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Standard Test Methods for Foot Protection[1]

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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 for the toe area of footwear; *(2)* compression resistance for the toe area of footwear; *(3)* metatarsal impact protection that reduces the chance of injury to the metatarsal bones at the top of the foot; *(4)* conductive properties that reduces hazards that may result from static electricity buildup and reduce the possibility of ignition of explosives and volatile chemicals; *(5)* electric shock resistant non-conductive; *(6)* static dissipative (SD) properties to reduce hazards due to excessively low footwear resistance that may exist where SD footwear is required; *(7)* puncture resistance of foot bottoms; *(8)* chain saw cut resistance hazards; and *(9)* dielectric hazard.

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, *(2)* compression resistance, *(3)* metatarsal impact resistance, *(4)* resistance to electrical conductivity, *(5)* resistance to electric shock, *(6)* static dissipative performance, *(7)* puncture resistance of outsoles, *(8)* chain saw cut resistance, and *(9)* dielectric insulation.

1.3 The values stated in SI units are to be regarded as 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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

B117 Practice for Operating Salt Spray (Fog) Apparatus

F1116 Test Method for Determining Dielectric Strength of Dielectric Footwear

F1458 Test Method for Measurement of Cut Resistance to Chain Saw of Foot Protective Devices

2.2 *CSA Standard:*[3]

CAN/CSA Z195 Protective Footwear

3. Terminology

3.1 *Definitions:*

3.1.1 *footwear*, *n*—wearing apparel for the feet (such as shoes, boots, slippers, or overshoes), excluding hosiery.

3.1.1.1 *Discussion*—This term can refer to either left foot or right foot units or pairs.

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

3.1.2 *insert*, *n*—footbed normally made of a foam product with leather or fabric cover shaped to cover the entire insole which can be inserted between the foot and insole board.

3.1.3 *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.

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

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

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

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

3.1.8 *product category*, *n*—description for a type of footwear designed and manufactured for a specific hazard or hazards.

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

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

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

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

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

3.1.14 *socklining*, *n*—material placed over the insole which is imprinted with a brand name or other designation.

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

3.1.15.1 *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.

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

4. Significance and Use

4.1 The purpose of these test methods is to provide measurable criteria for various hazards.

4.2 The protection that can be demonstrated by evaluation of footwear includes the following:

4.2.1 The effectiveness of impact resistant footwear to eliminate or diminish the severity of injury to the toe area of the foot when subjected to a falling object.

4.2.2 The effectiveness of compression resistant footwear to eliminate or diminish the severity of injury to the toe area of the foot when subjected to a compressive force.

4.2.3 The effectiveness of metatarsal protective footwear to eliminate or diminish the severity of injury to the metatarsal area adjacent to where the toes and the bones of the upper foot intersect.

4.2.4 The effectiveness of conductive footwear to safely reduce the buildup of static electricity from wearer to ground so as to reduce the possibility of ignition of explosives and volatile chemicals.

4.2.5 The effectiveness of electric shock resistant footwear to provide resistance to electric shock when accidental contact is made with live wires.

4.2.6 The effectiveness of static dissipative footwear to reduce the hazards due to excessively low footwear electrical resistance that may exist where SD footwear is required.

4.2.7 The effectiveness of puncture resistant footwear to reduce the possibility of puncture injury to the bottom of the human foot.

4.2.8 The effectiveness of chain saw cut resistant footwear to reduce the chance of injury when exposed to a running power chain saw.

4.2.9 The effectiveness of dielectric insulative footwear to reduce the possibility of injury when exposed to a high voltage charge.

5. Impact Resistance

5.1 *Summary of Method*:

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

5.1.2 After impact, the height of the clay cylinder is measured.

5.2 *Apparatus*:

5.2.1 The apparatus as shown in Fig. 1 consists of a frame structure that permits the impactor to be constrained to fall along a known and repeatable path.

5.2.1.1 The impactor consists of a steel weight having a mass of 22.7 ± 0.23 kg (50 ± 0.5 lb). The nose of the impactor is a steel cylinder having a diameter of 25.4 ± 0.8 mm (1 ± 0.03 in.) and length of 50.8 mm (2.0 in.). The impact side of the cylinder has a smooth spherical surface with a radius of 25.4 ± 0.127 mm (1.00 ± 0.005 in.). The longitudinal centerline of the cylinder is parallel and coincident with 3.175 mm (0.125 in.) to the symmetry of its vertical axis.

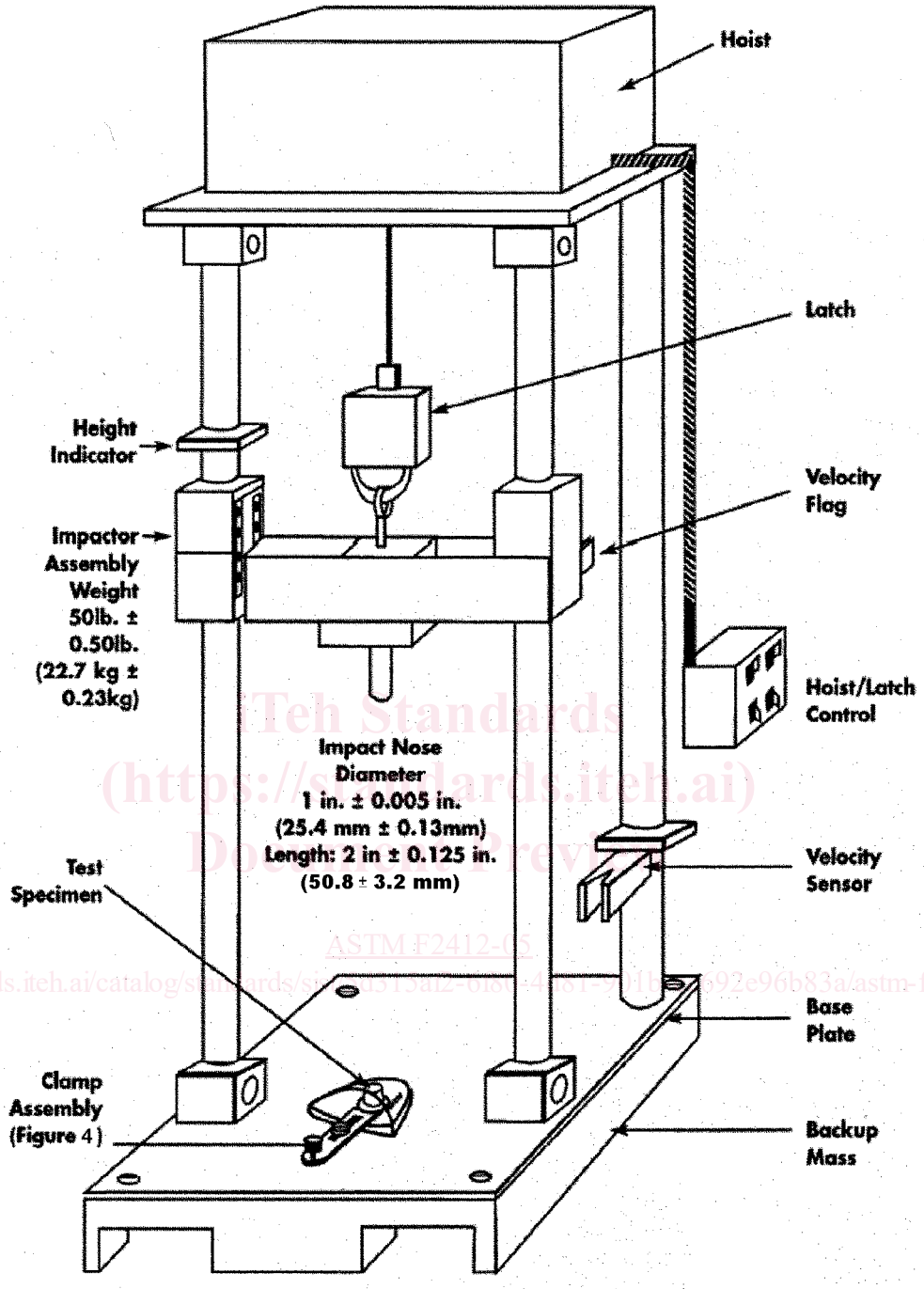
5.2.1.2 Apparatus incorporates a means of measuring the velocity at impact with a tolerance of ±2 %. The use of a velocity metering system allows for determining the time required for a 25.4-mm (1-in.) wide blade to pass completely through a beam of light prior to the impactor striking the specimen.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

$$V = \frac{1000}{t_g} \tag{1}$$

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^2 (1 ft^2) and minimum thickness of 25.4 mm (1 in.). The base is anchored to a structure having a minimum mass of 909.1 kg (2000 lb) to provide sufficient stability to the apparatus before, during, and after testing.

5.3 *Sampling*:



NOTE—Dimensions are in inches (millimetres).

FIG. 1 Footwear Impact Test Apparatus

5.3.1 Three half-pair test specimens shall include both left and right footwear, of each product category are prepared from new manufactured footwear randomly selected from stock inventory.

5.3.1.1 Men's footwear specimens are prepared from size 9D, medium width.

5.3.1.2 Women's footwear specimens are prepared from size 8B, medium width.

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 as shown in Fig. 2.

5.4 *Specimen Mounting*:

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

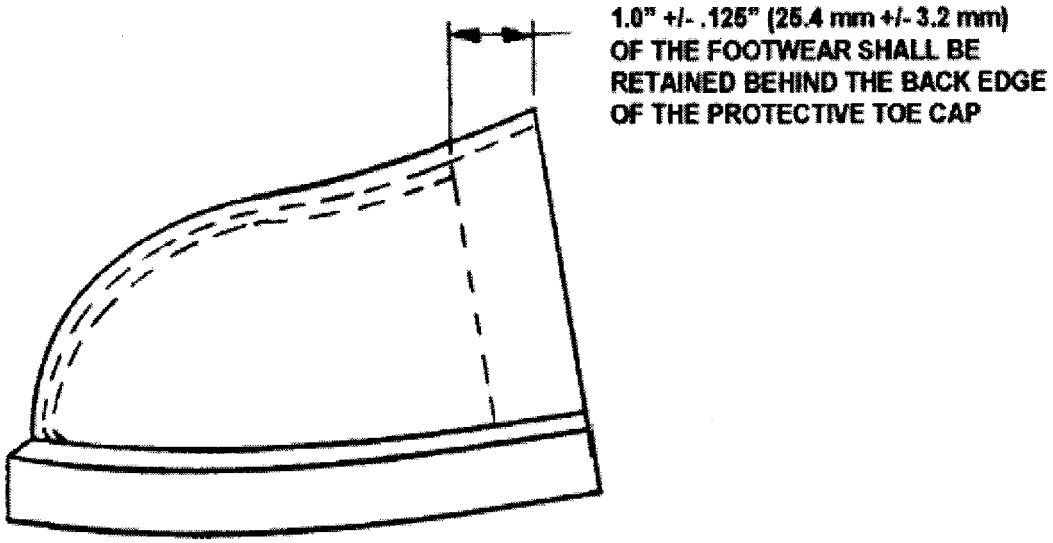


FIG. 2 Specimen Prepared for Compression Testing

5.4.1.1 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 ± 1.6 mm (0.50 ± 0.0625 in.) toward the front as measured from the back edge of the protective toe cap (see Fig. 3).

5.4.2 The specimen is held in position during test by use of a clamping device as shown in Fig. 4.

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

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

5.4.2.3 Clamping screw shall be tightened using a force less than 28 Nm (25 in. lbs).

5.5 *Procedure*:

5.5.1 Prior to impact testing, a lump of modeling clay formed as a vertical cylinder is positioned inside the specimens directly under the point of impact (see Fig. 3).

5.5.1.1 The clay shall be shaped so that the cylinder simultaneously makes contact with the insole/sock of the footwear and the dome of the protective toe cap.

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

5.5.1.2 The diameter of the cylinder shall not exceed 25.4 mm (1 in.).

5.5.2 After impact, carefully remove the clay cylinder from inside the specimen and measure the height of the cylinder at its lowest point using a measuring device capable of measuring to the nearest 0.1 mm (0.004 in.).

5.5.2.1 This value is reported as the impact minimum interior height clearance for the specimen.

5.5.3 To measure Class 75 product classification footwear, the impactor is dropped from a height that results in an impact velocity of 2995 ± 61 mm/s (117.9 ± 2.4 in./s), creating a force of 101.75 J (75 ft-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.

5.5.4 To measure Class 50 Product Classification footwear, the impactor is dropped from a height that results in an impact velocity of 2438 ± 48.3 mm/s (96 ± 1.9 in./s), creating a force of 67.8 J (50 ft-lbf).

NOTE 3—In a vacuum, the distance would be 305 mm (12 in.). Due to

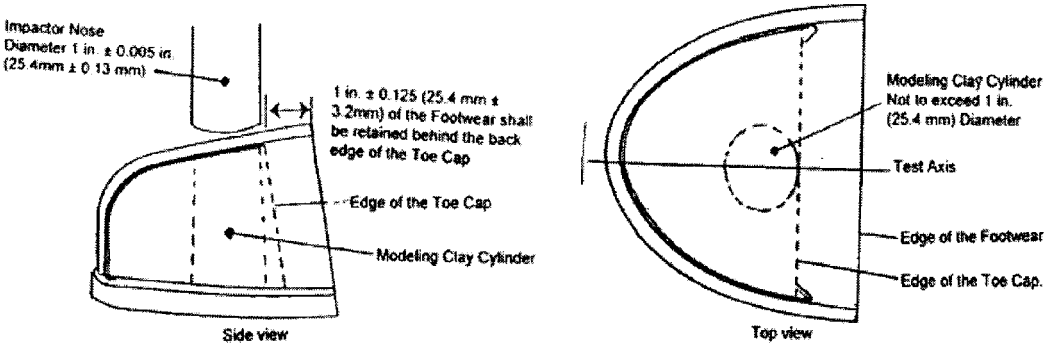
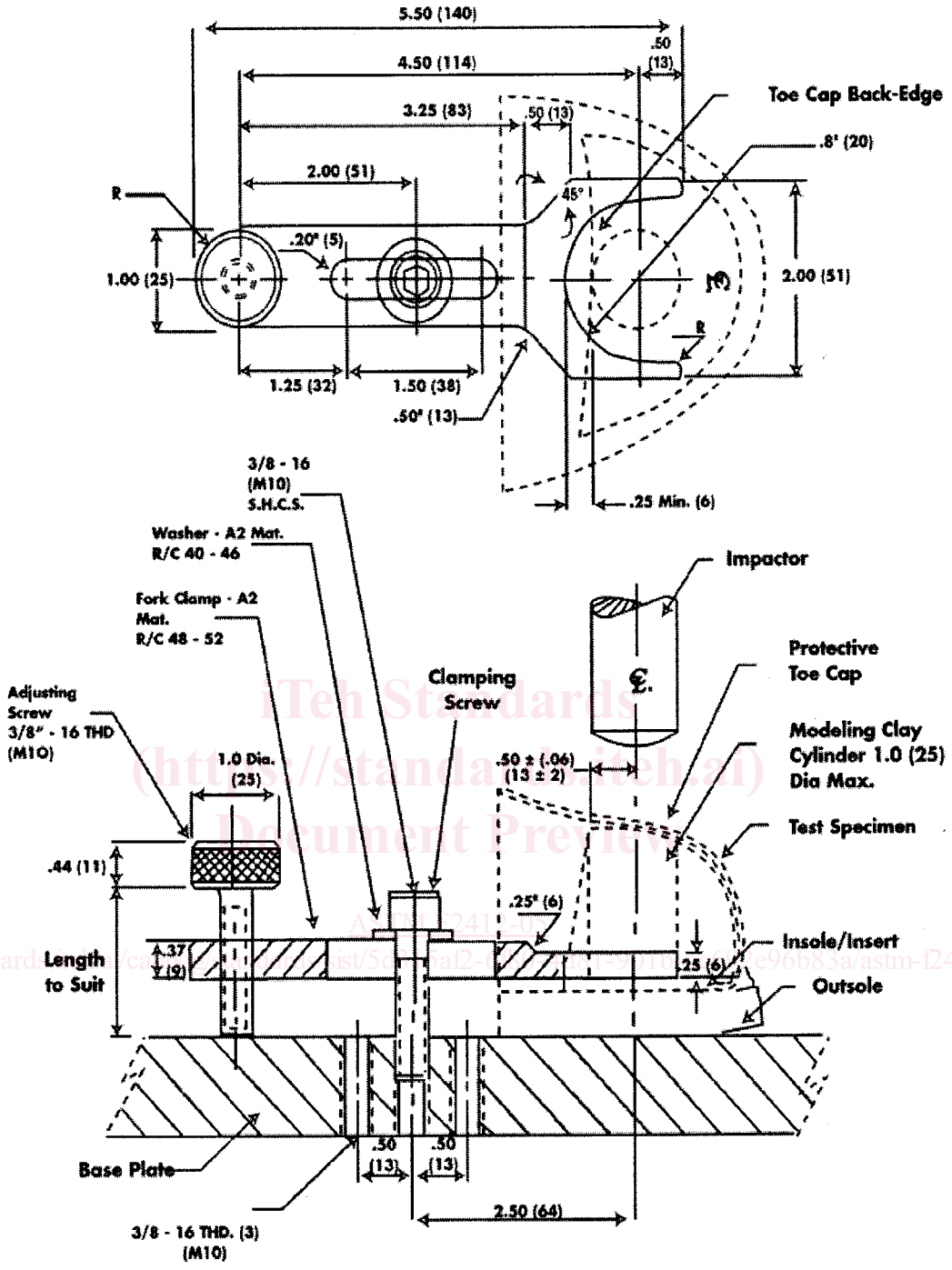


FIG. 3 Specimen Prepared for Impact Testing



NOTE—Dimensions are in inches (millimetres).

FIG. 4 Position/Clamping/Impact Arrangement

friction and air resistance, the height used for the test is somewhat greater.

5.6 *Test Report*—Report the minimum height of the clay cylinder, without rounding up, to the nearest 0.1 mm (0.004 in.) as the clearance result for the product category for all three specimens.

6. Compression Resistance

6.1 *Summary of Method*:

6.1.1 Footwear with a protective toe cap is exposed to a compressive force.

6.1.2 During application of the compressive force, the interior space of the toe cap is measured using a clay cylinder.

6.2 *Apparatus*:

6.2.1 Compression testing equipment that is equipped with smooth steel compression test surfaces.

6.2.1.1 Test surfaces must remain parallel during application of force up to 44 482 N (10 000 lbf).

6.2.1.2 Pressure head has a minimum diameter of 76.2 mm (3 in.) and a bed plate with a minimum width of 152.4 mm (6 in.).

6.2.1.3 Equipment must be graduated in increments so as to measure compressive force between 222.4 N (50 lbf) to 44 482 N (10 000 lbf).

6.3 *Sampling*:

6.3.1 *A total of three half pair specimens*, which shall include both left and right footwear of each product category, are prepared from new manufactured footwear randomly selected from stock inventory.

6.3.1.1 Men's footwear specimens are prepared from size 9D, medium width.

6.3.1.2 Women's footwear specimens are prepared from size 8B, medium width.

6.3.2 The specimens shall be prepared 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 as shown in Fig. 2.

6.4 *Specimen Mounting*:

6.4.1 The specimen is positioned on the bed plate of the test apparatus so that the highest point of the protective toe cap is perpendicular to the direction of force.

6.4.2 The stabilizing fork clamp device rests on the insert and can be adjusted by means of a screw (see Fig. 4).

6.4.2.1 This adjustment secures the specimen parallel to the bed plate and prevents movement.

6.4.2.2 Clamping screw shall be tightened using a force less than 28 Nm (25 in. lbs).

6.5 *Procedure*:

6.5.1 Prior to compression testing, a lump or modeling clay as a vertical cylinder is positioned inside the specimen directly under the center of the protective cap (see Fig. 3).

6.5.2 The clay shall be shaped so that the cylinder simultaneously makes contact with the insert/sock liner of the footwear and the dome of the protective cap (see Note 1).

6.5.3 The diameter of the cylinder shall not exceed 25.4 mm (1 in.).

6.5.4 A compressive force is applied to the specimen at an approximate rate of 222.4 N/s (50 lbf/s).

6.5.5 After compression testing, carefully remove the clay cylinder from the specimen and, using a measuring device capable of measuring to the nearest 0.1 mm (0.004 in.) measure the height of the cylinder at its lowest point, without rounding up.

6.6 *Test Report*—Report the minimum interior height clearance for the specimen to the nearest 0.1 mm (0.004 in.), without rounding up for each of three specimens as the compression resistance and classification for the product category.

7. Metatarsal Impact Resistance

7.1 *Summary of Method*:

7.1.1 Footwear with a protective toe cap and metatarsal guard is impacted with the appropriate force.

7.1.2 After impact, the height of the wax form is measured.

7.2 *Apparatus*:

7.2.1 The same apparatus as used in 5.2 (Fig. 1) for impact testing of protective footwear, with certain modifications, is used for metatarsal impact testing. The modifications to the apparatus are shown in Fig. 5 and Fig. 6.

7.2.1.1 The striking surface that impacts the metatarsal protection is a horizontal bar that is perpendicular to the vertical traverse of the test apparatus. The bar of polished steel has a diameter of 25.4 ± 0.5 mm (1 ± 0.02 in.) and a length of 152.4 ± 3.2 mm (6 ± 0.125 in.).

7.2.1.2 The striking bar is positioned so that the impact is perpendicular to the longitudinal plane of the heel/toe axis at the appropriate impact point for men's and women's footwear (see Fig. 7).

7.3 *Sampling*:

7.3.1 A total of three half-pair test specimens (shall include both left and right footwear) of each product category are prepared from new manufactured footwear randomly selected from stock inventory.

7.3.1.1 Men's footwear specimens are prepared from size 9D, medium width.

7.3.1.2 Women's footwear specimens are prepared from size 8B, medium width.

7.4 *Specimen Mounting*:

7.4.1 Mount specimen in a device, as shown in Fig. 6, that retains footwear in place during testing.

7.4.2 Mount specimen so that outsole is resting on base of apparatus and positioned so that the point of contact for the striking bar is appropriate for the specimen as shown in Fig. 7.

7.4.2.1 Men's footwear requires that the point of contact for the striking bar is 89 mm (3.5 in.) when measured backwards from the front point of the toe toward the heel.

7.4.2.2 Women's footwear requires that the point of contact for the striking bar is 86 mm (3.375 in.) when measured backwards from the front part of the toe toward the heel.

7.5 *Procedure*:

7.5.1 Insert a wax form, as described in Annex A1, into the specimen. The insert/sock lining of the footwear shall remain in the footwear during testing.

7.5.1.1 The wax form shall completely fill the protective footwear cavity and extend toward the quarter of the footwear approximately 76.2 mm (3 in.) beyond the back edge of the protective toe cap.

7.5.1.2 The use of a heel block is used to secure the wax form in place and also to fill the cavity between the back edge of the wax form and the quarter.

7.5.2 Position the impactor on test apparatus to the proper height for product classification of footwear (see 5.5.3 and 5.5.4).

7.5.2.1 Release the impactor,

7.5.3 Reposition the impactor on test apparatus, and carefully remove the wax form from the specimen.

7.5.4 *Test Report*—Measure the distance from the lowest point of the impression made in the wax form to the bottom surface of the form as shown in Fig. 7 and report the results to the nearest 0.1 mm (0.004 in.) for all three test specimens without rounding up.