



Designation: F2412 – 18

## Standard Test Methods for Foot Protection<sup>1</sup>

This standard is issued under the fixed designation F2412; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### INTRODUCTION

For more than sixty years, the predecessor to these test methods, ANSI Z41, established the performance criteria for a wide range of footwear to protect from the hazards that affect the personal safety of workers. The value of these standards was recognized early in the history of the Occupational Safety and Health Administration (OSHA) and incorporated as a reference standard in the Code of Federal Regulation (CFR) Section 1910.

These test methods contains test protocols developed in conjunction with ANSI Z41 as well as other ASTM standards that are used to evaluate the performance of footwear when exposed to a variety of hazards: (1) impact resistance (I) for the toe area of footwear; (2) compression resistance (C) for the toe area of footwear; (3) metatarsal impact protection (Mt) that reduces the chance of injury to the metatarsal bones at the top of the foot; (4) conductive properties (Cd) that reduce hazards that may result from static electricity buildup and reduce the possibility of ignition of explosives and volatile chemicals; (5) electric hazard resistant (EH) non-conductive; (6) static dissipative (SD) properties to reduce hazards due to excessively low footwear electrical resistance that may exist where SD footwear is required; and (7) puncture resistance (PR) of foot devices.

### 1. Scope

1.1 These test methods measure the resistance of footwear to a variety of hazards that can potentially result in injury.

1.2 These test methods may be used to test for compliance to minimum performance requirements in established safety standards.

1.2.1 By agreement between the purchaser and the supplier, or as required by established safety standards, these test methods can be used to determine any one, or all of the following: (1) impact resistance (I), (2) compression resistance (C), (3) metatarsal impact resistance (Mt), (4) resistance to electrical conductivity (Cd), (5) resistance to electric hazard (EH), (6) static dissipative performance (SD), and (7) puncture resistance (PR).

1.3 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.4 *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.*

1.5 *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>2</sup>

**B117 Practice for Operating Salt Spray (Fog) Apparatus**

2.2 *CSA Standard:*<sup>3</sup>

**CAN/CSA Z195 Protective Footwear**

### 3. Terminology

3.1 *Definitions:*

3.1.1 *footbed (removable), n—also known as ‘insock,’ a component typically made of a foam material with a leather or*

<sup>1</sup> These test methods are under the jurisdiction of ASTM Committee F13 on Pedestrian/Walkway Safety and Footwear and are the direct responsibility of Subcommittee F13.30 on Footwear.

Current edition approved Feb. 1, 2018. Published March 2018. Originally approved in 2005. Last previous edition approved in 2011 as F2412 – 11. DOI: 10.1520/F2412-18.

<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 Canadian Standards Association (CSA), 178 Rexdale Blvd., Toronto, ON Canada M9W1R3.

fabric cover/sockliner and often shaped or contoured covering the entire insole board which can be inserted between the foot and insole board.

3.1.2 *insole, n*—foundation of the shoe; the inner sole of the shoe which is next to the foot, under the sock liner or insert, onto which the upper is lasted.

3.1.3 *last, n*—solid hinged form, in the general shape of a foot, around which footwear is constructed.

3.1.4 *lasting, v*—building of footwear around a specific foot form.

3.1.5 *lining, n*—term used to describe all components that can be used to construct the interior of the upper portion of the footwear.

3.1.6 *outsole and heel, n*—exterior bottom platform of the footwear; the bottom surface.

3.1.7 *product category, n*—group of similar footwear items manufactured for a specific hazard or hazards and that:

- Have same protective toe cap, protective insole or met-guard materials
- Have the same supplier for each of those components
- Have the same outsole design, compound and hardness (including midsole)
- Have the same thickness (within a  $\pm 12.5\%$  range) of upper, lining, sole and insole
- Are manufactured using the same method of construction; cemented, welted, etc.
- Are manufactured in the same factory
- Are manufactured using the same last

3.1.8 *product classification, n*—footwear manufactured to meet a minimum performance requirement for a specific hazard or hazards.

3.1.9 *protective footwear, n*—footwear that is designed, constructed, and classified to protect the wearer from a potential hazard or hazards.

3.1.10 *protective toe cap, n*—component designed to provide toe protection that is an integral and permanent part of the footwear.

3.1.11 *quarter, n*—entire back portion of the footwear upper.

3.1.12 *size, n*—length and breadth measurements of footwear determined by using a specific grading; the American system of footwear grading.

3.1.13 *socklining (non-removable), n*—fabric material placed over the insole, footbed, or insert that may be imprinted with a brand name or other designation.

3.1.14 *specimen, for protective footwear, n*—footwear units evaluated for various hazards.

3.1.14.1 *Discussion*—Footwear units may be a left foot, a right foot, or a matched pair. The exact number and type of footwear units is indicated by test method.

3.1.15 *upper, n*—parts of a shoe or boot that are above the sole.

#### 4. Significance and Use

4.1 These test methods contain requirements to evaluate the performance of footwear for the following:

4.1.1 Impact resistance for the toe area of footwear (I/75),

4.1.2 Compression resistance for the toe area of footwear (C/75),

4.1.3 Metatarsal protection that reduces the chance of injury to the metatarsal bones at the top of the foot (Mt/75),

4.1.4 Conductive properties which reduce hazards that may result from static electricity buildup, and reduce the possibility of ignition of explosives and volatile chemicals (Cd),

4.1.5 Electric Hazard by stepping on live wire (EH),

4.1.6 Static dissipative (SD) properties to reduce hazards due to excessively low footwear electrical resistance that may exist where SD footwear is required, and

4.1.7 Puncture resistance footwear devices (PR).

4.2 Any changes to the original components of safety toe footwear such as replacing or adding after-market footbeds/inserts could cause non-compliance to any or all parts of this standard rendering the ASTM label invalid. Protective toe footwear specimens or samples shall be retested for any of the following changes.

4.2.1 Change in material used to make protective toe cap, change in protective cap manufacturer, change in the design of the toe cap.

4.2.2 Change in construction method used to make footwear or change in factory in which footwear is produced.

4.2.3 Change in the upper or insole material thickness greater than 25 %, change to the soling system or a change in the hardness of the outsole.

4.2.4 Change in shape of last used in the manufacturing of footwear.

4.2.5 Change in material or supplier of protective insole.

4.2.6 Change in material or supplier of met guard.

#### 5. Protective Toe Impact Resistance (I)

##### 5.1 Summary of Method:

5.1.1 Footwear shall be constructed and manufactured so that a protective toe cap is an integral and permanent part of the footwear.

5.1.2 Footwear with a protective toe cap is impacted with a specified force.

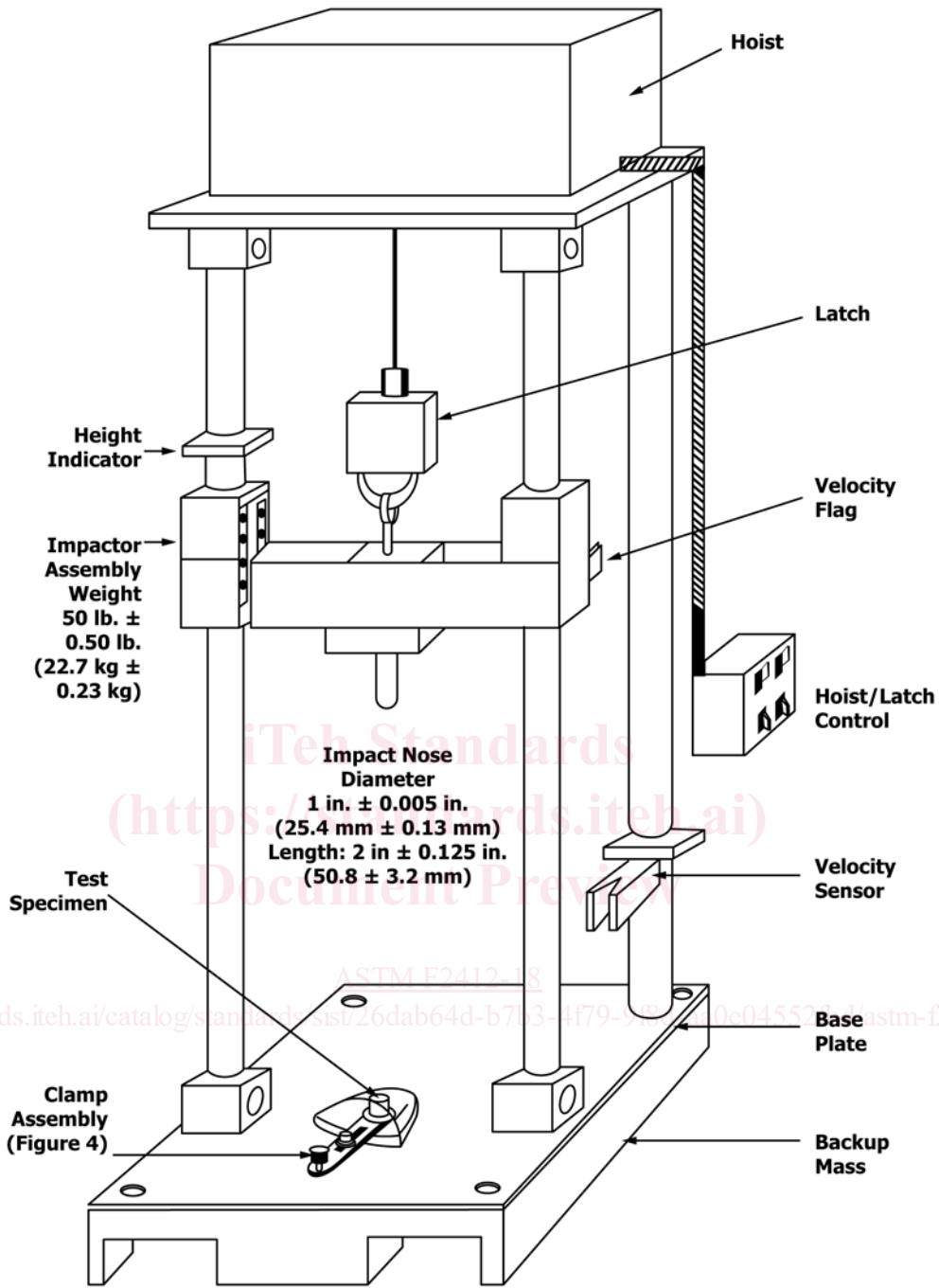
5.1.3 After impact, the height of the modeling clay cylinder is measured.

##### 5.2 Apparatus:

5.2.1 The apparatus as shown in Fig. 1 and Fig. 1(a)<sup>4</sup> consists of a frame structure that permits the impactor to be constrained to fall along a known and repeatable path. Provision shall be made for a mechanism to catch the striker after the initial impact so that the test specimen is struck only once.

5.2.1.1 The impactor consists of a steel weight having a mass of  $22.7 \pm 0.23$  kg ( $50 \pm 0.5$  lb). The nose of the impactor is a solid steel cylinder having a diameter of  $25.4 \pm 0.8$  mm ( $1 \pm 0.03$  in.) and protruding a length of  $50.8 \pm 3.2$  mm ( $2.0 \pm 0.13$  in.) from the impact assembly. The impact side of the cylinder has a smooth spherical surface with a radius of  $25.4 \pm 0.127$  mm ( $1.00 \pm 0.005$  in.). The longitudinal centerline of the

<sup>4</sup> Imagery as shown within Ells, W., Ed., *Safety and Occupational Footwear, MNL71-EB*, ASTM International, 2014.



NOTE 1—Dimensions are in inches (millimeters).

FIG. 1 Footwear Impact Test Apparatus

cylinder is parallel and coincident within 3.175 mm (0.125 in.) to the vertical axis of the impactor.

5.2.1.2 Apparatus incorporates a means of measuring the velocity at impact with a tolerance of  $\pm 2\%$ . The use of a velocity metering system allows for determining the time required for a 25.4-mm (1-in.) wide blade to pass completely through a beam of light immediately prior to the impactor striking the specimen. The result, referred to as gate time, is measured in milliseconds (ms). The speed in in./s can be calculated using the following formula:

$$V = \frac{1000}{t_g} \quad (1)$$

where:

$V$  = velocity in in./s, and

$t_g$  = gate time in ms.

5.2.2 The base of the apparatus consists of a steel plate with a minimum area 0.3 m<sup>2</sup> (1 ft<sup>2</sup>) and minimum thickness of 25.4 mm (1 in.). The base is anchored to a structure having a

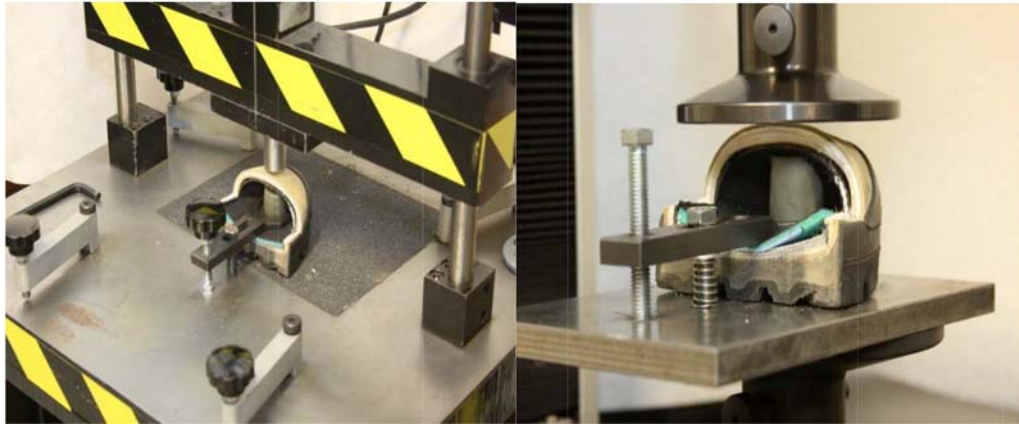


FIG. 1 (a) Impact Testing (Left) and Compression Testing (Right)<sup>4</sup> (continued)

minimum mass of 909.1 kg (2000 lb) to provide sufficient stability to the apparatus before, during, and after testing.

5.3 Sampling:

5.3.1 Randomly select three half-pair test specimens, including both left and right footwear, of each product category from unworn manufactured footwear. If footwear is manufactured with a removable sockliner (footbed) the test is to be performed with the sockliner in place. All testing must be performed at standard conditions of 22°C (± 2°C) and 50 % RH (± 5 %).

- 5.3.1.1 Men’s footwear specimens shall be size 9.
- 5.3.1.2 Women’s footwear specimens shall be size 8.

5.3.2 The specimens shall be obtained by completely removing the toe portion of the footwear. This is done by cutting across the width of the footwear 25.4 ± 3.2 mm (1 ± 0.125 in.) behind the back edge of the protective toe cap and cutting the upper material back to the edge of the protective toe cap as shown in Fig. 2.

5.4 Prior to impact testing, modeling clay shall be kept at standard conditions and formed approximately as a 1 in. diameter vertical cylinder, shall be placed under the protective toe cap positioned inside the specimens directly under the point of impact (see Fig. 3) with the edge of the clay cylinder aligned with the back edge of the toe cap.

5.4.1 Modeling clay for the test forms shall be stored in a sealed container at room temperature and tested in accordance with 5.4.2 – 5.4.9. Test frequency shall be no less than once every month or sooner, if the color or consistency changes. It is recommended that this quality test be conducted on the clay just prior to its use during an impact test (see Fig. 4).

5.4.2 Weigh out a 50 ± 2 g sample of modeling clay.

5.4.3 Form material into a 35 ± 2 mm (1.375 ± 0.075 in.) cylinder and allow material to sit at room temperature for 24 h.

5.4.4 The modeling clay cylinder shall be placed vertically on the base plate at the center point of the impact tester.

5.4.5 A block having nominal dimensions of 75 by 75 by 44 mm (3 by 3 by 1.75 in.), with a hole drilled in the center of the block that is 25 mm (1 in.) in diameter and 25 mm (1 in.) deep, is slipped onto the impact nose.

5.4.6 The block/impactor assembly is carefully lowered until the wooden block makes contact with the modeling clay cylinder.

5.4.7 The impactor assembly is released allowing full weight to compress the cylinder for ±1 s.

5.4.8 Immediately afterwards, the impactor assembly is raised and the modeling clay cylinder if necessary cut in half to measure.

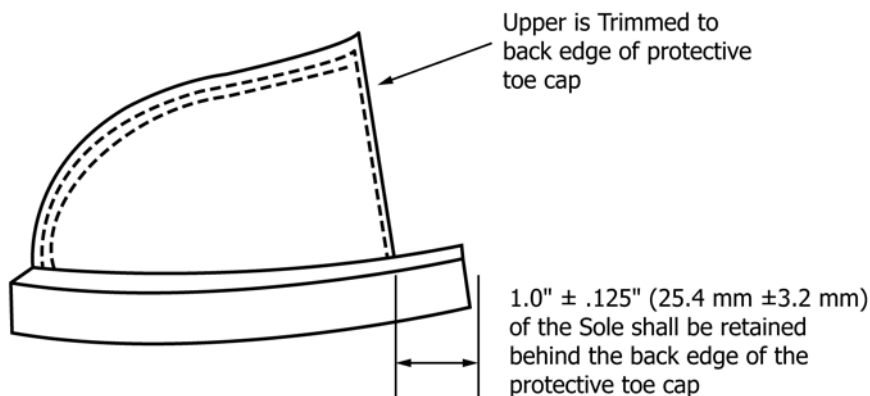


FIG. 2 Specimen Prepared for Impact and Compression Testing

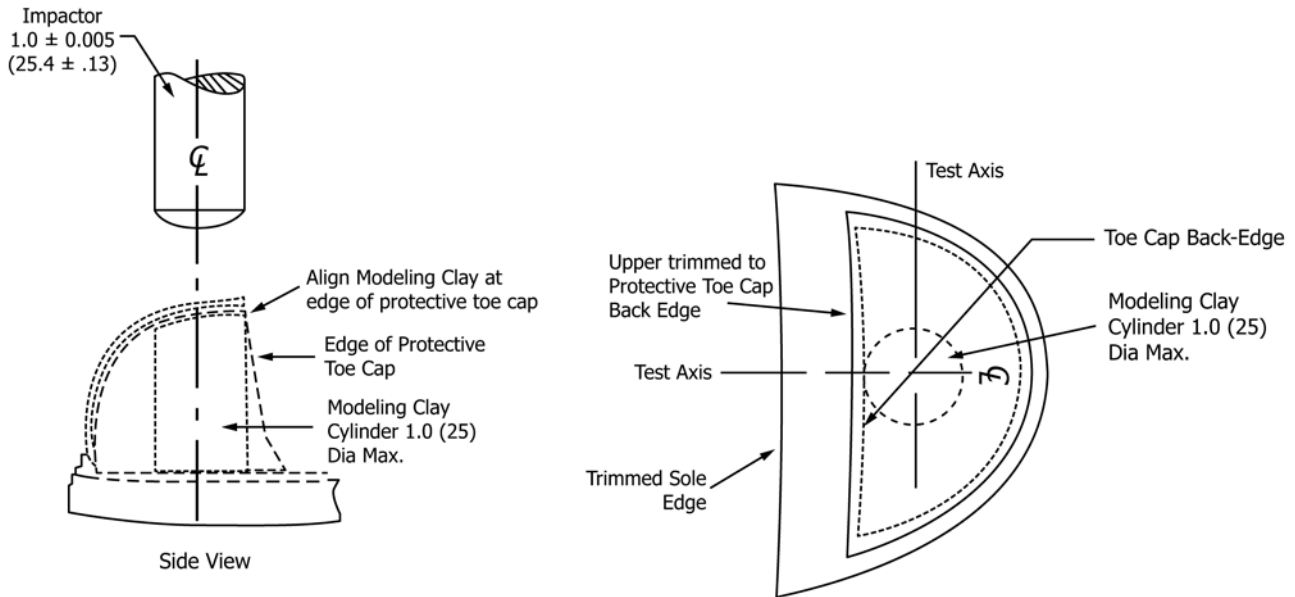


FIG. 3 Specimen Prepared for Impact and Compression Testing

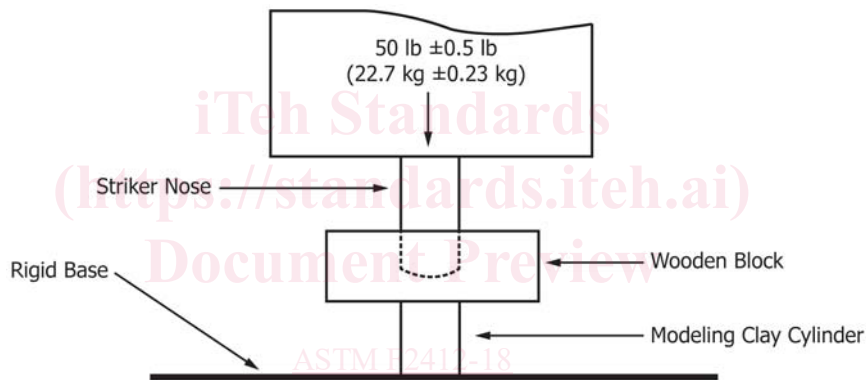


FIG. 4 Apparatus for Modeling Clay Quality Test

5.4.9 A modeling clay cylinder having a compressed thickness of  $15 \pm 2$  mm is acceptable to use in impact resistance.

5.5 Specimen Mounting:

5.5.1 Specimens are to be placed on the test apparatus base plate so that the sole is parallel with the base.

5.5.1.1 The specimen is positioned so that the longitudinal center of the nose of the impactor strikes the approximate center of the protective toe cap at a point that is  $12.7 \pm 1.6$  mm ( $0.50 \pm 0.0625$  in.) toward the front as measured from the back edge of the protective toe cap (see Fig. 3).

5.5.2 The specimen is held in position during test by use of a clamping device as shown in Fig. 5.

5.5.2.1 The stabilizing fork clamp device rests on the insert and can be adjusted by means of a screw.

5.5.2.2 The adjustment secures the specimen parallel to the base plate and prevents movement when the impactor strikes the specimen.

5.5.2.3 Clamping screw shall be tightened using a force of 2.8 Nm (25 in. lbs).

5.6 Procedure:

5.6.1 When in place, the modeling clay cylinder shall be shaped having a diameter of approximately 25 mm (1 in.) nominal and positioned so that the cylinder makes contact with the insert/sock liner/footbed of the footwear and the dome of the protective toe cap.

NOTE 1—A small piece of release paper such as wax paper or cellophane can be placed on either the bottom side or top side of the clay cylinder to prevent the modeling clay from adhering to either the insert/sock liner or dome.

5.6.2 To measure Impact 75 product footwear, the impactor is dropped from a height that results in an impact velocity of  $2995 \pm 61$  mm/s ( $117.9 \pm 2.4$  in./s), creating an energy of 101.75 J (75 lbf).

NOTE 2—In a vacuum, the distance would be 457 mm (18 in.). Due to friction and air resistance, the height used for the test is somewhat greater.

5.6.3 Release the impactor.

5.6.4 After impact raise and secure the impactor on test apparatus, carefully remove the clay cylinder from inside the specimen and measure the height of the modeling clay cylinder

