



Designation: E3111/E3111M – 22

Standard Test Methods for Ballistic Resistant Head Protection¹

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

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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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

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 V₅₀ 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 Center⁴

2.3 Other Standards:

AATCC Test Method 169 Weather Resistance of Textiles: Xenon Lamp Exposure⁵

CSA Z262.2-14 Specifications for facially featured head-forms⁶

ISO/IEC 17025 General Requirements for the Competence of Testing and Calibration Laboratories⁷

NIJ Standard-0106.01 NIJ Standard for Ballistic Helmets⁸

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

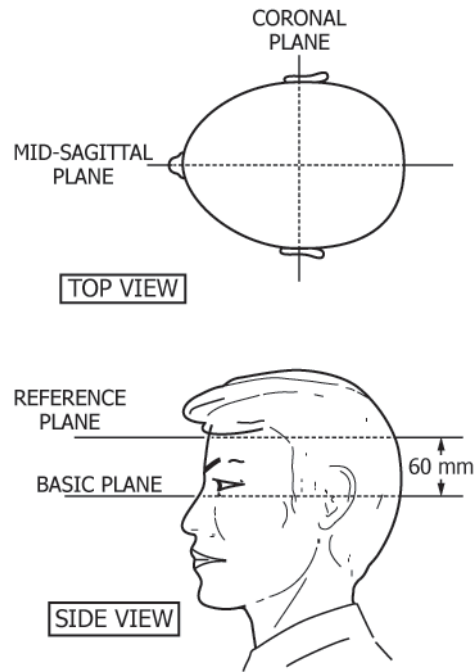


FIG. 1 Head Planes

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, V₀, V_{0.5}, V₅₀, 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,

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 Collieran 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/>.

and other protective products, fasteners pass into or through the protective material and include such devices as bolts, anchors, screws, and rivets.

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.

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 Cadex¹¹ 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 Headforms¹² 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

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.

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 V₅₀ 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.

9. Test Requirements

9.1 The intended obliquity or other shot direction details, if any, for all shots shall be specified in other standards and specifications.

NOTE 4—Typical obliquities are 0°, 30°, and 45°, with most obliquities being 0°.

9.2 Fair Hits:

9.2.1 To be considered a fair hit, unless specified elsewhere, each ballistic impact shall meet the requirements listed below. **Appendix X2** contains a flowchart showing the decision tree.

9.2.2 The test threat shall impact the test item at an obliquity within 5° of the intended angle.

9.2.3 Verify the test threat yaw within 31 cm [12 in.] of the test item. Yaw shall be $\leq 3^\circ$ for rifle threats or $\leq 5^\circ$ for fragment and handgun threats. Check yaw for every test threat shot.

9.2.4 For backface deformation (BFD) and resistance to penetration (RTP) testing, the test threat velocity shall be within the specified range given in other standards and specifications. If no specified range is given, the range shall be required velocity $-0 \text{ m/s} + 15 \text{ m/s}$ [$-0 \text{ ft/s} + 50 \text{ ft/s}$]. For a test threat having a velocity lower than the specified range with a complete penetration, the impact is considered a fair hit.

9.2.5 For all ballistic testing, no overlap of damage (delamination) caused by impacts is allowed, and there shall be at least 13 mm [0.5 in.] between damaged areas when inspected visually. If necessary, multiple test items shall be used to allow two impacts in each section without overlapping damage. Any shot, other than a weak point shot, that impacts within 25 mm [1 in.] of a potential weak point is an unfair hit. See **15.1.4** for details regarding weak points.

9.2.6 For test threat impacts to fasteners, the test threat shall impact the fastener as indicated below.

9.2.6.1 *Fastener Head Shot, 0-degree Obliquity*—The shot shall be placed such that the test threat projectile directly impacts the center of the fastener head. There shall be visual evidence that the center of the fastener was impacted.

9.2.6.2 *Fastener Glancing Shot, Slight Angle*—The shot shall be lined up at 0-degree obliquity on the fastener head center. Then, the headform shall be rotated slightly so that the test threat projectile will impact primarily the ballistic material and partially the fastener edge. There shall be visual evidence that the fastener was impacted.

9.2.7 The test threat projectile shall impact the test item no closer to the edge of the test item than the minimum shot-to-edge distance and no closer to a prior hit than the minimum shot-to-shot distance. Take the measurement from the center of the projectile impact to the edge of the ballistic material in the test item or to the center of a previous impact.

9.2.7.1 *Minimum Shot-to-Edge Distance*—The minimum shot-to-edge distance shall be no less than 25 mm [1 in.], measured from the impact center to the edge of the test item.

9.2.7.2 *Minimum Shot-to-Shot Distance*—The minimum shot-to-shot distance shall be no less than 38 mm [1½ in.], measured center-to-center, from a prior impact.

9.2.7.3 *Maximum Shot-to-Edge Distance*—For intended edge shots, the maximum shot-to-edge distance shall be no

more than 44 mm [1¾ in.] measured from the impact center to the edge of the test item.

9.2.8 A test threat projectile that impacts too close to the edge or to a prior hit, is of too high a velocity, but does not perforate shall be considered a fair hit.

9.2.8.1 A test item which is impacted with a high velocity shot (that is, velocity greater than allowed) that results in partial penetration and an excessive BFD measurement, that impact shall be considered an unfair hit, and that shot shall be repeated on a spare test item. If the high velocity shot results in a partial penetration with an allowable BFD measurement, that impact shall be considered a fair hit.

9.2.9 If the shot does not meet fair hit requirements due to excessive velocity, do not use the test item for any subsequent testing. The test shall be continued on an identical spare test item.

9.3 If warmer rounds are needed for weapon or target alignment or establishment of a specific striking velocity, fire a test threat through a witness panel to determine the exact point of impact. This witness panel can be any material that captures the path of the projectile such as cardboard or paper. Fire additional test threats as necessary until the proper alignment and a stable striking velocity have been achieved. The propellant charge versus velocity curve for the weapon being used should be referred to as a guide for establishing the required velocity within a practical tolerance.

NOTE 5—Normally, this tolerance is approximately $\pm 8 \text{ m/s}$ [$\pm 25 \text{ ft/s}$].

9.4 Acceptance Criteria for Helmets:

9.4.1 A complete penetration for resistance to penetration testing shall be specified in other standards and specifications.

9.4.2 The backface deformation limit shall be specified in other standards and specifications.

9.4.3 The V_{50} requirements shall be specified in other standards and specifications.

9.5 Acceptance Criteria for Face Shields:

9.5.1 After each shot, the face shield and witness material shall be inspected to determine if a complete penetration or face shield deflection has occurred. Unless specified elsewhere, the acceptance criteria shall be:

9.5.1.1 There shall be no complete penetration as evidenced by the projectile or any fragments from the projectile or face shield being present in the clay witness material.

9.5.1.2 Face shield deflection shall be less than 30.0 mm [1.18 in.] as evidenced by contact indicator material being present on the rear of the face shield.

10. Conditioning of Test Items

10.1 When specific conditioning is required, unless specified elsewhere, the following conditioning requirements apply for each type of conditioning. Perform a visual inspection both prior to and after conditioning and record any changes.

10.2 Temperature Conditioning:

10.2.1 *Controlled Ambient Conditioning*—Expose test items to controlled ambient conditions ($20 \text{ }^\circ\text{C} \pm 5.5 \text{ }^\circ\text{C}$ [$68 \text{ }^\circ\text{F} \pm 10 \text{ }^\circ\text{F}$] and $50 \% \pm 20 \%$ relative humidity (RH)) for at least 24 h.

10.2.2 *Extreme Heat Conditioning*—Subject test items to extreme heat conditioning for between 24 h and 48 h at 71 °C ± 5.5 °C [160 °F ± 10 °F] in a conditioning chamber.

10.2.3 *Extreme Cold Conditioning*—Subject test items to extreme cold conditioning for between 24 h and 48 h at –51 °C ± 5.5 °C [–60 °F ± 10 °F] in a conditioning chamber.

10.2.4 At the end of each temperature conditioning activity, remove the test item(s) from the conditioning chamber and complete ballistic testing within 30 min of removal from the conditioning chamber.

10.2.5 If ballistic testing cannot be completed within 30 min and the test item has been out of conditioning for 1 h or less, recondition the test item for a minimum of 1 h. If the test item has been out of the conditioning chamber for more than 1 h, recondition the test item for at least 24 h.

10.3 *Water Immersion Conditioning:*

10.3.1 Expose complete test items, including the shell, hardware, suspension system, and retention system, to controlled ambient temperature for a minimum of 3 h prior to immersion in water. (See 10.2.1 for the controlled ambient temperature.)

10.3.2 Completely submerge complete test items in water at controlled ambient temperature for 3 h to 4 h. After submersion, remove the test item, drain crown side up at controlled ambient, and ballistically test. Complete ballistic testing within 24 h ± 2 h after removal from the liquid.

10.3.2.1 The water may be either plain water or salt water. The water shall be replaced anytime there are visible impurities in the water.

(1) The plain water shall be clean and shall be either potable tap or demineralized water.

(2) The saltwater solution shall be as specified in Practice D1141.

10.3.3 A weight may be used to prevent the test item from floating while immersed.

10.4 *Artificial Weathering Conditioning:*

10.4.1 Perform weathering of test items in accordance with AATCC Test Method 169 with the modifications listed below:

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

10.4.1.2 Equip the test apparatus with an automatic light monitor and that is capable of automatically controlling irradiance, temperature, and humidity.

10.4.1.3 The apparatus shall be maintained in accordance with manufacturer recommendations.

10.4.1.4 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 to the test item, 60 min of light, and 60 min of darkness. Repeat the cycle until the total energy exposure is equal to 100 kJ/m². Terminate the weather cycle at that point.

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

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

10.4.1.7 Set the temperature and RH as specified in Table 1.

TABLE 1 Temperatures and Humidities 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.) |

10.4.2 After the required exposure period, the test items shall be removed from the apparatus. Complete ballistic testing within 96 h after completion of weathering.

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

11. **Helmet Resistance to Penetration (V₀) and Backface Deformation (BFD) Testing**

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

11.2 *Test Items:*

11.2.1 The test item shall be a complete helmet, including the shell, hardware, suspension system, and retention system, and the test item shall be mounted on a headform for testing. The quantity of test items and other relevant test item details are specified in other standards or specifications. If the helmet has a face shield, remove it prior to testing.

11.2.2 When the Cadex headform is specified for testing, only size large (nominally size 7¼, 58 cm) helmets shall be used.

11.3 *Test Item Marking:*

11.3.1 Locate the internal crown benchmark on the shell, transpose to the external location, and mark the external location. If there is no benchmark on the crown, then either the approximate center of the crown may be used or an alternate means may be used as specified in other standards or specifications. Record the procedure used in the test report. Draw an approximately 127 mm [5 in.] diameter circle on the shell using the external crown benchmark as the center. Refrain from placing any sharp or pointed object on the test item. Make sure all points are blunted.

11.3.2 Mark the 45°, 135°, 225°, and 315° positions of the ring on the shell as shown in Fig. 2.

11.3.3 Draw permanent lines that are aligned with the 45°, 135°, 225°, and 315° marks and the external crown benchmark but only extend from the edge of the shell to a point on the circle.

11.4 *Test Threats:*

11.4.1 Test threats and velocities to be used shall be specified in other standards and specifications.

11.5 *Headform Preparation:*

11.5.1 The headform shall be a Cadex Model 100_00_ HNME headform.

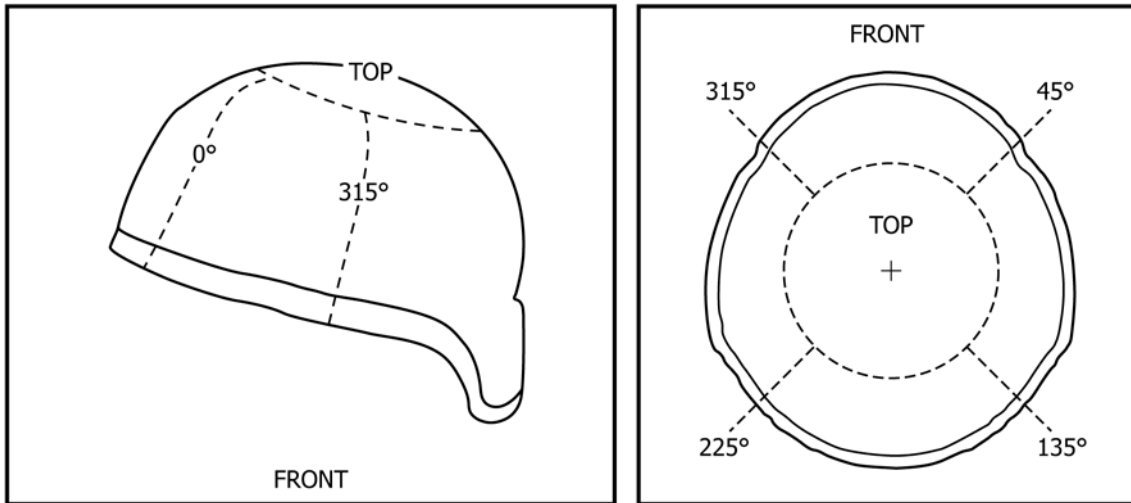


FIG. 2 Location of Helmet Sections

11.5.2 Use ROMA Plastilina No. 1[®] modeling clay as the backing material in the headform to make BFD measurements, preparing the headform as follows:

11.5.2.1 Fill the bottom of the headform with one layer of small flat thumb-sized pieces of ROMA Plastilina No. 1[®] clay.

11.5.2.2 Using thumb and fingers, blend each piece together and work any voids and air bubbles to the outside of the channels.

11.5.2.3 Continue to add layers of clay to the headform until the headform is filled with clay. Make sure the clay extends slightly beyond the outside surface of the headform.

11.6 Clay Block and Headform Conditioning:

11.6.1 Prepare one clay block according to Specification E3004, with the exception that the size of the clay block shall be as described in 6.4 of these test methods.

11.6.2 Place the clay block and up to eight prepared headforms in the conditioning chamber with the headforms surrounding the clay block such that all clay in each headform is within 304.8 mm [12 in.] of the nearest edge of the clay block (refer to Fig. 3).

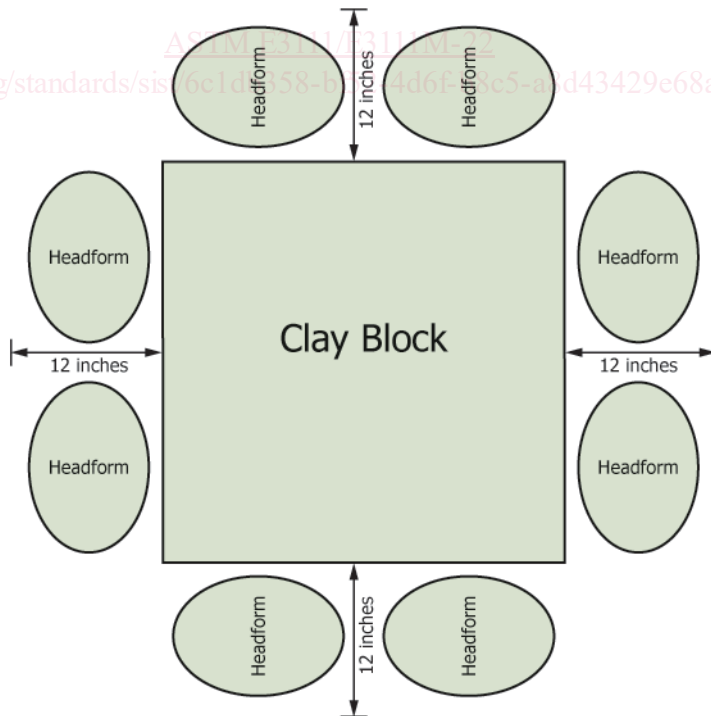


FIG. 3 Illustration of Clay Block-Headform Position During Conditioning

NOTE 6—The orientation of the headforms during conditioning is not significant.

11.6.3 Heat each clay block and headform(s) such that the clay will pass the verification drops listed in 11.7 according to the requirements below:

11.6.3.1 New clay blocks and new headforms shall be heated for at least 24 h.

11.6.3.2 Any clay block or headform that has been out of the conditioning chamber shall be reheated for no less than 3 h.

11.6.3.3 Any clay block or headform that has been out of the conditioning chamber for more than 1 h shall be reheated for at least three times the time out of the chamber. If the time required exceeds 24 h, the requirement for new clay blocks and headforms applies.

11.6.3.4 While 24 h is the maximum time required for reheating any clay block or headform, a clay block or headform may remain in the chamber indefinitely.

11.7 Verification of the Clay Block and Headforms:

11.7.1 Verify the clay block and headforms per Specification E3004, with the following exceptions:

11.7.1.1 Instead of using the impact location template of Specification E3004, the impact locations shall be at least 76 mm [3 in.] from the closest edge of the clay block when measured from the edge of the indentation. Allow at least 76 mm [3 in.] between the centers of each indentation (that is, 32 mm [1.25 in.] from edge-to-edge).

NOTE 7—A laser may be used as a positioning guide, and a template may be used to ensure that the distance between the edge of the indentations and the edge of the clay block is maintained.

11.7.1.2 The impactor shall be the cylindrical clay verification impactor.

11.7.1.3 The acceptance requirement is that each impact indentation depth is 25.4 mm \pm 2.5 mm [1.0 in. \pm 0.1 in.].

11.7.1.4 The clay block and paired headforms are usable for a period of 4 h. The 4-h time limit starts at the completion of the third verification impact on the clay block.

11.7.1.5 Return the clay block to the conditioning chamber after verification and repair.

11.8 Preparation of the Clay-filled Headform:

11.8.1 Remove one of the conditioned headforms from the conditioning chamber. Complete testing using that headform within 45 min of removal from the chamber.

11.8.2 Ensure that the clay extends slightly beyond the outside surface of the headform. If there is not enough clay for a thin layer to be removed with the clay contour tools, then add clay and return the headform to the conditioning chamber for at least 4 h.

11.8.3 Shape the clay to the headform using the appropriate contour shaping tools specified in Annex A1.

NOTE 8—Before use, the cutting edges of the clay contour shaping tools should be checked for sharpness, burrs, and other deformities. If deformities exist, they should be corrected prior to use of the tools.

11.8.3.1 To shape the clay along the coronal channel, use the coronal contour shaping tool to create a smooth clay surface that transitions uninterrupted to the headform. Use the contour shaping tool to shape each side of the channel from the top of the coronal slot to the base.

11.8.3.2 To shape the clay along the mid-sagittal channel, use the mid-sagittal contour shaping tool to create a smooth clay surface that transitions uninterrupted to the headform. Use the contour shaping tool to shape the entire mid-sagittal channel, including the top where the mid-sagittal and coronal planes intersect.

NOTE 9—There is no specified order of the steps for using the contour shaping tools.

11.8.3.3 To ensure that clay at the crown surface has been shaped to the contour of the headform, use the crown verification tool on the headform.

11.8.3.4 There shall be no gaps between the clay and the tool. If gaps exist, add clay from the conditioning chamber, and repeat 11.8.3.

11.8.3.5 When the tool is removed, there shall be no marks or grooves left in the clay. If marks or grooves exist, repeat 11.8.3.

11.9 Repair of Clay-filled Headform:

11.9.1 After ballistic testing on the headform is complete, repair the headform using small pieces of clay that have been temperature conditioned the same as the headform. Ensure that the clay is sufficiently built up to extend slightly beyond the surface of the headform. Return the headform to the conditioning chamber as specified in 11.6.

11.10 BFD Measurement:

11.10.1 Before each ballistic impact on the headform, scan the impact location using the LS/AACM. Follow the process of Test Plan to Qualify a Contractor-selected, Non-contact Back Face Deformation (BFD) Measurement System Rev 1.

11.10.2 After each impact, unless a complete penetration occurs, scan the impact location using the LS/AACM. If a complete penetration occurs, record it and a scan is not necessary.

11.10.3 Record the maximum backface deformation. In making this determination, ignore any clay surrounding the impression that has been raised above the original level of the surface (cratering). The measurand consists of measurements of the magnitude of the resultant deformation (if any) made from a point originating from a radius flush and consistent with the contour of the pre-shot clay surface along the shot-line.

11.11 Test Requirements:

11.11.1 Inspect the test item retention/suspension system after each shot. If any component of the retention system fails during the testing, replace it with an identical retention system. Retightening of the retention system is allowed. Should the test item become dislodged from the headform due to ballistic impact, note the occurrence, remount the test item, and continue testing without penalty.

11.11.2 If necessary, between shots, delaminations shall be pushed by hand back towards their original place in the helmet to facilitate fitting the helmet back on the headform. If the delaminations cannot be pushed back by hand, the use of an arbor press is allowed. Fig. X3.1 shows an example of an acceptable press.

11.11.3 If an impact causes the clay to bulge out of the channel for a subsequent shot, repair that channel following the

procedures listed in 11.9. Only the channel of interest needs to be repaired. This shall be done prior to the initial scan of the impact location.

11.11.4 Shots shall meet the fair hit requirements.

11.11.5 Document all measurements and observations.

11.12 *Test Procedure:*

11.12.1 Remove the headform from the conditioning chamber and install it on the test stand.

11.12.2 Scan the crown of the headform using the LS/AACM.

11.12.3 Mount the test item in the “as-worn” configuration on the headform, with the suspension and retention systems in place per manufacturer’s instructions and adjusted to ensure a proper snug fit. Only the suspension/retention system shall be used to hold the test item to the headform. For adjustable suspension systems, adjust the strapping to achieve a snug fit of the helmet on the headform per the manufacturer’s instructions.

11.12.4 Perform shot #1 on the item at the crown (at the approximate intersection of the mid-sagittal and coronal planes).

11.12.5 Remove the test item and check for evidence of a complete penetration. If no complete penetration, scan the crown of the headform.

11.12.6 Pivot the headform so that the right side is facing the threat. If the clay is bulged out past the channel edges, use the coronal shaping tool to remove excess clay.

11.12.7 Scan the right side of the headform using the LS/AACM.

11.12.8 Mount the test item on the headform.

11.12.9 Perform shot #2 on the right side on the coronal plane approximately 51 mm [2 in.] above the earflap, or lower edge of shell if there is no earflap, centered over the clay in the headform.

11.12.10 Remove the test item and check for evidence of a complete penetration. If no complete penetration, scan the right side of the headform.

11.12.11 Pivot the headform so that the left side is facing the threat. If the clay is bulged out past the channel edges, use the coronal shaping tool to remove excess clay.

11.12.12 Scan the left side of the headform using the LS/AACM.

11.12.13 Mount the test item on the headform.

11.12.14 Perform shot #3 on the left side on the coronal plane approximately 51 mm [2 in.] above the earflap, or lower edge of shell if there is no earflap, centered over the clay in the headform.

11.12.15 Remove the test item and check for evidence of a complete penetration. If no complete penetration, scan the left side of the headform.

11.12.16 Pivot the headform so that the front is facing the threat. If the clay is bulged out past the channel edges, use the mid-sagittal shaping tool to remove excess clay.

11.12.17 Scan the front of the headform using the LS/AACM.

11.12.18 Mount the test item on the headform.

11.12.19 Perform shot #4 on the front in the mid-sagittal plane approximately 51 mm [2 in.] above the edge of the shell centered over the clay in the headform.

11.12.20 Remove the test item and check for evidence of a complete penetration. If no complete penetration, scan the front of the headform.

11.12.21 Pivot the headform so that the back is facing the threat. If the clay is bulged out past the channel edges, use the mid-sagittal shaping tool to remove excess clay.

11.12.22 Scan the back of the headform using the LS/AACM.

11.12.23 Mount the test item on the headform.

11.12.24 Perform shot #5 on the back on the mid-sagittal plane approximately 76 mm [3 in.] above the edge of the shell centered over the clay in the headform.

11.12.25 Remove the test item and check for evidence of a complete penetration. If no complete penetration, scan the back of the headform.

11.12.26 Repair the headform and return it to the conditioning chamber.

11.12.27 Repeat the steps above for each test item in each of the conditions for each test threat.

12. Helmet Ballistic Limit (V_{50}) Testing

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

12.2 Unless specified elsewhere, the following requirements shall be followed.

12.3 Test Items

12.3.1 The test item is the helmet shell only. Remove all retention/suspension systems and interior padding/suspension systems prior to testing.

12.3.2 Mark the test items as specified in 11.3.

12.3.3 Test threats to be used are specified in other standards or specifications.

12.4 Test Requirements

12.4.1 Multiple identical test items may be used for the purpose of determining any of the ballistic resistance requirements for a particular test threat and conditioning.

12.4.2 Mount the test items as specified in 6.6.

12.4.3 Place a witness panel approximately 100 mm by 150 mm [4 in. by 6 in.] into a holder. The witness panel may be made larger if necessary to catch all fragments from the test. An example fixture with a witness panel is shown in Fig. 4.

12.4.4 Place the holder such that the witness panel is inside the test item shell behind the area of intended impact. Refer to other standards and specifications for the witness panel distance specification. If no specification is listed, place the witness panel 76 mm \pm 25 mm [3.0 in. \pm 1.0 in.] behind the area of impact. If the witness panel cannot be placed far enough back due to limited space inside of the test item shell, then it should be placed as far back as possible. The actual distance shall be recorded in the test report.

12.4.5 A suitable plate shall be placed at a distance of no closer than 25 mm [1 in.] behind the witness panel to stop any

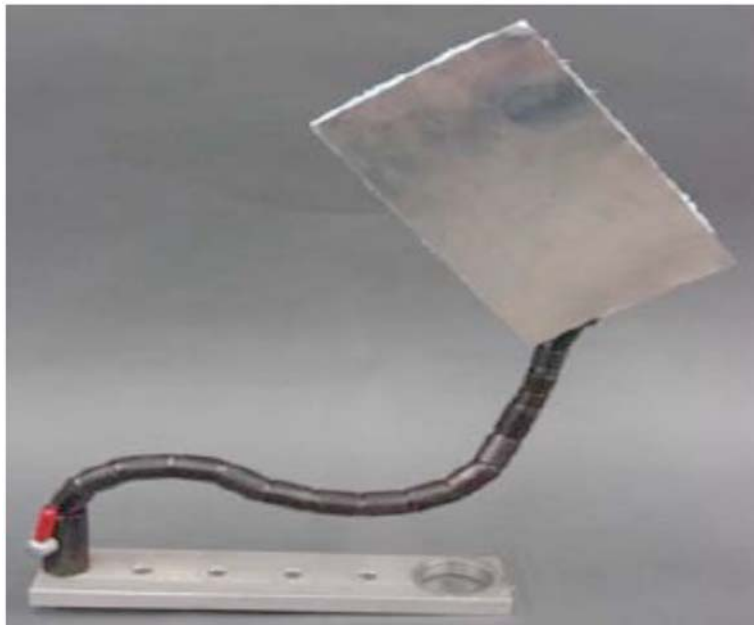


FIG. 4 Example of Witness Panel Holder

threat fragments from impacting the opposite side of the shell in the event of a complete penetration.

12.4.6 *Impact Locations:*

12.4.6.1 Each section of the test item shall have two impacts adhering to the fair hit requirements. Rather than placing two shots in one section and then moving to the next section, fire one shot in each section prior to placing a second impact on any section.

12.4.6.2 Arbitrarily place two fair impacts in each section following the fair hit requirements, except that one of the two fair impacts in the top section shall be placed within 25 mm [1.0 in.] of the benchmark at the crown of the test item.

12.4.6.3 An impact resulting in a complete penetration shall be considered unfair if it is within 38 mm [1.5 in.] of another impact, within 38 mm [1.5 in.] of the closest edge of any hole, within 25 mm [1.0 in.] of the edge of the test item.

12.4.6.4 If two fair impacts cannot be placed in a section, place the second impact on another identical spare test item but not in the same location as the first impact. Even though it is called a “second impact,” it may be the first impact on the spare test item.

12.4.6.5 If five shots cannot be placed on one test item, then each section must be shot using another identical spare test item before any section in the shot progression can sustain a second shot. Repeat the cycle of impacting all five sections prior to beginning a new cycle.

12.4.6.6 Inspect the test item after each shot for evidence of delamination. If it appears that delamination has occurred, then locate the second shot in the section such that it impacts in a non-delaminated portion and the resultant delamination does not overlap prior delamination. If two fair impacts cannot be placed in a section, place the second impact on another identical spare test item but not in the same location as the first impact. Even though it is labeled “second impact” it may be the first impact on the spare test item.

12.5 *Procedure:*

12.5.1 The procedure shall be according to Test Method E3110/E3110M, Section 13, V₅₀ Ballistic Limit Procedure: Up-Down Method Based on MIL-STD-662F, with the following modifications:

12.5.1.1 The test item shall be mounted as specified in 6.6 of this standard.

12.5.1.2 The required number of highest partial penetrations and lowest complete penetrations and the maximum allowable velocity range shall be as specified in Table 2.

(1) For bullet testing, if the six shot conditions (3 × 3) of Table 2 cannot be satisfied, and (1) there are at least three partial penetrations at velocities in excess of the required velocity, (2) there are no complete penetrations at or below the

TABLE 2 Shot Outcome Numbers and Maximum Allowable Velocity Ranges

| Test Threat | Label | Number of Highest Partial Penetrations | Number of Lowest Complete Penetrations | Maximum Allowable Velocity Range |
|-------------|-------|--|--|----------------------------------|
| Bullet | 3 × 3 | 3 | 3 | 38 m/s [125 ft/s] |
| Fragment | 5 × 5 | 5 | 5 | 46 m/s [150 ft/s] |
| Fragment | 7 × 7 | 7 | 7 | 53 m/s [175 ft/s] |

required velocity, (3) at least six fair shot impact velocities have been made in the test item(s), it shall be determined to have satisfied the threat condition requirement.

(2) For fragment testing, if the ten shot conditions (5 × 5) of Table 2 cannot be satisfied, and (1) there are at least five partial penetrations at velocities in excess of the required velocity, (2) there are no complete penetrations at or below the required velocity, and (3) at least ten fair shot impact velocities have been made in the helmet(s), it shall be determined to have satisfied the threat condition requirement.

(3) For fragment testing, if the 14 shot conditions (7 × 7) of Table 2 cannot be satisfied, and (1) there are at least seven partial penetrations at velocities in excess of the required velocity, (2) there are no complete penetrations at or below the required velocity, and (3) at least 14 fair shot impact velocities have been made in the helmet(s), it shall be determined to have satisfied the threat condition requirement.

(4) Should none of the above conditions apply, the test item has failed the V₅₀ testing, and V₅₀ testing will be stopped.

12.5.1.3 No more than three shots per section are allowed. There may be no delamination overlap between shots.

12.5.1.4 During testing, if deformed material of the helmet prohibits the witness panel from being placed for subsequent shots then push the deformed material back towards its original location to facilitate testing of subsequent shots.

13. Face Shield Ballistic Testing

NOTE 10—This test method was developed using VPAM HVN 2009: 2017 as an initial concept.

13.1 Test Threats:

13.1.1 Test threats and velocities to be used shall be specified in other standards and specifications.

13.2 Test Equipment:

13.2.1 Test Fixture:

13.2.1.1 A test fixture shall be used to rigidly affix the helmet and witness material block such that they remain in place and at the required relative positioning and angle during the test. See Fig. 5 for a graphical representation of the test

fixture assembly with the helmet and witness material in place.

13.2.1.2 The witness material block shall be attached to a positioning mechanism that allows the spacing, location, and angle to be adjusted.

13.2.1.3 The same clamping fixture described in 6.6 of this standard shall be used to hold the helmet in position.

NOTE 11—The helmet is not required to be clamped in the same locations as for the ballistic limit test, but should be clamped on the sides and back as shown in Fig. 5.

13.2.2 Witness Material Block:

13.2.2.1 ROMA Plastilina No. 1[®] clay, conditioned at controlled ambient, shall be used as the witness material for complete penetration.

13.2.2.2 The clay shall be mounted on a base plate to create the witness material block. See Fig. 6 for the dimensions and details for the witness material block. The tolerance on all dimensions in Fig. 6 shall be ±2.5 mm [0.1 in.].

13.2.2.3 The base plate is attached to the positioning mechanism.

13.2.3 Contact Indicator Material:

13.2.3.1 A paste, grease, or other suitable material shall be used to indicate contact between the face shield and the witness material.

13.3 Test Items:

13.3.1 Each test item shall be a face shield that is mounted on the helmet for testing.

13.3.2 Unless specified elsewhere, two identical test items and at least one helmet shall be provided by the supplier.

13.3.3 Unless specified elsewhere, the test items shall be conditioned at controlled ambient for at least 24 h.

13.4 Test Requirements:

13.4.1 The face shield shall be impacted with two shots.

13.4.1.1 The first shot shall be located in the horizontal-vertical center of the face shield. The deflection shall be assessed for the first shot only.

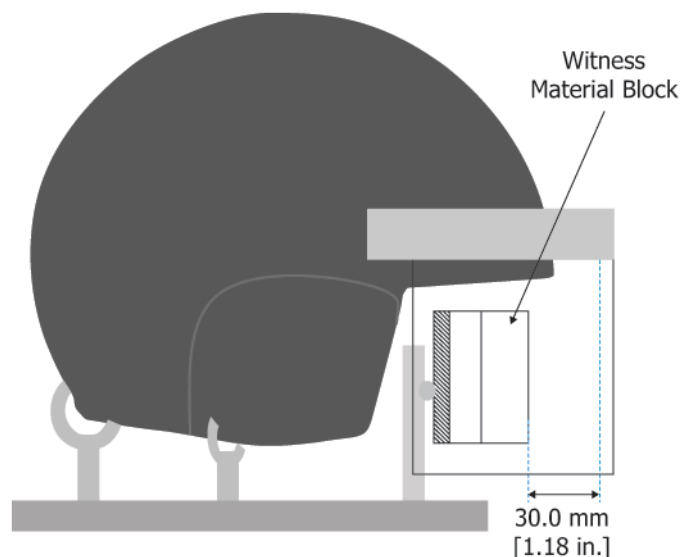


FIG. 5 Graphical Representation of Test Fixture

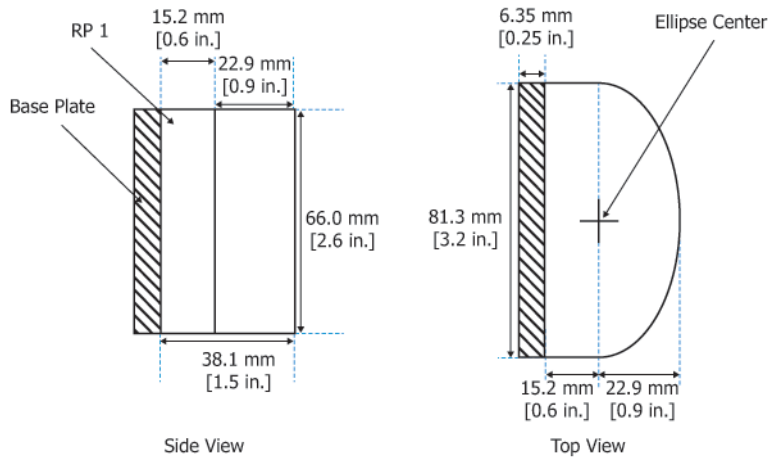


FIG. 6 Dimensions and Details for Witness Material Block

13.4.1.2 The second shot shall be located at least 100.0 mm [4.0 in.] from the first shot and at least 50.0 mm [2.0 in.] from the face shield edge.

13.4.2 The angle of incidence and obliquity for both shots shall be 0°.

13.4.3 The witness material surface for both shots shall be placed 30.0 mm ± 1.5 mm [1.20 in. ± 0.06 in.] from the face shield interior surface.

13.4.4 The witness material center shall be aligned with the line of fire for each shot.

13.5 Test Procedure:

13.5.1 Mark the shot locations on the face shield.

13.5.2 Clamp the helmet to the test fixture using the 3-point clamp.

13.5.3 Install the face shield on the helmet per manufacturer instructions with the face shield in the up position.

13.5.4 Install the witness material block in the test fixture and smear a thin layer of contact indicator material on the witness material.

13.5.5 Adjust the angle and location of the face shield and witness material block to meet alignment and angle requirements for shot 1.

13.5.6 Lower the face shield into the fully down position and adjust spacing between the face shield surface and the witness material surface.

13.5.7 Take shot 1 on the face shield.

13.5.8 Perform visual examinations and document the outcomes:

13.5.8.1 Examine the face shield for the presence of contact indicator material;

13.5.8.2 Examine the witness material for any fragments from the projectile or face shield; and

13.5.8.3 If the visual examination revealed no contact indicator material on the face shield and no fragments in the witness material, continue the procedure.

NOTE 12—If either fragments or contact are seen, the test may be discontinued.

13.5.9 Raise the face shield and adjust the angle and location of the face shield and witness material block to meet alignment and angle requirements for shot 2.

13.5.10 Lower the face shield into the fully down position and adjust spacing between the face shield surface and the witness material surface.

13.5.11 Take shot 2 on the face shield.

13.5.12 Perform visual examinations and document the outcomes:

13.5.12.1 Examine the witness material for any fragments from the projectile or face shield.

13.5.12.2 Examine the face shield attachment points for visible damage.

14. Fastener RTP Testing

14.1 Test Items:

14.1.1 Each test item shall be a complete helmet, including the shell, fasteners, hardware, suspension system, and retention system. If the helmet has a face shield, remove it prior to testing.

14.1.2 Each test item shall be sized for and mounted on the appropriate “Cadex Ballistic Testing Headform” (or equivalent) for the location being shot. The headform shall be filled with conditioned ROMA Plastilina No. 1® modeling clay.

14.1.3 Additional relevant test item details are specified in other standards or specifications.

14.2 Headform Preparation and Verification:

14.2.1 Fill the headform with one layer of small, flat thumb-sized pieces of ROMA Plastilina No. 1® clay.

14.2.2 Using thumb and fingers, blend each piece together and work out any voids and air bubbles.

14.2.3 Continue to add layers of clay to the headform until the headform is filled with clay. Smooth and form the clay as much as possible to the intended final shape.

14.2.4 Put the clay-filled headform into the associated headform mold and place the mold in a press. Press the mold to properly shape the clay.

14.2.4.1 If there is excess clay between the two halves of the mold, remove the excess clay and press the mold again. Repeat this step until there is no excess clay between the two mold halves.

14.2.5 Condition the clay-filled headform in accordance with 11.6.