



Designation: E3078 – 17

## Standard Practice for Conditioning of Hard Armor Test Items<sup>1</sup>

This standard is issued under the fixed designation E3078; 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 practice applies to the conditioning of hard armor test items prior to ballistic resistance testing. Hard armor is an item of personal protective equipment that is constructed of rigid materials and is intended to protect the wearer from threats that may include ballistic threats, stabbing, fragmentation, or blunt impact, or combinations thereof. (Terminology E3005.) Hard armor is also referred to as hard armor plate and plate.

*Note*—Ballistic resistance testing is not covered in this practice.

1.2 This practice describes requirements for subjecting test items to conditions intended to assess the capability of the test item to withstand environmental conditions that induce responses similar to those that might result from conditions encountered during use. This practice includes the conditioning procedures listed below:

- (1) Controlled ambient conditioning procedure,
- (2) Thermal/temperature shock procedure,
- (3) Temperature extremes procedure,
- (4) Weathering procedure,
- (5) Fluid exposure procedure,
- (6) Altitude exposure procedure,
- (7) Vibration conditioning procedure,
- (8) Impact Durability pre-conditioning,
- (9) Impact Durability procedure for torso front and back plates, and
- (10) Impact Durability procedure for other plates (that is, other than torso front and back plates).

1.3 The user of this practice shall determine which conditioning procedures apply.

*Note*—This practice may not be applicable to all types of hard armor.

1.4 In this practice, “other standards and specifications” and “unless specified elsewhere” refer to documents (for example, military standards, purchase specifications) that require the use of this practice. Purchasers and other users are responsible for

the “other standards and specifications” and for specifying any requirements that supersede those of this practice.

1.5 This practice does not address pass/fail requirements for test items subjected to these procedures.

1.6 This practice does not address visual inspections or radiographic inspections of test items that may be required prior to or following conditioning.

*Note*—It is recommended that a thorough visual examination of each test item prior to and after the exposures be performed to document any change in physical appearance resulting from the exposure.

1.7 This practice does not address subsequent conditioning or testing of test items.

1.8 *Units*—The values stated in SI units are to be regarded as standard. The values given in parentheses are mathematical conversions to inch-pound units that are provided for information only and are not considered standard.

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 and health practices and determine the applicability of regulatory limitations prior to use.*

### 2. Referenced Documents

#### 2.1 ASTM Standards:<sup>2</sup>

D1141 Practice for the Preparation of Substitute Ocean Water

D1776 Practice for Conditioning and Testing Textiles

E3005 Terminology for Body Armor

#### 2.2 AATCC Standard:<sup>3</sup>

AATCC TM 169 Weather Resistance of Textiles: Xenon Lamp Exposures

<sup>2</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.

<sup>3</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>1</sup> This practice 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).

Current edition approved Feb. 1, 2017. Published March 2017. DOI: 10.1520/E3078-17.

### 2.3 Military Standard:<sup>4</sup>

**MIL-STD-810G Test Method Standard for Environmental Engineering Considerations and Laboratory Tests**

## 3. Terminology

3.1 The terms and definitions of Terminology **E3005** apply for the following terms: *ballistic resistance, conditioning, hard armor plate, in conjunction with armor, shoot pack, soft armor, strike face, and test item.*

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

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

3.2.2 *controlled ambient, n*—conditions with temperature of  $20 \pm 5.5^\circ\text{C}$  ( $68 \pm 10^\circ\text{F}$ ) and  $50 \pm 20\%$  relative humidity (RH). Within this practice, this definition applies to any direct or indirect reference to controlled ambient.

## 4. Significance and Use

4.1 It is anticipated that this practice will be referenced by certifiers, purchasers, and other users in order to meet their specific needs. Those users will specify which conditioning procedures are applicable.

## 5. Test Items

5.1 The test items are individual hard armor plates.

5.2 The quantity and size of test items to be conditioned and other relevant test item details are specified in other standards or specifications.

5.3 Unless otherwise specified, test items shall be stored in controlled ambient conditions following conditioning procedures.

## 6. Controlled Ambient Conditioning Procedure

6.1 Test items shall be subjected to controlled ambient conditions for at least 24 hours.

## 7. Temperature Shock Procedure

7.1 Tests shall be performed in accordance with MIL-STD-810G, Method 503.5, Procedure I-A, with the following modifications:

7.1.1 The extreme temperatures shall be T1:  $-31.7 \pm 3^\circ\text{C}$  ( $-25 \pm 5^\circ\text{F}$ ) and T2:  $48.9 \pm 3^\circ\text{C}$  ( $120 \pm 5^\circ\text{F}$ ).

7.1.2 Test items shall be subjected to temperature conditioning steps as follows: (1) controlled ambient, (2) T1, (3) T2, and (4) controlled ambient. Transfer of test items from one condition to another shall be accomplished in less than one minute. Ramping of temperature is prohibited.

7.1.3 The test items shall be subjected to each specified temperature for a minimum of 2 h, not to exceed 2 h and 15 min.

<sup>4</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>.

## 8. Temperature Extremes Procedure

8.1 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).

8.2 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.

8.2.1 The starting temperature shall be controlled ambient.

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

## 9. Weathering Procedure

9.1 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 with the strike face toward the light source.

(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 the test item, 60 min of light, and 60 min 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 1**.

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

## 10. Fluid Exposure Procedure

10.1 MIL-STD-810G, Procedure II, Method 504.1 and Procedure I, Method 512.5 shall be used with modifications as described below:

(1) Test items shall be subjected to conditioning in fluids, with each fluid at a temperature between  $16$  and  $26^\circ\text{C}$  ( $60$  and  $80^\circ\text{F}$ ).

(2) Each test item shall be subjected to only one fluid. The type of fluid used shall be documented.

(3) Fluid conditioning equipment shall consist of a fluid container of sufficient size to allow at least one test item of the largest size to rest horizontally. Test items shall not be stacked atop each other during conditioning but may be placed side-by-side.

**TABLE 1 Temperatures for Weathering Procedure**

	Dark Cycle	Light Cycle
Black Panel	$38 \pm 3^\circ\text{C}$ ( $100 \pm 5^\circ\text{F}$ )	$77 \pm 3^\circ\text{C}$ ( $171 \pm 5^\circ\text{F}$ )
Relative Humidity	$\geq 95\%$	$50 \pm 5\%$

(This does not apply to light cycle with water spray.)

(4) A “20-lb weight” shall be placed on each test item to prevent floating while in fluid.

(5) Test items shall be conditioned in containers of fluid using one of the methods described below:

(a) 30w lubricating oil of commercial grade SE or better. The test item shall be placed strike face down in a container that is then filled with enough fluid to cover the strike face. The test item shall remain in the fluid for 2 h, not to exceed 2 h and 15 min.

*Note*—The test item is not required to be completely submerged.

(b) 10w-40 lubricating oil of commercial grade SE or better. The test item shall be weighed to the nearest 5 g (0.01 lb) prior to fluid conditioning. The test item shall be placed in a container that is filled with enough fluid for the test item to be completely immersed. The test item shall be immersed for 10 min, not to exceed 11 min. Following conditioning, the test item shall be wiped clean and weighed to the nearest 5 g (0.01 lb).

*Note*—The test item is required to be completely submerged.

(c) Vehicle fuel. The test item shall be placed strike face down in a container that is then filled with enough fluid to cover the strike face. The test item shall remain in the fluid for 2 h, not to exceed 2 h and 15 min.

*Note*—Examples of vehicle fuels that may be used include gasoline, diesel, F-24, and JP-8.

*Note*—The test item is not required to be completely submerged.

(d) Vehicle fuel. The test item shall be weighed to the nearest 5 g (0.01 lb) prior to fluid conditioning. The test item shall be placed in a container that is filled with enough fluid for the test item to be completely immersed. The test item shall be immersed for 10 min, not to exceed 11 min. Following conditioning, the test item shall be wiped clean and weighed to the nearest 5 g (0.01 lb).

*Note*—The test item is required to be completely submerged.

(e) Salt water. The test item shall be placed in a container that is filled with enough fluid for the test item to be completely immersed. The salt water shall have a concentration of 4.6 % sodium chloride (NaCl), and the test item shall be immersed for 2 h, not to exceed 2 h and 15 min. An alternative to salt water is Substitute Ocean Water, prepared in accordance with Practice **D1141**.

*Note*—The test item is required to be completely submerged.

(f) Cleaner, Lubricant, and Preservative. The test item shall be weighed to the nearest 5 g (0.01 lb) prior to fluid conditioning. The test item shall be placed in a container that is filled with enough fluid for the test item to be completely immersed. The test item shall be immersed for 10 min, not to exceed 11 min. Following conditioning, the test item shall be wiped clean and weighed to the nearest 5 g (0.01 lb).

*Note*—The test item is required to be completely submerged.

10.2 Following each exposure in which the test item is not required to be wiped clean, the test items shall be positioned vertically to drip dry for at least 5 min.

*Note*—Other standards or specifications will give the time interval between removal from the fluid and any subsequent procedure.

## 11. Altitude Exposure Procedure

11.1 The test items shall be placed in an air pressure chamber to simulate changes in altitude.

11.2 The change rate of the air pressure shall simulate a change in altitude of 460 to 610 m/min (1500 to 2000 ft/min).

11.3 The temperature(s) in the chamber shall be specified by the user of this practice.

11.4 The initial air pressure shall be zero gauge pressure.

11.5 The air pressure shall be decreased to 18.8 kPa or 2.73 PSIA (5.5 in. Hg) to simulate an ascent to 12 200 m (40 000 ft) altitude and shall be maintained for 1 h  $\pm$  5 min.

11.6 The air pressure shall be increased to 57.2 kPa or 8.3 PSIA (16.9 in. Hg) to simulate a descent to 4600 m (15 000 m) altitude and shall be maintained for 1 h  $\pm$  5 min.

11.7 The air pressure shall be changed to initial air pressure and maintained for 30  $\pm$  5 min, and the test items shall be removed from the chamber.

## 12. Vibration Conditioning Procedure

12.1 Tests shall be performed in accordance with MIL-STD-810G, Method 514.6, Procedure II for Loose Cargo with the following modifications:

(1) The test item shall be placed strike face down in a wooden box. The box shall be rectangular having width and length 25.4 to 38.1 mm (1.0 to 1.5 in.) larger than the maximum width and maximum length of the test item. The box shall have a lid attached to prevent the test item from flipping over. The internal height of the box shall be approximately 89 mm (3.5 in.).

*Note*—The box has a bottom, sides, and a lid.

(2) The test item shall be positioned with the top and bottom edges parallel to the x-axis.

(3) Vibration shall be caused by motion in the x and y plane (that is, circular motion around the z-axis. Refer to **Fig. 1** to show positioning of test item in box (drawing not to scale; top and front of box not shown).

(4) The wooden box shall be mounted to the vibration table.

(5) The simulation of the loose cargo environment requires the use of a vibration table that imparts a 25.4  $\pm$  2.5 mm (1.0  $\pm$  0.1 in.) peak-to-peak, circular synchronous motion to the table at a frequency of 5 Hz  $\pm$  1.25 % for at least 1 h, not to exceed 1 h and 15 min.

## 13. Impact Durability Pre-Conditioning

13.1 *Laboratory Configuration and Test Equipment:*

13.1.1 *Environmental Chamber:*

13.1.1.1 The environmental chamber shall have a controller that maintains a set temperature to within  $\pm 3^{\circ}\text{C}$  ( $5^{\circ}\text{F}$ ) and that maintains a set relative humidity to within  $\pm 5\%$ .

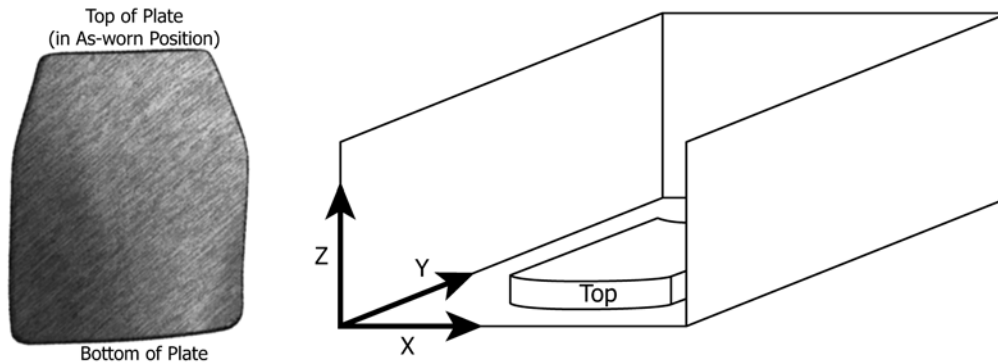


FIG. 1 Positioning of Test Item in Box

13.1.1.2 The environmental chamber shall allow for the test items to be positioned in the vertical orientation in which they are intended to be used.

13.1.2 *Environmental Chamber Monitoring Equipment:*

13.1.2.1 The monitoring equipment shall include measurement and recording device(s), independent from the chamber controllers.

13.1.2.2 The monitoring equipment shall provide and allow documentation of temperature and relative humidity inside the environmental chamber.

13.2 The pre-conditioning procedure is detailed below:

13.2.1 Place the test items into the environmental chamber under controlled ambient conditions.

13.2.2 Set the environmental chamber for uniform thermal exposure at a temperature of  $65 \pm 2^\circ\text{C}$  ( $149 \pm 3.6^\circ\text{F}$ ) and  $80 \pm 5\%$  RH and ensure the change in conditions does not exceed  $3^\circ\text{C}/\text{min}$  ( $5^\circ\text{F}/\text{min}$ ) and  $5\%$  RH per minute to avoid shocking the test items.

13.2.3 Subject the test items to the specified conditions for  $240 \pm 1$  h.

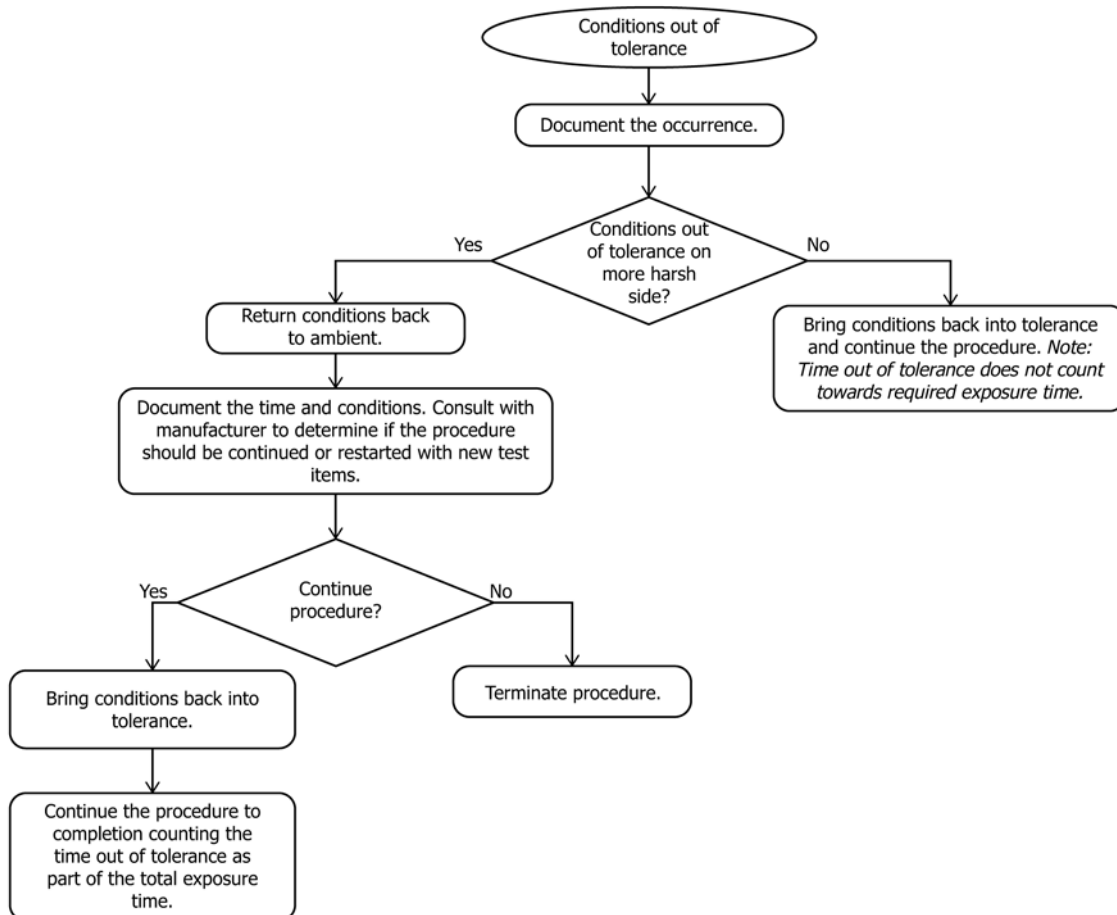


FIG. 2 Decision Tree for Chamber Out-of-Tolerance Conditions



13.2.4 If an event occurs causing the chamber conditions to go out of tolerance within the 240 h period, consult the decision tree provided in Fig. 2.

13.2.5 Upon completion of the 240 h exposure, bring the test items back to controlled ambient and ensure the change in condition does not exceed 3°C (5°F) per minute and 5 % per minute.

*Note*—When changing conditions, the humidity should be reduced before the temperature to avoid creating a condensing atmosphere inside the environmental chamber.

13.2.6 Remove the test items from the environmental chamber.

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

13.2.8 Place the test items into an environmental chamber preset to the initial conditions of Step 1 in Table 2.

13.2.9 Subject the test items to the conditions in Table 2. Each step transition shall take place and stabilize in less than 30 min.

*Note*—Exposure time includes the stabilization time.

13.2.10 If an event occurs causing the chamber conditions to go out of tolerance within the time period, consult the decision tree provided in Fig. 2.

13.2.11 Upon completion of the 12-step exposure protocol in Table 2, return the test items in the chamber to the initial conditions of Step 1 in Table 2 at ramp rates listed in 13.2.2.

13.2.12 Remove the test items from the environmental chamber.

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

**14. Impact Durability Conditioning Procedure for Torso Front and Back Plates**

14.1 The purpose of this procedure is to subject hard armor test items to durability conditioning including temperature, humidity, and impact.

**14.2 Impact Apparatus:**

14.2.1 Detailed drawings of the impact apparatus are provided on www.astm.org, and the impact apparatus shall be constructed according to those detailed drawings. Fig. 3 provides an illustration of how the impact apparatus may look.

14.2.2 The following items shall be used with the impact apparatus during testing:

14.2.2.1 Each test item is required to have an applique between the wear face and the mounting plate. The applique shall be Roma Plastilina No. 1<sup>®5</sup> weighing 4.54 ± 0.05 kg (10 ± 0.1 lb). For in conjunction with armor<sup>6</sup>, the hard armor shall be inserted into the appropriate soft armor or a shoot pack, and the applique shall be positioned between the outside wear face of the soft armor or shoot pack and the mounting plate.

*Note*—Additional details about the applique are provided in other standards, specifications, and test methods.

14.2.2.2 A retention mechanism is required to hold the test item with is applique securely in position in approximately the center of the mounting plate. The retention mechanism may be a strap, belt, band, or tape and shall be positioned to avoid interference with the test item’s impact when dropped.

*Note*—The retention mechanism is not shown in Fig. 3.

14.2.2.3 The mounting plate and pivot arm (both shown in the detailed drawings) and the retention mechanism shall have a combined weight of 3.86 ± 0.23 kg (8.5 ± 0.5 lb).

14.2.2.4 The impact block shall be concrete, at least 46 by 46 cm (18 by 18 in.), with a thickness of at least 76 mm (3 in.) and a flat, level surface. The impact block shall not move or flex during impact.

*Note*—A concrete floor is an acceptable impact block.

14.2.2.5 A pivot point height adjustment shall be set so that the pivot arm is horizontal in its stopping position and the test item strikes the impact surface squarely as shown in Fig. 4.

14.2.2.6 The solid base provides a rigid support for the attached components and shall either be weighted or solidly affixed to the facility structure to prevent movement during the procedure.

**14.3 Impact Procedure:**

14.3.1 Perform durability pre-conditioning per Section 13.

14.3.2 Apply the backing material applique to the wear face of the test item:

14.3.2.1 If the test item is intended to be stand-alone, the applique shall allow the test item to be positioned against the mounting plate surface with no obvious air gaps.

14.3.2.2 If the test item is part of an in conjunction with armor<sup>6</sup>, the test item shall be backed by the applicable soft armor panel in addition to the applique.

14.3.3 Align the centers of the applique and the test item with the center of the mounting plate, and affix the applique and test item to the mounting plate using the retention mechanism.

14.3.4 To ensure correct positioning at impact, gently lower the test item until it rests on the impact block and adjust the pivot point height so that the pivot arm is horizontal.

14.3.5 Return the pivot arm to the vertical position. Release the pivot arm allowing the test item to drop and hit the impact surface. Perform this step a second time.

14.3.6 Remove the test item from the impact apparatus.

**TABLE 2 Exposure Conditions**

Steps	Time (hours) (±5 minutes)	Temperature (°C) (±2°C (±3.6°F))	Relative Humidity (%)
1	2	25°C (77°F)	50 ± 5 %
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 ± 5 %
9	2	45°C (113°F)	50 ± 5 %
10	2	60°C (140°F)	50 ± 5 %
11	2	75°C (167°F)	50 ± 5 %
12	2	90°C (194°F)	50 ± 5 %

<sup>5</sup> U.S. Government standards require ROMA Plastilina No. 1<sup>®</sup>, from Sculpture House, Inc., as the backing material for ballistic-resistance testing.

<sup>6</sup> In conjunction with armor is defined in Terminology E3005.

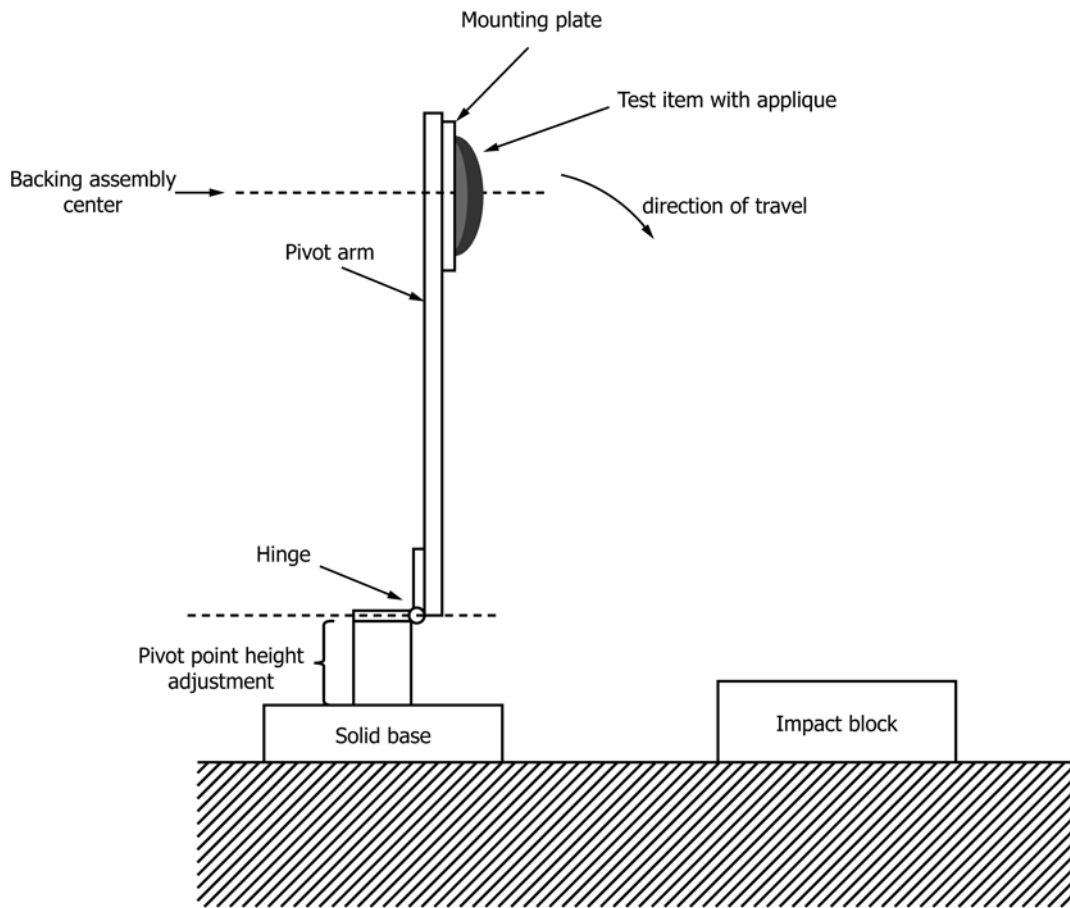


FIG. 3 Impact Apparatus – Starting Position

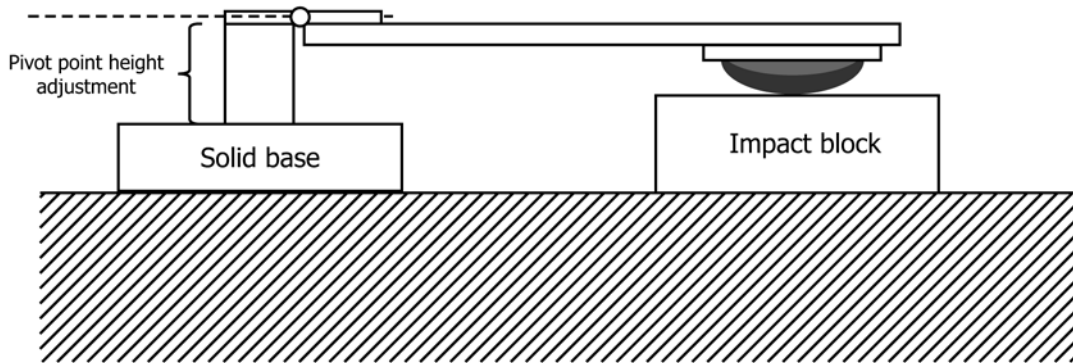


FIG. 4 Impact Apparatus – Final Position

**15. Impact Durability Procedure for Other Plates (that is, Other than Torso Front and Back Plates)**

15.1 Perform durability pre-conditioning per Section 13.

15.2 The test item shall be dropped unhindered from the specified height below onto an impact block.

15.2.1 The impact block shall be concrete, at least 45.8 cm<sup>2</sup> (18 by 18 in.), with a thickness of at least 76.2 mm (3.0 in.) and a flat, level surface. The impact block shall not move or flex during impact.

*Note*—A concrete floor is an acceptable impact block.

15.2.2 The drop height shall be 122 ± 1.3 cm (48.0 ± 0.5 in.), measured from the test item strike face to the impact block surface.

15.2.3 The test item shall be positioned such that the strike face is parallel to the impact surface and the impact occurs as near as possible to the center of the test item strike face (that is, not near an edge).

15.3 Drop the test item two times.

**16. Reporting of Results**

16.1 Steps, observations, interruptions, and other details of conditioning shall be documented.

**17. Keywords**

17.1 ballistic resistance; conditioning; hard armor; hard armor plate

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