N 8.52.8.4 The faceshield shall be mounted with only enough force to secure the faceshield in the sample holder. The mounting screws shall not be tightened to the point of distorting the faceshield or sample holder.

8.53 Radiant Heat Resistance Test 3.

8.53.1 Application. This test shall apply to helmet shell systems.

8.53.2 Samples.

8.53.2.1 One sample helmet shell shall be used.

8.53.2.2 The sample helmet shall have any reflective outer covering in place as intended for use, but shall have all shock absorbing and thermally insulating materials removed from the interior.

8.53.3 Specimens. Specimens shall be conditioned as specified in 8.1.3.2.

8.53.4 Apparatus.

8.53.4.1 The test apparatus shall be the radiant exposure chamber as specified in 8.1.6.

8.53.4.2 The sensor shall be an exposed bead Type J or K30 AWG thermocouple that will be connected to a recording device that is capable of reading degrees centigrade.

8.53.5 Calibration Procedure. The chamber shall be calibrated according to the calibration procedure specified in 8.1.6 to obtain a stable uniform irradiance of $1.0 \text{ W/cm}^2 \pm 0.1 \text{ W/cm}^2$.

8.53.6 Procedure.

8.53.6.1 One specimen helmet shell, with any reflective outer covering in place as intended for use but with all shock absorbing and/or thermally insulating materials removed from the interior, shall be used.

8.53.6.2 An exposed bead Type J or K30 AWG thermocouple shall be fastened to the inner surface of the specimen helmet shell in such a way that the thermocouple bead is in contact with the shell material. The thermocouple bead shall be permitted to be placed at any location within a 100 mm (4 in.) diameter of where the front rear axis of the center line of the shell and the intersection of the bitragion coronal meet. There shall be no internal or external projections greater than 2 mm ($\frac{1}{16}$ in.) in height on the shell within 25 mm (1 in.) of the thermocouple bead in any direction. The thermocouple shall be connected to a recording device that reads degrees centigrade.

8.53.6.3 The specimen helmet with thermocouple shall be placed in the radiant exposure chamber specified in 8.1.6. With the radiant panel adjusted to provide a stable uniform irradiance of $1.0 \text{ W/cm}^2 \pm 0.1 \text{ W/cm}^2$ in accordance with 8.1.6, the sample shall be placed in the chamber so that the thermocouple location is in the center of the area of radiant exposure.

8.53.6.4 The specimen shall be exposed to an irradiance of $1.0 \text{ W/cm}^2 \pm 0.1 \text{ W/cm}^2$ for 180 seconds.

8.53.6.5 Thermocouple temperatures shall be recorded at the beginning and at the end of the 180 seconds.

8.53.7 Report. The difference of the initial temperature and the temperature at 180 seconds shall be recorded and reported.

8.53.8 Interpretation. Any rise in temperature greater than 25° C (78°F) shall constitute failure of this test.

8.54 Wet Flex Test.

8.54.1 Application. This test method shall apply to garment outer shell materials, glove outer shell materials, helmet face-shields, footwear, helmet outer covers, and helmet shrouds.

8.54.2 Samples. Samples shall be conditioned as specified in 8.1.3.

8.54.3 Specimens. Specimens shall be 100 mm \times 200 mm (4 in. \times 8 in.) with the long dimension parallel to the warp or wale direction and shall be from the fabric lot used in the construction of the proximity protective garment.

8.54.3.1 Five (5) specimens from each sample unit shall be tested with no two specimens containing the same yarns.

8.54.3.2 The specimens shall be immersed in water at 60° C $\pm 3^{\circ}$ C (140° F $\pm 5^{\circ}$ F), for 15 minutes.

8.54.3.3 Upon removal from the water, the test specimen shall be placed on two layers of absorbent-type blotters and covered by two additional layers.

8.54.3.4 The blotting paper shall conform to the requirements in AATCC 35, *Water Resistance: Rain Test.*

8.54.3.5 After placing the wet specimens between the blotters, a 4.5 kg (10 lb) weight, a steel rod 75 mm (3 in.) in diameter and 125 mm (5 in.) long, shall be rolled over the test specimen for four complete cycles, eight passes.

8.54.3.6 The specimen shall be removed from between the blotters and placed in the flexing device as specified in 8.54.3.4.

8.54.4 Apparatus.

8.54.4.1 The flexing device as shown in Figure 8.54.4.1(a) and Figure 8.54.4.1(b) shall be used.

8.54.4.2 The flexing device shall have a suitable weight on the weight arm to produce a 13.5 N to 15.75 N (3 lb to 3.5 lb) tension on the specimen during flexing.

8.54.4.3 The tensioning jaw or clamp shall be so located that, with the tension jaw arm vertical, any point on the tensioning jaw would be the apex of a cone of motion generated between that point and the corresponding point of the moving jaw.

8.54.4. The crank arms shall be equal in effective length and in angular phase so that the moving jaw connecting the two arms remains parallel to the tension jaw throughout a complete revolution of the arms.

8.54.4.5 A tray or board, flat black in color and sufficiently large to catch any particles that are removed from the fabric, shall be cleaned before each test and examined for material particles after each test.

8.54.4.6 A motor-driven apparatus shall be permitted to be used in lieu of the manual device specified.

8.54.5 Procedure.

8.54.5.1 The specimens shall be taken directly from the blotter paper and placed in the flexing device with the warp or wale direction perpendicular to the jaw line.



FIGURE 8.54.4.1(a) End View of Flexing Device.



Δ FIGURE 8.54.4.1(b) Top View of Flexing Device.

8.54.5.2 The distance between jaw lines shall be 135 mm $(5\frac{1}{4} \text{ in.})$.

8.54.5.3 The specimen shall be placed in the device with the moving jaw at bottom dead center, the tension jaw arm vertical, and the face of the cloth down.

8.54.5.4 Each jaw shall clamp the specimen across the entire width.

8.54.5.5 The crank handle shall be turned at a rate of 50 revolutions ± 10 revolutions per minute of the crank arms and moving jaw during the test.

8.54.5.6 The specimen shall be flexed for 1000 cycles, then removed from the apparatus, and shall be visually inspected to determine pass/fail.

8.54.6 Report. Evidence of any cracking or delamination shall be identified and defined and shall be recorded and reported.

8.54.7 Interpretation.

8.54.7.1 Any cracking or delamination closer than 22 mm ($\frac{7}{8}$ in.) from either jaw line shall not be considered.

8.54.7.2 Failure of any one specimen shall constitute failure of sample unit.

8.55 Adhesion After Wet Flex-Tape Method Test.

8.55.1 Application.

8.55.1.1 This test method shall apply to the following proximity fire fighting protective ensemble elements: garment outer shell materials, glove outer shell materials, helmet outer covers, and helmet shrouds.

8.55.1.2 This test shall apply only to coated or laminated materials of the noted element components.

8.55.2 Samples. The same samples used in Section 8.54, Wet Flex Test, shall be the samples used for this test.

8.55.3 Specimens. The same specimens specified in 8.54.3 shall be the specimens used for this test.

8.55.4 Apparatus.

8.55.4.1 The tensile-testing machine described in ASTM D5034, *Standard Test Method for Breaking Strength and Elongation of Textile Fabrics (Grab Test)*, shall be used with the modification that all machine attachments for determining maximum load shall be disengaged and the speed of the pulling clamp shall be 505 mm/min (20 in./min).

8.55.4.2 Five 50 mm \times 100 mm (2 in. \times 4 in.) steel plates conforming to Class 301 or Class 304 of ASTM A666, *Standard Specification for Annealed or Cold Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar*, which have been polished to a No. 4 finish shall be used.

8.55.4.3 A 38 mm $(1\frac{1}{2}$ in.) wide steel roller weighing 4.53 kg \pm 0.06 kg (10 lb \pm 2 oz), shall be used.

8.55.4.4 A pressure sensitive tape used for testing the adhesion of the coating or the laminate shall be used and shall have the required adhesion value specified in 8.55.4.6.11.

8.55.4.5 Candidate pressure sensitive tapes, for potential use in testing the adhesion of coatings or laminates, shall have the adhesion value of the candidate tapes be determined by the procedure specified in 8.55.4.6.12.

8.55.4.6 Procedure for Determining Adhesion Value of Candidate Pressure Sensitive Tapes.

8.55.4.6.1 The equipment specified in 8.55.4.1, 8.55.4.2, and 8.55.4.3 shall be used in the procedure for adhesion value determination.

8.55.4.6.2 Prior to each adhesion value determination procedure, the steel plates specified in 8.55.4.2 shall be thoroughly cleaned with diacetone alcohol, methyl alcohol, or methyl ethyl ketone, using a clean piece of lint-free wiping tissue.

8.55.4.6.3 Five specimens from the same production batch of each candidate pressure sensitive tape shall be tested. Each

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candidate tape specimen shall measure 25 mm \times 200 mm (1 in. \times 8 in.).

8.55.4.6.4 Each of the five tape specimens of one candidate tape sample, specified in 8.55.4.6.3, shall be applied to the clean surface of each of the five steel plates, specified in 8.55.4.2, so that it covers the entire length of the plate and extends 100 mm (4 in.) beyond one end of the plate.

8.55.4.6.5 Each candidate tape specimen shall be pressed down by passing the roller, specified in 8.55.4.3, over the tape six times, three times in each direction.

8.55.4.6.6 The free end of the candidate tape specimen shall be doubled back over the specimen 180 degrees, and 25 mm (1 in.) of the tape shall be peeled off the plate.

8.55.4.6.7 Each plate, with the candidate tape specimen affixed, shall be tested separately for adhesion value determination.

8.55.4.6.8 The plate shall be inserted and clamped in the bottom jaw of the tensile-testing machine, specified in 8.55.4.1, with the free end of the candidate tape specimen oriented downward.

8.55.4.6.9 The free end of the candidate tape specimen shall be looped upward and inserted and clamped in the upper jaw so as to peel the tape specimen from the plate when the jaw motion is started.

8.55.4.6.10 The minimum tension required to remove the remainder of the candidate tape specimen from the steel plate, excluding the final 25 mm (1 in.), shall be recorded by an autographic recording device.

8.55.4.6.11 The recorded minimum tension value of the candidate tape specimen shall be the adhesion value.

8.55.4.6.12 All five specimens of the candidate tape shall have an adhesion value of not less than 4.8 N/cm $(2\frac{3}{4} \text{ lb/in.})$ width, and not more than 6.2 N/cm $(3\frac{1}{2} \text{ lb/in.})$ width for the pressure sensitive tape to be selected for use in testing the adhesion of the coating or the laminate.

8.55.5 Procedure.

8.55.5.1 Immediately after each of the five specimens has completed the testing specified in Section 8.54, Wet Flex Test, the five specimens shall be tested and evaluated for adhesion.

8.55.5.2 A razor cut design shall be symmetrically centered within the 100 mm \times 200 mm (4 in. \times 8 in.) of each of the five specimens. The cut design shall be two X cuts and three horizontal cuts and shall be made as shown in Figure 8.55.5.2. The cuts shall be made with a sharp razor blade through the coating or laminate and adhesive layers, but shall not cut through the base cloth.

8.55.5.3 Five 25 mm \times 200 mm (1 in. \times 8 in.) pieces of pressure sensitive tape, taken from a lot of material that has qualified for use in testing the adhesion of coatings or laminates by the procedure specified in 8.55.4.6, shall be used for adhesion testing.

8.55.5.4 One piece of the pressure sensitive tape, specified in 8.55.5.3, shall be used for each of the specimens.

8.55.5.5 The pressure sensitive tape shall be applied to the specimens so that it covers the entire length of the specimen, centered over the X cuts and horizontal cuts as shown in



Note: Solid lines indicate cut lines.

FIGURE 8.55.5.2 Cuts.

Figure 8.55.5.2, and extending 100 mm (4 in.) beyond one end of the specimen.

8.55.5.6 The pressure sensitive tape shall be pressed onto the specimen by passing the roller over the specimen six times, three times in each direction.

8.55.5.7 The free end of the pressure sensitive tape shall be doubled back over the specimen 180 degrees, and 25 mm (1 in.) of the pressure sensitive tape shall be peeled off the specimen.

8.55.5.8 The specimen shall then be inserted and clamped in the bottom jaw of the tensile-testing machine, specified in 8.55.4.1, with the free end of the pressure sensitive tape downward.

8.55.5.9 The free end of the tape shall be looped upward and inserted and clamped in the upper jaw of the tensile-testing machine so as to peel the pressure sensitive tape from the specimen when the jaw motion is started.

8.55.5.10 The jaw motion of the tensile-testing machine shall be engaged to peel the pressure sensitive tape from the specimen.

8.55.5.11 Following removal of the pressure sensitive tape, the tape and specimen shall be visually examined for compliance.

8.55.6 Report.

8.55.6.1 Evidence of any delamination shall be recorded and reported.

8.55.6.2 Evidence of any particulate on the pressure sensitive tape adhesive from the coating shall be recorded and reported.

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8.55.7 Interpretation.

8.55.7.1 A moderate number of specks on the pressure sensitive tape adhesive from the coating shall not constitute failure.

8.55.7.2 Evidence of separation or removal of the surface coating shall constitute a failure.

8.55.7.3 The failure of any one specimen shall constitute failure of the test.

8.56 Flex at Low Temperature Test.

8.56.1 Application. This test method shall apply to garment outer shell materials, glove outer shell materials, helmet face-shields, footwear, helmet outer covers, and helmet shrouds.

8.56.2 Samples.

8.56.2.1 Samples shall be taken from the fabric lot used in the construction of the garment.

8.56.2.2 Samples shall be conditioned as specified in 8.1.3.

8.56.3 Specimens.

8.56.3.1 A minimum of five specimens shall be tested.

8.56.3.2 Specimens shall measure $25 \text{ mm} \times 100 \text{ mm}$ (1 in. $\times 4 \text{ in.}$), with the long dimension in the warp or wale direction.

8.56.4 Apparatus. The test jig as shown in Figure 8.56.4 shall be used.

8.56.5 Procedure.

8.56.5.1 The test samples and test jig, as shown in Figure 8.56.4, shall be conditioned for 4 hours at a temperature of -32° C (-25° F).

8.56.5.2 At the end of the conditioning period, with the jig and the test specimens still in the test atmosphere, the specimen shall be placed in the open jig with the rod in the center of the fabric. The face of the fabric shall be positioned away from the rod.

8.56.5.3 The jig shall be closed in less than 3 seconds so that the specimen is bent face out around the rod until the back of the specimen touches itself.

8.56.5.4 The tested fabric shall be examined without magnification.

8.56.6 Interpretation. Failure of any one specimen shall constitute failure of sample unit of production.

8.57 Resistance to High-Temperature Blocking Test.

8.57.1 Application. This test method shall apply to proximity fire fighting garment outer shell materials, proximity fire fighting glove outer shell materials, proximity fire fighting helmet outer covers, and proximity fire fighting helmet shrouds.

8.57.2 Specimens. Specimens shall be tested after being subjected to the procedure specified in 8.1.3.

8.57.3 Procedure.

8.57.3.1 Blocking test procedure shall be as stated in Method 5872, *Temperature, High, Effect on Cloth Blocking*, of Federal Test Method Standard 191A, *Textile Test Methods*.

8.57.3.2 Following each test procedure the test specimen shall be examined to determine pass or fail performance.

8.57.4 Report. Any evidence of blocking shall be recorded and reported.



Smooth machine finish all over.

FIGURE 8.56.4 Jig Assembly — Resistance to Low Temperature Test.

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8.57.5 Interpretation. Failure of any one specimen shall constitute failure of the unit of product.

8.58 Drag Rescue Device (DRD) Materials Strength Test.

8.58.1 Application.

8.58.1.1 This test shall apply to DRD materials and DRD seams, splices, and joints.

8.58.1.2 Modifications to this test method for testing DRD seams, splices, and joints shall be as specified in 8.58.7.

8.58.2 Samples.

8.58.2.1 Five samples shall be taken from each different DRD material.

8.58.2.2 Five samples shall be taken from each different type of DRD seam, splice, and joint.

8.58.2.3 Samples for conditioning shall be at least 1 m (1 yd) lengths of material including seams for seam testing.

8.58.3 Specimens.

8.58.3.1 Specimens shall be tested after being subjected to the conditioning specified in 8.1.2.

8.58.3.2 A total of five material specimens representative of the DRD materials shall be tested for each material type.

8.58.3.3 A minimum of five seam, splice, and joint specimens representative of the DRD seams, splices, and joints shall be tested for each seam, splice, and joint type.

8.58.4 Procedure. Specimens shall be tested for breaking strength only as specified in ASTM D6775, *Standard Test Method for Breaking Strength and Elongation of Textile Webbing, Tape and Braided Material.*

8.58.5 Report.

8.58.5.1 The breaking strength of each specimen shall be recorded and reported.

8.58.5.2 The average breaking strength of all specimens shall be calculated, recorded, and reported.

8.58.6 Interpretation. The average breaking strength shall be used to determine pass or fail performance.

8.58.7 Specific Requirements for Testing DRD Seams, Splices, and Joints.

8.58.7.1 The test specimen shall be as specified in ASTM D6775, *Standard Test Method for Breaking Strength and Elongation of Textile Webbing, Tape and Braided Material,* and shall include the seam, splice, and joint in the middle of the test specimen.

8.58.7.2 Testing shall be performed as specified in 8.58.4.

8.59 Drag Rescue Device (DRD) Function Test.

8.59.1 Application. This test shall apply to DRD installed in protective coats and protective coverall elements.

8.59.2 Samples.

8.59.2.1 Samples shall consist of complete protective coats or protective coveralls with DRD installed.

8.59.2.2 Samples shall be conditioned as specified in 8.1.3.

8.59.3 Specimens.

8.59.3.1 Specimens for testing shall be complete coat or complete coverall garment elements with DRD.

8.59.3.2 A minimum of three specimens shall be tested for each garment element type.

8.59.3.3 Each specimen shall have all garment layers in place.

8.59.4 Apparatus.

8.59.4.1 One pair of protective gloves shall be provided.

8.59.4.1.1 The gloves shall be certified as compliant with this standard and shall be properly sized to fit the test technician.

8.59.4.1.2 For structural fire fighting ensembles, the protective gloves shall be structural fire fighting gloves.

8.59.4.1.3 For proximity fire fighting ensembles, the protective gloves shall be proximity fire fighting gloves.

8.59.4.2 One IAFF "Rescue Randy" Model 1475 mannequin, or equivalent, shall be provided as the test mannequin.

8.59.4.3 One open-circuit SCBA shall be provided.

▲ 8.59.4.3.1 The SCBA shall be certified as compliant with NFPA 1981.

8.59.4.3.2 The SCBA shall be equipped with an empty 60-minute rated breathing air cylinder.

8.59.5 Procedure.

8.59.5.1 The DRD shall be inspected to insure correct installation within the garment element in accordance with manufacturer's instructions.

8.59.5.2 The DRD shall be in the secured, non-deployed, position.

8.59.5.3 The size of the specimen shall properly fit the mannequin by conforming to the dimensions of the mannequin chest circumference in accordance with the manufacturer's sizing system.

8.59.5.4 The test specimen shall be donned on the test mannequin in accordance with the manufacturer's instructions for proper wearing, and shall be tested with an SCBA.

8.59.5.5 The SCBA shall be donned in accordance with the SCBA manufacturer's instructions over the specimen.

8.59.5.6 The test mannequin shall be placed on its side on a concrete surface.

8.59.5.7 With the test mannequin in position, the test technician shall don the gloves specified in 8.59.4.1.

8.59.5.8 The test technician shall deploy the DRD according to the manufacturer's instructions.

8.59.5.9 Deployment time shall be measured beginning when the test technician touches the mannequin and shall stop when the dragging motion begins.

8.59.5.10 The test technician shall drag the mannequin in a straight line using the DRD, in accordance with the manufacturer's instructions, for a distance of 2.5 m, +0.5/-0 m (8 ft, $+1\frac{1}{2}/-0$ ft).

8.59.5.11 The deployment of the DRD and the dragging of the mannequin shall be observed to determine if the SCBA is dislodged from the "as donned position."

8.59.6 Report.

8.59.6.1 The deployment time of the DRD shall be recorded and reported.

8.59.6.2 The ability to drag the mannequin the required distance shall be recorded and reported.

8.59.6.3 Change in the position of the SCBA during either the deployment of the DRD or the dragging of the mannequin shall be recorded and reported.

8.59.7 Interpretation.

8.59.7.1 The inability to deploy the device in 10 seconds or less, or the inability to drag the mannequin 2.5 m (8 ft) shall constitute failing performance.

8.59.7.2 Failure of one or more specimens shall constitute failing performance.

8.60 Conductive Heat Resistance Test 3.

8.60.1 Application. This test method shall apply to proximity footwear upper material.

8.60.2 Samples.

8.60.2.1 Samples for conditioning shall be whole footwear.

8.60.2.2 There shall be at least three samples of footwear.

8.60.3 Specimens.

8.60.3.1 A total of three specimens of footwear shall be tested.

8.60.3.2 Footwear specimens shall be cut from portions of the footwear upper or from a composite that is representative of footwear upper construction at the thinnest part. Specimens shall consist of each composite of footwear upper used in the actual footwear construction, including the tongue but excluding the gusset, with the layers arranged in proper order. Where a composite is identical to another composite except for additional reinforcement layer(s), the composite with no reinforcement layers shall be tested.

8.60.3.3 Specimens shall be conditioned as specified in 8.1.3.

8.60.4 Procedure. Specimens shall be tested in accordance with ASTM F1060, *Standard Test Method for Thermal Protective Performance of Materials for Protective Clothing for Hot Surface Contact*, with the following modifications:

- Specimens shall be tested using an exposure temperature of 100°C (212°F). The pressure applied during the test shall be 3.45 kPa, ±0.35 kPa (0.5 psi, ±0.05 psi).
- (2) The test exposure duration shall be 10 minutes.

8.60.5 Report. The maximum temperature during the 10 minute exposure shall be recorded and reported.

8.60.6 Interpretation. Pass/fail determinations shall be based on the average temperature of all specimens tested.

8.61 Radiant Heat Resistance Test 2.

8.61.1 Application. This test method shall apply to proximity protective footwear.

8.61.2 Samples. Samples for conditioning shall be complete footwear.

8.61.3 Specimen Preparation.

8.61.3.1 A minimum of three complete footwear items shall be tested.

8.61.3.2 Specimens shall be conditioned in accordance with 8.1.3.

▲ 8.61.4 Apparatus. The apparatus shall consist of the following:

- (1) Radiometer of the Schmidt-Boelter or Gardon type with radiant heat flux transducer with a diameter of 25 mm (1 in.), a minimum viewing angle of 150 degrees, a minimum spectral response flat within 3 percent over a range of at least 1.0 μ m to 10.0 μ m, and an overall accuracy of at least ±5 percent of the reading.
- (2) Radiant panel with an effective radiating surface of not less than 150 mm × 150 mm (6 in. × 6 in.) and an emittance approximating that of a blackbody of $1000K \pm 200K$ (1340°F ± 360°F)
- (3) Thermocouple with meter
- (4) Test chamber that prevents interference from air movement
- (5) A means of holding the boot in place so that boot material shrinkage does not cause movement of the boot away from the panel

8.61.5 Procedure.

8.61.5.1 Tests shall be done on each area of the footwear upper, including the tongue but excluding the gusset, which consists of a different composite. Where a composite is identical to another composite except for additional reinforcement layer(s), the composite with no reinforcement layers shall be representative of the composite with reinforcement layer(s).

8.61.5.2 The radiant panel shall be placed in front of the radiometer, parallel to the plane tangent to the radiometer. The radiant panel shall be adjusted to obtain a stable, uniform irradiance of 4.0 W/cm², +0.4/-0.0 W/cm² (1.0 cal/cm²/sec, +0.01/-0.0 cal/cm²/sec), over a minimum 75 mm (3 in.) diameter circle located on the above plane and centered at the center of the test area. Calibration shall be achieved when the irradiance changes by less than 10 percent during a 3-minute period.

8.61.5.3 The thermocouple shall be affixed with thermally conductive adhesive to the inside surface of the lining next to the foot in the center of the test area. The radiometer shall be replaced with the protective footwear with the test area oriented parallel to the plane tangent to the heat source at the same distance from the heat source. The area shall be exposed for 100 seconds, +5/-0 seconds.

8.61.5.4 The thermocouple temperature shall be recorded at 100 seconds of exposure.

8.61.6 Report.

8.61.6.1 The temperature at 100 seconds of exposure shall be reported for each specimen.

8.61.6.2 The average temperature at 100 seconds of exposure for all specimens shall also be calculated and reported.

8.61.7 Interpretation. The average temperature at 100 seconds of exposure for all specimens tested shall be used to determine pass/fail performance.

8.62 Light Degradation Resistance Test.

△ 8.62.1 Application. This test method shall apply to moisture barrier materials.

8.62.2 Samples.

8.62.2.1 Samples for conditioning shall be at least 380 mm (15 in.) square and shall consist of a composite constructed using a layer of 7.5 oz woven 93 percent meta-aramid, 5 percent para-aramid, 2 percent antistat fiber, the moisture barrier, a layer of 3.8 oz \pm 0.3 oz, aramid needle punched nonwoven, quilted to a 3.4 oz \pm 0.2 oz, aramid woven plain weave thermal barrier material, and another layer of 7.5 oz woven 93 percent meta-aramid, 5 percent para-aramid, 2 percent antistat fiber. The four-layer composite sample shall be stitched around the entire periphery.

8.62.2.2 Where the layer intended to be the moisture barrier is configured of a composite that includes outer shell, moisture barrier, or thermal barrier combinations, the samples to be conditioned shall be constructed using those materials.

8.62.2.3 The moisture barrier layer shall be removed from the four-layer composite samples after all conditioning has been completed and shall become the moisture barrier specimen.

8.62.2.4 Where the moisture barrier is configured as indicated in 8.62.2.2, specimens shall be permitted to be a composite of layers provided that the layer intended to be the moisture barrier will face the light source in the test apparatus and provided that the specimen was conditioned according to 8.62.2.2.

8.62.3 Sample Preparation. Sample composites shall be subjected to two cycles of the following conditioning:

- (1) The sample shall first be subjected to the procedure specified in 8.1.2.
- (2) The sample shall then be conditioned as specified in 8.1.3.
- (3) The sample shall then be conditioned as specified in 8.1.5.
- (4) The sample shall then be conditioned at a temperature of 21°C ± 3°C (70°F ± 5°F), and a relative humidity of 65 percent ± 5 percent for at least 4 hours.

8.62.4 Specimen Preparation.

8.62.4.1 The moisture barrier material will be removed from the conditioned sample composite and be cut into specimens at least 150 mm (6 in.) square.

8.62.4.2 A minimum of four specimens shall be tested.

8.62.5 Procedure.

8.62.5.1 Light resistance testing shall be conducted in accordance with ASTM G155, *Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials*, using Cycle 8 Exposure Conditions. Both inner and outer filters shall be borosilicate. Exposure duration shall not include dark cycles.

8.62.5.2* For each specimen, a piece of cardstock shall be cut in equal dimensions to the specimen. The specimen shall be stapled to the cardstock at each corner with the film side of the specimen away from the cardstock. The cardstock-backed specimen shall be clipped into the test apparatus, insuring clips do

not contact the specimen, and the film side of the specimen is oriented toward the light source.

8.62.5.3 Specimens shall be subjected to 40 hours of continuous light exposure.

8.62.5.4 Specimens shall be removed from the test apparatus and conditioned in a dark environment at a temperature of $21^{\circ}C \pm 3^{\circ}C$ (70°F ± 5°F), and a relative humidity of 65 percent ± 5 percent, for at least 4 hours.

8.62.5.5 Specimens shall be tested in accordance with ASTM D751, *Standard Methods for Testing Coated Fabrics, Hydrostatic Resistance*, Procedure B – Rising Column Water Method, Procedure 2, Sections 46–49, with the following modifications:

- (1) Alternative test apparatus shall be permitted provided that the exposed area of the specimen is at least 108 mm $(4\frac{1}{4}$ in.) in diameter and the pressure can be applied uniformly over the exposure period at a precision of ± 0.1 kPa (± 0.2 psi).
- (2) The applied pressure shall be 13.8 kPa (2 psi) for an exposure period of 1 minute.
- (3) Restraining materials shall not be used.
- (4) Failing performance shall be if any water appears on the surface of the specimen during the exposure period as discerned by a person with 20/20 vision, or vision corrected to 20/20, at a nominal distance of 305 mm (12 in.) with standard room illumination.

8.62.5.5.1 The moisture barrier specimen shall be placed in the apparatus with the film side facing away from the water source.

8.62.6 Reports. The pass or fail performance for each specimen shall be recorded and reported.

8.62.7 Interpretation. One or more test failures of any specimen shall constitute failure of material.

8.63 Liner Retention Test.

8.63.1 Application. This test method shall apply to protective gloves.

8.63.2 Samples. Samples for conditioning shall be whole gloves.

8.63.3 Specimens.

8.63.3.1 A minimum of three whole gloves each for size 70W (wide) and size 76W (wide) with each liner type shall be tested.

8.63.3.2 Each digit of the glove shall be tested.

8.63.3.3 Specimens shall be conditioned as specified in 8.1.2 and then conditioned as specified in 8.1.3.

8.63.4 Apparatus. Liner retention shall be evaluated with the use of locking forceps and a force measuring gauge.

8.63.5 Procedure.

8.63.5.1 The locking forceps shall be attached to the inner liner of the digit to be tested ensuring that an unattached liner or the outer shell is not grabbed.

8.63.5.2 The hook of the force gauge shall be looped around the locking bridge of the forceps.

8.63.5.3 The digit of the glove shell shall be gripped ensuring that the inner liner is not impeded.

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8.63.5.4 The force gauge shall be pulled until 25 N ($5\frac{1}{2}$ lbf) registers on the dial and then released.

8.63.5.5 Each digit shall be inspected for indication of detachment of inner liner and/or moisture barrier.

8.63.6 Report. Results shall be recorded and reported as pass or fail.

8.63.7 Interpretation.

8.63.7.1 Failure of any digit of any glove shall constitute failure.

8.63.7.2 Glove shall be permitted to be cut open to verify detachment.

8.64 Reserved.

8.65 Reserved.

N 8.66 Particle Inward Leakage Test.

N 8.66.1 Application. This test shall apply to liquid and particulate protective ensembles.

N 8.66.2 Samples.

- **N 8.66.2.1** Samples shall consist of liquid and particulate protective ensembles, including the ensemble garment, helmet, glove, and footwear elements, and the SCBA specified for the ensemble by the ensemble manufacturer. The hood interface component shall also be tested where the hood is not part of the liquid and particulate protective ensemble garment elements.
- **N 8.66.2.2** The ensemble shall be tested with each style of the SCBA specified by the manufacturer.
- **N 8.66.2.3** Garment, glove, and hood elements shall be conditioned as specified in 8.1.11.
- **N 8.66.2.4** Where the ensemble garment element does not include attached booties, the footwear shall be conditioned by flexing for 100,000 cycles in accordance with Appendix B of FIA 1209, *Whole Shoe Flex*, with the following modifications:
 - (1) Water shall not be used.
 - (2) The flex speed shall be 60 cycles/min ± 2 cycles/min.
 - (3) Alternative flexing equipment shall be permitted to be used when the flexing equipment meets the following parameters:
 - (a) The alternative flexing equipment shall be capable of providing the angle of flex as described in FIA 1209.
 - (b) The alternative flexing equipment shall be capable of a flex speed of 60 cycles/min ± 2 cycles/min.
 - (c) The alternative flexing equipment shall provide a means of securing the footwear during flexing.
- **N 8.66.2.5** Samples shall be conditioned at $21^{\circ}C \pm 6^{\circ}C$ (70°F $\pm 11^{\circ}F$) and 50 percent ± 30 percent relative humidity for at least 4 hours.

N 8.66.3 Specimens.

N 8.66.3.1 Specimens shall consist of the garment, helmet, glove, and footwear elements, and the respirator specified for the ensemble by the ensemble manufacturer. The hood interface component shall also be tested where the hood is not part of the liquid and particulate protective ensemble garment elements.

- **N 8.66.3.2** A minimum of three specimens shall be tested.
- **N 8.66.3.3** 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.
- **N 8.66.3.4** None of the ensembles or components of the ensemble to be tested shall have been previously subjected to particle inward leakage testing unless it can be demonstrated that the ensemble or components are free of contamination.

N 8.66.4 Apparatus.

- **N 8.66.4.1** The test shall be conducted in a chamber large enough to conduct testing on at least one test subject.
- **N 8.66.4.2** The test chamber shall have a system capable of providing a stable, uniform airflow directed at the test subject.
- **N 8.66.4.3** The test chamber shall prevent significant aerosol contact with any areas of the facility not intended as exposure areas, to prevent contamination.
- **N 8.66.4.4** The test chamber shall have an aerosol generator capable of maintaining the aerosol mass concentration as specified in the procedure.
- N 8.66.4.5 The challenge aerosol shall be a combination of amorphous silica, 50 percent by weight; tetraethylene glycol, 42 percent by weight; uranine, 6 percent by weight; and Tinopal[™], 2 percent by weight.
- **N 8.66.4.6** Test subjects shall wear a close-fitting, one- or multiple piece full-body garment made of black synthetic material that is sized to the individual test subject. The bodysuit must be clean and free of visible lint, to the extent practicable, prior to donning the candidate garment ensemble.
- **N** 8.66.4.7 Visual inspection of the test participant, while wearing the indicator garment, shall be performed under illumination by black light in a dark room after doffing the candidate garments. Inspection shall be performed while the test participant is fully illuminated by black light with a wavelength of 365 nm.
- **N 8.66.4.8*** A separate handheld black light with a wavelength of 365 nm and an intensity of 1200 μ W/cm² at 380 nm shall be used to inspect areas where the presence of fluorescent particles could be unclear.
- **N 8.66.4.9** A 35 mm camera or digital equivalent with the appropriate capabilities and settings for taking photographs under UV light shall be provided for documenting the visual condition of the test subject before and after exposure to the aerosol.
- **N 8.66.4.10** The test facility shall have separate garment storage, donning, doffing, and control room areas to prevent contamination.
- **N 8.66.4.11** All test subjects shall have a medical doctor's certificate that substantiates that they are medically and physically suitable to perform these tests without danger to themselves. The medical certificate shall have been issued within 12 months prior to testing.
- **N 8.66.4.12** Test subjects shall be familiar with the use of structural fire fighting protective clothing and equipment and with the selected respirator.

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N 8.66.5 Procedure.

N 8.66.5.1 The test chamber shall be stabilized with the following conditions:

- Average wind speed shall be 47 m/sec ± 0.89 m/sec (10.0 mph ± 2 mph) at the fan outlet airflow station.
- (2) Temperature shall be $21^{\circ}C \pm 6^{\circ}C$ (70°F ± 5°F).
- (3) Relative humidity shall be $45 \text{ percent} \pm 15 \text{ percent}$.
- (4) Average aerosol concentration shall be 160 mg/m^3 , $\pm 25/-0 \text{ mg/m}^3$.
- (5) Aerosol aerodynamic mass median diameter shall be $2.5 \ \mu\text{m} \pm 0.5 \ \mu\text{m}$.
- **N 8.66.5.2** The test subject shall don black indicator garments that cover the wearer's torso, arms, hands, legs, ankles, and head excluding the face. The indicator garments shall provide a dark uniform appearance under black light illumination.
- **N** 8.66.5.3* At least 10 specific areas of the indicator garment shall be masked with a suitable tape or masking product that will remain in place during testing and not affect the appearance of the indicator garment under black light illumination.
- **N 8.66.5.3.1** At least 10 masked areas, with minimum dimensions of $25 \text{ mm} \times 50 \text{ mm}$ (1 in. $\times 2$ in.) shall be distributed over the indicator garment.
- **N 8.66.5.4** The test subject shall don the protective ensemble and respirator in accordance with the manufacturer's instructions in a clean area separate from the test chamber.
- **N 8.66.5.5** Once the test chamber has reached the conditions stated in 8.66.5.1, the test subject will enter the chamber and be properly positioned in the wind.
- **N 8.66.5.6** The 30-minute test period begins when the test subject is positioned in the wind.
- **N 8.66.5.7** During the 30-minute test period, the test subject shall perform the three stationary exercises as specified in Table C.2 of Test Operations Procedure (TOP) 10-2-022, *Chemical Vapor and Aerosol System-Level Testing of Chemical/Biological Protection Suits.*
- **N 8.66.5.8** At the conclusion of the 30-minute test period, the test subject shall exit the test chamber and enter the doffing area.
- **N** 8.66.5.9 The test subject shall then be assisted to doff the ensemble to prevent contact of the outside surface of the ensemble with the subject's skin or indicator garment.
- **N 8.66.5.10** After doffing, the masked areas shall be unmasked and the test subject shall be examined under black light in the viewing area for evidence of particulate inward leakage.
- **N 8.66.5.11** Photographs shall be taken of the test subject under black with the following minimum positions:
 - (1) Front, right, back, and left side of test subject's neck and head
 - (2) Front, right, back, and left side of test subject's upper torso
 - (3) Front, right, back, and left side of test subject's lower torso
- **N** 8.66.5.12* A separate black light shall be used to inspect any areas where the presence of fluorescent particles might be unclear.

- **N 8.66.5.12.1** The exposure of the black light shall be bracketed to provide photographs with varying contrast to permit documentation of any observed fluorescence.
- **N 8.66.5.13** The laboratory shall be permitted, but is not required, to further sample any areas that are suspect for particle contamination using the procedures established in 8.66.5.7. These procedures, when used, shall be employed for documentation purposes only and shall not be used for interpreting compliance with the performance requirement.

N 8.66.6 Sampling and Analysis of Black Indicator Garment.

- **N 8.66.6.1** The test subject's black indicator garment shall be sampled to recover aerosol that has deposited. This garmentrinse sampling shall be performed by pressing a tube against the portion of the black indicator garment to be sampled and adding 20 mL of 0.01 N sodium hydroxide (NaOH). The solution shall be washed over the black indicator garment for approximately 10 seconds, then pipetted into a clean container.
- **N 8.66.6.2** All samples shall be labeled appropriately before they are analyzed.
- **N 8.66.6.3** For each of the black indicator garment-rinse samples, approximately 5 mL of each of the samples shall be analyzed in a fluorometer to determine the mass of aerosol that is present in the sample. The results shall be recorded and verified to identify and eliminate any errors in reading or recording the data.
- **N 8.66.7** After each trial, upon completion of the garment-rinse sampling and black light photography, the test subject shall return to a locker room and shower.
- **N 8.66.8 Report.** The report shall consist of the following elements:
 - (1) Photographic records documenting the test ensemble and results consisting of the following:
 - (a) A photograph of the front head-to-toe view of the test subject in the full test ensemble immediately before entering the aerosol chamber. Additional photographs of the test subject in the ensemble showing design details shall be included as warranted.
 - (b) Black light photographs of the test subject after doffing. These photographs shall cover all body locations with the test subjects wearing shorts, and, for female test subjects, a sports bra.
 - (c) If the post-exposure photographs show no aerosol deposits and show only a black garment in a dark room, the following statement shall be permitted in lieu of post-exposure photographs: "No visible aerosol deposits were revealed in the photographs."
 - (2) The test conditions, including the following:
 - (a) The challenge aerosol mass concentration averaged for the duration of the test
 - (b) The average wind speed, temperature, and relative humidity for the test
 - (c) Date of test and test operator
 - (3) Specific observations for the location of any deposited aerosol on the test subject's indicator garments as noted during visual observation under a black light
 - (4) Any notable observations by the test operators, especially system openings, mask breaches, or poor fits

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- (5) Any supplemental test data sampling and analysis of the black indicator garments provided for documentation purposes only
- **N 8.66.9 Interpretation.** Any evidence of particulate inward leakage on any test subject's indicator garment as determined by visual inspection under a black light shall constitute failure.

8.67 Transmitted and Stored Thermal Energy Test.

8.67.1 Application.

8.67.1.1 This test method shall apply to garment sleeve composites containing enhancements as defined in 7.2.4 exterior to the outer shell.

8.67.1.2 Modifications to this test method for testing garment sleeve composites containing enhancements exterior to the outer shell shall be specified in 8.67.7.

N 8.67.1.3 Modifications to this test method for testing the glove body composite at the back of the glove shall be as specified in 8.67.8.

8.67.2 Samples. Samples shall measure 150 mm \times 150 mm \pm 6 mm (6 in. \times 6 in. \pm $\frac{1}{4}$ in.), and shall consist of all layers representative of the item to be tested. Samples shall not be stitched to hold individual layers together during testing. Enhancements shall be sewn to the center of the outer shell of the composite if they cannot meet the sample measurement requirements.

8.67.3 Specimens.

8.67.3.1 Transmitted and stored thermal energy testing shall be conducted on five specimens.

8.67.3.2 Garment sleeve composites shall be conditioned in accordance with ASTM F2731, *Standard Test Method for Measuring the Transmitted and Stored Energy in Fire Fighter Protective Clothing Systems*, Section 9.3.

8.67.4 Procedure.

8.67.4.1 Transmitted and stored thermal energy testing shall be conducted in accordance with ASTM F2731, *Standard Test Method for Measuring the Transmitted and Stored Energy in Fire Fighter Protective Clothing Systems*, Procedure B, with the modification specified in 8.67.4.1.1.

8.67.4.1.1 For garment sleeve composites, the exposure time shall be for a period of 120 seconds, +1/-0 seconds.

8.67.5 Report. The average time to second degree burn shall be calculated and reported. If no burn injury occurs, the time to second degree burn shall be reported as "no burn."

8.67.6 Interpretation. Pass/fail determination shall be based on the average reported time to second degree burn of all specimens tested.

8.67.7 Specific Requirements for Testing Garment Sleeve Composites Containing Enhancements Exterior to the Outer Shell.

8.67.7.1 A three-layer composite shall be used to test enhancements exterior to the outer shell. The composite shall be constructed using a layer of 7.5 oz/yd² natural woven 93 percent meta-aramid, 5 percent para-aramid, 2 percent antistat fiber, $4.7 \text{ oz/yd}^2 \pm 0.2 \text{ oz/yd}^2$, expanded PTFE laminated to a woven aramid fabric, and a layer of 3.8 oz/yd² \pm 0.3 oz/yd²,

aramid needle punched nonwoven, quilted to 3.4 oz/yd^2 , aramid plain weave thermal barrier material. Additional layers found used in the construction of the garment shall be placed in the composite as found in the garment.

N 8.67.8 Specific Requirements for Testing Glove Body Composites at the Back of the Glove.

- **N 8.67.8.1** Specimens shall be representative of the glove body composite construction at the back of the glove at the following glove areas described in 8.1.17: A-A, B-B, the 25 mm (1 in.) of C-B adjacent to the wrist crease, D-B, and E-B.
- **N 8.67.8.2** Glove body composites at the back of the glove shall be conditioned as specified in 8.1.9.
- N 8.67.8.3 The specimens shall be tested as specified in 8.67.4 with the exception that the radiant heat exposure period shall continue until the second-degree burn point is reached. No compression period shall be used for this testing.
- **N 8.67.8.4** The testing shall be run on separate samples at each of the three moisture conditions specified in 8.1.9.

8.68 Torque Test.

8.68.1 Application. This test method shall apply to protective gloves.

8.68.2 Samples.

8.68.2.1 Samples for conditioning shall be whole gloves.

8.68.2.2 Sample glove pairs shall be conditioned as specified in 8.1.3.

8.68.3 Specimens.

8.68.3.1 A minimum of three glove specimens each for size 70W (wide) and size 76W (wide) shall be used for testing.

8.68.3.2 Each specimen glove shall be tested in new, asdistributed condition.

8.68.3.3 Specimen gloves shall be tested for each material and construction combination.

 Δ 8.68.4 Apparatus. The apparatus shall be as specified in ASTM F2961, Standard Test Method for Characterizing Gripping Performance of Gloves Using a Torque Meter.

8.68.5 Procedure. The testing procedures shall be as specified in ASTM F2961, *Standard Test Method for Characterizing Gripping Performance of Gloves Using a Torque Meter.*

8.68.6 Report. The average percentage of bare-handed control value shall be recorded and reported for each specimen glove size.

8.68.7 Interpretation.

8.68.7.1 The average percentage of bare-handed control value for size 70W (wide) and size 76W (wide) shall be used to determine pass or fail performance.

8.68.7.2 Failure of either size shall constitute failure of the test.

8.69 Fastener Tape Strength Test.

8.69.1 Application. This test shall apply to fastener tape used in the construction of garments.