



Designation: E3422/E3422M – 24

Standard Specification for Protective Helmets Worn by Pedestrian Roadway Workers¹

This standard is issued under the fixed designation E3422/E3422M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This standard specifies performance requirements and test methods for protective headgear worn by individuals who work on roadways, including personnel involved in:

- 1.1.1 Public safety (that is, fire service, emergency medical services, law enforcement, fire police);
- 1.1.2 Road and highway construction and maintenance;
- 1.1.3 Towing and recovery;
- 1.1.4 Departments of transportation; and
- 1.1.5 Safety service patrol.

1.2 This standard addresses performance in terms of impact protection, chin protection (if a chin bar is included), external projections, positional stability, retention system strength, horizontal field of view, and face/eye protection.

1.2.1 The performance requirements are listed within each test procedure as acceptance criteria.

1.2.2 To claim compliance with this specification, test items shall be tested as specified in Sections 9 – 16 and shall meet the acceptance criteria.

1.2.3 Optional tests and performance requirements are included in Appendix X1 – Appendix X3 for end users who have additional hazards of concern.

1.3 This standard specifies pre-conditioning procedures to address environmental conditions in which these helmets are worn.

1.4 This specification may be used by suppliers, certification or verification bodies, testing laboratories, research and development organizations, and others assessing the performance of protective helmets for pedestrian roadway workers.

1.5 This specification is divided into the following sections:

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4	Significance and Use
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16	Face Shield or Eye Protection Impact: Requirements
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18	Product Label and Package Label Requirements
19	Test Report
20	Keywords
Annex A1	Summary of Test Item Requirements and Related Details for Initial Type Testing
Annex A2	Summary of Test Item Requirements and Related Details for Surveillance Testing
Appendix X1	Optional Heat Resistance Test Procedure and Acceptance Criteria
Appendix X2	Optional Electrical Hazard Resistance Test Procedure and Acceptance Criteria
Appendix X3	Optional Visibility Test Procedure and Acceptance Criteria

1.6 Units—The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

1.7 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.

1.8 This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

¹ This specification is under the jurisdiction of ASTM Committee E54 on Homeland Security Applications and is the direct responsibility of Subcommittee E54.04 on Public Safety Equipment.

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2. Referenced Documents

2.1 ASTM Standards:²

- E2771** Terminology for Homeland Security Applications
E3215 Practice for Certification of Less Lethal Aerosol Devices Used by Law Enforcement, Corrections, and Other Public Safety Officers
E3343/E3343M Test Methods for Nonballistic-resistant Helmets Worn by Law Enforcement and Corrections
F1446 Test Methods for Equipment and Procedures Used in Evaluating the Performance Characteristics of Protective Headgear
F1587 Specification for Head and Face Protective Equipment for Ice Hockey Goaltenders
F1952 Specification for Helmets Used for Downhill Mountain Bicycle Racing
F2220 Specification for Headforms

2.2 AATCC Standard:³

- AATCC Test Method 169** Weather Resistance of Textiles: Xenon Lamp Exposure

2.3 ANSI/ISEA Standards:⁴

- ANSI/ISEA Z87.1** American National Standard for Occupational and Educational Personal Eye and Face Protection Devices
ANSI/ISEA Z89.1 American National Standard for Industrial Head Protection

2.4 CSA Standard:⁵

- CSA Z262.2-14** Specifications for facially featured headforms

2.5 ISO/IEC Standard:⁶

- ISO/IEC 17025** General requirements for the competence of testing and calibration laboratories

2.6 NFPA Standards:⁷

- NFPA 1971** Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting, Quincy, Massachusetts
NFPA 1977 Standard on Protective Clothing and Equipment for Wildland Fire Fighting and Urban Interface Fire Fighting

2.7 SAE Standard:⁸

- SAE Recommended Practice J211/1_201403** Instrumentation for Impact Test - Part 1 - Electronic Instrumentation

2.8 UNE Standard:⁹

- UNE EN12492** Mountaineering equipment, Helmets for mountaineers, Safety requirements and test methods

2.9 UNECE Standard:¹⁰

- ECE 22.06** Uniform provisions concerning the approval of protective helmets and of their visors for drivers and passengers of motor cycles and mopeds

3. Terminology

3.1 Definitions:

3.1.1 basic plane, *n*—an anatomical plane (Frankfort Horizontal Plane) that includes the superior rim of the external auditory meatus (upper edge of the external openings of the ear) and the inferior margin of the orbit (the lowest point of the floor of the eye socket) (see Figs. 1 and 2). **F1446**

3.1.2 boss, *n*—a location midway between the coronal plane and mid-sagittal plane, towards either the front or the rear of a helmet.

3.1.3 certification body, *n*—third-party conformity assessment body operating certification schemes and attesting to the conformity of products. **E3215**

3.1.3.1 Discussion—A certification body can be non-governmental or governmental (with or without regulatory authority) and can also be known as a certification organization.

3.1.4 certified product, *n*—any product that has successfully been tested and found to conform by an appropriately accredited certification body. **E3215**

3.1.5 chin bar, *n*—a protective component of or attachment to the helmet that extends down and around the chin to offer chin, jaw, or lower face protection.

⁹ Available from Spanish Association for Standardization (Asociación Española de Normalización, UNE), Génova, 6. 28004 Madrid, Spain, <http://www.une.org>.

¹⁰ Available from United Nations Economic Commission for Europe (UNECE), Palais des Nations, CH-1211 Geneva 10, Switzerland, <https://unece.org/unece-content/standard-collection>.

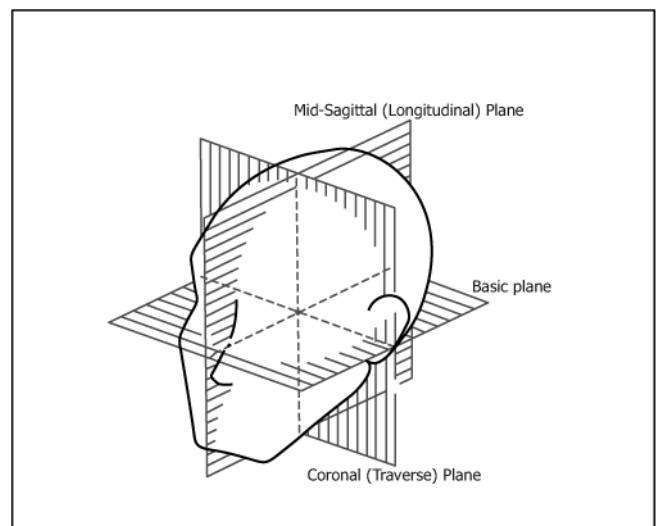


FIG. 1 Anatomical Planes

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at www.astm.org/contact. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

³ Available from American Association of Textile Chemists and Colorists (AATCC), P.O. Box 12215, Research Triangle Park, NC 27709-2215, <http://www.aatcc.org>.

⁴ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

⁵ Available from Canadian Standards Association (CSA), 178 Rexdale Blvd., Toronto, ON M9W 1R3, Canada, <http://www.csagroup.org>.

⁶ Available from International Organization for Standardization (ISO), ISO Central Secretariat, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, <https://www.iso.org>.

⁷ Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169-7471, <http://www.nfpa.org>.

⁸ Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096, <http://www.sae.org>.

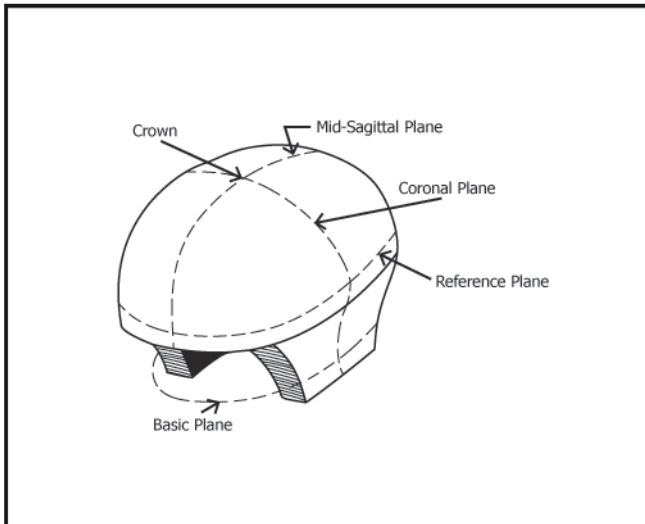


FIG. 2 Headform with Locations for Anatomical Planes

3.1.15 *perforation, n*—an opening that passes through the entire thickness of a helmet or the thickness of a helmet shell.

3.1.16 *projection, n*—any part of a helmet shell or component attached to the shell, internal or external, that extends beyond the surface and may cause injury during an impact.

Adapted from F1446

3.1.16.1 *Discussion*—Examples of external projections include attachments for accessories (for example, rails) and fastener heads that are not radiused.

3.1.17 *reference plane, n*—a plane marked on the headforms at a specified distance above and parallel to the basic plane (see Fig. 2).

F1446

3.1.18 *retention system, n*—the complete assembly that secures the helmet, in a stable position, on the wearer's head.

F1446

3.1.19 *suspension system, n*—a component of a helmet that maintains a standoff distance between the helmet shell and the head and provides the primary means of absorbing energy during impact.

3.1.20 *test item, n*—a single article intended for testing.

E2771

3.1.21 *test line, n*—a line drawn on the helmet as specified in the individual performance standards.

F1446

3.1.22 *verification, n*—a system whereby a third-party independent organization determines that a supplier has demonstrated the ability to make a product that complies with the requirements of the specification, authorizes the supplier to use a label on products that comply with the requirements of the specification, and conducts a follow-up surveillance program to verify the methods the supplier uses to determine conformance with the requirements of the specification.

3.1.22.1 *Discussion*—Verification differs from certification in that the program requirements do not include manufacturing facility inspections nor quality system audits.

3.1.23 *verification body, n*—third-party conformity assessment body operating verification schemes and attesting to the conformity of products.

3.1.24 *verified product, n*—product that has successfully been tested and found to conform by an appropriately accredited verification body.

3.1.25 *verified product listing, n*—a publicly accessible listing of verified products.

4. Significance and Use

4.1 The purpose of this specification is to provide performance requirements and test methods for the evaluation of protective helmets worn by pedestrian roadway workers.

4.2 This specification may be used by suppliers, certification or verification bodies, testing laboratories, research and development organizations, and others assessing the performance of protective helmets.

4.3 This specification may be used by purchasers in their evaluation of products to meet their needs and requirements.

4.4 It is important that organizations using helmets complying with this specification conduct a hazard assessment that

3.1.6 *complete helmet, n*—the helmet shell and attached hardware, retention system, and suspension or padding system.

3.1.7 *conditioning, n*—a process that exposes an item, prior to testing, to a specified controlled environment or physical stresses, or both.

E2771

3.1.8 *controlled ambient, n*—conditions with temperature of $20^{\circ}\text{C} \pm 5.5^{\circ}\text{C}$ [$68^{\circ}\text{F} \pm 10^{\circ}\text{F}$] and $50\% \pm 20\%$ relative humidity (RH).

E2771

3.1.9 *coronal plane, n*—an anatomical plane perpendicular to both the basic and mid-sagittal planes and passing through the superior rims of the right and left auditory meatuses; the transverse plane corresponds to the coronal plane (see Figs. 1 and 2).

F1446

3.1.10 *field of vision, n*—angle of vision as measured on the reference headform (upward, downward, and peripheral).

F1446

3.1.11 *helmet, n*—a protective device worn on the head in an effort to reduce or minimize injury to that portion of the head that is within an area above the test line (as defined in the individual performance standards).

F1446

3.1.12 *helmet position index (HPI), n*—the vertical distance from the brow of the helmet to the basic plane, when the helmet is placed on a reference headform; the manufacturer shall specify the size of the headform and the vertical distance.

F1446

3.1.13 *mid-sagittal plane, n*—an anatomical plane perpendicular to the basic plane and containing the midpoint of the line connecting the notches of the right and left inferior orbital ridges and the midpoint of the line connecting the superior rims of the right and left external auditory meatus; the longitudinal plane corresponds to the mid-sagittal plane (see Figs. 1 and 2).

F1446

3.1.14 *modular elastomer programmer (MEP), n*—a cylindrical-shaped pad used as the impact surface for the spherical impactor.

F1446



to determine the suitability of this specification and helmets complying with this specification for the specific hazards that they face in their operations on roadways.

5. Design Requirements

5.1 For a helmet that has an inner comfort liner, it shall be removable to allow it to be washed, cleaned, or replaced.

5.2 Test items shall be verified to have no sharp edges or projections on the helmet's inner surface, such as is likely to cause skull fracture when impacted.

5.2.1 There shall be no projection on the helmet's inner surface that projects more than 5 mm [0.2 in.] into the helmet interior.

6. Testing Requirements

6.1 Test Item Requirements:

6.1.1 Test items shall be actual products that are sized as specified in subsequent sections of this specification.

6.1.2 The supplier shall supply a build sheet and dimensioned diagram with the test items.

6.1.3 All test items shall be identical in materials of construction and material configuration.

6.1.4 Test items of the same size shall be identical in construction.

6.2 Test Line:

6.2.1 The test line shall be marked on each test item.

6.3 Fair Hit Requirements for Impact Testing:

6.3.1 Each impact on a test item shall be within 12.7 mm [0.5 in.] of the marked impact location.

6.3.2 Each impact on a test item shall be at least 25 mm [1.0 in.] from any attachment points, unless the test method specifies impacting attachment points.

7. Conditioning Requirements

7.1 Prior to conditioning, photograph at least one test item of each size to document the features.

7.2 Perform a visual inspection of test items both prior to and after conditioning, and record observations and changes in physical features.

8. Conditioning Procedures

8.1 Temperature and Humidity Conditioning Procedures:

8.1.1 Equipment:

8.1.1.1 The environmental chamber shall be capable of achieving and maintaining the required temperature and humidity within the specified tolerances for the duration of the conditioning procedure.

8.1.1.2 The monitoring equipment shall include measurement and recording device(s), independent from the chamber controllers.

8.1.1.3 The monitoring equipment shall provide and allow documentation of temperature and relative humidity measurements inside the chamber.

8.1.2 Controlled Ambient Conditioning:

8.1.2.1 Subject each test item to controlled ambient conditions of 15 °C to 25 °C [58 °F to 78 °F] and 50 % ± 20 % relative humidity (RH) for at least 24 h.

8.1.3 High Temperature Conditioning:

8.1.3.1 Subject each test item to high temperature conditioning for between 24 h and 48 h at 47 °C to 53 °C [117 °F to 127 °F] and relative humidity of 50 % ± 20 % in a conditioning chamber.

8.1.4 Low Temperature Conditioning:

8.1.4.1 Subject each test item to low temperature conditioning for between 24 h and 48 h at –13 °C to –17 °C [9 °F to 1 °F] in a conditioning chamber.

8.2 Artificial Weathering Procedure:

8.2.1 The test equipment shall be as described in AATCC Test Method 169.

8.2.2 Weathering of test items shall be performed in accordance with AATCC Test Method 169 with the modifications listed below:

8.2.2.1 The test apparatus shall be a xenon weatherometer with reflective panels.

8.2.2.2 The test apparatus shall be equipped with an automatic light monitor and shall be capable of automatically controlling irradiance, temperature, and humidity. The apparatus shall be maintained in accordance with manufacturer recommendations.

8.2.2.3 The weathering cycle shall be a total of 180 min, consisting of the following in order: 40 min of light, 20 min of light with water spray on the test item, 60 min of light, and 60 min of darkness. The cycle shall be repeated until the total energy exposure is equal to 100 kJ/m², and the weathering cycle shall be terminated at that point.

8.2.2.4 The spectral irradiance level shall be 0.55 W/m²/nm ± 0.01 W/m²/nm bandpass at 340 nm.

8.2.2.5 The glass filter combination shall be quartz inner filter and a borosilicate type “S” outer filter.

8.2.2.6 The temperatures and RH shall be as specified in Table 1.

8.2.3 After the required exposure period, the test items shall be removed from the apparatus.

8.2.4 Any area of the helmet shell may be tested due to the light reflecting off the panels used in the weatherometer.

8.3 Water Submersion Conditioning Procedure:

8.3.1 Equipment and Materials:

8.3.1.1 Equipment shall consist of a fluid container of sufficient size to allow at least one test item of the largest size to be fully submersed.

8.3.1.2 Appropriate range weight scale capable of measuring to the nearest 0.5 g [0.001 lb] shall be used for weighing test items.

TABLE 1 Temperature and Humidity for Weathering Procedure

	Dark Cycle	Light Cycle
Black Panel	38 °C ± 3 °C [100 °F ± 5 °F]	77 °C ± 3 °C [171 °F ± 5 °F]
Conditioning Water	40 °C ± 3 °C [104 °F ± 5 °F]	53 °C ± 3 °C [127 °F ± 5 °F]
Wet Bulb Depression	0 °C ± 3 °C [32 °F ± 5 °F] RH ≥ 95 %	10 °C ± 3 °C [50 °F ± 5 °F] RH = 50 % ± 5 % (This does not apply to light cycle with water spray.)



8.3.1.3 The water shall be plain water at a temperature between 16 °C and 26 °C [60 °F and 80 °F], shall be clean, and shall be either potable tap or demineralized water.

8.3.1.4 The water shall be replaced any time there are visible impurities in the water.

8.3.1.5 An appropriate weight may be used to prevent the test item from floating while immersed. The weight shall not have a mass greater than 9.3 kg [20.5 lbm].

8.3.1.6 Each test item shall be conditioned at controlled ambient conditioning prior to submersion.

8.3.2 Procedure:

8.3.2.1 Weigh each test item to the nearest 1 g [0.002 lb] prior to immersion.

8.3.2.2 Immerse the test item(s), with crown pointed down, in water at the required temperature. Each test item is required to be completely submerged, with the uppermost part approximately 15 cm [6 in.] beneath the surface of the water.

8.3.2.3 Test items shall not be stacked atop each other during immersion but may be placed side-by-side.

8.3.2.4 If necessary to prevent floating while in fluid, place a weight on or in each test item.

8.3.2.5 The test item(s) shall be immersed for 3 h to 4 h.

8.3.2.6 Following immersion, allow the test item to drain crown-up for 5 min $\pm$ 10 s to shed non-absorbed water before final weighing. Do not wipe excess moisture from the test item.

8.3.2.7 Promptly weigh the test item to the nearest 1 g [0.002 lb].

8.3.2.8 Examine the test item for softening, peeling, blistering, cracking, or delamination.

8.3.3 Documentation:

8.3.3.1 Observations of degradation shall be documented.

9. Impact against Hard Surface: Requirements and Test Procedures

9.1 Overview of Test:

9.1.1 This test simulates an individual's head striking a hard surface and involves dropping the helmet (attached to a headform) onto three anvils (flat, triangular, and hemispherical).

9.1.2 The test is based on the procedures of Test Methods **F1446** and incorporates improvements from other standards.

9.2 Equipment:

9.2.1 Headforms:

9.2.1.1 Headforms shall meet the requirements of Specification **F2220** and shall be variable mass configuration with mass of each size as shown in **Table 2**.

NOTE 1—The reference plane is defined by Specification **F2220**, and it is typically marked on headforms meeting Specification **F2220**.

TABLE 2 Mass of Each Size Headform (Test Methods **F1446)**

Size	Mass
A	3.1 kg $\pm$ 0.10 kg [6.8 lb $\pm$ 0.2 lb]
C	3.6 kg $\pm$ 0.10 kg [7.9 lb $\pm$ 0.2 lb]
E	4.1 kg $\pm$ 0.12 kg [9.0 lb $\pm$ 0.3 lb]
J	4.7 kg $\pm$ 0.14 kg [10.4 lb $\pm$ 0.3 lb]
M	5.6 kg $\pm$ 0.16 kg [12.3 lb $\pm$ 0.4 lb]
O	6.1 kg $\pm$ 0.18 kg [13.5 lb $\pm$ 0.4 lb]

9.2.1.2 One of the following six headform sizes shall be selected to most closely match the required helmet size: F2220-A, F2220-C, F2220-E, F2220-J, F2220-M, and F2220-O.

9.2.1.3 The headform shall be appropriately sized for the test item and include mountings for accelerometers situated at the headform center of gravity.

(1) The test lines shall be drawn in accordance with the headform that will be used for testing.

9.2.2 Free Fall Test Setup:

9.2.2.1 The test setup shall consist of a guided free fall system for a drop assembly and shall have a fixture for supporting the headform and test item.

9.2.2.2 The helmet shall be secured to the headform so that it does not shift position prior to or during impact. During impact testing, the retention system shall be secured in a manner that does not interfere with free fall or impact.

9.2.2.3 The drop assembly shall consist of the headform, the accelerometer, and the supporting fixture. The center of mass of the drop assembly shall lie within a cone, with its axis vertical and forming a 10° included angle with the vertex at the point of impact (Test Methods **F1446**).

9.2.2.4 The supporting fixture shall not affect the measurement of acceleration at the center of gravity of the headform.

9.2.2.5 An example test setup is shown in **Fig. 3** (Specification **F1587**).

9.2.3 Velocity Measuring System:

9.2.3.1 A velocity measuring system shall be used and shall be capable of measuring the velocity of the test item within 50 mm [2 in.] of the top of the test anvil with an accuracy of ± 0.1 m/s [0.3 ft/s].

9.2.4 Accelerometer (Test Methods **F1446**):

9.2.4.1 A uni-axial accelerometer capable of withstanding a shock of at least 9810 m/s² [1000 g] in the headform, with a minimum measuring range of 3923 m/s² [0 g to 400 g] acceleration with an accuracy of ± 5 % shall be used.

9.2.4.2 The accelerometer data channel, including all instrumentation which may alter the frequency content of the test data and all recoding and analysis procedures, shall comply with SAE Recommended Practice J211/1_201403 requirements for channel class 1000. The minimum data sampling rate shall be 10 kHz.

9.2.5 Instrument System Check Equipment (Test Methods **F1446**):

9.2.5.1 The impact surface for the instrument system check shall be a flat modular elastomer programmer (MEP), 152 mm [6 in.] in diameter and 25 mm [1 in.] in thickness. The MEP shall have a durometer of 60 Shore "A" $\pm$ 2 Shore "A." It is affixed to the top surface of a flat, 6.35 mm [0.25 in.] thick aluminum plate.

9.2.5.2 A spherical impactor made of low resonance material (for example, magnesium), aluminum alloy, or stainless steel that couples mechanically with the ball arm connector of the drop assembly shall be used in place of the headform. When mounted, the device presents a spherically machined impact face with a radius of 73 mm [3 in.] on its bottom surface. All radii from the center of curvature of the impact face to its outer edge shall form angles of 10° or less with