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.

Designation: E3068 – 17ε1

Standard Test Method for Contact Measurement of Backface Deformation in Clay Backing During Body Armor Testing[1]

This standard is issued under the fixed designation E3068; 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.

ε[1] NOTE—Added research report footnote to Section 12 editorially in April 2017.

1. Scope

1.1 This test method describes test methods for the contact measurement of backface deformation (BFD) in clay backing caused by a test threat that produces a partial penetration in a body armor test item.

1.2 This test method is applicable to testing of planar and nonplanar soft armor and hard armor.

1.3 This test method is not applicable to testing of helmets.

1.4 The purpose of this test method is to achieve consistent measurements between laboratories and reduce differences that could result from using different measurement techniques.

1.5 It is anticipated that this test method will be referenced by certifiers, purchasers, and other users in order to meet their specific needs.

1.6 This test method does not specify BFD performance requirements for body armor. The performance requirements are included in other standards or specifications. The decision rules for determining conformance to specifications and the consideration of uncertainty are also included in other standards or specifications.

1.7 *Units*—The values stated in SI units are to be regarded as standard. Where appropriate, mathematical conversions to non-SI units are provided in parentheses for informational purposes.

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 and health 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]

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

E3005 Terminology for Body Armor

2.2 *Other Standards:*

MIL-STD-3027 Department of Defense Test Method Standard for Performance Requirements and Testing of Body Armor[3]

NIJ Standard 0101.06 Ballistic Resistance of Body Armor[4]

National Research Council Testing of Body Armor Materials Phase III[5]

3. Terminology

3.1 The terms and definitions of Terminology E3005 apply for the following terms: *backface deformation, backing fixture, backing material, body armor, complete penetration, hard armor, nonplanar, partial penetration, soft armor, test item*, and *test threat*.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *applique, n*—backing material intended to fill the space behind a nonplanar test item during testing or conditioning procedures.

3.2.2 *backface deformation (BFD), n*—the indentation in the backing material caused by a projectile impact on the test item during testing. **E3005**

3.2.2.1 *Discussion*—See Fig. 1.

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

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

[3] Available from IHS, 15 Inverness Way East, Englewood, CO 80112, http://www.global.ihs.com.

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

[5] Available from The National Academies Press, 500 Fifth St., NW, Washington, DC 20001, https://www.nap.edu.

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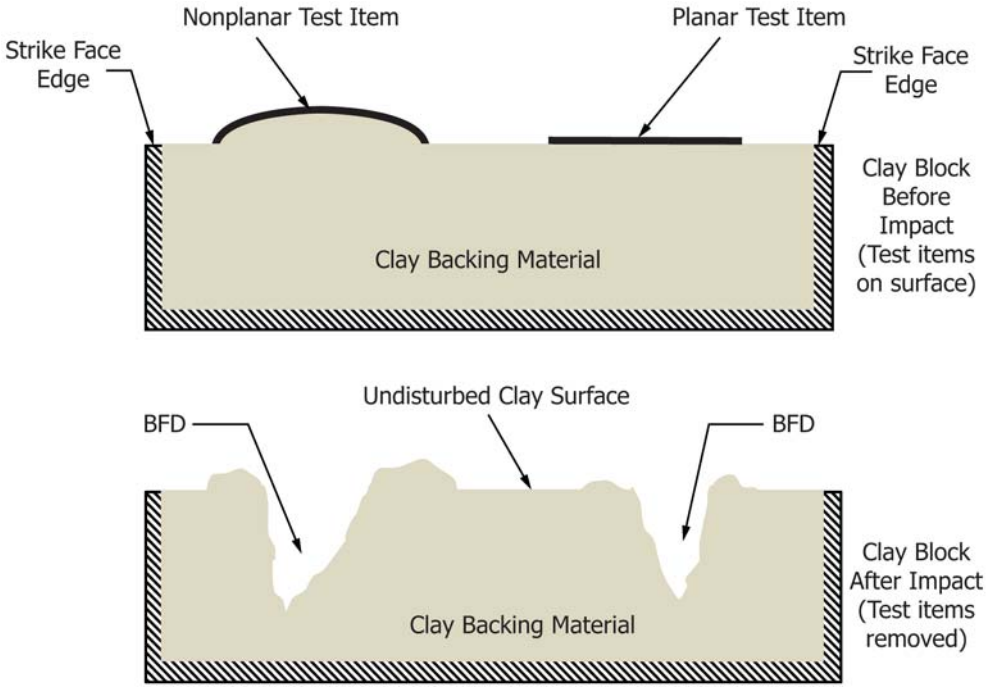


FIG. 1 Examples of Backface Deformation (Side View)

3.2.3 *bridge gauge, n*—an assembly used for measuring that consists of a depth gauge and supports that rest on opposite sides of the backing fixture. **E3004**

3.2.3.1 *Discussion*—See Fig. 2 for a photograph of a bridge gauge.

3.2.4 *check standard, n*—stable, durable artifact that may be used for training, comparing among measuring instruments, and checking instruments prior to and after calibration, maintenance, or normal use to detect changes in the instruments.

3.2.5 *clay block, n*—a type of backing assembly in which the backing material is *ROMA Plastilina No. 1*®[6] modeling clay. **E3004**

3.2.5.1 *Discussion*—See Fig. 3 for a graphical representation of a clay block.

3.2.6 *depth gauge, n*—instrument (for example, caliper) used to measure the indentations in the backing material.

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

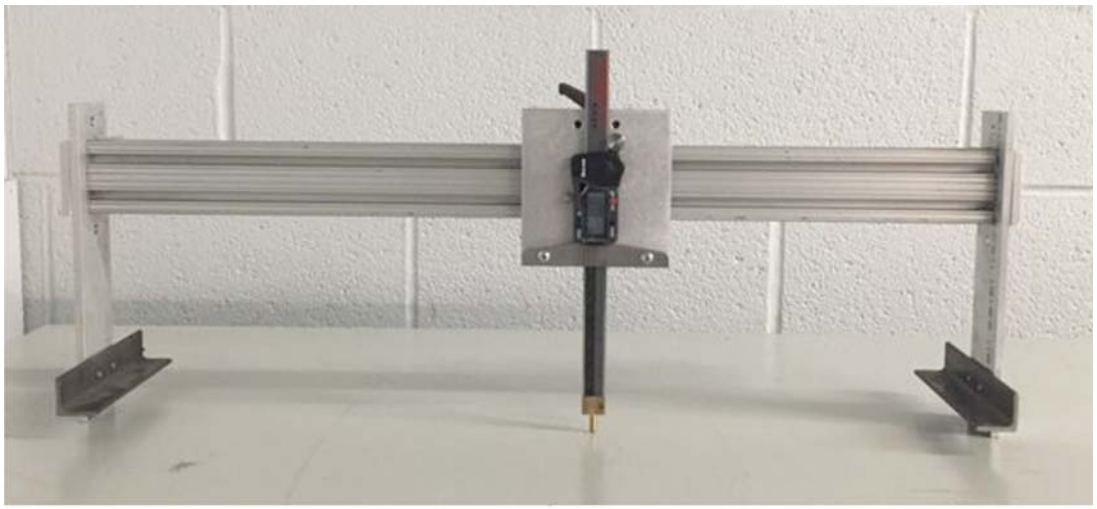
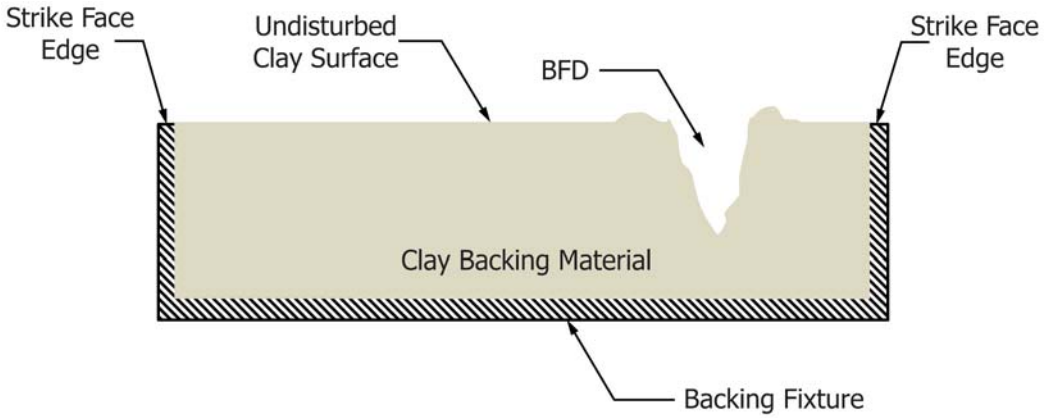


FIG. 2 Photograph of Bridge Gauge



Note: Strike face edge is synonymous with backing fixture edge.

FIG. 3 Side View of Clay Block (After Impact)

3.2.7 *floating gauge, n*—a depth gauge that rests on the surface of the backing material.

3.2.8 *striking device, n*—a device used on a clay block to establish an appropriate, flat surface on the clay backing material with respect to the backing fixture edges. E3004

4. Summary of Test Method

4.1 Ballistic testing of body armor typically requires shooting body armor test items mounted on clay blocks.

4.2 One of the ballistic test methods for body armor specifies that the BFD be measured when shooting of the test item results in a partial penetration. When the shot results in a complete penetration, BFD is not measured.

4.3 This test method describes the measurement instrumentation, the BFD measurand, and the procedure for the use of contact measurement instruments.

5. Significance and Use

5.1 U.S. Department of Defense and U.S. Department of Justice standards for assessing the performance of ballistic-resistant torso body armor require the measurement of BFD on backing assemblies made with *ROMA Plastilina No. 1*®.

5.2 This test method may be applicable for certification testing or for research and development testing.

6. Equipment and Instrumentation

6.1 The measuring instrument shall have a resolution of 0.01 mm (0.0004 in.) or better with an accuracy of ±0.1 mm (0.004 in.) or better.

6.2 Three types of contact measuring instruments may be used:

6.2.1 *Bridge Gauge*—The bridge gauge shall be a rigid assembly that rests on two parallel strike face edges of the backing fixture and supports a depth gauge that can slide back and forth on the assembly to measure depths across the surface of the backing material. The bridge shall be sufficiently rigid that it will not deflect during use or otherwise negatively affect the measurement.

6.2.2 *Floating Gauge*—The floating gauge shall be a rigid assembly that supports a depth gauge and has a base that rests on the clay surface. The base shall be at least 25 by 152 mm (1 by 6 in.) but not so large that it touches the backing fixture frame during measurements.

6.2.3 *Touch Probe*—The touch probe is a coordinate measuring machine consisting of an articulating arm, a contact probe, and software that calculates the BFD measurement.

6.3 The tip that touches the clay shall be hemispherical or spherical with a diameter of 6.35 ± 0.0254 mm or 0.25 ± 0.001 in. and attached to a cylindrical stem having a minimum length of 38.1 mm (1.5 in.) and maximum diameter of 6.35 mm (0.25 in.) such that only the tip touches the deepest location of the BFD. See Fig. 4 for examples of probe tip configurations that meet the above requirements.

6.4 General lighting on the range should provide adequate light levels to enable personnel to perform assigned duties. Local lighting to supplement general lighting, if needed, should be available to provide better visibility for tasks associated with measurements and instrument readings.

NOTE 1—Any light sources used on the range, including local lighting to aid measurement, should not change the required laboratory conditions or alter the surface temperature of the clay backing material.

6.5 Check standards should be used in the laboratory for training of technicians, monitoring for changes in instrumentation, checking instruments after calibration/re-calibration, checking software, and performing intra-laboratory and inter-laboratory comparisons.

6.5.1 These check standards should be calibrated.

7. BFD Measurand

7.1 For contact measuring instruments, the BFD measured is the length of the line segment, parallel to the test threat line of aim, between a plane passing through the point of aim on the pre-impact surface and a plane passing through the deepest point of the post-impact surface; the planes are parallel to each other and perpendicular to the test threat line of aim. The

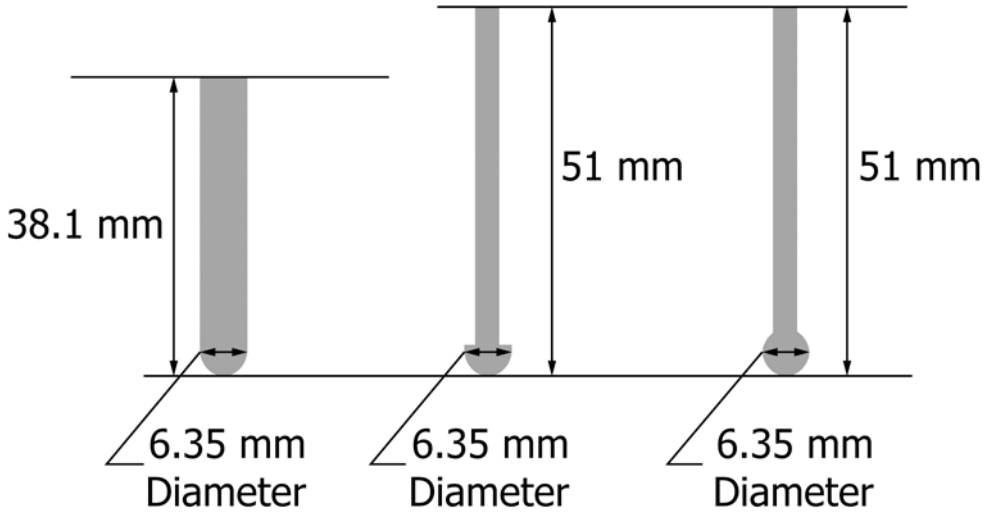


FIG. 4 Examples of Tip Probe Configurations

measurement planes are established by the probe tip as it makes contact with the clay surface without causing deformation. See Fig. 5.[7]

NOTE 2—The deepest point is not necessarily colinear with the line of aim.

8. BFD Measurement Procedure for Planar Armor

8.1 After each shot on the test item, remove the test item from the clay block and strike the clay by drawing the striking device at least once across parallel edges of the backing fixture.

8.2 Establish the point-of-aim measurement plane as "0" based on the clay surface near the impact.

8.3 Measure the deformation using either a floating gauge or a touch probe. When using a floating gauge, ensure that no part of the floating gauge touches the backing fixture frame. When using a touch probe, follow the manufacturer instructions to ensure the resolution and accuracy requirements are achieved.

NOTE 3—Caution is required when touching the probe tip to the clay to ensure that the probe tip does not indent the clay.

8.4 Adjust the position of the probe tip so that it contacts the deepest point of the indentation without disturbing the clay and measure the depth of the indentation relative to the established "0", with the following consideration:

8.4.1 At times, the bottom of the BFD is angled into the clay, which may interfere with the probe tip touching the deepest part of the BFD while maintaining the required measurement direction. In those cases, any clay that causes interference may be moved. Care should be taken such that the deepest point of the BFD is not influenced by this movement of clay. Movement of clay for this purpose shall be documented in the test report.

8.5 Record the measured value in millimeters. The raw measurements shall not be rounded off or truncated but shall be reported to the number of places read.

NOTE 4—For readings having more than four digits to the right of the decimal, the result does not need to be reported to more than 0.0001 mm.

8.6 All measurements and observations shall be documented and included in the test report.

[7] Fig. 5 is adapted from a NIST Report dated 17 Feb 2010: *Dimensional Metrology Issues of Army Body Armor Testing* (unpublished).

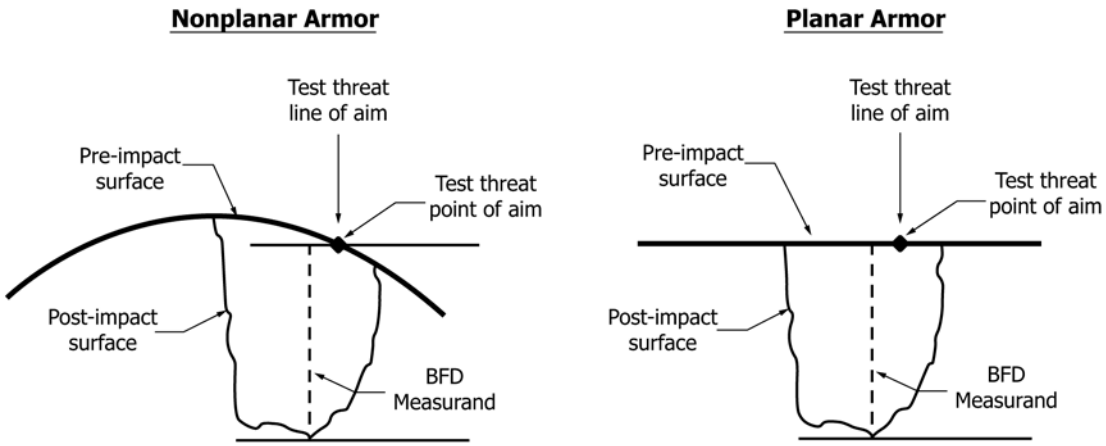


FIG. 5 BFD Measurand for Contact Measuring Instruments

9. BFD Measurement Procedure for Nonplanar Armor

9.1 Prior to shooting the test item, establish the point-of-aim measurement plane as "0" based on the surface of the applique, at the point of aim.

9.2 After each shot on the test item, remove the test item from the clay block.

9.3 Measure the deformation using either a bridge gauge or a touch probe. When using a bridge gauge, place the bridge gauge on the edges of the clay block and position the depth gauge over the indentation. When using a touch probe, follow the manufacturer instructions to ensure the resolution and accuracy requirements are achieved. See Note 3 in 8.3.

9.4 Position the probe tip so that it contacts the deepest point of the indentation without disturbing the clay and measure the depth of the indentation relative to the established "0", with the following consideration:

9.4.1 At times, the bottom of the BFD is angled into the clay, which may interfere with the probe tip touching the deepest part of the BFD while maintaining the required measurement direction. In those cases, any clay that causes interference may be moved. Care should be taken such that the deepest point of the BFD is not influenced by this movement of clay. Movement of clay for this purpose shall be documented in the test report.

9.5 Record the measured value in millimeters. The raw measurements shall not be rounded off or truncated but shall be reported to the number of places read. See Note 4 in 8.5.

9.6 All measurements and observations shall be documented and included in the test report.

10. Laboratory Documentation

10.1 A laboratory shall have documented instructions for all aspects of the BFD measurement process, including the following:

10.1.1 Use of check standards over the range and direction of interest.

10.1.2 Instructions for ensuring that there are no data entry or transposition errors in recording measurements.

11. Test Report and Data

11.1 The type of measuring instrument, hardware, and software used and configuration details shall be reported.

11.2 The measured value for each BFD shall be reported, as recorded in 8.5 or 9.5, without truncation or rounding, as per the number displayed on the measuring instrument. Observations shall also be included in the test report.

11.3 A statement of conformance to specifications, if required, shall be included in the test report.

12. Precision and Bias[8]

12.1 The repeatability standard deviation from a single operator has been determined to be 0.20 mm. An interlaboratory study of this test method will be conducted following publication of this test method, and a complete precision and bias statement is expected to be available by December 2018.

13. Keywords

13.1 backface deformation; back face deformation; body armor; backing material; ballistic-resistant

[8] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:E54-1002. Contact ASTM Customer Service at service@astm.org.

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