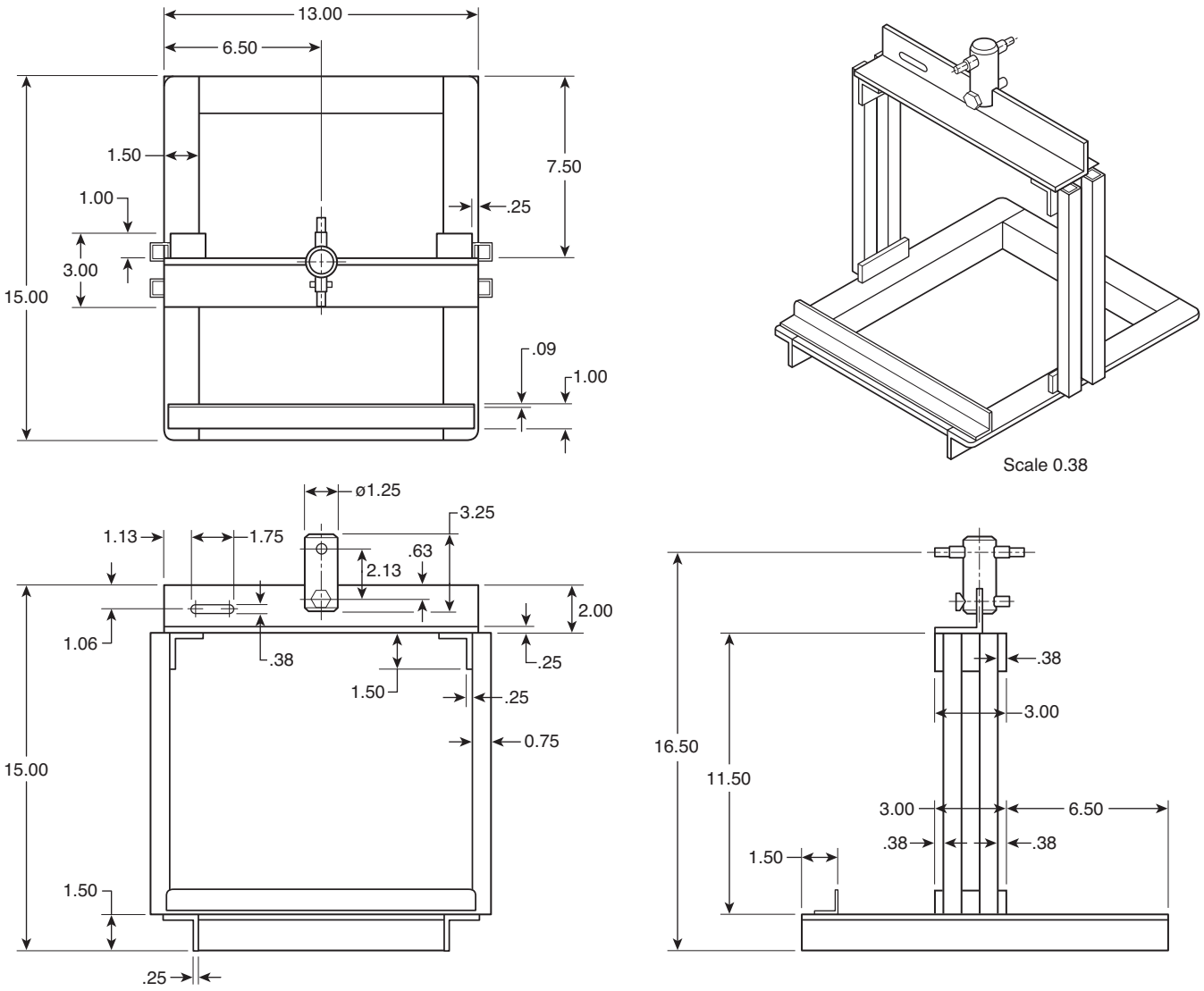

FIGURE 8.34.4.2(a) Retention Test Fixture.

8.35.4.2 The calibrated tensile test machine shall be capable of measuring the force applied to the retention system within 2 percent at the specified forces.

8.35.5 Procedure.

8.35.5.1 Each helmet suspension strap shall be cut such that sufficient length of strap remains to be gripped by the movable jaw of the testing machine.

8.35.5.2 Specimens shall be positioned and secured in the tensile testing machine so that the helmet's reference plane is horizontal.

8.35.5.3 Each attachment point of the crown strap shall be tested by applying a pull force along the centerline of the suspension strap, perpendicular to the reference plane to a maximum load of 45 N ± 5 N (10 lbf ± 1 lbf). The force shall be increased from 0 N to 45 N ± 5 N (0 lbf to 10 lbf ± 1 lbf), at a load rate of 25 mm/min, ± 5 mm/min (1 in./min ± 3⁄16 in./min).

8.35.5.4 After application of the force is complete, the load shall be released and the suspension system shall be inspected for any separation from the helmet shell.

8.35.6 Report. The individual pass or fail results for each attachment point shall be reported and recorded.

8.35.7 Interpretation.

8.35.7.1 Separation of the helmet suspension from the helmet shall constitute failing performance.

8.35.7.2 One or more helmet specimens failing this test shall constitute failing performance.

8.36 Glove Donning Test.

8.36.1 Application. This test shall apply to protective gloves.

8.36.2 Samples.

8.36.2.1 A minimum of three glove pairs each for size small and size large shall be used for testing.

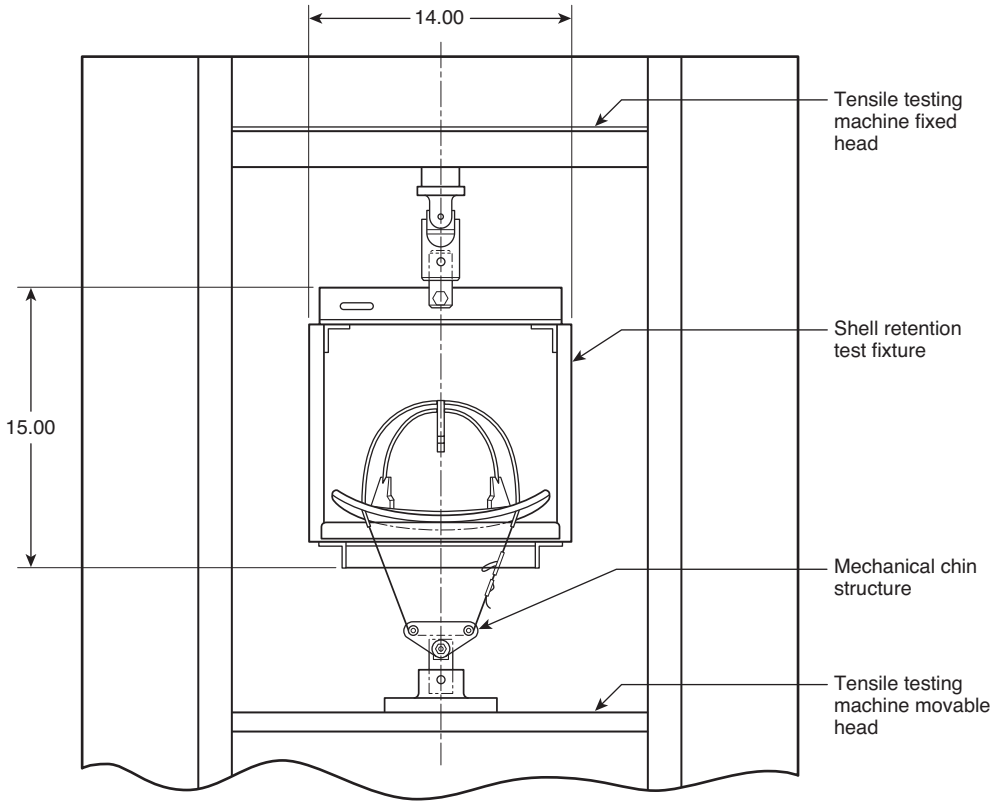

FIGURE 8.34.4.2(b) Retention Test Setup 1.

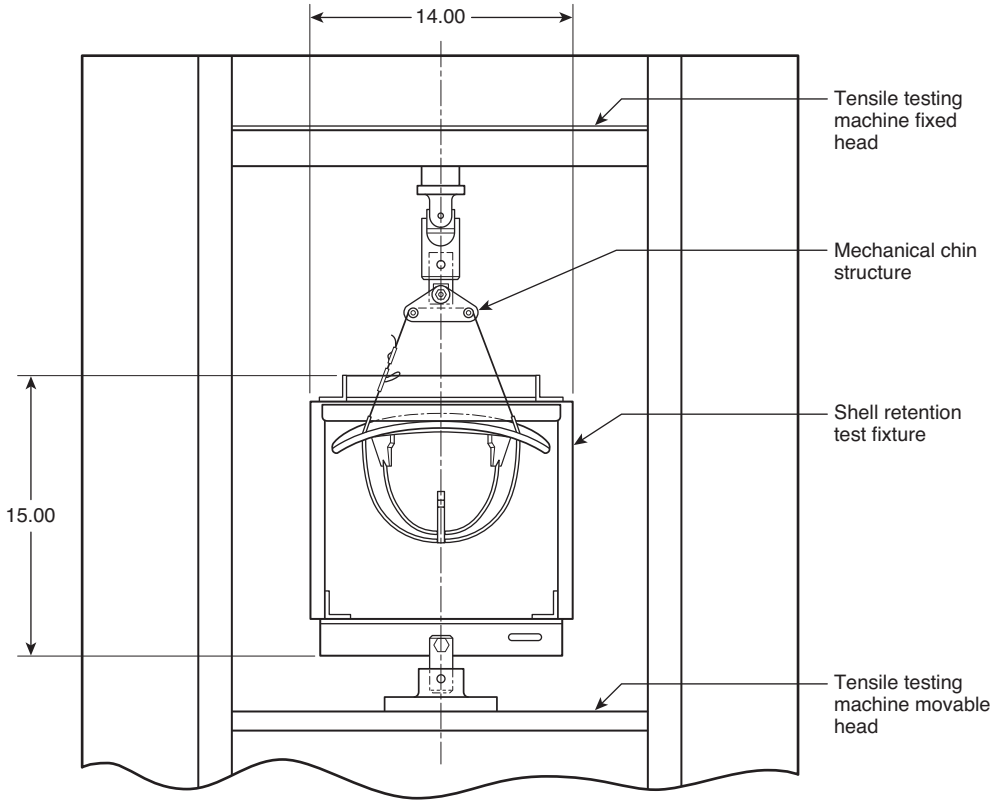

FIGURE 8.34.4.2(c) Retention Test Setup 2.

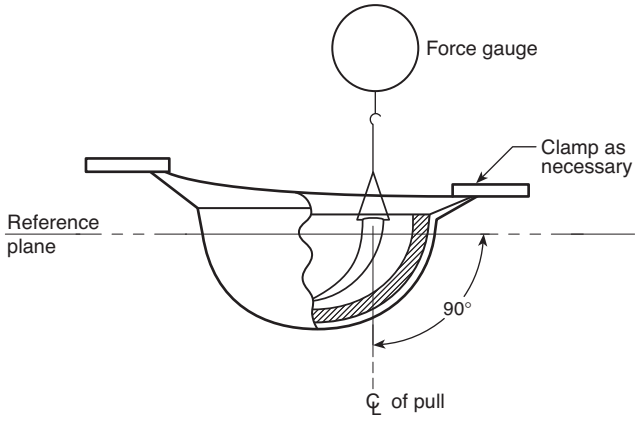

FIGURE 8.35.4.1 Suspension System Test Setup.

8.36.2.2 Samples for conditioning shall be whole gloves.

8.36.2.3 All glove opening configurations shall be considered for testing.

8.36.3 Specimens.

8.36.3.1 Specimens shall be conditioned as specified in 8.1.11 prior to testing.

8.36.3.2 Specimens shall be donned once after removal from the conditioning specified in 8.36.3.1 before beginning testing.

8.36.4 Procedure.

8.36.4.1 Test subjects shall be selected so that their hand dimensions are as close as possible to the middle of the range for hand length and hand circumference as specified in the tables provided for size small and size large gloves in 6.7.6.

8.36.4.2 Each donning trial shall start with the glove lying in front of the test subject and shall end when the test subject's fingers are seated in the specimen glove.

8.36.4.3 The time to don one glove of the pair specimen shall be determined by measuring the time it takes for the test subject to don the single glove on three consecutive trials without altering the specimen glove linings between donning. The test subject shall be permitted to don either the right hand glove or left hand glove according to individual preference.

8.36.4.3.1 The glove shall be donned in accordance with the manufacturer's donning procedure.

8.36.4.3.2 The glove shall then be removed by grasping the fingertip of the middle finger and pulling the hand out of the glove.

8.36.4.3.3 The test subject shall wear the glove of the opposite hand during the test.

8.36.4.3.4 Where the glove cannot be donned because of detachment of the inner liner or moisture barrier, then the trial for that glove shall be stopped. If any fingers cannot be fully inserted into the glove, then the trial for that glove shall be stopped.

8.36.4.4 The dry hand donning time shall be the average of the first three dry hand donning times as determined in 8.36.4.3.

8.36.4.5 The test subject shall repeat the trial specified in 8.36.4.3 for each pair of gloves.

8.36.4.6 The test hand shall then be completely submerged in room temperature water [21°C ± 3°C (70°F ± 5°F)] for 10 seconds before doffing the glove each time.

8.36.4.7 Immediately after the hand wetting procedure specified in 8.36.4.6, with no time lapse, the test subject shall then don one glove of the pair specimen. The test subject shall do this for three consecutive trials, for each specimen pair of gloves, as specified in 8.36.4.3 and 8.36.4.5. The times shall be recorded.

8.36.4.8 The wet hand donning time shall be the average of the first three wet hand donning times as determined in 8.36.4.7.

8.36.5 Report.

8.36.5.1 The dry hand donning time shall be recorded and reported to the nearest 0.1 second for each trial.

8.36.5.2 The wet hand donning time shall be recorded and reported to the nearest 0.1 second for each trial.

8.36.5.3 The average dry hand and wet hand donning times shall be calculated, recorded, and reported for each size.

8.36.5.4 Any inner liner or moisture barrier separations shall be recorded and reported.

8.36.5.5 Any glove digits that do not allow full insertion shall be recorded and reported.

8.36.6 Interpretation.

8.36.6.1 Pass or fail determinations shall be made using the average dry hand and wet hand donning times for size small and size large.

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

8.36.6.3 Any detachment of the inner liner and/or moisture barrier shall constitute failing performance.

8.36.6.4 Any glove digits that do not allow full insertion shall constitute failing performance.

▲ **8.37 Glove Hand Function Test.**

8.37.1 Application. This test shall apply to gloves.

8.37.2 Samples.

8.37.2.1 Samples for conditioning shall be whole glove pairs.

8.37.2.2 Glove pair samples shall be preconditioned as specified in 8.1.3.

8.37.3 Specimens.

8.37.3.1 A minimum of three glove pair specimens each for size small and size large shall be used for testing.

8.37.3.2 Each glove pair specimen shall be tested as a complete set of gloves in new, as distributed, condition.

8.37.3.3 Glove pair specimens shall not receive special softening treatments prior to tests.

8.37.4 Apparatus. The apparatus shall be as specified in ASTM F 2010, *Standard Test Method for Evaluation of Glove Effects on Wearer Hand Dexterity Using a Modified Pegboard Test* with the modification that the stainless steel pins shall be within a medium knurled 30 degree (25 teeth/in.) surface.

8.37.5 Procedures. The testing procedures shall be as specified in ASTM F 2010, *Standard Test Method for Evaluation of Glove Effects on Wearer Hand Dexterity Using a Modified Pegboard Test.*

8.37.6 Report.

8.37.6.1 The average percentage of bare-handed control shall be recorded and reported for each test subject.

8.37.6.2 The average percentage of bare-handed control for all test subjects shall be recorded and reported for each size.

8.37.7 Interpretation.

8.37.7.1 The average percentage of bare-handed control for size small and size large shall be used to determine pass or fail performance.

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

8.38 Grip Test.

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

8.38.2 Samples.

8.38.2.1 Samples for conditioning shall be whole gloves.

8.38.2.2 Sample glove pairs shall be preconditioned as specified in 8.1.3.

8.38.3 Specimens.

8.38.3.1 A minimum of three glove pair specimens each for size small and size large shall be used for testing.

8.38.3.2 Each specimen glove pair shall be tested as a complete set of gloves in new, as distributed, condition.

8.38.3.3 Specimen glove pairs shall be tested for each material and construction combination.

8.38.3.4 Specimen glove pairs shall be tested after being conditioned for wet conditions as specified in 8.1.9.

8.38.4 Apparatus.

8.38.4.1 Pulling Device. The pulling device shall be a 3.2 cm (1¼ in.) diameter fiberglass pole attached to an overhead calibrated force measuring device in such a fashion that pulls on the pole will be perpendicular to the ground and downward in direction. This pole shall be used until surface degradation occurs.

8.38.5 Procedure.

8.38.5.1 Test subjects shall be selected so that their hand dimensions are as close as possible to the middle of the range for hand length and hand circumference as specified in Table 6.7.6.1(a) and Table 6.7.6.1(d) for size small and size large gloves. At least three test subjects shall be selected for both size small and size large.

8.38.5.2 The gloves shall be conditioned by the wetting procedure specified in 8.1.9 before each set of three pulls by the test subject as described below.

8.38.5.3 The pulling device shall be wet conditioned before each individual pull by wiping with a damp rag.

8.38.5.4 The test subject shall then make three pulls on the pulling device with gloves with peak and minimum pull force values measured. Pulls shall be performed as described 8.38.5.4.1 through 8.38.5.4.6. The test subject shall extend the arms in front of the body at shoulder height to grab the pulling device for pulling vertically down from the ceiling.

8.38.5.4.1 The test subject shall stand with feet together, firmly planted on the ground, and knees slightly bent.

8.38.5.4.2 The stand shall be adjusted such that the cushioned bar is touching the test subject's chest. The stand shall prevent the test subject's forward movement during the pull.

8.38.5.4.3 The test subject shall stand in a comfortable pulling position with the arms bent at an angle of approximately 90 degrees and, in any case, the arms shall not be completely extended or touching the body.

8.38.5.4.4 The test subject shall grasp the pulling device with hands next to each other. Thumbs shall not overlap the fingers.

8.38.5.4.5 The test subject shall pull the rope or pole with as much pulling force as possible in a smooth, steady, swift, and non-jerking action. The test subject shall not bend the knees further or pull down with body weight during the pull.

8.38.5.4.6 The test subject shall continuously pull on the pulling device for a minimum of 5 seconds, +1/−0 seconds. The test subject shall continue to pull until the test facilitator observes a peak pulling force and instructs the test subject to end the pull.

8.38.6 Report.

8.38.6.1 The peak pull force value for each individual pull shall be recorded and reported.

8.38.6.2 The minimum pull force value occurring after the peak pull force value shall be recorded and reported.

8.38.6.3 The percentage drop between the peak pull force value and the minimum pull force value shall be calculated, recorded, and reported.

8.38.7 Interpretation.

8.38.7.1 The individual percentage drop between the peak pull force value and the minimum pull force value shall be used to determine pass or fail performance.

8.38.7.2 Failure during any pull shall constitute failure of the test.

8.39 Ladder Shank Bend Resistance Test.

8.39.1 Application. This test shall apply to protective footwear.

8.39.2 Samples.

8.39.2.1 Samples for conditioning shall be whole footwear,

8.39.2.2 Ladder shanks or whole sole equivalents shall be conditioned as specified in 8.1.3.

8.39.3 Specimens. A minimum of three footwear ladder shank specimens, or whole sole equivalent specimens, shall be tested.

▲ **8.39.4 Apparatus.** The apparatus shall consist of a tensile-testing machine, such as an Instron® or equivalent, that challenges a specimen with a simulated ladder rung. A 32 mm diameter × 50 mm long (1¼ in. diameter × 2 in. long) noncompressible probe shall be mounted on the movable arm. The specimen support assembly shall consist of two 50 mm × 25 mm × 25 mm (2 in. × 1 in. × 1 in.) noncompressible blocks placed 50 mm (2 in.) apart as shown in Figure 8.39.4.

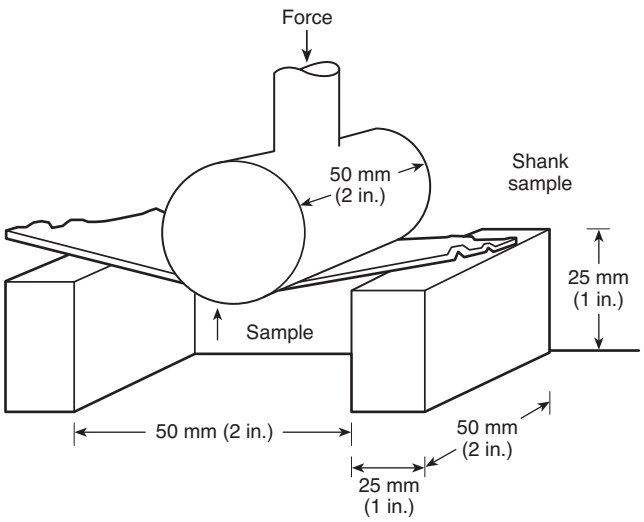

FIGURE 8.39.4 Shank Bend Test Setup.

8.39.5 Procedure. The specimen of the ladder shank or whole sole equivalent shall be placed on mounting blocks as it would be oriented toward the ladder, where the shank or whole sole equivalent is affixed into the protective footwear and subjected to force on its center with the test probe operated at 50 mm/min (2 in./min).

8.39.6 Report.

8.39.6.1 Deflection at 182 kg (400 lb) shall be recorded and reported to the nearest 1 mm (0.05 in.).

8.39.6.2 The average deflection shall be calculated, recorded, and reported to the nearest 1 mm (0.05 in.).

8.39.7 Interpretation. Pass or fail performance shall be determined using the average deflection for all specimens tested.

8.40 Slip Resistance Test.

8.40.1 Application. This test method shall apply to footwear.

8.40.2 Sample Preparation.

8.40.2.1 Samples shall be the whole footwear items in men's size 9D, medium width.

8.40.2.2 Samples shall be conditioned as specified in ISO 13287, *Personal protective equipment — footwear — test method for slip resistance.*

8.40.3 Specimens.

8.40.3.1 Specimens shall be the whole footwear in men's size 9D, medium width.

8.40.3.2 At least three specimens shall be tested.

8.40.4 Procedure. Slip resistance shall be performed in accordance with ISO 13287, *Personal protective equipment — footwear — test method for slip resistance*, in the following configurations. References to any other flooring and/or contaminate within ISO 13287 shall not apply.

(1) Footwear shall be tested both in the forepart and heel positions.

(2) Footwear shall be tested in the wet condition. The wet condition shall be achieved using distilled or de-ionized water. The water shall be applied to thoroughly wet the testing surface and make a pool at least as wide and long as the test portion of the footwear in the area of initial contact.

(3) Footwear shall be tested on a quarry tile surface that meets the following specifications:

(a) Is a flat and unglazed clay tile that is wider than the test specimen and long enough to allow a sliding distance of at least 75 mm (2.9 in.) without crossing a joint

(b) Is sufficiently flat to allow it to be secured on the mounting table such that no movement occurs between the tile and mounting table during the test

(c) Has a ribbed profile or directional marking on the underside to identify the direction in which the tile should be aligned (with the ribs parallel to the sliding direction)

(d) Conforms to the coefficient of friction values specified in Table 8.40.4 when calibrated by the Slider 96 method.

(4) *Calibration of the tiles shall be checked every 10 tests or prior to each day of testing, whichever is the less frequent, to ensure that they are not being worn smooth or otherwise damaged.

Table 8.40.4 Calibration Values for Quarry Tile

	Coefficient of Friction	
	Dry	**Wet**
Minimum	0.57	0.43
Maximum	0.63	0.49

8.40.5 Report.

8.40.5.1 The coefficient of friction of each specimen shall be reported.

8.40.5.2 The average coefficient of friction of all specimens for each configuration shall be calculated, recorded, and reported.

8.40.6 Interpretation. The average coefficient of friction for each configuration shall be used to determine pass/fail performance.

8.41 Label Durability and Legibility Test 1.

8.41.1 Application.

8.41.1.1 This test method shall apply to labels on protective garments, hoods, gloves, and boots.

8.41.1.2 Modifications to this test method for testing garment labels shall be as specified in 8.41.7.

8.41.1.3 Modifications to this test method for testing hood labels shall be as specified in 8.41.8.

8.41.1.4 Modifications to this test method for testing glove labels shall be as specified in 8.41.9.

8.41.1.5 Modifications to this test method for testing footwear labels shall be as specified in 8.41.10.

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

8.41.3 Specimens.

8.41.3.1 A minimum of three specimens of each type of label for each element shall be tested in each test.

8.41.3.2 Where labels have areas of "write-in" information, two additional specimens shall be tested that include those areas with sample information written in.

8.41.4 Procedures.

8.41.4.1 Laundering Durability Test.

8.41.4.1.1 Specimens shall be subjected to ten cycles of laundering and drying using Machine Cycle 1, Wash Temperature V, and Drying Procedure Ai of AATCC 135, *Dimensional Changes in Automatic Home Laundering of Woven and Knit Fabrics*.

8.41.4.1.2 A 1.8 kg ± 0.1 kg (4.0 lb ± 0.2 lb) load shall be used. A laundry bag shall not be used.

8.41.4.1.3 Specimens shall be examined for legibility to the unaided eye by a person with 20/20 vision, or vision corrected to 20/20, at a nominal distance of 305 mm (12 in.) in a well-illuminated area.

▲ **8.41.4.2 Abrasion Durability Test.**

8.41.4.2.1 Specimens shall be subjected to abrasion in accordance with ASTM D 4966, *Standard Test Method for Abrasion Resistance of Textile Fabrics*, with the following modifications:

(1) The standard abrasive fabric and the felt-backing fabric shall be soaked for 24 hours or agitated in distilled water so that they are thoroughly wet.
(2) The standard abrasive fabric shall be rewetted after each set of cycles by applying 20 ml (0.68 oz) of distilled water from a squeeze bottle by squirting on the center of the abrasive composite pad.
(3) Specimens shall be subjected to 200 cycles, 3200 revolutions, of the test apparatus.

8.41.4.2.2 Specimens shall be examined for legibility to the unaided eye by a person with 20/20 vision, or vision corrected to 20/20, at a nominal distance of 305 mm (12 in.) in a well-illuminated area.

8.41.4.3 Heat Durability Test.

8.41.4.3.1 Specimens shall be subjected to convective heat as specified in 8.1.5.

8.41.4.3.2 Specimens shall be examined for legibility to the unaided eye by a person with 20/20 vision, or vision corrected to 20/20, at a nominal distance of 305 mm (12 in.) in a well-illuminated area.

8.41.5 Report. The legibility for each specimen shall be recorded and reported as acceptable or unacceptable.

8.41.6 Interpretation. One or more label specimens failing this test shall constitute failing performance.

8.41.7 Specific Requirements for Testing Garment Labels.

8.41.7.1 For testing label legibility after laundering, specimens shall include individual labels sewn onto a 1 m (1 yd) square of ballast material no closer than 51 mm (2 in.) apart in parallel strips. The ballast material shall be as specified in AATCC 135, *Dimensional Changes in Automatic Home Laundering of Woven and Knit Fabrics*.

8.41.7.2 For testing label legibility after abrasion, specimens shall be individual labels.

8.41.7.3 For testing label legibility after convective heat exposure, specimens shall include individual labels sewn onto a separate 380 mm ± 13 mm (15 in. ± ½ in.) square of material that meets the outer shell requirements of this standard.

8.41.7.4 Sample conditioning shall be the same conditioning as specified for the respective tests.

8.41.7.5 Specimens shall be tested separately for legibility after laundering, abrasion, and heat durability tests as specified in 8.41.4.1, 8.41.4.2, and 8.41.4.3, respectively.

8.41.8 Specific Requirements for Testing Hood Labels.

8.41.8.1 For testing label legibility after laundering, specimens shall include complete hoods with labels attached.

8.41.8.2 For testing label legibility after abrasion, specimens shall be individual labels.

8.41.8.3 For testing label legibility after convective heat exposure, specimens shall include individual labels sewn onto a separate 380 mm ± 13 mm (15 in. ± ½ in.) square of hood material that meets the hood material requirements of this standard.

8.41.8.4 Sample conditioning shall be the same conditioning as specified for the respective tests.

8.41.8.5 Specimens shall be tested separately for legibility after laundering, abrasion, and heat durability tests as specified in 8.41.4.1, 8.41.4.2, and 8.41.4.3, respectively.

8.41.9 Specific Requirements for Testing Glove Labels.

8.41.9.1 For testing label legibility after laundering and convective heat exposure, specimens shall include complete gloves with labels attached.

8.41.9.2 For testing label legibility after abrasion, specimens shall be individual labels.

8.41.9.3 Sample conditioning shall be the same conditioning as specified for the respective tests.

8.41.9.4 Specimens shall be tested separately for legibility after laundering, abrasion, and heat durability tests as specified in 8.41.4.1, 8.41.4.2, and 8.41.4.3, respectively.

8.41.9.5 For the drying cycles of the laundering durability test specified in 8.41.4.1.1, gloves shall be tumble dried for 60 minutes and shall be removed immediately at the end of the drying cycle. At the conclusion of the final drying cycle, the gloves shall be direct dried on a Williams® G18PX dryer operated at 10°C (50°F) above current room temperature for 8 hours, +/− 45 minutes.

8.41.10 Specific Requirements for Testing Footwear Labels.

8.41.10.1 For testing label legibility after convective heat exposure, specimens shall include complete footwear items with the labels attached or representative sections of the footwear with labels attached.

8.41.10.2 Sample conditioning shall be the same conditioning as specified for the respective tests.

8.41.10.3 Specimens shall be tested separately for legibility after abrasion and heat durability tests as specified in 8.41.4.2 and 8.41.4.3, respectively.

8.42 Label Durability and Legibility Test 2.

8.42.1 Application. This test method shall apply to labels on helmets.

8.42.2 Samples.

8.42.2.1 Samples for conditioning shall be whole helmets with the labels attached.

8.42.2.2 Samples shall be conditioned as specified in 8.1.3, 8.1.4, 8.1.6, and 8.1.7.

8.42.3 Specimens. A minimum of three labels for each condition specified shall be tested.

8.42.4 Procedure. Label specimens shall be examined for legibility by a person with 20/20 vision, or vision corrected to 20/20, at a nominal distance of 305 mm (12 in.) in a well-illuminated area.

8.42.5 Report. The legibility for each label specimen shall be recorded and reported as acceptable or unacceptable.

8.42.6 Interpretation. One or more label specimens failing this test shall constitute failing performance.

8.43 Shell Retention Test.

8.43.1 Application. This test shall apply to protective helmets.

8.43.2 Samples.

8.43.2.1 Samples for conditioning shall be whole helmets.

8.43.2.2 Samples shall be conditioned as specified in 8.1.3.

8.43.3 Specimens. A minimum of three complete helmets shall be tested.

8.43.4 Apparatus.

8.43.4.1 The shell retention test fixtures shall consist of rigid material of sufficient thickness to facilitate firm attachment of the helmet shell while attached to the chinstrap tensile testing machine specified in 8.35.4.1.

8.43.4.2 The calibrated tensile test machine shall be capable of measuring the force applied to the retention system within 2 percent at the specified forces.

8.43.5 Procedure.

8.43.5.1 Specimens shall be positioned and secured in the tensile testing machine so that the helmet's reference plane is horizontal.

8.43.5.2 A pull force shall be applied to the helmet shell perpendicular to the reference plane. The force shall be applied to a maximum load of 356 N (80 lbf) within 30 seconds and shall be held at the maximum load for 1 minute, +5/−0 seconds.

8.43.6 Report.

8.43.6.1 Separation of the helmet shell from the helmet suspension system or the helmet retention system shall be recorded and reported.

8.43.6.2 The pass or fail result for each specimen shall be recorded and reported.

8.43.7 Interpretation. Any one specimen failing the test shall constitute failing performance for the item being tested.

8.44 Luminous (Visible) Transmittance Test.

8.44.1 Application. This test shall apply to faceshield/goggle component lenses.

8.44.2 Samples.

8.44.2.1 Samples for conditioning shall be complete faceshield/goggle components.

8.44.2.2 Samples shall be conditioned as specified in 8.1.3.

8.44.3 Specimens. A minimum of three faceshield/goggle component lenses shall be tested.

8.44.4 Apparatus. The standard source of radiant energy used in the measurement of luminous transmittance of filter lenses shall be a projection-type lamp No. T-8 or other high-powered, gas-filled, tungsten-filament incandescent lamp operated at the color temperature corresponding to Commission Internationale de l'Eclairage (CIE), Source A.

8.44.5* Procedure. Luminous transmittance shall be determined by one of the following means:

(1) By measuring the spectral transmittance and calculating the luminous transmittance through the use of published data on the spectral radiant energy of CIE Standard Illuminant A as specified in ISO/CIE 10526, *Calorimetric Illuminants*, and the relative luminous efficiency of the average eye
(2) By using a Gardner pivotal sphere haze meter and the standards of luminous transmittance maintained by the National Bureau of Standards

8.44.6 Report.

8.44.6.1 The percentage of light transmission shall be recorded and reported for each specimen.

8.44.6.2 The average light transmission of all specimens tested shall be calculated, recorded, and reported.

8.44.7 Interpretation. Pass or fail performance shall be based on the average light transmission measured.

8.45 Retroreflectivity and Fluorescence Test.

8.45.1 Application.

8.45.1.1 This test method shall apply to trim materials used on protective garments and helmets.

8.45.1.2 Trim materials shall be tested for each procedure specified in 8.45.4.

8.45.2 Samples.

8.45.2.1 Samples for conditioning shall include 305 mm (12 in.) long sections of trim.

8.45.2.2 Samples shall be conditioned as specified in 8.1.3.

8.45.3 Specimens.

8.45.3.1 A minimum of three trim test specimens shall be tested.

8.45.3.2 Each trim test specimen shall be 100 mm (4 in.) in length by the width of the finished trim product.

8.45.3.3 Where retroreflective and nonretroreflective surface areas are combined to form a trim, the specimen shall consist of the retroreflective and nonretroreflective portions of the finished trim product.

8.45.4 Procedures.

8.45.4.1 Measurement of Coefficient of Retroreflection.

8.45.4.1.1 The coefficient of retroreflection (R_a) shall be determined in accordance with ASTM E 809, *Standard Practice for Measuring Photometric Characteristics of Retroreflectors*, using the following modifications:

(1) Test distance shall equal 15.2 m (50 ft).
(2) Observation angle shall equal 0.2 degree.
(3) Entrance angle shall equal +5 degrees.
(4) Receiver shall be provided with an entrance aperture of 26 mm (1.024 in.), ±5 percent in diameter that is equivalent to 0.1 degree angular aperture.
(5) Exit aperture of the source shall be circular and 26 mm (1.024 in.), ±5 percent in diameter that corresponds to 0.1 degree angular aperture.
(6) Retroreflector reference angle shall equal 90 degrees.
(7) Datum mark shall be placed as specified by the trim manufacturer.

8.45.4.1.2 The coefficient of retroreflection (R_a) shall be calculated by the following equation:

$$Ra = \frac{R_I}{A_r}$$

where:
R_I = coefficient of luminous intensity measured as specified in 8.45.4.1.1
A_r = only the retroreflective surface area of the trim test specimen's surface area

8.45.4.1.2.1 A_r shall be calculated by subtracting the nonretroreflective surface area from the test specimen's total surface area.

8.45.4.2 Evaluation of Fluorescence.

8.45.4.2.1 Trim fluorescence shall be determined by its colorimetric properties. The color shall be measured in accordance with the procedures defined in ASTM E 991, *Standard Practice for Color Measurement of Fluorescent Specimens*, ASTM E 1164, *Standard Practice for Obtaining Spectrometric Data for Object Color Evaluation*, ASTM E 2152, *Standard Practice for Computing the Colors of Fluorescent Objects from Bispectral Photometric Data*, and ASTM E 2153, *Standard Practice for Obtaining Bispectral Photometric Data for Evaluation of Fluorescent Color* using the following test specifications:

(1) A polychromatic illumination of D65
(2) A 45 degree/0 degree (or 0 degree/45 degree) geometry
(3) A 2 degree standard observer
(4) A black underlay with a Cap Y, luminance factor, less than 4

8.45.4.2.2 The chromaticity shall be within one of the areas defined in Table 8.45.4.2.2, and the Cap Y, luminance factor, shall be not less than the corresponding minimum for the respective color.

Table 8.45.4.2.2 Color Requirements

Color	Chromaticity Coordinates		Minimum Luminance Factor (Cap Y)
Fluorescent yellow-green	0.387	0.610	70
	0.356	0.494	
	0.398	0.452	
	0.460	0.540	
Fluorescent orange-red	0.610	0.390	40
	0.535	0.375	
	0.570	0.340	
	0.655	0.344	
Fluorescent red	0.655	0.344	25
	0.570	0.340	
	0.595	0.315	
	0.690	0.310	

8.45.4.3 Rainfall Test.

8.45.4.3.1 Specimens of trim shall be tested for retroreflectivity when wet as specified in Annex A, "Method of Measuring Wet Retroreflective Performance," of EN 471, *Specification for High Visibility Warning Clothing*, at a rate of 110 mm/hr (4 5/16 in./hr).

8.45.4.3.2 The coefficient of retroreflectivity (R_a) shall be measured as specified in 8.45.4.1, 2 minutes ± 15 seconds, after the rainfall exposure has been started.

8.45.4.4 Convective Heat Exposure Test.

8.45.4.4.1 Specimens of trim shall be tested for retroreflectivity after convective heat exposure as specified in 8.1.5.

8.45.4.4.2 The coefficient of retroreflectivity (R_a) shall be measured as specified in 8.45.4.1.

8.45.4.4.3 The fluorescence shall be evaluated as specified in 8.45.4.2.

8.45.5 Report.

8.45.5.1 The coefficient of retroreflectivity (R_a) shall be recorded and reported for each specimen.

8.45.5.2 The average R_a of all specimens shall be calculated, recorded, and reported separately for each of the test procedures specified in 8.45.4.1, 8.45.4.3, and 8.45.4.4.

8.45.5.3 The number of fluorescent and nonfluorescent specimens shall be recorded and reported separately for each of the test procedures specified in 8.45.4.2 and 8.45.4.4.

8.45.6 Interpretation.

8.45.6.1 For trim retroreflectivity, pass or fail performance shall be determined using the average coefficient of retroreflection (R_a) reported for each group of specimens for each of the procedures specified in 8.45.4.1, 8.45.4.3, and 8.45.4.4.

8.45.6.2 For trim fluorescence, specimens that do not meet the chromaticity and luminance factor requirements shall be designated as nonfluorescent.

8.46 Hood Opening Size Retention Test.

8.46.1 Application.

8.46.1.1 This test shall apply to the face openings or SCBA facepiece interface openings of protective hoods.

8.46.1.2 Protective hoods with either elastic face openings or manually adjustable face openings shall be tested by the procedure specified in 8.46.4.

8.46.1.3 Protective hoods designed for interface with a SCBA facepiece(s) shall be tested by the procedure specified in 8.46.5.

8.46.2 Samples.

8.46.2.1 Samples for conditioning shall be whole hoods.

8.46.2.2 Samples shall be conditioned as specified in 8.1.3.

8.46.3 Specimens. A minimum of three whole hoods shall be tested.

8.46.4 Procedure for Hoods with Elastic or Manually Adjustable Face Openings.

8.46.4.1 The hood shall be laid on a flat surface with the face opening facing up.

8.46.4.2 The hood face opening shall be marked at a minimum of eight separate locations around the entire perimeter of the face opening. The hood shall be measured in four locations between opposite sets of marks.

8.46.4.3 The hood shall be positioned on the ISO size J headform specified in Figure 8.16.4.1 so that the hood is around the neck area of the headform with the neck and head area of the headform protruding through the face opening of the hood. The hood shall then be donned and doffed for 50 cycles, passing the hood face opening up and over the headform to cover the head, forehead, sides of face, chin, and neck each time and then passing the hood back down over the headform to the starting area around the neck. Hoods with manually adjustable face openings shall have the face opening adjusted during each cycle, once after donning and again before doffing.

8.46.4.4 Following the 50 cycles, the hood shall be removed from the headform, and the hood shall be allowed to relax for 1 minute.

8.46.4.5 The hood shall be laid on a flat surface with the face opening facing up.

8.46.4.6 The opening dimensions shall then be measured at the same locations marked around the entire perimeter of the face opening specified in 8.46.4.2.

8.46.4.7 The percent retention of each hood face opening dimensions shall be determined.

8.46.5 Procedure for Hoods with SCBA Facepiece Interface Openings.

8.46.5.1 The SCBA facepiece that the hood is designed to interface with shall be properly mounted, according to the SCBA manufacturer's instructions, on an ISO size J headform specified in Figure 8.16.4.1.

8.46.5.2 The hood shall then be donned on the headform, placing it over the SCBA facepiece.

8.46.5.3 The contact surface of the hood face opening with the SCBA facepiece shall be measured at a minimum of eight separate locations around the entire perimeter of the face opening contact area. The locations of measurement shall be marked on the hood.

8.46.5.4 With the SCBA facepiece in place, the hood shall then be positioned so that the hood is around the neck area of the headform with the neck and head area of the headform protruding through the face opening of the hood. The hood shall then be donned and doffed for 50 cycles, passing the hood face opening up and over the headform to cover the head and to contact the SCBA facepiece around the entire perimeter of the face opening contact area each time, and then passing the hood back down over the headform to the starting area around the neck. Where such hoods are designed to be manually adjustable around the hood face opening/SCBA facepiece interface area, the manual adjustment shall be made during each cycle, once after donning and again before doffing.

8.46.5.5 Following the 50 cycles, the hood shall be removed from the headform, and the hood shall be allowed to relax for 1 minute.

8.46.5.6 The hood shall then be donned on the headform, placing it over the SCBA facepiece.

8.46.5.7 The contact surface of the hood face opening with the SCBA facepiece shall be measured at the same locations marked around the entire perimeter of the face opening contact area specified in 8.46.5.3.

8.46.5.8 The amount of overlap shall be measured.

8.46.6 Report for Hoods with Elastic or Manually Adjustable Face Openings.

8.46.6.1 Each hood face opening dimension before and after donning shall be recorded and reported.

8.46.6.2 The percent retention of each hood face opening dimensions shall be recorded and reported.

8.46.6.3 The average percent retention of all hood face opening dimensions for each specimen shall be calculated, recorded, and reported.

8.46.7 Report for Hoods with SCBA Facepiece Interface Openings.

8.46.7.1 The amount of overlap shall be recorded and reported for each location.

8.46.7.2 The average amount of overlap shall be recorded and reported for each specimen.

8.46.8 Interpretation for Hoods with Elastic or Manually Adjustable Face Openings.

8.46.8.1 Pass or fail performance shall be based on the average percent retention of the hood face opening dimensions for each specimen. One or more hood specimens failing this test shall constitute failing performance.

8.46.9 Interpretation for Hoods with SCBA Facepiece Interface Openings. Pass or fail performance shall be based on the average amount of overlap for each specimen. One or more hood specimens failing this test shall constitute failing performance.

▲ **8.47 Whole Garment and Ensemble Liquid Penetration Test.**

8.47.1 Application.

8.47.1.1 This test method shall apply to protective garments, protective coats with an integrated garment-glove interface, protective trousers with integrated booties, and entire ensembles that are being evaluated for the optional CBRN terrorism agent protection.

8.47.1.2 Modifications to this test method for testing protective coats and protective coats with an integrated garment-glove interface shall be as specified in 8.47.9.

8.47.1.3 Modifications to this test method for testing protective trousers and protective trousers with integrated booties shall be as specified in 8.47.10.

8.47.1.4 Modifications to this test method for testing protective coat and trouser sets or protective coveralls shall be as specified in 8.47.11.

8.47.1.5 Modifications to this test method for testing proximity fire fighting ensemble garment elements shall be as specified in 8.47.12.

8.47.1.6 Modifications to this test method for testing entire ensembles for optional CBRN terrorism agent protection shall be as specified in 8.47.13.

8.47.2 Samples.

8.47.2.1 Samples shall be complete garments or ensemble elements.

8.47.2.2 Samples shall be conditioned as specified in 8.1.3.

8.47.3 Specimens.

8.47.3.1 A minimum of three specimens shall be tested. Specimens shall consist of individual coats, trousers, or coveralls elements; sets of coats and trousers elements, or entire ensembles for CBRN terrorism agent protection. Each element shall have in place all layers that are required for the element to be compliant.

8.47.3.2 The size of the elements comprising the specimens shall be chosen to conform with the dimensions of the mannequin for proper fit of the specimen on the mannequin in accordance with the manufacturer's sizing system. The size of the elements comprising the specimen shall be the same size as the mannequin in terms of chest circumference, waist circumference, and inseam height.

8.47.3.3 Specimens to be tested shall be conditioned as specified in 8.1.3.

8.47.3.4 A minimum of three specimens shall be tested. Specimens shall consist of individual coats, trousers, coveralls, sets of coats and trousers, or overall ensembles as addressed in 8.47.11. Each element shall have in place all layers that are required for the element to be compliant.

8.47.3.5 The size of the elements comprising the specimens shall be chosen to conform with the dimensions of the mannequin for proper fit of the specimen on the mannequin in accordance with the manufacturer's sizing system. The size of the elements comprising the specimen shall be the same size as the mannequin in terms of chest circumference, waist circumference, and inseam height.

8.47.4 Sample Preparation.

8.47.4.1 Specimens to be tested shall be conditioned as specified in 8.1.3.

8.47.4.2 Samples to be conditioned shall be complete garments.

8.47.5 Apparatus. The apparatus and supplies for testing shall be those specified in ASTM F 1359, *Standard Practice for Evaluating the Liquid-Tight Integrity of Chemical Protective Clothing*, with the following modifications:

(1) The surface tension of the water used in testing shall be 35 dynes/cm ± 5 dynes/cm.
(2)*The mannequin used in testing shall be fully upright and shall have straight arms and legs with the arms positioned at the mannequin's side.

8.47.6 Procedure. Liquid penetration testing of garments shall be conducted in accordance with ASTM F 1359, *Standard Practice for Evaluating the Liquid-Tight Integrity of Chemical Protective Clothing*, with the following modifications:

(1) No provision for partial garments shall be permitted.
(2) Blocking of the specimen shall be as specified in 8.47.8, 8.47.9, and 8.47.10, as appropriate, for the type of specimen being tested.
(3) The method used for mounting of the mannequin in the spray chamber shall not interfere with the water spray.
(4) The normal outer surface of the material shall be exposed to the liquid as oriented in the clothing item.
(5) Fluorescent or visible dyes shall not be used in the water for spraying the suited mannequin.
(6) The suited mannequin shall be exposed to the liquid spray 5 minutes in each of the four mannequin orientations for a total of 20 minutes.
(7) At the end of the liquid spray exposure period, excess liquid shall be removed from the surface of the specimen.
(8) The specimen shall be inspected within 10 minutes of the end of the liquid spray exposure period for evidence of liquid penetration.

8.47.7* Report. A diagram shall be prepared for each test that identifies the locations of any liquid leakage as detected on the liquid-absorptive garment.

8.47.8 Interpretation. Any evidence of liquid on the liquid-absorptive garment, as determined by visual, tactile, or absorbent toweling, shall constitute failure of the specimen.

8.47.9 Specific Requirements for Testing Coats and Coats with an Integrated Garment-Glove Interface.

8.47.9.1 The liquid-absorptive garment shall only cover the upper torso and arms of the mannequin from the middle of the mannequin's neck, down to the mannequin's waistline, and down to the mannequin's wrist crease.

8.47.9.2 The coat shall be donned on the mannequin in accordance with the manufacturer's instructions for proper wearing.

8.47.9.3 The coat collar shall be placed in the up position on the mannequin with the collar closure system fastened in the closed position. The head of the mannequin shall be sealed off with a plastic bag. The plastic bag shall extend downward over the collar a distance of not greater than 25 mm (1 in.) and shall be taped down using duct tape or similar waterproof tape. The tape shall not extend downward more than 75 mm (3 in.) from the top of the collar. The bottom edge of the tape