Designation: E3299/E3299M – 22

Standard Test Methods for Compression Resistance of Helmets[1]

This standard is issued under the fixed designation E3299/E3299M; 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 provides test methods for assessing compression resistance of helmets worn by military, law enforcement, and corrections personnel. These test methods are applicable for many styles of helmet (that is, high-cut, mid-cut, full-cut).

1.2 Three compression test methods are included: (*1*) top-to-bottom, (*2*) side-to-side, and (*3*) front-to-back.

1.3 It is anticipated that this standard will be referenced by suppliers, certifiers, purchasers, or other users to meet their specific needs. Those users will specify, in other standards and specifications, which test methods and conditioning procedures are applicable and will specify any performance categories or levels.

1.4 *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.

1.5 *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.*

1.6 *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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D2240 Test Method for Rubber Property—Durometer Hardness

D3575 Test Methods for Flexible Cellular Materials Made from Olefin Polymers

D4819 Specification for Flexible Cellular Materials Made From Polyolefin Plastics

E3005 Terminology for Body Armor

F1446 Test Methods for Equipment and Procedures Used in Evaluating the Performance Characteristics of Protective Headgear

2.2 *U.S. Government Standards:*

FMVSS No. 218 Laboratory Test Procedure for Motorcycle Helmets, National Highway Traffic Safety Administration[3]

2.3 *ISO/IEC Standards:*

ISO/IEC 17025 General Requirements for the Competence of Testing and Calibration Laboratories[4]

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 Fig. 1 and Fig. 2).

(Test Method F1446)

3.1.2 *controlled ambient, n*—conditions with temperature of 68 ± 10 °F [20.0 ± 5.6 °C] and 50 ± 20 % relative humidity (RH). **(Adapted from Terminology E3005)**

[1] These test methods are under the jurisdiction of ASTM Committee E54 on Homeland Security Applications and are the direct responsibility of Subcommittee E54.04 on Personal Protective Equipment (PPE).

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

[3] Available from National Highway Traffic Safety Administration (NHTSA), 1200 New Jersey Ave., SE, Washington, DC 20590, http://www.nhtsa.gov.

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

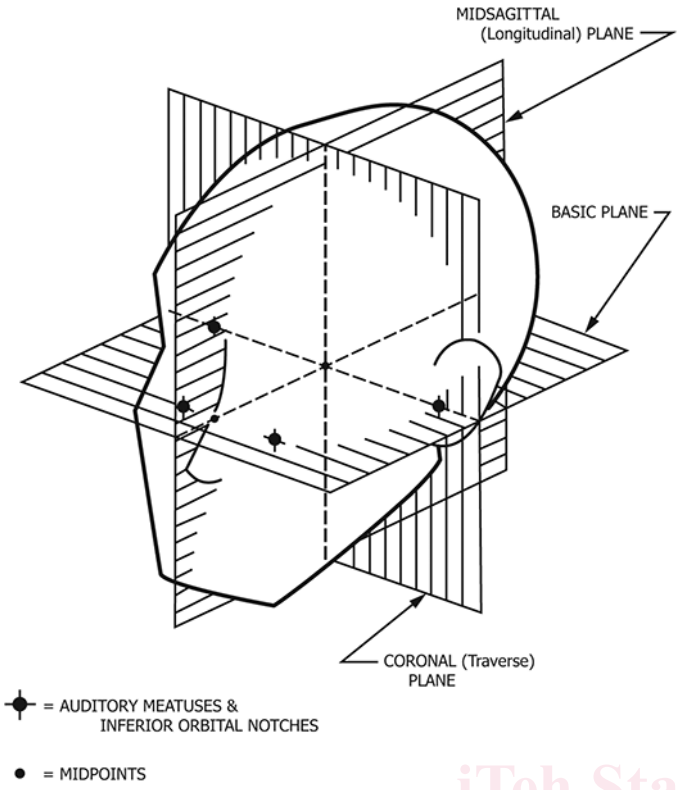

FIG. 1 Anatomical Planes

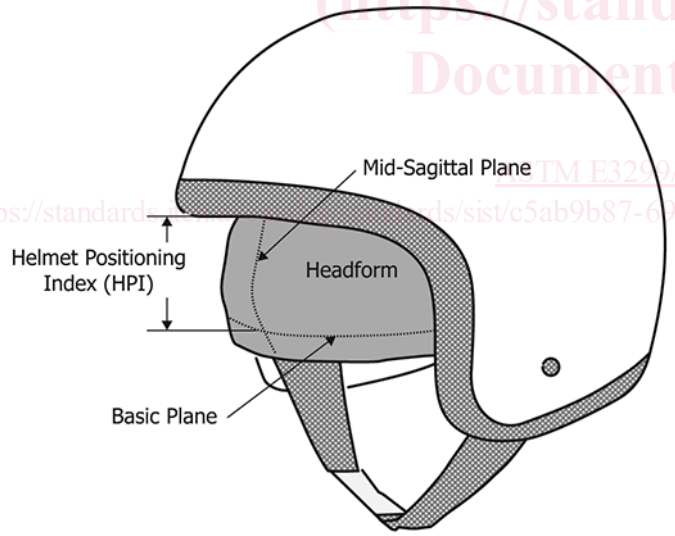

FIG. 2 Helmet Positioning Index

3.1.3 *coronal plane, n*—an anatomical plane perpendicular to both the basic and midsagittal planes and passing through the superior rims of the right and left auditory meatuses; the transverse plane corresponds to the coronal plane (see Fig. 1). **(Test Method F1446)**

3.1.4 *helmet positioning index (HPI), n*—the vertical distance from the brow of the helmet to an anatomical point of reference on the headform (for example, 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 (Test Method F1446); see Fig. 2. **(U.S. DOT FMVSS No. 218)**

3.1.5 *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 Fig. 1). **(Test Method F1446)**

4. Significance and Use

4.1 The purpose of this standard is to provide reliable and repeatable compression test methods for the evaluation of helmets used in law enforcement, corrections, and military applications.

4.2 It is anticipated that this standard will be referenced by certifiers, purchasers, or other users in order to meet their specific needs. Those users will specify which test methods apply and will specify any performance categories or levels.

5. Hazards

5.1 The tests described in this test method have inherent hazards. It is the responsibility of the testing laboratory to ensure adequate safeguards for personnel and property when conducting these tests.

6. Test Item Requirements

6.1 *Marking Helmet Planes:*

6.1.1 It is necessary to mark the helmet with the coronal and mid-sagittal planes before positioning the helmet in the test compression fixture. See Fig. 2.

6.1.2 A complete helmet is required, including the shell, suspension system, and padding (if applicable).

6.1.3 The helmet shall be placed on an appropriately sized headform, and an 11.0 ± 0.2 lb [5.0 ± 0.1 kg] static mass is applied to the crown of the helmet. The helmet shall then be adjusted on the headform to achieve the HPI.

6.1.3.1 The manufacturer or user of this standard shall specify the HPI, so that the testing laboratory can position the helmet appropriately on the defined headform.

6.1.4 Mark the helmet shell exterior with the coronal and mid-sagittal planes.

6.2 *Test Item for Compression Testing:*

6.2.1 The test item for compression testing shall be a marked (as indicated above) finished helmet shell without retention systems, suspension systems, or hardware. Unless otherwise specified, a face shield, a night vision goggle shroud, or other accessories attached to the helmet, shall be removed before testing. Unless otherwise specified, rails attached to the helmet shall be removed. Edging shall not be removed from the helmet.

6.2.2 The user of this standard shall specify whether a single helmet shell is required for multiple tests or whether a different helmet shell is required for each test.

6.2.3 The test item shall be conditioned at controlled ambient for at least 24 h prior to testing.

7. Equipment and Test Setup Requirements

7.1 A universal testing machine, with capacity of at least 25 % above the maximum force required, and capable of a compression rate of 6 in./min [152 mm/min], shall be used to apply compressive force to the helmet and to measure deflection.

7.1.1 The testing machine shall have a valid calibration certificate for the load cell (force verification) and for the specified crosshead speed (speed verification) of 6 in./min [152 mm/min] (compression).

7.1.2 The applied force shall be perpendicular to the base plate upon which the helmet rests. The base plate shall be a flat, rigid surface that is larger than the helmet.

7.2 A flat, steel anvil with a minimum thickness of 1 in. [2.5 cm] and a diameter of 2.5 ± 0.1 in. [6.4 ± 0.3 cm] shall be rigidly attached to the universal test machine as the contact with the helmet.

7.3 For side-to-side and front-to-back compression testing, a rigidly supported foam pad, positioned at 90° to the base plate and touching the crown of the helmet, shall be used to maintain the correct orientation and position of the helmet.

7.3.1 The foam pad shall be approximately 4 in. [10 cm] wide by 4 in. [10 cm] long by 2 in. [5 cm] thick.

7.3.2 The foam pad shall be closed-cell low-density cross-linked polyethylene foam[5] and shall meet the specifications provided in Table 1.

7.3.3 Rigid, nondeformable stops shall be placed opposite the foam pad to keep the helmet in position. Place the foam pad against the helmet so that the edges of the helmet remain in contact with the stops.

7.3.4 Fig. 3 shows the test setup for side-to-side compression, and Fig. 4 shows the test setup for front-to-back compression. As shown in the figures, the stops shall be vertically aligned with one another, and each stop's contact face shall be aligned with the center of the load cell. The foam pad shall be positioned with the 2 in. [5 cm] thickness between the rigid support and the helmet.

8. Compression Test: Top-to-Bottom

8.1 *Test Setup:*

8.1.1 The helmet shall be oriented such that the coronal and mid-sagittal planes are both approximately 90° to the base plate.

8.1.2 In order to maintain the correct orientation, the helmet shall be supported in one of the following two ways, unless specified elsewhere:

8.1.2.1 A fixture or jig shall be placed on the base plate beneath the helmet and shall be rigid and non-compressive. The fixture or jig shall completely support the helmet around its periphery. The fixture or jig shall extend at least 1 in. [25 mm] beyond the edge of the finished shell on the same plane as the edge (not up the sides of the helmet) to ensure that it is supported. The helmet shall be positioned and centered on the jig on the base plate so that the helmet is in the as-worn position. Anti-friction material, such as PTFE, shall be placed between the edge(s) of the helmet and the fixture, where they come in contact.

8.1.2.2 A rigid and non-compressive supporting material shall be placed in the gaps between the helmet edge and the base plate when the helmet is positioned in the as-worn position. The base plate and supporting material combined shall be in contact with at least 75 % of the edge, and the supporting material shall be sufficiently sized to prevent damage to the helmet edge at the points of contact. The supporting material shall extend at least 1 in. [25 mm] beyond the edge of the finished shell in the same plane as the edge (not up the sides of the helmet) to ensure that it is supported. An anti-friction material, such as PTFE, shall be placed between the edge(s) of the helmet and the base plate, where they come in contact.

8.1.3 Fig. 5 shows the test setup options for top-to-bottom compression (anti-friction material not shown).

8.1.4 Testing shall be performed at controlled ambient conditions.

8.2 *Test Procedure:*

8.2.1 Bring the anvil into contact with the apex of the helmet and apply a nominal force of 5 lb [22 N] to the helmet. Set this as the zero point (Point 1 Extension, see Fig. 6) for the deflection measurement.

8.2.2 Apply force, compressing the helmet at a rate of 6 in./min [152 mm/min], until a compressive force of 400 lb [1780 N] is reached and, unless specified elsewhere, maintain the applied force for 30 ± 5 s. Then release the force, at the

[5] This foam is often generically called "plastizote foam."

TABLE 1 Polyethylene Foam Specifications[A]

Parameter	Test Method	Requirement
Type	N/A	Closed cell
Standard Specification	ASTM D4819	D4819 Type I - B4
Density	ASTM D3575	2 ± 0.13 lb/ft^3 [32 ± 2 kg/m^3]
Compression Deflection	ASTM D3575	10 % at 5.8 ± 1.5 psi [40 ± 10 kPa] 25 % at 8.0 ± 1.5 psi [55 ± 10 kPa] 50 % at 18.0 ± 1.5 psi [125 ± 10 kPa]
Shore Hardness [OO Scale]	ASTM D2240	60 ± 3

[A] Foam meeting the specifications of LD 33 is acceptable.

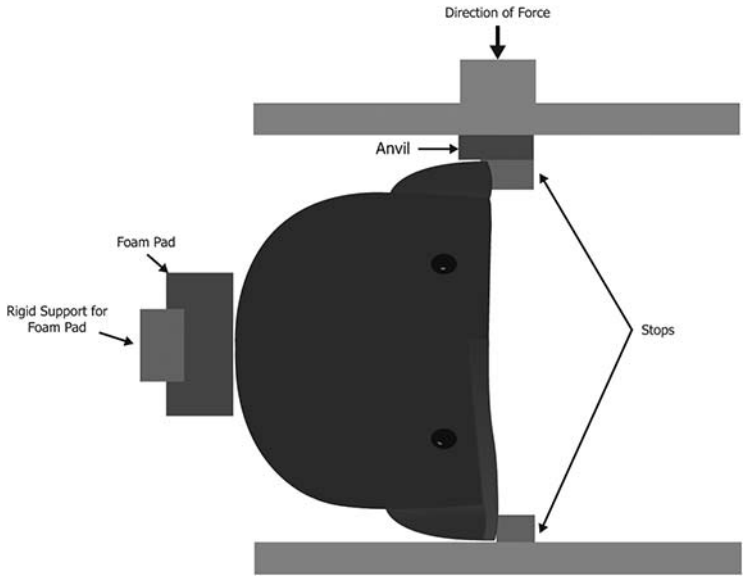

FIG. 3 Side-to-Side Compression Test Setup

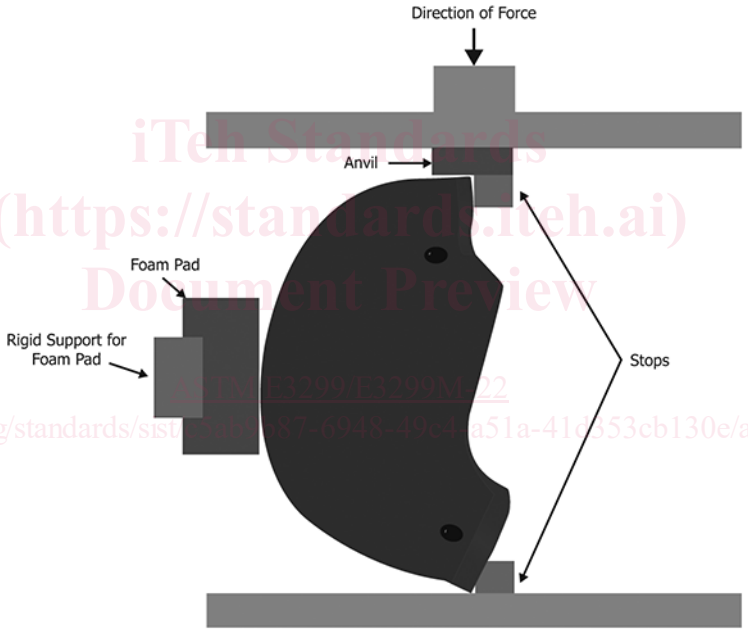

FIG. 4 Front-to-Back Compression Test Setup

same rate, back to a nominal force of 5 lb [22 N] and, unless specified elsewhere, maintain the applied force for 30 ± 5 s.

8.2.3 Unless specified elsewhere, repeat step 8.2.2 at least three additional times.

8.2.4 Apply force, compressing the helmet at a rate of 6 in./min [152 mm/min], until a compressive force of 400 lb [1780 N] is reached, and maintain the applied force for 30 ± 5 s.

8.2.5 Without releasing the force, record the final compression point (Point 2 Extension, see Fig. 6) and calculate the top-to-bottom deflection using Eq 1.

$$\text{Deflection} = \text{Point 2 Extension} - \text{Point 1 Extension} \quad (1)$$

8.2.6 Release the force.

8.2.7 Visually inspect the helmet shell for delamination, ply separation, distortion, or similar damage, and note accordingly.

9. Compression Test: Side-to-Side

9.1 *Test Setup:*

9.1.1 The helmet shall be oriented such that the coronal plane is approximately 90° to the base plate and the mid-sagittal plane is approximately 0° to the base plate. The sides of the helmet at the widest point shall be positioned against the upper and lower stops, and the foam support shall be touching the crown area. The upper and lower stops are to be vertically aligned with one another.

9.1.2 The test setup shall be consistent with Fig. 3.