High-Mass Impact Resistance Test, and shall have no full-thickness punctures, cracks, holes, or fractures.

•

7.6.2.8.2 Class 4 garment visor material seams shall be tested for seam strength as specified in Section 8.12, Seam/Closure Breaking Strength Test, and shall have a breaking strength of not less than 34 N/25 mm (7.5 lbf/1 in.).

N **7.6.2.9 Class 4 Elastomeric Interface Material Requirements.**

N **7.6.2.9.1*** Elastomeric interface materials shall have an elongation at rupture of not less than 125 percent when tested as specified in Section 8.28, Ultimate Tensile Strength Test.

N **7.6.2.9.2** Where the Class 4 garment includes elastomeric interface materials, each elastomeric interface material shall be tested for cut resistance as specified in Section 8.14, Cut Resistance Test, and shall have a blade travel distance of not less than 20 mm (0.8 in.).

N **7.6.2.9.3** Where the Class 4 garment includes elastomeric interface materials, each elastomeric interface material shall be tested for puncture resistance as specified in Section 8.15, Puncture Resistance Test 1, and shall have a puncture resistance of not less than 7 N (1.6 lbf).

N **7.6.2.9.4** Where the Class 4 garment includes elastomeric interface materials, each elastomeric interface material shall be tested for ultimate tensile strength as specified in Section 8.28, Ultimate Tensile Strength Test, and shall have an ultimate tensile strength of not less than 4 MPa (550 psi).

N **7.6.2.9.5** Where the Class 4 garment includes elastomeric interface materials, each elastomeric interface gasket material shall be tested for cold weather performance as specified in Section 8.11, Cold Temperature Performance Test 1, and shall have a bending moment of not greater than 0.057 N·m (½ in.·lbf) at an angular deflection of 60 degrees at –25°C (–13°F).

7.6.3 Class 4 Glove Element Requirements.

7.6.3.1 Class 4 gloves shall be tested for liquidtight integrity as specified in Section 8.21, Liquidtight Integrity Test 2, and shall show no leakage.

7.6.3.2 Class 4 glove materials and seams shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.20, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

7.6.3.3 Class 4 glove materials shall be tested for cut resistance as specified in Section 8.14, Cut Resistance Test, and shall have a blade travel distance of not less than 20 mm (0.8 in.).

7.6.3.4 Class 4 glove materials shall be tested for puncture resistance as specified in Section 8.15, Puncture Resistance Test 1, and shall have a puncture resistance of not less than 9 N (2 lbf).

7.6.3.5 Class 4 glove materials shall be tested for cold weather performance as specified in Section 8.11, Cold Temperature Performance Test 1, and shall have a bending moment of not greater than 0.057 N·m (½ in.·lbf) at an angular deflection of 60 degrees at –25°C (–13°F).

7.6.3.6 Class 4 gloves shall be tested for hand function as specified in Section 8.16, Glove Hand Function Test, and shall have an average percent increase over bare-handed control less than 200 percent.

7.6.4 Class 4 Footwear Element Requirements.

7.6.4.1 Class 4 footwear shall be tested for liquidtight integrity as specified in Section 8.21, Liquidtight Integrity Test 2, and shall show no leakage.

7.6.4.2 Class 4 footwear upper material shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.20, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

7.6.4.3 Class 4 footwear upper materials shall be tested for cut resistance as specified in Section 8.14, Cut Resistance Test, and shall have the distance of blade travel be not less than 20 mm (0.8 in.).

7.6.4.4 Class 4 footwear upper materials shall be tested for puncture resistance as specified in Section 8.15, Puncture Resistance Test 1, and shall have a puncture resistance of not less than 36 N (8 lbf).

7.6.4.5 Class 4 footwear soles and heels shall be tested for abrasion resistance as specified in Section 8.17, Abrasion Resistance Test, and the volume loss shall be not greater than 250 mm^3 (0.015 $in.^3$).

7.6.4.6 Class 4 footwear shall be tested for slip resistance as specified in Section 8.18, Slip Resistance Test, and shall have a coefficient of friction of 0.40 or greater.

7.6.4.7 Where the manufacturer specifies the use of a footwear cover to be worn over standard footwear, Class 4 footwear covers shall meet the requirements specified in 7.6.4.1, 7.6.4.2, 7.6.4.3, 7.6.4.4, 7.6.4.6, and 7.6.4.8, excluding 7.6.4.5.

7.6.4.8 Where the manufacturer specifies the use of a footwear cover to be worn over standard footwear, Class 4 footwear covers shall be tested for abrasion resistance as specified in Section 8.22, Abrasion Resistance Test 2, and shall show no wear-through after 3000 cycles.

7.6.4.9 Where footwear is designed and configured according to Section 6.4.10, the following requirements shall be met:

(1) The integrated socks shall meet the requirements specified in 7.6.4.2.
(2) The outer boot shall meet the requirements specified in 7.6.4.3 and 7.6.4.4.
(3) The integrity cover shall meet the requirements specified in 7.6.4.1, 7.6.4.7, and 7.6.4.8.

N **7.6.4.10** Where socks are used as part of a protective ensemble and the manufacturer permits the use of any outer boot of the footwear element that is certified to NFPA 1951, NFPA 1971, NFPA 1991, NFPA 1992, or NFPA 1999, the outer boot of the footwear element shall meet the minimum height requirement specified in 6.4.3 and cut resistance performance requirement specified in 7.6.4.3.

N **7.6.5 Class 4 Hood Element Requirements.**

N **7.6.5.1** Where a Class 4 protective hood is provided as a separate element and is not attached to the garment, the Class 4 protective hood shall meet all of the applicable requirements specified in 7.6.1, with the exception of 7.6.2.5 and 7.6.2.6 when the hood is part of a CBRN PAPR.

N **7.6.5.2*** Where the Class 4 hood includes an elastomeric interface material, the elastomeric interface material shall have an

elongation at rupture of not less than 125 percent when tested as specified in Section 8.28, Ultimate Strength Test.

N **7.6.5.3** Where the Class 4 hood includes an elastomeric interface material, the elastomeric interface material shall be tested for cut resistance as specified in Section 8.14, Cut Resistance Test, and shall have a blade travel distance of not less than 20 mm (0.8 in.).

N **7.6.5.4** Where the Class 4 hood includes an elastomeric interface material, the elastomeric interface material shall be tested for puncture resistance as specified in Section 8.15, Puncture Resistance Test 1, and shall have a puncture resistance of not less than 7 N (1.6 lbf).

N **7.6.5.5** Where the Class 4 hood includes an elastomeric interface material, the elastomeric interface material shall be tested for ultimate tensile strength as specified in Section 8.28, Ultimate Tensile Strength Test, and shall have an ultimate tensile strength of not less than 4 MPa (580 psi).

N **7.7 Class 4R Ensembles.**

N **7.7.1 Class 4R Ensemble General Requirements.**

N **7.7.1.1** Class 4R ensembles shall be tested for overall particulate inward leakage as specified in Section 8.5, Particle Inward Leakage Test, and shall allow no visual particulate inward leakage.

N **7.7.1.2** Class 4R ensembles shall be tested for overall function as specified in Section 8.3, Overall Garment Function and Integrity Test, and shall allow the test subject to complete all tasks within 15 minutes; the garment closure shall remain engaged during the entire garment function testing.

N **7.7.1.2.1** Where hoods are provided, garments shall accommodate head protection devices meeting the dimensional requirements of Type I, Class G helmets of ANSI/ISEA Z89.1, *American National Standard on Industrial Head Protection*.

N **7.7.1.2.2** Where hoods with visors are provided, garments shall permit the test subject to see with a visual acuity of 20/35 or better through the combination of the hood visor and the respirator facepiece lens.

N **7.7.1.2.3** Where protective flaps cover the closure, the protective flaps shall remain closed for the duration of the overall garment function test.

N **7.7.1.3** External fittings installed in Class 4R ensembles that are intended for tethered applications shall be tested for pull-out strength as specified in Section 8.6, Fitting Pull-Out Strength Test, and shall not have a failure force of less than 1000 N (225 lbf).

N **7.7.1.3.1** External fittings installed in Class 4R ensembles that are not intended for tethered applications shall be tested for pull-out strength as specified in Section 8.6, Fitting Pull-Out Strength Test, and shall not have a failure force of less than 135 N (30 lbf).

N **7.7.1.4** Exhaust valves installed in Class 4R ensembles shall be tested for mounting strength as specified in Section 8.23, Exhaust Valve Mounting Strength Test, and shall have a failure force greater than 135 N (30 lbf).

N **7.7.1.5** Exhaust valves installed in Class 4R ensembles shall be tested for inward leakage as specified in Section 8.24, Exhaust Valve Inward Leakage Test, and shall not exhibit a leakage rating exceeding 30 mL/min (1.83 in.^{3}/min).

N **7.7.2 Class 4R Garment Element Requirements.**

N **7.7.2.1** Class 4R garment materials and seams shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.20, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

N **7.7.2.2** Class 4R garment materials shall be tested for bursting strength as specified in Section 8.9, Burst Strength Test, and shall have a bursting strength of not less than 156 N (35 lbf).

N **7.7.2.3** Class 4R garment materials shall be tested for puncture propagation tear resistance as specified in Section 8.10, Puncture Propagation Tear Resistance Test, and shall have a puncture propagation tear resistance of not less than 31 N (7 lbf).

N **7.7.2.4** Class 4R garment materials shall be tested for cold weather performance as specified in Section 8.11, Cold Temperature Performance Test 1, and shall have a bending moment not greater than 0.057 N·m (½ in.·lbf) at an angular deflection of 60 degrees at −25°C (−13°F).

N **7.7.2.5** Class 4R garment materials shall be tested for evaporative heat transfer as specified in Section 8.8, Total Heat Loss Test, and shall have a total heat loss of not less than 450 W/m^2.

N **7.7.2.6** Class 4R garment materials shall be tested for evaporative resistance as specified in Section 8.19, Evaporative Resistance Test, and shall have an evaporative resistance of not greater than 30 Pa·m^2/W.

N **7.7.2.7** Class 4R garment seams shall be tested for seam strength as specified in Section 8.12, Seam/Closure Breaking Strength Test, and shall have a breaking strength of not less than 34 N/25 mm (7.5 lbf/1 in.).

N **7.7.2.8** Class 4R garment closure assemblies shall be tested for closure strength as specified in Section 8.12, Seam/Closure Breaking Strength Test, and shall have a breaking strength of not less than 34 N/25 mm (7.5 lbf/1 in.).

N **7.7.2.9 Class 4R Garment Visor Requirements.**

N **7.7.2.9.1** Class 4R garment visor materials shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.20, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

N **7.7.2.9.2** Class 4R garment visor materials shall be tested for high-mass impact resistance as specified in Section 8.13, Visor High-Mass Impact Resistance Test, and shall have no full-thickness punctures, cracks, holes, or fractures.

N **7.7.2.9.3** Class 4R garment visor material seams shall be tested for seam strength as specified in Section 8.12, Seam/Closure Breaking Strength Test, and shall have a breaking strength of not less than 34 N/25 mm (7.5 lbf/1 in.).

N **7.7.2.10 Class 4R Elastomeric Interface Material Requirements.**

N **7.7.2.10.1*** Elastomeric interface materials shall have an elongation at rupture of not less than 125 percent when tested as specified in Section 8.28, Ultimate Tensile Strength Test.

N **7.7.2.10.2** Where the Class 4R garment includes elastomeric interface materials, each elastomeric interface material shall be tested for cut resistance as specified in Section 8.14, Cut Resistance Test, and shall have a blade travel distance of not less than 20 mm (0.8 in.).

N **7.7.2.10.3** Where the Class 4R garment includes elastomeric interface materials, each elastomeric interface material shall be tested for puncture resistance as specified in Section 8.15, Puncture Resistance Test 1, and shall have a puncture resistance of not less than 7 N (1.6 lbf).

N **7.7.2.10.4** Where the Class 4R garment includes elastomeric interface materials, each elastomeric interface material shall be tested for ultimate tensile strength as specified in Section 8.29, Ultimate Tensile Strength Test, and shall have an ultimate tensile strength of not less than 4 MPa (580 psi).

N **7.7.2.10.5** Where the Class 4R garment includes elastomeric interface materials, each elastomeric interface material shall be tested for cold weather performance as specified in Section 8.11, Cold Temperature Performance Test 1, and shall have a bending moment of not greater than 0.057 N·m (½ in.·lbf) at an angular deflection of 60 degrees at −25°C (−13°F).

N **7.7.3 Class 4R Glove Element Requirements.**

N **7.7.3.1** Class 4R gloves shall be tested for liquidtight integrity as specified in Section 8.22, Liquidtight Integrity Test 2, and shall show no leakage.

N **7.7.3.2** Class 4R glove materials and seams shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.21, Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

N **7.7.3.3** Class 4R glove materials shall be tested for cut resistance as specified in Section 8.14, Cut Resistance Test, and shall have a blade travel distance of not less than 20 mm (0.8 in.).

N **7.7.3.4** Class 4R glove materials shall be tested for puncture resistance as specified in Section 8.15, Puncture Resistance Test 1, and shall have a puncture resistance of not less than 15 N (3.8 lbf).

N **7.7.3.5** Class 4R glove materials shall be tested for cold weather performance as specified in Section 8.11, Cold Temperature Performance Test 1, and shall have a bending moment of not greater than 0.057 N·m (½ in.·lbf) at an angular deflection of 60 degrees at −25°C (−13°F).

N **7.7.3.6** Class 4R gloves shall be tested for hand function as specified in Section 8.16, Glove Hand Function Test, and shall have an average percent increase over barehanded control less than 200 percent.

N **7.7.4**

N **7.7.4.1** Class 4R footwear shall be tested for liquidtight integrity as specified in Section 8.22, Liquidtight Integrity Test 2, and shall show no leakage.

N **7.7.4.2** Class 4R footwear upper material shall be tested for resistance to liquid or bloodborne pathogens as specified in Section 8.21 Viral Penetration Resistance Test, and shall allow no penetration of the Phi-X-174 bacteriophage for at least 1 hour.

N **7.7.4.3** Class 4R footwear upper materials shall be tested for cut resistance as specified in Section 8.14, Cut Resistance Test, and shall have a blade travel distance of not less than 20 mm (0.8 in.).

N **7.7.4.4** Class 4R footwear upper materials shall be tested for puncture resistance as specified in Section 8.15, Puncture Resistance Test 1, and shall have a puncture resistance of not less than 36 N (8 lbf).

N **7.7.4.5** Class 4R footwear soles and heels shall be tested for abrasion resistance as specified in Section 8.17, Abrasion Resistance Test 1, and the volume loss shall be not greater than 250 mm^3.

N **7.7.4.6** Class 4R footwear shall be tested for slip resistance as specified in Section 8.18, Slip Resistance Test, and shall have a coefficient of friction of 0.40 or greater.

N **7.7.4.7** Where the manufacturer specifies the use of a footwear cover to be worn over standard footwear, Class 4R footwear covers shall meet the requirements specified in 7.7.4.1, 7.7.4.2, 7.7.4.3, 7.7.4.4, 7.7.4.6, and 7.7.4.8, excluding 7.7.4.5.

N **7.7.4.8** Where the manufacturer specifies the use of a footwear cover to be worn over standard footwear, Class 4R footwear covers shall be tested for abrasion resistance as specified in Section 8.22, Abrasion Resistance Test 2, and shall show no wear-through after 3000 cycles.

N **7.7.4.9** Where footwear is designed and configured according to 6.4.10, the following requirements shall be met:

(1) The socks shall meet the requirements specified in 7.7.4.2.
(2) The outer boot shall meet the requirements specified in 7.7.4.3 and 7.7.4.4.
(3) The integrity cover shall meet the requirements specified in 7.7.4.1, 7.7.4.7, and 7.7.4.8.

N **7.7.4.10** Where socks are used as part of a protective ensemble and the manufacturer permits the use of any outer boot of the footwear element that is certified to NFPA 1951, NFPA 1971, NFPA 1991, NFPA 1992, or NFPA 1999, the outer boot of the footwear element shall meet the minimum height requirement specified in 6.4.3 and cut resistance performance requirement specified in 7.7.4.3.

N **7.7.5 Class 4R Hood Element Requirements.**

N **7.7.5.1** Where a Class 4R protective hood is provided as a separate element and is not attached to the garment, the Class 4R protective hood shall meet all of the applicable requirements specified in 7.7.1, with the exception of 7.7.2.5 and 7.7.2.6 when the hood is part of a CBRN PAPR.

N **7.7.5.2*** Where the Class 4R hood includes an elastomeric interface material, the elastomeric gasket material shall have an elongation at rupture of not less than 125 percent when tested as specified in Section 8.28, Ultimate Tensile Strength Test.

N **7.7.5.3** Where the Class 4R hood includes an elastomeric interface material, the elastomeric gasket material shall be tested for cut resistance as specified in Section 8.14, Cut Resistance Test, and shall have a blade travel distance of not less than 20 mm (0.8 in.).

N **7.7.5.4** Where the Class 4R hood includes an elastomeric interface material, the elastomeric interface material shall be tested for puncture resistance as specified in Section 8.15,

Puncture Resistance Test 1, and shall have a puncture resistance of not less than 7 N (1.6 lbf).

N **7.7.5.5** Where the Class 4R hood includes an elastomeric interface material, the elastomeric interface material shall be tested for ultimate tensile strength as specified in Section 8.28, Ultimate Tensile Strength Test, and shall have an ultimate tensile strength of not less than 4 MPa (580 psi).

N **7.8 Optional Chemical Flash Fire Escape Protection Requirements.**

N **7.8.1** Class 1 ensembles and ensemble elements shall also meet the applicable requirements specified in Section 7.1.

N **7.8.2** Class 2 ensembles and ensemble elements shall also meet the applicable requirements specified in Section 7.2.

N **7.8.3** Class 2R ensembles and ensemble elements shall also meet the applicable requirements specified in Section 7.3.

N **7.8.4** Class 3 ensembles and ensemble elements shall also meet the applicable requirements specified in Section 7.4.

N **7.8.5** Class 3R ensembles and ensemble elements shall also meet the applicable requirements specified in Section 7.5.

N **7.8.6** Class 4 ensembles and ensemble elements shall also meet the applicable requirements specified in Section 7.6.

N **7.8.7** Class 4R ensembles and ensemble elements shall also meet the applicable requirements specified in Section 7.8.

N **7.8.8** Protective ensembles or elements shall be tested for overall flash protection as specified by Section 8.29, Overall Ensemble Flash Test, and shall show afterflame times no longer than 2 seconds; in subsequent testing by test subjects of the ensemble shall allow no liquid penetration; and where a hood with visor is provided shall allow test subjects to have a visual acuity of 20/100.

N **7.8.9** Garment materials and, where applicable, visor, glove, footwear, and elastomeric interface materials shall be tested for heat transfer performance (HTP) as specified in Section 8.30, Heat Transfer Performance Test, and shall have an average HTP rating of not less than 12 cal/cm^2.

N **7.8.10** Garment materials and, where applicable, visor, glove, footwear, and elastomeric interface materials shall be tested for resistance to flame impingement as specified in Section 8.27, Flammability Resistance Test, and shall not burn a distance greater than 100 mm (4 in.), shall not sustain burning for more than 2 seconds, and shall not melt and drip.

N **7.9 Optional Stealth Requirements.**

N **7.9.1** Class 1 ensembles and ensemble elements shall also meet the applicable requirements specified in Section 7.1.

N **7.9.2** Class 2 ensembles and ensemble elements shall also meet the applicable requirements specified in Section 7.2.

N **7.9.3** Class 2R ensembles and ensemble elements shall also meet the applicable requirements specified in Section 7.3.

N **7.9.4** Class 3 ensembles and ensemble elements shall also meet the applicable requirements specified in Section 7.4.

N **7.9.5** Class 3R ensembles and ensemble elements shall also meet the applicable requirements specified in Section 7.5.

N **7.9.6** Class 4 ensembles and ensemble elements shall also meet the applicable requirements specified in Section 7.6.

N **7.9.7** Class 4R ensembles and ensemble elements shall also meet the applicable requirements specified in Section 7.8.

N **7.9.8** Garment, glove, footwear, and hood outer materials shall be tested for color/visibility in accordance with Section 8.31, Color/Visibility Test Method, and shall have a Y brightness value less than 25 and an L* value less than 55.

N **7.9.9** Ensembles shall be tested for audible signature as specified in Section 8.32, Audible Signature Test, and the audible signature in dBA shall be reported on both the product label and in the technical data package.

Chapter 8 Test Methods

8.1 Sample Preparation Procedures.

8.1.1 Application.

8.1.1.1 The sample preparation procedures contained in this section shall apply to each test method in this chapter, as specifically referenced in the sample section of each test method.

8.1.1.2 Only the specific sample preparation procedure or procedures referenced in the sample section of each test method shall be applied to that test method.

8.1.2 Room Temperature Conditioning Procedure for Garments, Gloves, Footwear, Hoods, Garment Materials, Visor Materials, Glove Materials, Footwear Materials, Hood Materials, Seams, and Closures.

8.1.2.1 Samples shall be conditioned at a temperature of 21°C ± 3°C (70°F ± 5°F) and a relative humidity of 65 percent ± 5 percent until equilibrium is reached, as specified in ASTM D1776, *Standard Practice for Conditioning and Testing Textiles*, or for at least 24 hours, whichever is shorter.

8.1.2.2 Samples shall be tested within 5 minutes after removal from conditioning.

Δ **8.1.3 Flexural Fatigue Procedure for Garment Materials.** Samples shall be subjected to flexural fatigue in accordance with ASTM F392/F392M, *Standard Practice for Conditioning Flexible Barrier Materials for Flex Durability*, with the following modifications:

(1) In lieu of Flexing Conditions A, B, C, D, or E, standard class test specimens shall have a flex period of 100 cycles at 45 cycles per minute. A cycle shall be full flex and twisting action.
(2) In lieu of Flexing Conditions A, B, C, D, or E, test specimens for Class Type R shall have a flex period of 1000 cycles at 45 cycles per minute. A cycle shall be a full flex and twisting action.
(3) Anisotropic materials shall be tested in both machine and transverse directions.
(4) All layers of garment material in the ensemble shall be present during flex conditioning.

Δ **8.1.4 Abrasion Procedure for Element Materials.** Samples shall be abraded in accordance with ASTM D4157, *Standard Test Method for Abrasion Resistance of Textile Fabrics (Oscillatory Cylinder Method)*, under the following conditions and with the following modifications:

(1) A 2.3 kg (5 lb) tension weight shall be used.

(2) A 1.6 kg (3.5 lb) head weight shall be used.
(3) Silicon carbide, ultrafine, 600 grit sandpaper shall be used as the abradant.
(4) The specimen shall be as shown in Figure 8.1.4.
(5) Standard class specimens shall be abraded for 10 continuous cycles. Class Type R specimens shall be abraded for 100 continuous cycles.
(6) All layers of the element material shall be subjected to the abrasion conditioning.

8.1.5 Flexural Fatigue Procedure for Gloves.

8.1.5.1 Sample gloves shall be subjected to one full cycle of testing for hand function as specified in Section 8.16, Glove Hand Function Test.

8.1.5.2 All layers of glove material shall be present during flex conditioning.

Δ **8.1.6 Flexural Fatigue Procedure for Footwear.** Sample footwear shall be subjected to 100,000 flexes in accordance with Appendix B of FIA Standard 1209, *Whole Shoe Flex*, with the following modifications:

(1) Water shall not be used.
(2) The flex speed shall be 60 ± 2 cycles per minute.
(3) Alternative flexing equipment shall be permitted to be used when the flexing equipment meets the following parameters:
   (a) The alternative flexing equipment is capable of providing the angle of flex as described in FIA 1209.
   (b) The alternative flexing equipment is capable of a flex speed of 60 ± 2 cycles per minute.
   (c) The alternative flexing equipment provides a means of securing the footwear during flexing.

8.1.7 Fatigue Procedure for Suit Closure Assemblies. Sample suit closure assemblies shall be exercised a total of 50 openings and 50 closings.

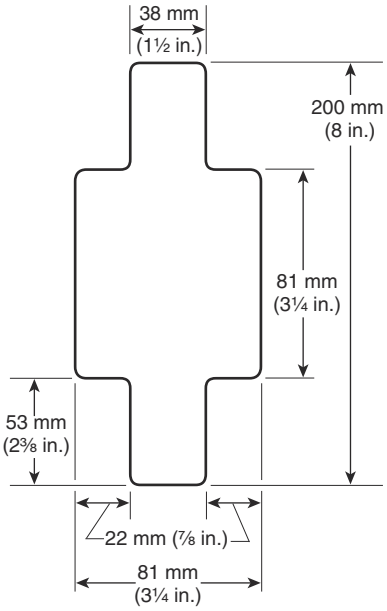


FIGURE 8.1.4 Specimen Configuration.

8.1.8 Elevated Humidity Conditioning Procedure for Garment, Glove, Footwear Seam, Closure, Visor Materials, and Exhaust Valves. Samples for elevated humidity shall be conditioned at 21°C ± 3°C (70°F ± 5°F) and a relative humidity of 80 percent ± 5 percent until equilibrium is reached, as specified in ASTM D1776, *Standard Practice for Conditioning and Testing Textiles*, or for at least 24 hours, whichever is shorter.

N **8.1.9 Class Type R Ensemble Preconditioning Procedure.**

N **8.1.9.1** Samples shall be washed and dried alternately for a total of five washing cycles and five drying cycles.

N **8.1.9.2** Samples shall be washed and dried with all closures fastened.

N **8.1.9.3** A front-loading washer/extractor shall be used for washing the samples.

N **8.1.9.4** The wash load shall be two-thirds the rated capacity of the washer.

N **8.1.9.4.1** If ballast is needed to reach two-thirds capacity, ballast shall be used.

N **8.1.9.4.2** Two-thirds of the rated capacity shall not be exceeded.

N **8.1.9.5** The wash cycle procedure in Table 8.1.9.5 shall be followed.

N **8.1.9.6** A tumble dryer with a dry stack temperature of 38°C to 49°C (100°F to 120°F) measured 20 minutes into the drying cycle shall be used for drying the samples.

N **8.1.9.7** Samples shall be removed from the dryer after 20 minutes of tumble drying. At the conclusion of the final drying cycle, the sample shall be allowed to dry completely for at least 48 hours in accordance with 8.1.2.

8.2 Man-In-Simulant Test (MIST).

8.2.1 Application. This test shall apply to Class 1, Class 2, Class 2R, Class 3, and Class 3R ensembles.

Table 8.1.9.5 Wash Cycle Procedure for Type R Ensembles

Operation	Time (min)	Temperature °C ± 3°C	Temperature °F ± 5°F	Water Level
Suds using AATCC detergent #1993, 1.0 g/4 L (1 gal) water				
Drain	1			
Carryover	5	49	120	Low
Drain	1			
Rinse	2	38	100	High
Drain	1			
Rinse	2	38	100	High
Drain	1			
Rinse	2	38	100	High
Drain	1			
Extract	5			

8.2.2 Samples.

8.2.2.1 Samples for conditioning shall be complete ensembles and shall include the respirator where the ensemble utilizes the respirator facepiece as the ensemble visor.

8.2.2.2 Samples for Class Type R shall be conditioned as specified in 8.1.9.

N **8.2.2.3** Samples shall be conditioned as specified in 8.1.2.

8.2.3 Specimens.

8.2.3.1 The specimen shall be a complete ensemble with gloves and footwear and shall include the respirator where applicable.

8.2.3.2 Where the ensemble utilizes the respirator facepiece as the ensemble visor as specified in 6.1.7, the ensemble shall be tested with each type or model of the respirator specified by the manufacturer.

8.2.3.3 Where the respirator is completely encapsulated by the ensemble, the ensemble shall be tested with a respirator specified by the manufacturer.

8.2.3.4 A minimum of four specimens shall be tested. The specimens shall represent a minimum of two different ensemble sizes.

8.2.3.5 Where the ensemble has multiple types of external fittings, each type of external fitting shall be present on each specimen at the time of testing.

8.2.3.6 Specimens shall be provided to fit or be adjustable to fit the selected test subjects in accordance with the manufacturer's sizing provisions that are specific to each ensemble.

8.2.3.7* None of the ensembles or components of the ensemble to be tested shall have been previously subjected to MIST testing unless it can be demonstrated that the ensemble or components are free of contamination.

8.2.3.8 Underclothing and socks shall be permitted to be reused, provided they have been laundered with a detergent that has been demonstrated not to cause interference with the analytical method.

N **8.2.3.9** Where socks are used as part of the protective ensemble, it shall be permitted that testing be performed on only one representative outer boot style for the evaluation of the ensemble.

8.2.4 Apparatus.

8.2.4.1 Test Facility.

8.2.4.1.1 The test facility shall include areas for dressing, a first-stage undressing area adjacent and accessible to the chamber, and a second-stage undressing area adjacent and accessible to the first-stage undressing area.

8.2.4.1.2 The test shall be conducted in a sealed chamber with a minimum volume of sufficient dimensions to permit free movement of the test subject(s) when fully dressed in the ensemble and for the test subject(s) to carry out the physical exercise routine specified in 8.2.5.8.

8.2.4.1.3 More than one test subject shall be permitted in the chamber at the same time, provided that they can complete all tasks in the appropriate time period and that they have an unobstructed direct path to the wind stream.

8.2.4.1.4 The test chamber shall have a temperature of 25°C ± 2°C, relative humidity of 55 percent ± 10 percent, and a nominal wind speed of 0.9 m/sec to 2.2 m/sec (2 mph to 5 mph). The average wind speed shall be 1.6 m/sec ± 0.2 m/sec (3.5 mph ± 0.5 mph).

8.2.4.2 Test Chemical and Analytical Equipment.

8.2.4.2.1 The test simulant shall be methyl salicylate (MeS; $C_8H_8O_8$), CAS 119-36-8, more commonly known as oil of wintergreen. The MeS minimum purity shall be 95 percent. Vapor doses shall be measured using passive adsorbent dosimeters (PADs).

8.2.4.2.2* The standard concentration of MeS in the vapor chamber shall be 150 mg/m^3 ± 15 mg/m^3 as measured by a real-time infrared analysis of the chamber air or other validated real-time analytical technique.

8.2.4.2.3 Infrared readings shall be taken every 60 seconds to verify compliance with the concentration requirement, and an air sample shall be taken at least every 10 minutes for validation of infrared readings.

8.2.4.2.4 The generation of liquid aerosol shall be avoided.

8.2.4.2.5 The sensitivity of the analytical technique used for the measurement of MeS in the PADs shall provide a detection limit of 30 ng MeS per PAD. The analytical technique shall have an upper limit of quantification of 31,500 ng.

Δ **8.2.4.3* Passive Adsorbent Dosimeters (PADs).** The test shall be conducted using passive adsorbent dosimeters (PADs) that affix directly to the skin of the test subjects and that have the following characteristics:

(1) The PADs shall be a foil packet that contains an adsorbent material covered by a high-density polyethylene film that acts as a pseudo-skin barrier.
(2) The PADs shall have an uptake rate of 3.0 cm/min or greater.

8.2.4.4 Test Subjects.

8.2.4.4.1 All test subjects shall be medically and physically suitable to perform these tests without danger to themselves, and a medical certificate for each test subject shall have been issued within 12 months prior to testing.

8.2.4.4.2 Test subjects shall be familiar with the use of chemical protective ensembles and with the selected CBRN SCBA.

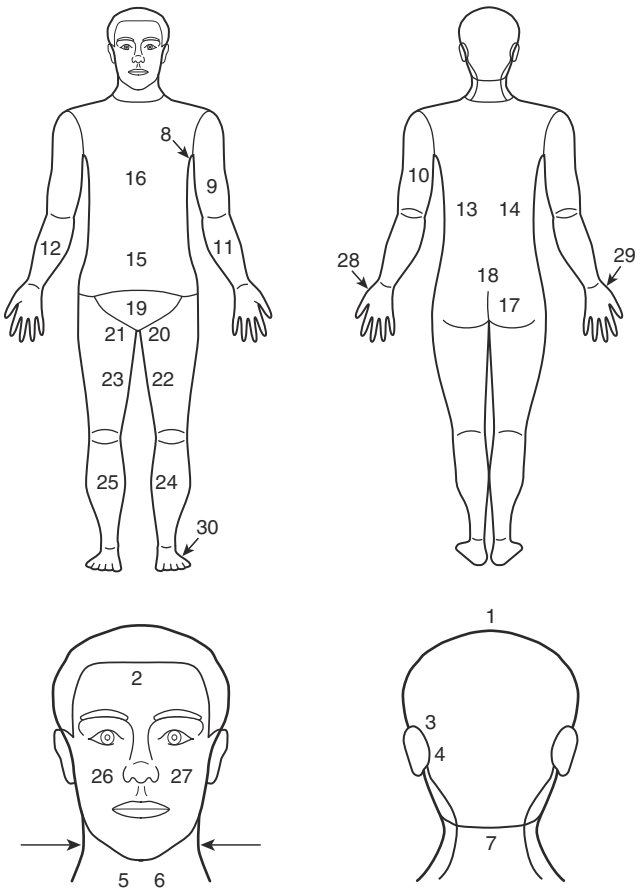
8.2.5 Procedure.

8.2.5.1 Test subjects shall have followed pretrial procedures that include proper hydration and avoiding personal hygiene products that could contain MeS.

8.2.5.2 PADs shall be placed on test subjects at the body region locations shown in Figure 8.2.5.2.

8.2.5.2.1 All PADs shall be applied in a clean dressing area, by personnel who have followed pretrial procedures to minimize contamination. Test subjects shall also follow pretrial procedures to minimize contamination.

8.2.5.2.2 Cheek PADs shall be located entirely within the respirator facepiece, and all other PADs shall be located entirely outside the seal of the respirator facepiece.



1: scalp (SCA)
2: forehead (F)
3: behind left ear upper (LED)
4: behind left ear (LE)
5: neck right (NED)
6: neck left (NE)
7: nape (NA)
8: left armpit (LA)
9: left inner upper arm (LIU)
10: left outer upper arm (LOU)
11: left forearm (LFA)
12: right forearm (RFA)
13: middle back (MB)
14: middle back dup. (MBD)
15: abdomen (AB)
16: chest (C)
17: right buttock (RB)
18: lower back (LB)
19: groin (GR)
20: crotch (LCR)
21: crotch (RCR)
22: left inner thigh (LIT)
23: right inner thigh (RIT)
24: left inner shin (LIS)
25: right inner shin (RIS)
26: cheek (RM)
27: cheek (LM)
28: left hand (G)
29: right hand (GD)
30: foot (B)

FIGURE 8.2.5.2 Locations of Passive Adsorption Dosimeters (PADs) on Test Subjects.

8.2.5.3 Three additional PADs shall be used to conduct background sampling and for quality control during the trial. These PADs shall be located in the dressing area, the Stage 1 undress area, and the Stage 2 undress area.

8.2.5.4 The test subject shall don the protective ensemble and respirator in accordance with the manufacturer's instructions in an area located away from the test chamber. The test subject shall wear clothing under the CBRN protective ensemble as specified by the manufacturer. If no undergarments are specified or required by the manufacturer as part of the certified ensemble, the test subject shall wear a short-sleeve cotton shirt and shorts or underwear.

8.2.5.5 After sealing the ensemble, the test subject shall enter the test chamber, and the test chamber shall be sealed.

8.2.5.6 The test duration will be 30 minutes in the chamber with a 5-minute decontamination period.

8.2.5.7 The start of the test, in which the test subject enters the MIST chamber, shall be initiated within 60 minutes after removal of the ensemble from the conditioning environment.

8.2.5.8 Physical Exercise Routine.

Δ **8.2.5.8.1** Once the chamber concentration has been established, the test subject(s) shall perform the following physical activity protocol. The chamber concentration shall remain within acceptable limits during the exercise protocol.

(1) Drag 70 kg (154 lb) human dummy using both hands a distance of 10 m (33 ft) over a 15-second period. Stop and rest for 15 seconds. Repeat exercise twice.
(2) Duck squat, pivot right, pivot left, stand. Rotate orientation 90 degrees to wind stream between each repetition. Repeat exercise twice in each orientation for a total of 1 minute.
(3) Stand erect. With arms at sides, bend body to left and return, bend body forward and return, bend body to right and return. Rotate orientation 90 degrees to wind stream between each repetition. Repeat exercise twice in each orientation for a total of 1 minute.
(4) Stand erect. Extend arms overhead in the lateral direction, then bend elbows. Extend arms overhead in the frontal direction, then bend elbows. Rotate orientation 90 degrees to wind stream between each repetition. Repeat exercise twice in each orientation for a total of 1 minute.
(5) Stand erect. Extend arms perpendicular to the sides of torso. Twist torso left and return, twist torso right and return. Rotate orientation 90 degrees to wind stream between each repetition. Repeat exercise twice in each orientation for a total of 1 minute.
(6) Stand erect. Reach arms across chest completely to opposite sides. Rotate orientation 90 degrees to wind stream between each repetition. Repeat exercise twice in each orientation for a total of 1 minute.
(7) Climb two steps of the ladder and touch the ceiling with one hand (use alternate hands each time). Climb down, squat, and touch the floor with both hands. Repeat exercise three times within 1 minute.
(8) Crawl in place for 1 minute. Rotate orientation 90 degrees to wind stream every 15 seconds.
(9) Sit on stool (facing wind) for 1 minute.
(10) Sit on stool (back to wind) for 1 minute.

8.2.5.8.2 Physical activities and rest periods shall be performed in a chamber location that provides an unobstructed exposure of the protective ensemble to the required wind stream.

8.2.5.8.3 Each physical activity and rest cycle shall be 10 minutes. The cycle of exercise and rest shall be completed a total of three times, for a total chamber exposure of 30 minutes. Each exercise cycle shall consist of eight 1-minute activities followed by a 2-minute rest (sitting) period.

8.2.5.8.4 The test subject shall begin the first repetition of each activity facing the wind stream and shall rotate 90 degrees between each repetition until the time period for that exercise has ended.

8.2.5.8.5 For activity 8 (crawling in place), the test subject shall rotate 90 degrees on 15-second intervals during the 1-minute period.

8.2.5.8.6 All physical activities shall be a full range of motion and performed at a moderate speed.

8.2.5.9 Decontamination and Doffing.

8.2.5.9.1 After completion of the 30-minute MIST exposure, the subjects shall move to a decontamination area, where they shall remain for at least 5 minutes. This area shall be well-ventilated to assist in off-gassing of the outside of the ensemble.

8.2.5.9.2 In the decontamination area, all exposed ensemble surfaces, including such items as the respirator, boots, gloves, and helmets, shall be washed with a liquid soap solution.

8.2.5.9.2.1 If the garment is designed for wet decontamination, it shall be washed with the soap solution as well.

8.2.5.9.2.2 Alternative decontamination methods, such as an air wash, shall be permitted if the selected decontamination method can be demonstrated to remove MeS to levels that do not result in contamination of the test subjects during the doffing of the protective ensemble.

8.2.5.9.3 The decontaminated test subject shall move to the first-stage undressing room where all remaining items of clothing, except underwear, shall be doffed. The undressing process shall not exceed 5 minutes.

8.2.5.9.4 As soon as the garment is unsealed and the PADs on the test subject's body are exposed to the ambient atmosphere in the first-stage undressing room, three fresh PADs shall be placed near the test subject to detect background MeS concentrations.

8.2.5.9.5 As soon as all items of clothing, except underwear, are removed, the decontaminated test subject shall proceed to the second-stage undressing room and the background PADs shall be collected and handled as specified in 8.2.5.9.7. The exposure time for the first-stage undressing room background PADs shall be recorded.

8.2.5.9.6 When the test subject enters the second-stage undressing room, three additional PADs shall be placed near the test subject and the exposure PADs shall be removed from the test subject's body. Both the second-stage undressing room background PADs and the exposure PADs taken off the test subject's body shall be handled as specified in 8.2.5.9.7. The exposure time for the second-stage undressing room PADs shall be recorded.

8.2.5.9.7 Where an adhesive is used on the back of the PADs, each PAD shall be backed with aluminum foil, placed in individual sealed glass vials with a nonadsorbent lid liner, and shall remain at room temperature of 25°C ± 3°C (77°F ± 5°F) for 30 min ± 5 min immediately after exposure.

8.2.6 PAD Qualification and Analysis.

8.2.6.1 The uptake rate for each lot of PADs shall be determined in accordance with 8.2.6.2, using a minimum of seven PADs selected randomly from the lot.

8.2.6.2* Measurement of PAD Uptake Rate.

8.2.6.2.1 The PAD uptake rate shall be measured by exposing PADs in a small-scale chamber under the following conditions:

(1) The concentration of MeS shall be 1 mg/m^3 ± 0.5 mg/m^3.
(2) The temperature shall be 35°C ± 2°C (94°F ± 4°F).
(3) The relative humidity shall be 55 percent ± 20 percent.
(4) The flow of MeS in the humidified air or nitrogen shall be at a rate of 1 cm/sec ± 0.2 cm/sec over the PAD.
(5) The exposure shall be conducted for a period of 30 min +1/-0 min.

8.2.6.2.2 The PAD uptake rate shall be calculated in accordance with the procedures provided in 8.2.6.2.1. The average of all PAD uptake rates shall be calculated and used in the calculation of MeS dosage on the test subject PADs.

8.2.6.3 After their initial 30 minutes at room temperature, the PADs shall be subjected to one of the following handling and analysis procedures:

(1) The PADs shall be stored at a cold temperature sufficient to prevent the migration of MeS from the adhesive until extraction or analysis.
(2) The PADs shall be extracted within 4 hours.
(3) The adsorbent shall be removed and thermally desorbed within 4 hours.

8.2.6.3.1 The determination of a sufficiently low temperature that prevents migration of the MeS from the adhesive shall be made by exposing 12 PADs simultaneously in the test chamber in a vertical position at a concentration of 100 mg/m^3 of MeS for 30 min +5/–0 min. After this exposure, the PADs shall be covered in foil, each placed in a sealed container, and stored at 25°C ± 3°C (77°F ± 5°F) for 30 min ± 5 min. Four of the PADs shall be packed in dry ice for 24 hours, four placed in the proposed cold storage temperature for 24 hours, and four extracted or analyzed within 4 hours. The average mass absorbed on the four PADs stored at the proposed storage temperature shall equal with 95 percent confidence the average mass absorbed on four PADs stored for 24 hours in dry ice and the four PADs analyzed immediately after exposure.

8.2.6.3.2 Where liquid extraction of the PADs samples is performed, the liquid extracts shall be stored at 0°C to 4°C (32°F to 39°F) for up to 14 days following their exposure before analysis.

8.2.6.4 The actual MeS vapor exposure concentration and the actual time of exposure shall be used to determine the uptake rate from the following equation:

N

$$u = m / ACt \qquad \textbf{[8.2.6.4]}$$

where:
u = uptake rate (cm/min)
m = total mass of MeS measured on the PAD (mg)
A = average active area of the PAD (cm^2)
Ct = exposure vapor dosage (mg·min/cm^3)

8.2.6.5 The range of the analytical technique shall be sufficient to measure the expected range of MeS dosage on the test subject PADs.

8.2.6.5.1 When liquid extraction is used as the analytical technique, the calibration curve used for determining the equipment response to MeS shall be established using at least four MeS concentration standards accounting for the proper density of the extraction solvent.

8.2.6.6 For the test results to be considered valid for a given ensemble, no more than one PAD from each of the body region locations tested (i.e., no more than one PAD of the four replicates for any particular region) shall be permitted to be lost to analysis over the course of the four test subjects.

8.2.7 Calculations.

8.2.7.1 The dosage measured by each PAD ($Ct_{inside,i}$) shall be determined using the average uptake rate determined for the PAD lot used in the evaluation of a specific ensemble using the following equation:

N

[8.2.7.1]

$$Ct_{inside,i} = m_i / u_{avg} A$$

where:

$Ct_{inside,i}$ = MeS vapor dosage at the specific PAD (mg/min/cm^3)
m_i = total mass of MeS measured on the specific PAD (mg)
u_{avg} = average uptake of the PAD lot (cm/min)
A = average active area of the PAD (cm^2)

8.2.7.1.1 The protection factor at each PAD location shall be calculated using the following equation where the $Ct_{outside}$ shall be determined from the measured chamber vapor dosage of the individual trial over the entire exposure. The value for $Ct_{outside}$ shall be the average of the chamber MS concentration readings taken during the course of the test subject exposure period:

N

[8.2.7.1.1]

$$PF_i = \frac{Ct_{outisde}}{Ct_{inside_i}}$$

8.2.7.1.2 Where the measured total mass of MeS for a given PAD falls below 30 ng, the value of 30 ng shall be used for that specific PAD.

8.2.7.2 All results for each PAD location shall be expressed in terms of the local physiological protective dosage factor (PPDF) value and shall be calculated according to the following equation:

N

[8.2.7.2]

$$local\ PPDF_i = \frac{OSED_i}{25} PF_i$$

Δ **8.2.7.2.1*** The site-specific onset of symptoms exposure dosages (OSED) for each PAD shall be based on ECt_{10} values for mustard blistering/ulceration according to Table 8.2.7.2.1.

8.2.7.2.2 The average local PPDF values at each PAD location for all specimens tested shall be calculated.

Δ **8.2.7.3** A systemic PPDF shall also be calculated from the PAD data. The systemic protection analysis shall use the systemic weighting body region hazard analysis values from Defence Research Establishment Suffield Report and National Research Council Report listed in 2.3.9 to calculate the systemic PPDF for each ensemble test ($PPDF_{sys}$). The $PPDF_{sys}$ for each specimen is calculated as follows, where each of the terms is calculated using the information in Table 8.2.7.3. The value of PF_i used in the calculation is the average of the measured PF_i for each body region listed in the table under the heading "Body Region I for BRHA Model."

Δ **Table 8.2.7.2.1 Site-Specific Onset of Symptoms Exposure Dosage (OSED) by PAD Location**

Body Region	PAD Location	OSED (mg·min·m^{-3})
Head/neck	1, 2, 3, 4, 5, 6 26, 27	100
Torso/buttocks (excluding perineum)	13, 14, 15, 16, 17, 18, 19	100
Arm/hand	8, 9, 10, 11, 12, 28, 29	50
Leg/foot	22, 23, 24, 25, 30	100
Perineum	20, 21	25

N

[8.2.7.3]

$$PPDF_{sys} = \frac{\sum_i \frac{dz_i}{ED_{50_i}}}{\sum_i \frac{dz_i}{ED_{50_i} PF_i}}$$

8.2.7.3.1 The average systemic PPDF for all specimens tested shall be calculated.

8.2.8 Report.

8.2.8.1* The individual specimen and geometric mean local $PPDF_i$ values for each PAD location shall be recorded and reported.

8.2.8.2* The $PPDF_{sys}$ value for each specimen and the geometric mean $PPDF_{sys}$ value for the ensemble tested shall be recorded and reported.

8.2.8.3 A spreadsheet shall be prepared that shows all test measurements and calculations including at least the following:

(1) The MeS vapor exposure concentration for PAD lot qualification
(2) The exposure time used for PAD lot qualification
(3) The measured MeS mass on each PAD used for PAD lot qualification
(4) The individual and the average PAD uptake rates
(5) The measured MeS mass on each PAD used in the dressing room, first-stage undressing room, and second-stage undressing room
(6) The measured MeS mass on each PAD placed on the test subject
(7) The calculated vapor dosage for each PAD placed on the test subject

8.2.9 Interpretation. The geometric mean $PPDF_i$ value at each PAD location and the geometric mean $PPDF_{sys}$ value shall be used to determine pass or fail performance.

Δ Table 8.2.7.3 ED_{50i} Values by PAD and Body Location

Body Region *i* forBRHA Model	PADs Mapped to This Region (Average Dosage from Each PAD, Then Calculate PF_i)	Area of Body Region(dz_i, cm^2)	ED_{50i} for Severe Effects (VX) for Body Region (mg/ Individual)
Scalp	1, 2	350	0.76
Ears	3, 4	50	0.46
Face, cheeks, and neck	5, 6, 26, 27	300	0.48
Chin and neck	5, 6	200	0.36
Nape	7	100	1.72
Abdomen	16	2858	2.23
Back	13, 14, 18	2540	2.65
Axillae	8	200	2.07
Upper arm medial	9	488	2.8
Upper arm lateral	10	706	6.57
Elbow fold	9, 10, 11, 12	50	2.09
Elbow	9, 10, 11, 12	50	2.25
Forearm extensor	11, 12	487	2.8
Forearm flexor	11, 12	706	6.57
Hands dorsum	28, 29	200	2.91
Hands palmar	28, 29	200	9.24
Buttocks	17	953	4.26
Groin	15, 19	300	1.22
Scrotum	20, 21	200	0.11
Thigh anterior	22, 23	2845	6.57
Thigh posterior	22, 23	1422	4.26
Knee	22, 23, 24, 25	200	7.14
Popliteal space (back of knees)	22, 23, 24, 25	100	2.09
Shins	24, 25	1897	6.57
Calves	24, 25	948	2.8
Feet dorsum	30	500	6.6
Feet plantar	30	300	7.14

8.3 Overall Garment Function and Integrity Test.

8.3.1 Application. This test method shall apply to complete ensembles with gloves, footwear, hoods, and respirator if applicable.

•

8.3.2 Samples.

Δ 8.3.2.1 Samples shall be complete ensembles with gloves, footwear, hoods, and respirator as applicable.

***N* 8.3.2.2** Samples for Class Type R shall be conditioned as specified in 8.1.9.

8.3.2.3 Samples shall be conditioned as specified in 8.1.2.

8.3.3 Specimens.

8.3.3.1 Specimens shall be complete ensembles with gloves, footwear, hoods, and respirator, as applicable.

8.3.3.2 At least three specimens shall be tested.

8.3.3.3 The specimen shall include all outerwear and other items required for the ensemble to be compliant with this standard.

8.3.3.4 Where the ensemble offers multiple types of external fittings, each type of external fitting shall be installed in the ensemble prior to testing.

8.3.3.5 Where the ensemble uses the respirator facepiece as the ensemble visor as specified in 6.1.7, each style of the ensemble shall be tested with each style of the respirator specified by the manufacturer.

***N* 8.3.3.6** Where socks are used as part of the protective ensemble, it is permitted that testing be performed on only one representative outer boot style for the evaluation of the ensemble.

***N* 8.3.4 Apparatus.** The equipment and supplies specified in ASTM F1154, *Standard Practices for Qualitatively Evaluating the Comfort, Fit, Function, and Durability of Protective Ensembles and Ensemble Components*, shall be used along with the following additional items:

(1) A Snellen eye chart for a 6 m (20 ft) distance
(2) A stopwatch or other timing device
(3) A protractor or other device to measure the angle of the placard relative to the test subject
(4) An NFPA 704–based placard as seen in Figure 8.3.4.