Designation: E3111/E3111M – 22

Standard Test Methods for Ballistic Resistant Head Protection[1]

This standard is issued under the fixed designation E3111/E3111M; 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 These test methods describe the tests for ballistic-resistant head protection which consists of helmets and face shields. Test methods address backface deformation, resistance to penetration, and ballistic limit. It is anticipated that these test methods will be referenced by purchasers or other users in specifications or performance standards for helmets in order to meet the user's specific needs.

NOTE 1—ISO/IEC 17025 specifies the general requirements for the competence to carry out tests or calibrations, or both. It covers testing and calibration performed using standard methods, non-standard methods, and laboratory-developed methods.

1.2 These test methods do not address eye protection other than ballistic-resistant face shields that are attached to the helmet.

1.3 These test methods do not specify performance criteria or usages of the test results.

1.4 These test methods include procedures for conditioning of test items prior to ballistic testing.

1.5 In these test methods, "other standards and specifications" and "unless specified elsewhere" refer to documents (for example, military standards, purchase specifications) that require the use of these test methods. Purchasers and other users are responsible for the "other standards and specifications," and for specifying any requirements that supersede those of these test methods.

1.5.1 Other standards and specifications will specify and describe the ballistic test threats to be used.

1.6 *Units*—Values stated in either the International System of Units (metric) or U.S. Customary units (inch-pound) are to be regarded separately as standard. The values stated in each system may not be exact equivalents. Both units are referenced to facilitate acquisition of materials internationally and minimize fabrication costs. Tests conducted using either system maintain repeatability and reproducibility of the test method and results are comparable.

1.7 If there is a discrepancy between these test methods and a user supplied document, the user supplied document takes precedence.

1.8 *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.*

1.9 *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]

D1141 Practice for Preparation of Substitute Ocean Water

E3004 Specification for Preparation and Verification of Clay Blocks Used in Ballistic-Resistance Testing of Torso Body Armor

E3005 Terminology for Body Armor

E3062 Specification for Indoor Ballistic Test Ranges for Small Arms and Fragmentation Testing of Ballistic-resistant Items

E3110/E3110M Test Method for Collection of Ballistic Limit Data for Ballistic-resistant Torso Body Armor and Shoot Packs

[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 Public Safety Equipment.

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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.

2.2 *Department of Defense Standards:*[3]

MIL-STD-662F V_{50} Test for Armor

Test Plan to Qualify a Contractor-selected, Non-contact Back Face Deformation (BFD) Measurement System Rev 1, Release: November 19, 2020, U.S. Army Aberdeen Test Center[4]

2.3 *Other Standards:*

AATCC Test Method 169 Weather Resistance of Textiles: Xenon Lamp Exposure[5]

CSA Z262.2-14 Specifications for facially featured headforms[6]

ISO/IEC 17025 General Requirements for the Competence of Testing and Calibration Laboratories[7]

NIJ Standard-0106.01 NIJ Standard for Ballistic Helmets[8]

VPAM HVN 2009: 2017 Test Guideline: Bullet-resistant Helmet with Visor and Neck Guard, Association of Test Centres for Attack-resistant Materials and Constructions (VPAM)[9]

3. Terminology

3.1 For terms not defined in these test methods, the following definitions of Terminology E3005 apply: *backface deformation, clay block, conditioning, complete penetration, controlled ambient, fair hit, obliquity, partial penetration, shot-to-edge distance, shot-to-shot distance, strike face, test item, test series, test stand, unfair hit,* V_x, V_0, V_{05}, V_{50}, and *witness panel*.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *basic plane, n*—the plane through the centers of the external ear openings and the lower edges of the eye sockets.

3.2.1.1 *Discussion*—See Fig. 1 for a pictorial representation of the location of the basic plane.

3.2.2 *coronal plane, n*—the plane, perpendicular to the basic and mid-sagittal planes, which passes through the centers of the external ear openings.

3.2.2.1 *Discussion*—See Fig. 1 for a pictorial representation.

3.2.3 *fastener, n*—a hardware device that mechanically joins or affixes two or more objects together; for helmets, shields, and other protective products, fasteners pass into or through the protective material and include such devices as bolts, anchors, screws, and rivets.

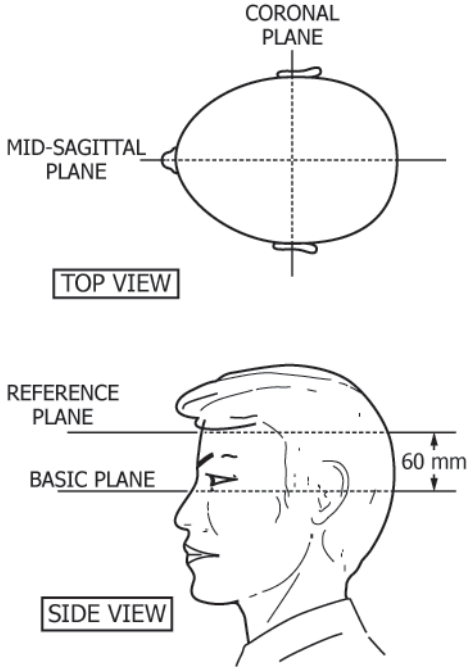

FIG. 1 Head Planes

3.2.4 *head protection, n*—the ensemble consisting of helmet, face shield, straps, padding, and other accessories designed to protect the user's head.

3.2.5 *mid-sagittal plane, n*—the plane, perpendicular to the basic and coronal planes, which symmetrically bisects the head.

3.2.5.1 *Discussion*—See Fig. 1 for a pictorial representation.

3.2.6 *reference plane, n*—the plane 60 mm ± 1 mm [2.36 in. ± 0.04 in.] above and parallel to the basic plane.

3.2.6.1 *Discussion*—See Fig. 1 for a pictorial representation.

4. Summary of Test Methods

4.1 These test methods specify the methods for assessing the penetration resistance, backface deformation, and ballistic limit for ballistic-resistant helmets and for assessing the penetration resistance and backface deformation for ballistic-resistant face shields.

4.2 A number of individual test items, some mounted on a headform and some clamped in a fixture, are impacted with ballistic test threats. The type and velocity of the test threats are specified in other standards and specifications, and the quantity of test items and shot patterns may be specified in other standards or specifications.

5. Significance and Use

5.1 U.S. Department of Defense and U.S. Department of Justice standards and specifications may require these test methods for assessing the penetration resistance and backface deformation of ballistic-resistant helmets and face shields.

[3] Available from U.S. Government Printing Office, Superintendent of Documents, 732 N. Capitol St., NW, Washington, DC 20401-0001, http://www.access.gpo.gov.

[4] Distribution authorized to the DOD and US DOD contractors only who are actively seeking to or are contracted to measure Back Face Deformation on Body Armor and/or Helmets; November 2020. Other requests for this document shall be referred to the Materials & Measurements Test Branch, U.S. Army Aberdeen Test Center, 6943 Colleran Road, Building 400, Aberdeen Proving Ground, MD 21005-5059.

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

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

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

[8] Available from National Institute of Justice (NIJ), 810 7th St., NW, Washington, DC 20531, http://nij.gov.

[9] Available from the Association of Test Centers for Attack-resistant Materials and Constructions (VPAM), Zum Roten Berge 18-24 48165 Münster Germany https://www.vpam.eu/pruefrichtlinien/aktuell/hvn-2009/.

5.2 These test methods may be used by private-sector and government laboratories, manufacturers, research and development organizations, and others assessing the ballistic resistance of helmets and face shields or performing research and development of new materials.

5.3 It is intended that these test methods will be referenced by other standards and specifications.

6. Test Equipment and Apparatus

6.1 Test item details, including quantity, size, and conditioning, shall be specified in other standards and specifications.

6.2 The ballistic test range shall meet the requirements of Specification E3062.

6.3 Some systems for determining yaw are yaw cards, flash radiograph, or photography. Yaw shall be measured by the system to an accuracy of at least 1°.

6.4 When a backing assembly for validating the clay within a headform is required, the backing assembly shall be a clay block and shall have a rigid metal frame with a plywood bottom. The inside dimensions of the metal frame shall be 300 mm ± 2 mm [12.0 in. ± 0.08 in.] by 300 mm ± 2 mm [12.0 in. ± 0.08 in.] with a depth of 100 mm ± 2 mm [4.0 in. ± 0.08 in.]. The top and bottom edges of the metal frame shall be planar. Attach plywood, of any grade, that is nominally "¾ in." or "18 mm," to the outside of the frame to form the bottom of the fixture. Prior to attaching the plywood, add a plastic liner as defined in Specification E3004. Fill the backing assembly with ROMA Plastilina No. 1®.[10]

6.5 Some ballistic test methods require use of a headform.

6.5.1 For helmet shell and face shield testing that requires a headform, the headform shall be one of the following:

6.5.1.1 Cadex Model 100_00_HNME that meets the specifications given in the drawings in Annex A1 unless otherwise directed by another specification or requirements document.

NOTE 2—The Cadex[11] Model 100_00_HNME is the headform currently used for ballistic testing of helmets to National Institute of Justice and U.S. Army standards. This headform is commonly referred to as the "NIJ ballistic testing headform." It is intended that additional headform options will be added as they become available.

6.5.1.2 Facially featured headform as specified in CSA Z262.2-14 and shall be size 575.

6.5.1.3 Set of "Cadex Ballistic Testing Headforms" or equivalently dimensioned headforms that are made from rigid material and meet the specifications given in the drawings in Annex A2, unless otherwise directed by another specification or requirements document.

NOTE 3—The Cadex Ballistic Testing Headforms[12] are the newest ballistic testing headforms available. The tolerances shown in Figs. A2.2-A2.6 are not required to be as precise as is shown in the figures. The required tolerance will be specified in other standards or specifications. It is intended that additional headform options will be added as they become available.

(1) The set shall include five separate headforms for testing the left, right, front, back, and crown locations, and shall include a mold for properly forming the clay in the headform.

6.5.2 For testing that requires a headform, affix the test item to the appropriate headform. The headform shall be rigidly held by the test stand that permits the entire test item and headform to be shifted vertically and horizontally and to be tilted such that the intended impact locations and angles can be accomplished.

6.5.3 When scanning the headform, use a laser scanner attached to an articulating arm coordinate measuring machine (LS/AACM) that meets the requirements of Test Plan to Qualify a Contractor-selected, Non-contact Back Face Deformation (BFD) Measurement System Rev 1.

6.6 For V_{50} testing, use a fixture that securely clamps the test item at three points on the helmet, such as the ear flaps and a point along the front or back mid-sagittal plane of the test item shell. The securing method shall be capable of retaining the shell and withstanding shock resulting from a ballistic impact. The mount shall be capable of adjustment so that obliquity impacts can be achieved anywhere on the test item. A drawing of an acceptable fixture is located in Appendix X1.

6.6.1 For opaque test items such as the helmet, the witness panel shall be a 0.50 mm [0.020 in.] thick sheet of 2024-T3, 2024-T4, or 5052 aluminum alloy sheet.

6.6.2 For transparent test items such as the face shield, the witness panel shall be a nominal 0.025 mm [0.001 in.] thick sheet of aluminum foil.

6.7 The temperature conditioning chamber for test items shall be capable of a temperature range at least –56 °C to 77 °C [–70 °F to 170 °F].

6.8 The immersion conditioning tank shall be capable of fully submerging the test items.

6.9 The weatherometer test apparatus shall be as defined in American Association of Textile Chemists and Colorists (AATCC) Test Method 169.

7. Hazards

7.1 The ballistic tests described in these test methods have inherent hazards. Employ adequate safeguards for personnel and property when conducting these tests.

8. Sampling and Test Items

8.1 The test items shall be helmets or face shields. For some tests, the helmet shell alone is the test item while for other tests the test item is the helmet shell with its hardware, suspension system, and retention system. The face shield will always be attached to the helmet during face shield testing.

8.2 Test item details, including quantity, size, and conditioning, shall be specified in other standards and specifications.

[10] U.S. Government standards require ROMA Plastilina No. 1®, from Sculpture House, Inc., as the backing material for ballistic-resistance testing.

[11] Information on Cadex Model 100_00_HNME headforms can be found at http://www.cadexinc.com/nij_ballistic.php.

[12] Information on the Cadex Ballistic Testing Headforms can be found by contacting Cadex at http://www.cadexinc.com/contact_us.php.