Designation: ~~E3111/E3111M – 18~~ E3111/E3111M – 21

Standard Test ~~Method~~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 This test method describes the tests for ballistic-resistant head protection which consists of helmets and face shields. Test methods address back face deformation, resistance to penetration, and ballistic limit. It is anticipated that this test method 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 This test method does not address eye protection other than face shields that are attached to the helmet.~~

~~1.3 The test method does not specify performance criteria or usages of the test results.~~

~~1.4 This test method addresses conditioning of test items.~~

~~1.5 Purchasers and other users will specify and describe the ballistic test threats to be used. Within this test method, the reference will be called the "test threats document."~~

~~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 this test method and a user supplied document, the user supplied document takes precedence.~~

~~1.8 In this test method, "other standards and specifications" and "unless specified elsewhere" refer to documents (for example, military standards, purchase specifications) that require the use of this test method. Purchasers and other users are responsible for the "other standards and specifications" and for specifying any requirements that supersede those of this test method.~~

~~1.9 *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] ~~This~~These test ~~method is~~methods are under the jurisdiction of ASTM Committee E54 on Homeland Security Applications and ~~is~~are the direct responsibility of Subcommittee E54.04 on Personal Protective Equipment (PPE).

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1.10 *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]

E18 Test Methods for Rockwell Hardness of Metallic Materials

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

2.2 *Department of Defense Standards:*[3]

MIL-STD-3027 Test Method Standard for Performance Requirements and Testing of Body Armor

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

TOP 10-2-210 Test Operations Procedure Ballistic Testing of Hard Body Armor Using Clay Backing, Change 3

ATC-MMTB-IOP 051 Measurement of Back Face Deformation (BFD) using Faro Quantum Laser Scan Arm and Geomagic 2014 Control and Studio for Helmets (RPS Alignment)

2.3 *Other Standards:*

NIJ Standard-0106.01 NIJ Standard for Ballistic Helmets[4]

ISO/IEC 17025 General Requirements for the Competence of Testing and Calibration Laboratories[5]

AATCC Test Method 169 Weather Resistance of Textiles: Xenon Lamp Exposure[6]

3. Terminology

3.1 For terms not defined in this test method, the following definitions of Terminology E3005 apply: *back face deformation, conditioning, complete penetration, fair hit, obliquity, partial penetration, shot-to-edge distance, shot-to-shot distance, strike face, test item, 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 *clay block, n*—a type of backing assembly in which the backing material is ROMA Plastilina No. 1® modeling clay.

3.2.2.1 *Discussion*—

See Specification E3004 for more information on the type of clay.

3.2.3 *controlled ambient, n*—conditions with temperature of 20 °C ± 5.5 °C [68 °F ± 10 °F] and 50 % ± 20 % relative humidity (RH).

3.2.3.1 *Discussion*—

Within this test method, this definition applies to any direct or indirect reference to controlled ambient.

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

3.2.4.1 *Discussion*—

See Fig. 1 for a pictorial representation.

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

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

[8] Available from American Association of Textile Chemists and Colorists (AATCC), P.O. Box 12215, Research Triangle Park, NC 27709-2215, http://www.aatcc.org.National Institute of Justice (NIJ), 810 7th St., NW, Washington, DC 20531, http://nij.gov.

[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.

[5] Available from National Institute of Justice (NIJ), 810 7th St., NW, Washington, DC 20531, http://nij.gov.American Association of Textile Chemists and Colorists (AATCC), P.O. Box 12215, Research Triangle Park, NC 27709-2215, http://www.aatcc.org.

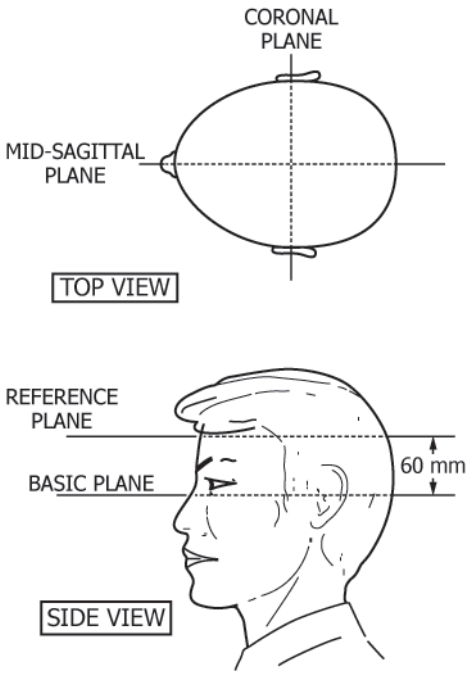

FIG. 1 Head Planes

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

3.2.6.1 *Discussion*—

See Fig. 1 for a pictorial representation.

3.2.7 *obliquity, n*—the angle between the test threat line of aim and the line normal to a reference plane based on features of the test item at the point of aim.

adapted from MIL-STD-3027

3.2.7.1 *Discussion*—

A zero degree obliquity could be indicated by shining a laser down the barrel to a reflection device mounted to the helmet and having the reflection return to the origin.

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

3.2.8.1 *Discussion*—

See Fig. 1 for a pictorial representation.

3.2.9 *test series, n*—the set of all shots necessary to obtain the required number of fair hits on a single test item or the set of all shots necessary to generate ballistic response data.

3.2.10 *test stand, n*—a rigid or massive component of the test item mounting system that supports other components.

3.2.10.1 *Discussion*—

See Specification E3062 for more details.

4. Summary of Test Method

4.1 This test method specifies the methods for assessing the penetration resistance and back face deformation for ballistic-resistant helmets and face shields.

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

4.3 Multi-hit performance may also be demonstrated during this test by firing multiple test threats on an individual test item (the specific number of test threats fired at a test item is specified by the end user).

5. Significance and Use

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

5.2 This test method 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 this test method be referenced by other standards, specifications, or test methods.

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 1°.

6.4 The backing assembly for validating the clay within a headform 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®.

6.5 For testing that requires a headform, the headform shall be a Cadex Model 100_00_HNME that meets the specifications given in drawings in Annex A1 unless otherwise directed by another specification or requirements document.

NOTE 2—The Cadex[7] Model 100_00_HNME is the only headform currently used for ballistic testing of helmets to National Institute of Justice and U.S. Army standards.

6.6 For testing that requires a headform, affix the test item to the above-specified 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.

6.7 For V_0 and 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 0° and 45° obliquity impacts can be achieved anywhere on the test item. A drawing of an acceptable fixture is located in Appendix X1.

6.8 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.

6.9 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.

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

6.10 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].

6.11 The temperature conditioning chamber for clay blocks and headforms shall meet the requirements of Specification E3004.

6.12 The liquid dunk tank shall be capable of fully submerging the test items.

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

6.14 When scanning the headform, use a laser scanner attached to an articulating arm coordinate measuring machine (LS/AACM) that meets the requirements of ATC-MMTB-IOP 051.

7. Hazards

7.1 The ballistic tests described in this test method 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 3—Typical obliquities are 0°, 30°, and 45°, with most obliques 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 at the proposed impact distance. Yaw shall be ≤3° for rifle threats or ≤5° for fragment and handgun threats. Check yaw for every test threat shot.

9.2.4 For back face deformation (BFD) and resistance to perforation (RTP) testing, the test threat velocity shall be within the specified range given in the test threats document. If no specified range is given, the range shall be required velocity –0 + 15 m/s [–0 + 50 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 V_{50} 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 that impacts within 25 mm [1 in.] of a potential weak point, such as an earflap crease, hole, or bolt, is an unfair hit.

9.2.6 For test threat impacts to hardware with a head such as a bolt, the test threat shall impact the hardware head. An impact is defined as the tip of the projectile impacting within the diameter of the hardware head as indicated by visual examination.

9.2.7 The test threat 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. For intended edge shots, the test threat shall impact the test item no further than the maximum shot-to-edge distance.

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 center-to-center, from a prior impact.

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*—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 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.

9.2.9 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 4—Normally, this tolerance is approximately ±8 m/s [±25 ft/s].

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 Procedure*—Expose test items to controlled ambient conditions for at least 24 h.

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

10.2.3 *Extreme Cold*—Subject test items to extreme cold conditioning for between 24 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 *Dunk Test:*

10.3.1 Expose test items to controlled ambient temperature for a minimum of 3 h prior to immersion in the liquid. Both prior to and after conditioning, the test sample should be weighed and the weights recorded in the report.

10.3.2 Completely submerge test items in a liquid at controlled ambient temperature for 3 to 4 h. After submersion, remove the test item, wipe dry, weigh and ballistically test. Complete ballistic testing within 2 h after removal.

10.3.3 For a saltwater solution, the solution will consist of 3 % by weight sodium chloride, 0.5 % by weight magnesium chloride and adjusted to a pH of 8.2.

10.4 *Exposure to Artificial Weathering:*

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

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

10.4.1.2 Position the test item strike face toward the light source.

10.4.1.3 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 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/m^2. Terminate the weather cycle at that point.

10.4.1.4 The spectral irradiance level shall be 0.55 W/m^2/nm ± 0.01 W/m^2/nm bandpass at 340 nm.

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

10.4.2 Complete ballistic testing within 96 h after completion of weathering.

11. Helmet Back Face 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 BFD testing.

11.2.2 Only size large (nominally size 7¼, 58 cm) helmets shall be used for BFD testing.

11.3 *Test Threats:*

11.3.1 Test threats and velocities to be used shall be specified in a test threats document.

11.4 *Headform Filling with Backing Material:*

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]
Relative Humidity	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.)

~~11.4.1 Use ROMA Plastilina No. 1®[8] modeling clay as the backing material in the headform to make BFD measurements, preparing the headform as follows:~~

~~11.4.1.1 Fill the bottom of the headform with one layer of small flat thumb-sized pieces of ROMA Plastilina No. 1® clay.~~

~~11.4.1.2 Using thumb and fingers, blend each piece together and work any voids and air bubbles to the outside of the channels.~~

~~11.4.1.3 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.~~

~~11.5 *Clay Block and Headform Conditioning:*~~

~~11.5.1 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 this test method.~~

~~11.5.2 Place the calibration 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. 2).~~

~~NOTE 5—The orientation of the headforms during conditioning is not significant.~~

~~11.5.3 Heat each clay block and headform such that the clay will pass the verification drops listed in 11.6 according to the requirements below:~~

~~11.5.3.1 New clay blocks and new headforms shall be heated for at least 24 h.~~

~~11.5.3.2 Any clay block or headform that has been out of the conditioning chamber shall be reheated for no less than 3 h.~~

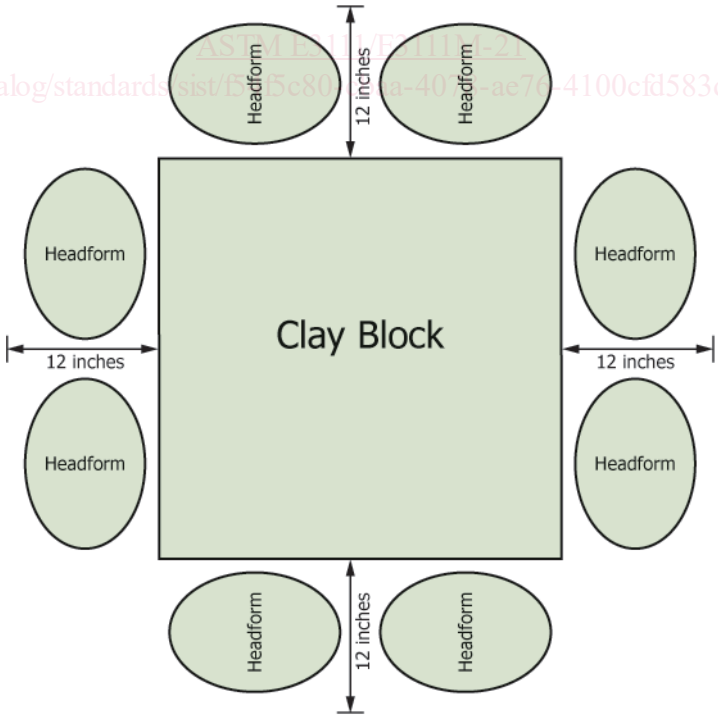

FIG. ~~2~~3 Illustration of Clay Block-Headform Position During Conditioning

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

11.5.3.3 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.

11.5.3.4 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.

11.6 *Verification of the Clay Block and Headforms:*

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

11.6.1.1 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 6—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.

11.6.1.2 The acceptance requirement is that each impact indentation depth is 25.4 mm ± 2.5 mm [1.0 in. ± 0.1 in.].

11.6.1.3 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.

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

11.7 *Preparation of the Clay-filled Headform:*

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

11.7.2 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.

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

NOTE 7—Before use, the cutting edges of the clay contour shaping tools should be checked for sharpness, burrs, and other deformities. If deformities exist, they shall be corrected prior to use of the tools.

11.7.3.1 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.

11.7.3.2 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 8—There is no specified order of the steps for using the contour shaping tools.

11.7.3.3 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.

11.7.3.4 There shall be no gaps between the clay and the tool. If gaps exist, add clay from the conditioning chamber, and go back to 11.7.3.1.

11.7.3.5 When the tool is removed, there shall be no marks or grooves left in the clay. If marks or grooves exist, go back to 11.7.3.1.

11.8 *Repair of Clay-filled Headform:*

11.8.1 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 11.5.

11.9 *BFD Measurement:*

11.9.1 Before each ballistic impact on the headform, scan the impact location using the LS/AACM. Follow the process of ATC-MMTB-IOP 051.

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

11.9.3 Record the maximum 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.

11.10 *Test Requirements and Steps:*

11.10.1 *Test Requirements:*

11.10.1.1 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.

11.10.1.2 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.

11.10.1.3 If an impact causes the clay to bulge out of the channel for a subsequent shot, repair that channel following the procedures listed in 11.7.3. Only the channel of interest needs to be repaired. This shall be done prior to the initial scan of the impact location.

11.10.1.4 Shots shall meet the fair hit requirements.

11.10.1.5 Document all measurements and observations.

11.10.2 *Test Steps:*

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

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

11.10.2.3 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.

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

11.10.2.5 Remove the test item and scan the crown of the headform.

11.10.2.6 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.

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

11.10.2.8 Mount the test item on the headform.

11.10.2.9 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.

11.10.2.10 Remove the test item, and scan the right side of the headform.

11.10.2.11 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.

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

11.10.2.13 Mount the test item on the headform.

11.10.2.14 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.

11.10.2.15 Remove the test item and scan the left side of the headform.

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

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

11.10.2.18 Mount the test item on the headform.

11.10.2.19 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.

11.10.2.20 Remove the test item and scan the front of the headform.

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

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

11.10.2.23 Mount the test item on the headform.

11.10.2.24 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.

11.10.2.25 Remove the test item and scan the back of the headform.

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

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

12. Helmet Resistance to Perforation (RTP) (V_0) Testing

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

12.2 *Test Items:*

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

12.3 *Test Item Marking:*

12.3.1 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 the governing test requirement documentation. 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.

12.3.2 Mark the 45°, 135°, 225°, and 315° positions of the ring on the shell as shown in Fig. 3.

12.3.3 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.

12.4 *Test Threats:*

12.4.1 Test threats and velocities to be used shall be specified in a test threats document.

12.5 *Test Procedures:*

12.5.1 *Test Item Mounting:*

12.5.1.1 Clamp the test item securely in a fixture identified in 6.7.

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

12.5.1.3 Place the holder such that the witness panel is inside the test item shell behind the area of intended impact. Refer to the test threats document for the witness panel distance specification. If no specification is listed, place the witness panel 76 mm ± 25 mm [3.0 in. ± 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.

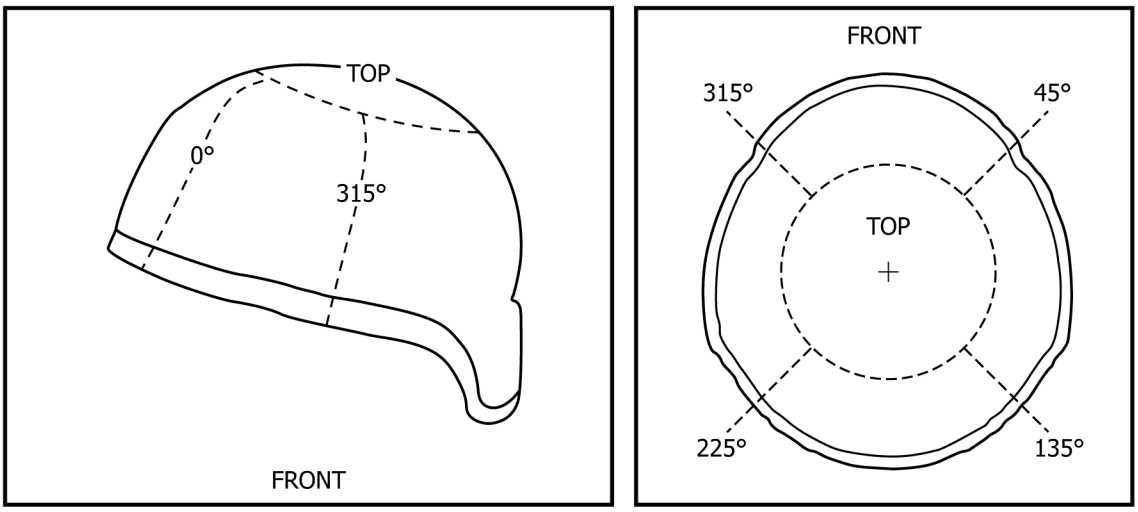

FIG. 32 Location of Helmet Sections

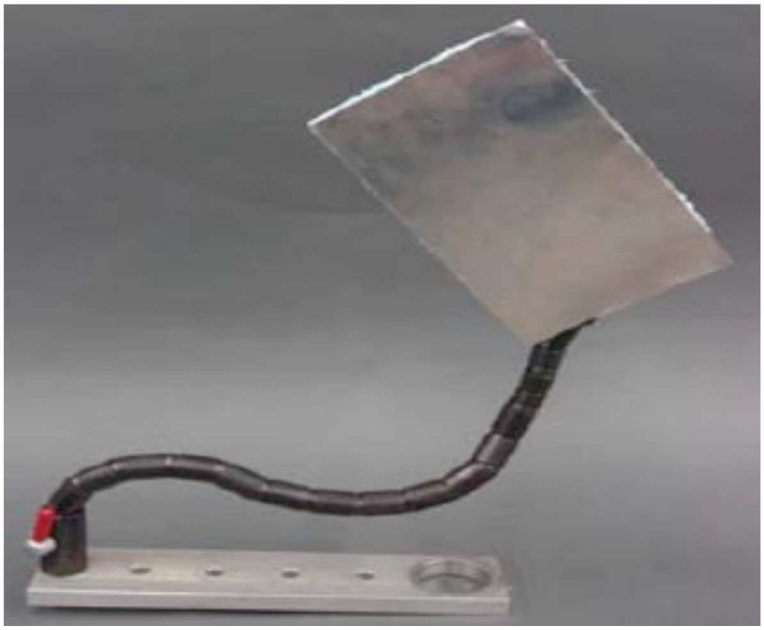

FIG. 4 Example of Witness Panel Holder

~~12.5.1.4 A suitable plate shall be placed a distance of no closer than 25 mm [1 in.] behind the witness panel to stop any threat fragments from impacting the opposite side of the shell in the event of a complete penetration.~~

~~12.5.2 *Impact Locations and Test Threat Velocity:*~~

~~12.5.2.1 Unless specified elsewhere, each section of the test item shall have two impacts adhering to the fair hit requirements. If the second group of impacts cannot be placed on the opposite side of the test item due to damage from previous impacts, the second group of shots can be placed on a spare test item.~~

~~12.5.2.2 The shot sequence shall be:~~

~~12.5.2.3 Test item #1: two impacts on the right side followed by two impacts on the left side.~~

~~12.5.2.4 Test item #2: two impacts on the front followed by two impacts on the back.~~

~~12.5.2.5 Test item #3: two impacts on the crown, unless the crown impacts can fit on test items #1 and #2 without damage overlap into previously impacted sections.~~

~~12.5.2.6 Test items #4 and #5: Spare.~~

~~12.5.3 Unless specified elsewhere, the shot sequence per section of a test item shall be as follows:~~

~~12.5.3.1 Place the first shot at the right side and front sections on a suspected weak point, if one exists. These weak points may be the crease of an earflap, an attachment bolt, or mounting holes. Place the first shot at the left and back sections at a location other than a suspected weak point. Place the first shot at the crown section within 25 mm [1.0 in.] of the benchmark at the crown of the helmet.~~

~~12.5.3.2 The second impact at the right side and front sections is at a location other than a suspected weak point. Place the second impact at the left, back, and crown sections on a suspected weak point different than the weak point on the opposing side, if one exists. An example is shooting the bolt on the right side and shooting the earflap crease on the left side.~~

~~12.5.4 Document all impact locations and use of spares in the test report.~~