



Designation: **E3112/E3112M – 19 E3112/E3112M – 20**

## Standard Test Method for Ballistic-resistant Products and Shoot Packs<sup>1</sup>

This standard is issued under the fixed designation E3112/E3112M; 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 reappraisal. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reappraisal.

### 1. Scope

1.1 This test method assesses resistance to complete penetration by projectiles and applies to ballistic-resistant products or shoot packs, either flexible or rigid, that are intended to provide protection against projectiles from small arms.<sup>2</sup> This test method does not assess blunt impact resistance.

1.2 This test method does not apply to body armor, armor panels, inserts, trauma packs, trauma plates, materials, or other items intended to be worn or located against the body to limit blunt trauma.

1.3 This test method applies only to products related to homeland security and public safety.

1.4 This test method is not intended to address architectural products covered by Test Method **F1233**, such as building materials and security glazing.

1.5 This test method is applicable to products or shoot packs that are constructed with identical layouts of ballistic materials over the entire product or shoot pack. The product or shoot pack may have stitching, seams, or other joints.

NOTE 1—For example, this test method is applicable for evaluating a ballistic-resistant blanket constructed from multiple sheets of different materials laminated together; however, this test method is not applicable for evaluating a ballistic-resistant shield that has a discontinuity at the interface between opaque and transparent component materials.

1.6 The test method does not specify performance criteria or usage of the test results.

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

1.7.1 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.

1.7.2 Purchasers and other users will specify the ballistic test threats, and the associated velocities, to be used.

1.8 *Units*—The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

1.8.1 The user of this standard will identify the system of units to be used, and it is critical to ensure that any cross-referenced standards maintain consistency of units between standards.

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.*

1.10 *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*:<sup>3</sup>

**B211/B211M Specification for Aluminum and Aluminum-Alloy Rolled or Cold Finished Bar, Rod, and Wire**

<sup>1</sup> 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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<sup>2</sup> Small arms are defined as portable firearms, typically including handguns, shotguns, rifles, and light machine guns (Terminology **E3005**).

<sup>3</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard’s Document Summary page on the ASTM website.

B221 Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes  
E3005 Terminology for Body Armor  
E3062/E3062M Specification for Indoor Ballistic Test Ranges for Small Arms and Fragmentation Testing of Ballistic-resistant Items  
E3078/E3078M Practice for Conditioning of Hard Armor Test Items  
E3107/E3107M Test Method for Resistance to Penetration and Backface Deformation for Ballistic-resistant Torso Body Armor and Shoot Packs  
F1233 Test Method for Security Glazing Materials And Systems

## 2.2 Other Documents:

AATCC TM 169 Weather Resistance of Textiles: Xenon Lamp Exposure<sup>4</sup>  
ISO/IEC 17025 General Requirements for the Competence of Testing and Calibration Laboratories<sup>5</sup>  
MIL-STD-810G Test Method Standard for Environmental Engineering Considerations and Laboratory Tests<sup>6</sup>  
ANSI/SAAMI Z299.1 Voluntary Industry Performance Standards for Pressure and Velocity of Rimfire Sporting Ammunition for the Use of Commercial Manufacturers<sup>7</sup>  
ANSI/SAAMI Z299.2 Voluntary Industry Performance Standards for Pressure and Velocity of Shotgun Ammunition for the Use of Commercial Manufacturers<sup>7</sup>  
ANSI/SAAMI Z299.3 Voluntary Industry Performance Standards for Pressure and Velocity of Centerfire Pistol and Revolver Ammunition for the Use of Commercial Manufacturers<sup>7</sup>  
ANSI/SAAMI Z299.4 Voluntary Industry Performance Standards for Pressure and Velocity of Rifle Sporting Ammunition for the Use of Commercial Manufacturers<sup>7</sup>

## 3. Terminology

3.1 For terms not defined in this test method, the following definitions of Terminology E3005 apply: *armor panel, blunt impact resistance, body armor, cartridge, complete penetration, controlled ambient, fair hit, insert, obliquity, partial penetration, projectile, shot-to-edge distance, shot-to-shot distance, shoot pack, small arms, stop, strike face, test item, test item mounting system, test stand, test threat, trauma pack, trauma plate, unfair hit, witness panel, universal receiver, warmer rounds, and yaw.*

3.1.1 From Terminology E3005: *armor panel, blunt impact resistance, body armor, cartridge, complete penetration, fair hit, insert, obliquity, partial penetration, projectile, shot-to-edge distance, shot-to-shot distance, shoot packs, small arms, stop, strike face, test item, test threat, trauma pack, trauma plate, unfair hit, witness panel, and yaw.*

3.1.2 From Specification E3062/E3062M: *test item mounting system, test stand, and universal receiver.*

3.1.3 From Practice E3078/E3078M: *controlled ambient.*

3.1.4 From Test Method E3107/E3107M: *warmer rounds.*

### 3.2 Definitions of Terms Specific to This Standard:

3.2.1 *shoot pack, n*—a test item prepared with materials, or with materials and construction features, utilized in ballistic-resistant products, but not intended to be used as a ballistic-resistant product. (Adapted from Terminology E3005.)

## 4. Summary of Test Method

4.1 The ballistic resistance of a product or shoot pack is determined by firing a series of test threats at each of a set of test items and assessing the number of partial penetrations and complete penetrations.

4.2 The performance requirements and test threats shall be specified in other standards and specifications.

NOTE 2—The performance requirements may be defined in terms of either: (1) The number of required fair hit impacts and the allowable number of complete penetrations, (2) The minimal acceptable calculated probability of a single impact being stopped and a corresponding confidence level. In this case, a minimum number of required fair hits may also be set, or (3) A combination of the above.

## 5. Significance and Use

5.1 The test method is intended to determine the resistance to penetration of a ballistic-resistant product or shoot pack to specified projectiles impacting at specified velocities. No other properties of the ballistic-resistant product or shoot pack are evaluated by this test method.

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 products or shoot packs or performing research and development of new products.

<sup>4</sup> Available from American Association of Textile Chemists and Colorists (AATCC), P.O. Box 12215, Research Triangle Park, NC 27709-2215, <http://www.aatcc.org>.

<sup>5</sup> 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>.

<sup>6</sup> Available from U.S. Government Printing Office, Superintendent of Documents, 732 N. Capitol St., NW, Washington, DC 20401-0001, <http://www.access.gpo.gov>.

<sup>7</sup> Available from Sporting Arms and Ammunition Manufacturers' Institute, Flintlock Ridge Office Center, 11 Mile Hill Rd., Newtown, CT 06470-2359, [www.saami.org](http://www.saami.org).

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 threats, and the associated velocities, shall be specified in other standards and specifications.

6.2 The ballistic test range shall meet the requirements of Specification **E3062/E3062M**.

6.3 The test item fixture, including position and attitude adjustments, shall be specified in other standards and specifications.

6.3.1 When not specified elsewhere, the test item mounting system shall be a frame as described below:

6.3.1.1 The frame shall consist of two layers of metal between which the test item is secured.

6.3.1.2 The frame shall be of sufficient size to restrain the test item during ballistic impact.

6.3.1.3 The frame, supports, clamps, and mounting fixtures shall be capable of securely retaining the test item and withstanding shock resulting from ballistic impact by the test projectiles. At a minimum, the clamps holding the test item in the frame shall be positioned in the center of each side of the frame or at the four corners of the frame.

6.4 The method for measuring projectile yaw may be with yaw cards, flash radiography, high speed video, or photography and shall be capable of determining, at the point of measurement, whether the angle of yaw is greater or less than 5°.

6.5 A witness panel shall be used to determine whether a complete penetration has occurred.

6.5.1 The witness panel outer dimensions shall be at least 305 mm by 305 mm [12 in. by 12 in.]. The height and width of the witness panel may be increased in order to allow for impact by all fragments resulting from projectile penetration.

6.5.2 For opaque test items, the witness panel shall be a sheet of 2024-T3, 2024-T4, or 5052 aluminum alloy<sup>8</sup> and shall be nominally 0.50 mm [0.020 in.] thick.

6.5.3 For transparent test items, the witness panel shall be a 0.0254 mm [0.001 in.] thick sheet of aluminum foil.

## 7. Hazards

7.1 The ballistic tests described in this test method have inherent hazards. Adequate safeguards for personnel and property shall be employed when conducting these tests.

## 8. Sampling and Test Items

8.1 Test item details (including quantity, size, and required conditioning) shall be specified in other standards and specifications.

NOTE 3—A sufficient number of test items is required for testing, based on the conditioning requirements, anticipated total number of projectile impacts, and the number of projectile impacts that may be placed on each test item.

8.2 The supplier is responsible for providing the number of test items to accomplish the required testing. It is recommended that spare test items be provided.

8.2.1 When the use of a spare test item is required, details about selecting the appropriate spare test item shall be specified in other standards and specifications.

8.2.2 When not specified elsewhere and when the test item is either a shoot pack or a coupon representing a portion of the finished product, the size of each test item shall be at least 305 mm by 305 mm [12 in. by 12 in.].

NOTE 4—It is recommended that each test item that represents a product be the typical size and shape of that product.

## 9. Conditioning Procedures

9.1 This section describes conditioning procedures that may be applicable for ballistic-resistant products or shoot packs.

9.2 A thorough visual examination of each test item prior to and after the exposures shall be done to document any change in physical appearance resulting from the exposure.

9.3 *Temperature Conditioning:*

9.3.1 Place the test items into an environmental chamber preset to the initial conditions of Step 1 in **Table 1**.

9.3.1.1 For some products, not all steps in **Table 1** are required. In those cases, other specifications will state the required steps.

9.3.2 Subject the test items to the conditions in **Table 1**. Each step transition shall take place and stabilize in less than 30 minutes.

NOTE 5—Exposure time includes the stabilization time.

9.3.3 Upon completion of the exposure protocol in **Table 1**, return the test items in the chamber to the initial conditions of Step 1 in **Table 1**.

9.3.4 Remove the test items from the environmental chamber.

9.3.5 Perform a thorough visual examination of each test item and document any change in physical appearance resulting from exposure.

9.4 *Temperature Extremes Conditioning:*

<sup>8</sup> Specifications **B211/B211M** and **B221** contain information related to aluminum alloys.



TABLE 1 Exposure Conditions

Steps	Time (hours) (±5 minutes)	Temperature (°C) (±2°C [±4°F])	Relative Humidity (%) (±5 %)
1	2	25°C [77°F]	50
2	2	15°C [59°F]	N/A
3	2	5°C [41°F]	N/A
4	2	-5°C [23°F]	N/A
5	2	-15°C [5°F]	N/A
6	2	0°C [32°F]	N/A
7	2	15°C [59°F]	N/A
8	2	30°C [86°F]	50
9	2	45°C [113°F]	50
10	2	60°C [140°F]	50
11	2	75°C [167°F]	50
12	2	90°C [194°F]	50

9.4.1 Tests shall be performed in accordance with constant temperature exposure procedures of MIL-STD-810G, Method 501.5, Procedure I (high temperature) and Method 502.5, Procedure I (low temperature).

9.4.2 One set of test items shall be subjected to high temperature, and another set shall be subjected to low temperature. Ramping of temperature is prohibited.

9.4.2.1 The starting temperature shall be controlled ambient.

9.4.2.2 One set of test items shall be heated in a chamber operating at  $71.1^{\circ}\text{C} \pm 3^{\circ}\text{C}$  [ $155^{\circ}\text{F} \pm 5^{\circ}\text{F}$ ] for a minimum of 6 h, not to exceed 7 h.

9.4.2.3 One set of test items shall be cooled in a chamber operating at  $-51.1^{\circ}\text{C} \pm 3^{\circ}\text{C}$  [ $-60^{\circ}\text{F} \pm 5^{\circ}\text{F}$ ] for a minimum of 6 h, not to exceed 7 h.

#### 9.5 Weathering Conditioning:

9.5.1 Weathering of test items shall be performed in accordance with AATCC Test Method 169 with the modifications listed below:

(1) The test apparatus shall be equipped with an automatic light monitor and shall be capable of automatically controlling irradiance, temperature, and humidity.

(2) The test items shall be positioned strike face toward the light source.

(3) The weathering cycle shall be a total of 180 minutes, consisting of the following in order: 40 minutes of light, 20 minutes of light with water spray on the test item, 60 minutes of light, and 60 minutes of darkness. The cycle shall be repeated until the total energy exposure is equal to  $100 \text{ kJ/m}^2$ , and the weathering cycle shall be terminated at that point.

(4) The spectral irradiance level shall be  $0.55 \pm 0.01 \text{ W/m}^2/\text{nm}$  bandpass at 340 nm.

(5) The temperatures and RH shall be as specified in Table 2.

9.5.2 After the required exposure period, the test items shall be removed from the apparatus.

TABLE 2 Temperatures for Weathering Procedure

	Dark Cycle	Light Cycle
Black Panel	$38^{\circ}\text{C} \pm 3^{\circ}\text{C}$ [ $100^{\circ}\text{F} \pm 5^{\circ}\text{F}$ ]	$77^{\circ}\text{C} \pm 3^{\circ}\text{C}$ [ $171^{\circ}\text{F} \pm 5^{\circ}\text{F}$ ]
Relative Humidity	$\geq 95 \%$	$50 \% \pm 5 \%$ (This does not apply to light cycle with water spray.)

### 9.6 Conditioning by Submersion in Salt Water:

NOTE 6—This conditioning is not intended to cause corrosion or simulate artificial aging.

#### 9.6.1 Equipment:

9.6.1.1 A water bath shall be used that is sufficiently sized to allow at least one test item to be submersed at least 50 mm below the surface of the water, and the test item edges and seals shall not contact the surfaces of the tank or be significantly obstructed by any weight used to keep the test item submersed.

9.6.1.2 The salt water solution shall consist of 3 % by weight sodium chloride and 0.5 % by weight magnesium chloride and be adjusted to a pH of 8.2. The water shall be replaced anytime there are visible impurities in the water. The water temperature shall be 21°C + 3°C/–6°C [70°F + 5°F/–10°F].

#### 9.6.2 Procedure:

9.6.2.1 Expose the test item to controlled ambient for a minimum of 3 hours.

9.6.2.2 Weigh the test item.

9.6.2.3 Completely submerge the test item in the salt water solution at controlled ambient temperature for 3 to 4 hours. For test items that are buoyant, attach weights to keep the test item under water.

9.6.2.4 Dry and weigh the test item.

(1) For soft armor, allow each test item to drip dry for 10 to 15 minutes, wipe it dry, and weigh it. Any change in weight shall be documented.

(2) For hard armor, wipe each test item dry and weigh it. Any change in weight shall be documented.

### 9.7 Conditioning by Submersion in Plain Water:

NOTE 7—This conditioning is not intended to cause corrosion or simulate artificial aging.

#### 9.7.1 Equipment:

9.7.1.1 A water bath shall be used that is sufficiently sized to allow at least one test item to be submersed at least 50 mm below the surface of the water, and the test item edges and seals shall not contact the surfaces of the tank or be significantly obstructed by any weight used to keep the test item submersed.

9.7.1.2 The water in the bath shall be clean and shall be either potable tap or demineralized water. The water shall be replaced anytime there are visible impurities in the water. The water temperature shall be 21°C + 3°C/–6°C [70°F + 5°F/–10°F].

#### 9.7.2 Procedure:

9.7.2.1 Weigh the test item.

9.7.2.2 Place the test item in the water bath for 30 min (+5 min/–0 min). For test items that are buoyant, attach weights to keep the test item under water.

9.7.2.3 Remove the test item from the water.

9.7.2.4 Dry and weigh the test item.

(1) For soft armor, allow each test item to drip dry for 10 to 15 minutes, wipe it dry, and weigh it. Any change in weight shall be documented.

(2) For hard armor, wipe each test item dry and weigh it. Any change in weight shall be documented.

## 10. Mounting of Test Items

10.1 The test item shall be mounted securely in a test item mounting system described in 6.3.1 or in other standards and specifications.

10.2 The witness panel shall be positioned behind the test item and perpendicular to the line of flight of the projectile. The witness panel distance to the test item rear surface shall be specified in other standards and specifications.

10.2.1 When not specified elsewhere, the witness panel shall be mounted at a distance of 150 mm ± 25 mm [6.0 in. ± 1.0 in.] behind the test item at the intended point of impact. The witness panel shall be positioned such that there is at least 76 mm [3 in.] from the widest dispersion of debris from the rear of the test item to the edge of the witness panel.

## 11. Test Requirements

11.1 Unless otherwise specified, each ballistic impact shall meet the requirements listed below to be considered a fair hit:

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

11.1.2 The test threat shall have yaw verified to be ≤5° using a yaw card, flash radiograph, high speed video, or photography. Yaw shall be checked for every test threat shot.

NOTE 8—Projectile yaw does not need to be checked for spherical projectiles or near-spherical projectiles, such as lead shotgun slugs.

11.1.2.1 The yaw measurement equipment shall be positioned perpendicular to the projectile line of flight. The yaw measurement equipment shall be securely mounted and anchored to maintain its required position and alignment.

11.1.2.2 When photographic means are used to assess the projectile yaw angle, the measurement shall be made as close as practical to the strike face of the test item but not more than 305 mm [12 in.] from the front of the strike face.



11.1.2.3 When yaw cards are used to assess the projectile yaw angle, the cards shall be positioned between 51 mm and 305 mm [2 in. and 12 in.] from the front of the strike face of the test item.

11.1.3 The test threat shall impact the test item no closer to the edge of the test item than the minimum shot-to-edge distance. The measurement for shot-to-edge distance shall be taken from the center of the projectile impact to the nearest edge of the ballistic material in the test item. When not specified elsewhere, the minimum shot-to-edge distance shall be 51 mm [2 in.].

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

11.1.5 The test threat shall impact the test item no closer to a prior impact than the minimum shot-to-shot distance. The measurement for shot-to-shot distance shall be taken from the center of one projectile impact to the center of another. When not specified elsewhere, the minimum shot-to-shot distance shall be 51 mm [2 in.].

NOTE 9—When assessing whether a particular impact location meets the minimum shot-to-shot distance requirements, the shot-to-shot distances should be measured from that impact location to all prior impact locations. There is no requirement to record acceptable shot-to-shot distances or physically measure distances that are obviously greater than the minimum shot-to-shot distance.

11.1.6 For grouped shots, the test threat impacts shall be within the specified spacing or pattern.

11.1.7 The test threat velocity shall conform to the requirements given in the test threats document or other standards and specifications. If no specification is given, the test threat velocity shall be within  $\pm 9.1$  m/s [ $\pm 30$  ft/s] of the required velocity.

11.2 When warmer rounds are necessary, a test threat shall be fired through the projectile firing system to determine the exact point of impact. Additional test threats shall be fired as required until the proper alignment and a stable striking velocity have been achieved.

11.3 An impact shall be a complete penetration if any part of the test projectile, or any part or fragment of the test item, has damaged the witness panel such that the light from a light source of at least 800 lumens can be seen through the witness panel.

## 12. Verification of Fair Hit

12.1 For every shot, a determination shall be made as to whether the shot is a fair hit or unfair hit according to [Annex A1](#) and [12.1.6](#).

NOTE 10—The procedures in [A1.1](#) and [12.1.6](#) are the same but use different wording.

12.1.1 The obliquity shall be assessed to determine if the angle is within the specified range.

12.1.2 The yaw angle shall be assessed to determine if it is within the specified range.

12.1.3 The difference between the velocity readings from each independent instrument shall be compared as specified in Specification [E3062/E3062M](#).

12.1.4 The velocity shall be checked to determine whether it is within the specified range.

12.1.4.1 When the velocity exceeds the specified velocity, the supplier may request that no additional shots be performed on that test item. In such a case, all required shots shall be repeated on a spare test item.

12.1.5 The shot spacing shall be assessed to determine if shot-to-edge and shot-to-shot distance are within specified requirements.

12.1.6 *Determination Procedure for Fair Hit or Unfair Hit:*

12.1.6.1 If the requirements of [12.1.1](#), [12.1.2](#), and [12.1.3](#) are not met, then the shot is an unfair hit. Document the result and continue as described in [12.2](#).

12.1.6.2 If the velocity is acceptable and the shot spacing requirements are met, the shot is a fair hit. Document the result and continue with the next shot.

12.1.6.3 If the result was a **partial penetration**, then:

(1) If the velocity was less than allowed, then the shot is an unfair hit. Document the results and continue as described in [12.2](#).

(2) If the impact location was too far from an edge (for an edge shot) or outside of a shot group (for cluster shots), then the shot is an unfair hit. Document the result and continue as described in [12.2](#).

(3) Otherwise, the shot is a fair hit. Document the result and continue with the next shot.

12.1.6.4 If the result was a **complete penetration**, then:

(1) If the velocity was greater than allowed, then the shot is an unfair hit. Document the result and continue as described in [12.2](#).

(2) If the impact location was too close to an edge (for an edge shot) or too close to a prior impact, then the shot is an unfair hit. Document the result and continue as described in [12.2](#).

(3) Otherwise, the shot is a fair hit. Document the result and continue with the next shot.

12.2 If the projectile impact location does not meet requirements specified in other standards and specifications, then the impact is an unfair hit.

12.3 When not specified elsewhere, if the shot is determined to be an unfair hit, another shot shall be taken on that test item in a location that meets shot spacing requirements. If there is not sufficient room on the test item for an additional shot, all required shots shall be repeated on a spare test item. The spare test item shall be of the same size, if available.