumstances the property owner or his designated agent assumes the role of the "authority having jurisdiction"; at government installations, the commanding officer or departmental official may be the "authority having jurisdiction."

A-1-3 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which do not recognize equipment as listed unless it is also labeled. The "authority having jurisdiction" should utilize the system employed by the listing organization to identify a listed product.

A-1-4.1 English units are used throughout Chapter 4 with metric equivalents provided in parentheses. This practice is also followed in Chapter 5 with the exception of Section 5-4, where metric units are exclusively used for units of volume.

A-2-2.1 The certification organization should have sufficient breadth of interest and activity so that the loss or award of a specific business contract would not be a determining factor in the financial well being of the agency.

A-2-2.3 The contractual provisions covering a certification program should contain clauses advising the manufacturer that if requirements change, the product should be brought into compliance with the new requirements by a stated effective date through a compliance review program involving all currently listed products.

Without the clauses, certifiers would not be able to move quickly to protect their name, marks, or reputation. A product safety certification program would be deficient without these contractual provisions and the administrative means to back them up.

A-2-2.4 Investigative procedures are important elements of an effective and meaningful product safety certification program. A preliminary review should be carried out on products submitted to the agency before any major testing is undertaken.

A-2-2.7 Such inspections should include, in most instances, witnessing of production tests. With certain products the certification organization inspectors should select samples from the production line and submit them to main laboratory for countercheck testing. With other products, it may be desirable to purchase samples in the open market for test purposes.

A-3-1.1 Purchasers should use the technical data package to compare garment or glove performance data in purchasing emergency medical garments or gloves. The purchaser should determine the relative ranking of performance data to aid this selection process.

A-3-2.4 This documentation requirement provides information to the end user about the flame resistance of the garment material. Material flame resistance is measured using a modified version Method 5903.1 of FTMS 191A, where a folded edge of the material is suspended over a flame. The test involves two flame exposures: an initial 3 second exposure and subsequent 12 second exposure.

Ignition of the material is noted after each exposure period, with measurement of both burn distance and burn time for each material specimen tested, if the specimen ignites. These measurements provide an assessment for the ease of material ignition, if the material does ignite, and whether the material is self-extinguishing.

A-3-2.5 This documentation requirement provides information to the end user about the abrasion resistance of the garment material. Material abrasion resistance is measured by subjecting material specimens to a standard abrasion technique designed to simulate wear on an asphalt-like surface. These material specimens are then tested for penetration resistance to bacteriophage (described in A-4-1). End users should assess the abrasion resistance of the garment material by comparing the material bacteriophage penetration before abrasion (as required in 4-1.4 of this standard) and after abrasion.

A-3-2.6 This documentation requirement provides information to the end user about the flexing resistance of the garment material. Material abrasion resistance is measured by subjecting material specimens to a standard flexing technique designed to simulate wear from repeated material bending, twisting, and compression. These material specimens are then tested for penetration resistance to bacteriophage (described in A-4-1). End users should assess the flexing resistance of the garment material by comparing the material bacteriophage penetration before flexing (as required in 4-1.4 of this standard) and after flexing.

A-4-1 There are one design and eight performance requirements for emergency medical garments. Only those portions of the garment intended to act as a barrier to liquid-borne pathogens are evaluated for performance. This approach permits the certification of partial or non-full body protective clothing used in emergency medical operations. An example of a possible clothing configuration would be a clothing item designed to provide barrier protection to the wearer's front torso and arms by using barrier materials on the front of the garment while the back of the garment is composed of non-barrier materials. In this case, only the front of the garment and garment sleeves would be evaluated to the requirements in Section 4-1.

(a) *Fittings Quality (4-1.2).* This design requirement prevents fittings being used in the construction of garments that could potentially snag or test protective clothing materials.

(b) *Overall Watertight Integrity (4-1.3).* This performance requirement entails testing of the complete garment in a "shower-like" test that is designed to assess how well garment materials, seams, and closures and interfaces resist penetration from liquid splashes. The test is not intended to simulate exposure from liquid splashes. This requirement is similar to that required in NFPA 1993, *Standard on Support Function Protective Garments in Hazardous Chemical Operations*. The test is intended to assess watertight integrity of those portions of the garment for which protection is to be provided. Non-full body clothing such as coveralls, aprons, and sleeve protectors may be tested using the procedure in Section 5-3.

(c) *Bacteriophage Penetration Resistance (4-1.4).* This test is intended to determine how well garment materials prevent penetration of biological agents (liquid-borne pathogens). The resistance of protective clothing materials to

penetration by blood-borne pathogens is determined using a modified form of ASTM F 903, *Standard Test Method for Resistance of Protective Clothing Materials to Penetration by Liquids*. Procedure C from ASTM F 903 was chosen as the most appropriate because of its high degree of correlation to human factors evaluations as shown by Mccullough and Schoenberger, *Liquid Barrier Properties of Nine Surgical Gown Fabrics*, INDA Journal of Nonwovens Research, Vol. 3, No. 3, Summer 1991. The protective clothing materials are challenged with a Phi-X-174 Bacteriophage suspension for 5 minutes at atmospheric pressure, 1 minute at 2.0 psi, and 54 minutes at atmospheric pressure, or until liquid penetration. Then the reverse side of the test material is rinsed and assayed for the Phi-X-174. Phi-X-174 Bacteriophage best approximates Hepatitis C virus but also simulates Hepatitis B virus and Human Immunodeficiency Virus (HIV). It was chosen as the most appropriate blood-borne pathogen model because of its size, spherical morphology, environmental stability, non-human infectivity, high assay sensitivity, rapid growth, and high titer (available in large concentrations).

Testing prior to degradation by other physical, chemical, and thermal stress that could negatively impact the performance of the protective barrier could lead to a false sense of security. See 3-2.5 and 3-2.6 for the affects of abrasion and flexing. Other affects might be shelf life, laundering, and sterilization. Prewetting by such things as alcohol and contamination by such things as perspiration can also affect barrier performance of the material. The authority having jurisdiction should consider these affects when comparing materials.

All remaining performance requirements are identical to those provided in NFPA 1993, *Standard on Support Function Protective Garments for Hazardous Chemical Operations*. The same requirements were adopted since the subcommittee believed the working environment for emergency medical clothing to be the same as for support function protective clothing.

(d) *Tensile Strength (4-1.5).* This requirement was designed to ensure materials provide adequate strength when pulled or stretched.

(e) *Burst Strength (4-1.6).* This requirement was designed to simulate material bursting from protruding objects within the emergency medical garment.

(f) *Puncture Propagation Tear Resistance (4-1.7).* This requirement is designed to simulate material snagging and subsequent tearing from sharp objects, such as walking past a protruding rail.

(g) *Tear Resistance (4-1.8).* This requirement is designed to simulate how the material tears when pulled apart.

(h) *Seam Strength (4-1.9).* This requirement is based on documentation of adequate strength from field performance data.

(i) *Closure Strength (4-1.10).* Garment closure assemblies are required to meet the same minimum tensile strength requirements as garment seams.

A-4-2 There are one design and eight performance requirements for emergency medical gloves.

(a) *Hardware Quality (4-2.1).* This requirement prevents any glove hardware that could potentially snag or tear protective clothing materials from being used in the construction of the glove.

(b) *Watertight Integrity (4-2.2).* This requirement assesses the overall integrity of the gloves in a procedure developed by ASTM in which water is poured into a glove, with the glove checked for leakage after 2 minutes.

(c) *Sizing (4-2.3).* This requirement addresses dimensional requirements of gloves. ASTM D 3578, *Standard Specification for Rubber Surgical Gloves*, specifies width and length requirements for 8 different glove sizes.

(d) *Bacteriophage Penetration Resistance (4-2.4).* This requirement is analogous to the Bacteriophage Penetration Resistance test described in A-4-1(c). The test is conducted differently in that entire gloves are evaluated as opposed to material specimens. Gloves are turned inside out and placed in a flask. The "new" inside surface of the glove is filled with media containing the Phi-X-174 Bacteriophage. The "new" outside surface of the glove is rinsed and assayed for bacteriophage penetration after one hour contact with the bacteriophage. The analysis of the assay media is evaluated in the same manner as done for garment material specimens.

(e) *Tensile Strength Elongation and 300 Percent Modulus (4-2.5).* This requirement is designed to simulate the failure mode of gloves that occurs from pulling the glove onto the hand with its subsequent breaking and tearing.

(f) *Isopropanol Degradation Resistance (4-2.6).* In this requirement, the degradation resistance of the glove is measured following a 2-hour immersion in isopropanol with measurement of glove elongation. The inability of the glove to elongate 500 percent is cause for failure. Isopropanol is a common medical solvent that, when in contact with glove materials, may remove plasticizer or other additives necessary for adequate glove function.

(g) *Heat Aging Degradation Resistance (4-2.7).* Analogous to Isopropanol Degradation Resistance, the heat aging degradation resistance is measured by subjecting sample gloves to an accelerated heat aging at 100°C for 22 hours. This protocol was adopted from ASTM D 3577, *Standard Specification for Rubber Surgical Gloves*, and is designed to simulate the effects of long term storage of gloves at elevated temperature and subsequent glove degradation through loss of plasticizers or other additives necessary for adequate glove function. Glove degradation resistance is measured using glove elongation.

(h) *Puncture Resistance (4-2.8).* This requirement is designated to simulate the puncture of gloves by sharp (nail-like) objects. It is not designed to simulate needle-pricks or similar medical instrument punctures.

(i) *Dexterity (4-2.9).* The overall glove performance is assessed through a standard glove dexterity test in which test subjects ability to manipulate fine objects is determined. Test subject performance is compared with and without gloves.

A-4-3 There are one design and three performance requirements for emergency medical face protection devices. The basis and rationale for each requirement are given below:

(a) *Hardware Quality (4-3.1).* This design requirement prevents hardware that could potentially snag or tear protective clothing materials from being used on face protective devices.

(b) *Light Transmission (4-3.2).* This requirement ensures emergency medical devices provide clear and undistorted visor through the vision or eye piece portions of the device. Although similar, this requirement is not the same as that established in ANSI Z87.1 for protective visors.

(c) *Watertight Integrity (4-3.3).* This requirement is analogous to the test performed on emergency medical garments described in A-4-1(b). Watertight integrity is assessed on a standard mannequin head form.

(d) *Bacteriophage Penetration Resistance (4-3.4).* This requirement is analogous to the requirement for medical emergency garments described in A-4-1(c). It applies only to those portions of the face protection device intended to provide protection to the face or head.

A-5-4.2 The penetration test cell and apparatus is available from Wilson Road Machine Shop, 1170 Wilson Road, Rising Sun, MD 21911; PFFE Gasket material needed to seal the test cell and material specimen may be obtained from W.L. Gore & Associates, Inc., Industrial Sealant Group, Elkton, MD 21921.

A-5-4.4 Phi-X-174 ATCC 13706 B1 Bacteriophage and *E. coli* C ATCC 13706 are available from American Type Culture Collection, 12301 Parklawn Drive, Rockville, MD 20852.

A-5-4.5 Tween 80 is available from Aldrich Chemical Company, Inc., 1001 West Saint Paul Avenue, Milwaukee, WI 53233.

A-5-4.6 Nutrient Broth and Bacto-Agar are available from Difco, Detroit, Michigan.

A-5-4.7 A 2.8 in. (70 mm) square is convenient. Protective clothing materials that incorporate an impervious layer between two fabric layers or have absorptive substrates may be sensitive to false positives by wicking. In order to prevent "wicking" modes of failure, the edges of the test sample should be sealed with an adhesive or parafin wax prior to testing.

A-5-4.9.1 11 × 11 nylon screen (No. 9818T12), 14 × 14 Polypropylene screen (No. 9275T11), and 13 × 13 Polyester screen (No. 9218T12), available from McMaster-Carr Supply Company, P.O. Box 4355, Chicago, IL 60680, meet this purpose.

A-5-4.13 Mylar film is available from E. I. du Pont de Nemours & Co., Wilmington, DE 19898.

A-6-1.1 ASTM publications can be obtained from American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19130.

A-6-1.2 GSA publications can be obtained from General Services Administration Specifications Activity; Printed Materials Supply Division; Building 197, Naval Weapons Plant, Washington, DC 20407. Single copies are generally available without charge at the General Service Administration Business Centers in cities throughout the U.S. Federal Test Method standards are available from the U.S. Government Printing Office, Washington, DC 20402.

A-6-1.3 This publication is available from The Psychological Corporation, 555 Academic Court, San Antonio, TX 78204.

Appendix B

This appendix is not part of the requirements of this NFPA document, but is included for information purposes only.

B-1 NOTICE TO THE READER. The following test method is given so that persons who are interested in evaluating and comparing the heat transfer qualities of fabrics can do so to an established method.

This test method is NOT a requirement of this document, and nothing contained herein can be construed to be a part of the mandatory requirements of this document. The use of the term "shall" in this test method is to emphasize critical procedures that are part of the test and not to indicate a mandatory requirement of this document. A simple criterion — the watts/m^2 of heat transferred through the composite by the combined dry and evaporative heat exchanges from 95°F (35°C), fully sweating test plate surface in a 77°F (25°C), 65 percent RH environment — provides a single number for comparing each fabric.

B-1.1 Total Heat Loss Test.

NOTE: Practitioners of this method should be intimately familiar with ASTM D 1518, although this Total Heat Loss Test contains significant differences.

B-1.2 The test plate and guard ring shall have a wettable surface.

NOTE: One useful sweating hot plate, apparatus is available form Holometrix, Inc., 99 Erie Street, Cambridge, MA 02139 (telephone 617-868-8050). An environmental chamber with air temperature, humidity, and air velocity control is also required.

B-1.3 The test plate shall have a temperature of 35°C ± 0.5°C (95°F ± 1°F). The guard ring and bottom plate shall be controlled to eliminate lateral and downward heat transfer from the test plate.

B-1.4 The local environmental climate shall be 25°C ± 0.5°C (77°F ± 1°F) and 65 percent RH, ± 4 percent RH. The air velocity shall be the same for all calibrations and tests. These conditions shall be measured continuously in the free flow air stream uninfluenced by the boundary of the test plate. Apparatus used to measure temperature shall be accurate to within ± 0.25°C. Apparatus used to measure humidity shall be accurate to within ± 4 percent RH.

B-1.5 The average bare plate thermal resistance, including the air layer and any apparatus contribution (Rcbp), shall be an average of at least 3 measurements with nothing mounted on the test plate.

B-1.6 The average intrinsic thermal resistance of the sample alone (Rcf) shall be determined by subtracting the average bare plate resistance (Rcbp) from the average of the total thermal resistance (Rct) of the specimens tested.

B-1.7 The total thermal resistance (Rct) of the specimen shall be calculated from the following equation:

$$Rct = \frac{(T_s - T_a)\,A}{H}$$

where

Rct = total thermal resistance of the specimen and surface air layer (cm^2/w)

T_s = temperature at the place surface (°C)

T_a = temperature in the local environment (°C)

A = area of the test plate (m^2)

B = power input (watts)

B-1.8 Data shall be collected when equilibrium is reached. Data shall be collected every 5 minutes. Equilibrium shall be a rate of change of less than 3 percent per hour of calculated thermal resistance over a period not less than 30 minutes. The standard deviation of the calculated thermal resistance shall be less than 1 percent.

B-1.9 The specimens shall be mounted on the test plate in the orientation it has in the finished garment from the skin surface (plate surface) to the outside.

B-1.10 The apparatus shall be calibrated to meet the following constraints:

(a) A graph of total thermal resistance versus number of layers of 7.5 oz/yd^2 Nomex duck shall be linear for the bare plate value, one, two, three, and four layers.

(b) The slope of the linear regression shall be 0.0206 cm^2 ± 10%/W.

(c) No individual data measurement shall be outside ± 10% of the value predicted by the linear regression.

(d) The intrinsic thermal resistance of four layers of 7.5 oz/yd^2 Nomex duck shall be 0.082cm^2 ± 10%/W.

NOTE: The standard sample of 7.5 oz/yd^2 Nomex duck should be obtained from Office of Standard Reference Materials, National Institute of Standards and Technologies, Gaithersburg, MD 20899; 301-957-6776.

B-1.11 The average intrinsic thermal resistance of the specimens shall be determined by averaging all values obtained over the equilibrium period (minimum of 6). The average intrinsic thermal resistance of the sample shall be determined by averaging the values for all specimens. If the results for any of the 3 individual specimens vary more than ± 10% from the average of all 3, then the test shall be repeated on the specimen(s) lying outside the ± 10% limit. If the retest produces a value(s) within the ± 10% limit, then the new value(s) shall be used instead. If the retest remains outside the ± 10% limit, then an additional 3 specimens shall be tested, and all original and retest results shall be reported along with the average and standard deviation for intrinsic thermal resistance and a statement identifying this sample as having a high variability.

B-1.12 Water shall be fed to the test plate and guard ring so that water uniformly wets the test plate and guard ring surface.

B-1.13 The test plate and guard ring shall be covered with a liquid barrier that prevents wetting of the test specimen by the liquid water. The permeability index of the bare plate with the liquid barrier in place shall be greater than 0.7.

NOTE: The permeability index of the bare plate should be calculated from the following equation:

$$i_m = 0.061 \times Rcbp/Rebp$$

where

i_m = permeability index

Rcbp = average bare plate thermal resistance (without liquid barrier) described in B-1.5 (°C/m^2/W)

Rebp = average bare plate evaporative resistance (with liquid barrier in place) described in B-1.15 (kPa/m^2/W)

NOTE: One source for uncoated cellophane that will meet this is 0lin, Ecusta Paper and Film Group, NC 28768.

B-1.14 The average bare plate evaporative resistance, including the air layer, the liquid barrier, and any apparatus contribution (Rebp), shall be an average of at least 3 measurements with only the liquid barrier mounted on the plate. The local environmental climate may be increased above 25°C (77°F) if necessary to maintain test plate temperature at 35°C (95°F).

B-1.15 The apparent total evaporative resistance (ARet) of the specimen shall be calculated from the following equation:

$$ARet = \frac{(P_s - P_a)\,A}{H - \frac{(T_s + T_a)\,A}{Rct}}$$

where

ARet = apparent total evaporative resistance of the specimen and surface air layer (kPa/m^2/W)

P_s = water vapor pressure at the plate surface (kPa)

P_a = water vapor pressure in the local environment (kPa)

A = area of the test plate (m^2)

H = power input (watts)

T_s = temperature at the plate surface (°C)

T_a = temperature in the local environment (°C)

Rct = total thermal resistance of the specimen and surface air layer (°C/m^2/W)

NOTE: The term "apparent" is used as a modifier for evaporative resistance to reflect the fact that condensation may occur within the specimen.

B-1.16 Data shall be collected when equilibrium is reached. Data shall be collected every 5 minutes. Equilibrium shall be a rate of change of less than 3 percent per hour of calculated apparent evaporative resistance over a period not less than 30 minutes. The standard deviation of the calculated apparent evaporative resistance shall be less than 1 percent.

If data collection cannot be completed within 4 hr after mounting the specimen on the test plate, the specimen shall be removed form the test plate and allowed to dry at least 24 hr at 60° - 80°F (16° - 25°C) before retesting. Subsequent data reporting shall state that drying was required. If the retest of the specimen still cannot meet these constraints, then it shall be reported that the specimen cannot be tested by this method.

B-1.17 The average apparent intrinsic evaporative resistance of the sample alone (ARef) shall be the apparent total evaporative resistance (ARet) minus the average bare plate evaporative resistance (Rebp).

B-1.18 The apparatus shall be calibrated to meet the following constraints:

(a) A graph of apparent total evaporative resistance versus number of layers of 7.5 oz/yd^2 Nomex duck shall be linear for the bare plate value, one, two, three and four layers.

(b) The slope of the linear regression shall be 0.005 kPa/m^2/W.

(c) No individual data measurement shall be outside ± 10% of the value predicted by the linear.

(d) The apparent intrinsic evaporative resistance of four layers of 7.5 oz/yd^2 Nomex duck shall be 0.020 kPa ± 10%/m^2/W.

B-1.19 The average apparent intrinsic evaporative resistance of the specimen shall be determined by averaging all values obtained over the equilibrium period (minimum of 6). The average apparent intrinsic evaporative resistance of the sample shall be determined by averaging the values of all specimens. If the results for any of the 3 individual specimens vary more than ± 10% from the average of all 3, then the test shall be repeated on the specimens(s) lying outside the ± 10% limit. If the retest produces a value(s) within the ± 10% limit, then the new value(s) shall be used instead. If the retest remains outside the ± 10% limit, then an additional 3 specimens shall be tested and all original and retest results shall be reported along with the average and standard deviation for apparent intrinsic evaporative resistance, and a statement identifying this sample as having a high variability.

B-1.20 The average total heat loss of the sample shall be determined and reported, subject of the reporting requirements in paragraphs 11, 16, and 19. The total heat loss of the sample shall be calculated from the following equation:

$$Q_t^* = \frac{10°C}{Rct + .04} + \frac{3.57\ kPa}{ARef + .0035}$$

where

Q_t = total heat loss (W/m^2)

Rct = average intrinsic thermal resistance of the sample determined in paragraph 5 (°C/m^2/W)

ARef = average apparent intrinsic evaporative resistance of the sample determined in paragraph 17 (kPa/m^2/W)

* These values are appropriate for a surface air layer at an air temperature of 25°C, a relative humidity of 65 percent, a skin temperature of 35°C, and a nominal effective air velocity of 2 m/s.

NOTE: This calculation is based on the temperature and vapor pressure differences between and the test plate and local environmental climate specified in this procedure. Other environmental conditions may alter the performance measured.

Using the total heat calculated under the conditions used here to extrapolate to other environmental temperatures and other environmental humidities may also produce inaccurate results because of possible condensation within a composite that would not be accounted for. The permeability index of the specimen and its associated air layer may also be calculated using the following equation:

$$i_m = 0.061 \times Rct/ARet$$

where

i_m = permeability index

Rct = total thermal resistance described in paragraph 6(°C/m^2/W)

ARet = apparent total evaporative resistance described in paragraph 15 (kPa/m^2/W)

i_m is the measure of the efficiency of evaporative heat transport in a clothing system. An i_m of 0 indicates that the clothing system allows no evaporative heat transfer. An i_m of 1 indicates that the clothing system achieves the theoretical maximum evaporative heat transfer allowed by its insulation. Casual dress clothing typically has values for i_m of 0.3 to 0.5. Protective clothing typically has values of i_m of 0.1 to 0.3.

Appendix C Referenced Publications

C-1 The following documents or portions thereof are referenced within this standard for informational purposes only and thus are not considered part of the requirements of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

C-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 1581, *Standard on Fire Department Infection Control Program*, 1991 edition

NFPA 1991, *Standard on Vapor-Protective Suits for Hazardous Chemical Emergencies*, 1990 edition

NFPA 1992, *Standard on Liquid Splash Protective Suits for Hazardous Chemical Emergencies*, 1990 edition

NFPA 1993, *Standard on Support Function Garments for Hazardous Chemical Operations*, 1990 edition

C-1.2 ASTM Publications. American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19130.

ASTM F 903, *Standard Test Method for Resistance of Protective Clothing Materials to Penetration by Liquids*, 1990

ASTM D 1518, *Standard Test Method for Thermal Transmittance of Textile Material*, 1985

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SUBMITTING PROPOSALS ON NFPA TECHNICAL COMMITTEE DOCUMENTS

Contact NFPA Standards Administration for final date for receipt of proposals on a specific document.

Note: All proposals must be received by 5:00 p.m. E.S.T./E.D.S.T. on the published proposal closing date.

INSTRUCTIONS

Use a separate proposal form for submitting each proposed amendment.

1. Type or print legibly in black ink.

2. Indicate the number, edition year, and title of the document. Also indicate the specific section or paragraph that the proposed amendment applies to.

3. Check the appropriate box to indicate whether this proposal recommends adding new text, revising existing text, or deleting text.

4. In the space identified as "Proposal" indicate the exact wording you propose as new or revised text, or the text you propose be deleted.

5. In the space titled "Statement of Problem and Substantiation for Proposal" state the problem which will be resolved by your recommendation and give the specific reason for your proposal. Include copies of test results, research papers, fire experience, or other materials that substantiate your recommendation.

6. Check the appropriate box to indicate whether or not this proposal is original material, and if it is not, indicate the source of the material.

7. Sign the proposal.

If supplementary material (photographs, diagrams, reports, etc.) is included, you may be required to submit sufficient copies for all members and alternates of the technical committee. The technical committee is authorized to abstract the "Statement of Problem and Substantiation for Proposal" if it exceeds 200 words for publication in the Technical Committee Reports.

NOTE: The NFPA Regulations Governing Committee Projects in Paragraph 10-10 state: Each proposal shall be submitted to the Council Secretary and shall include:

(a) identification of the submitter and his affiliation (Committee, organization, company) where appropriate, and

(b) identification of the document, paragraph of the document to which the proposal is directed, and

(c) a statement of the problem and substantiation for the proposal, and

(d) proposed text of proposal, including the wording to be added, revised (and how revised), or deleted.