Designation: F 1976 – 99

An American National Standard

Standard Test Method for Cushioning Properties of Athletic Shoes Using an Impact Test[1]

This standard is issued under the fixed designation F 1976; 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.

1. Scope

1.1 This test method describes procedures for the measurement of the impact response properties of athletic shoes using Procedure A of Test Method F 1614.

1.2 This test method is limited to tests using a falling weight impact machine, as defined by Procedure A of Test Method F 1614.

1.3 This test method is intended for use on the heel and or forefoot regions of whole, intact athletic shoe cushioning systems. An athletic shoe cushioning system is defined as all of the layers of material between the wearer's foot and the ground surface that are normally considered a part of the shoe. This may include any of the following components: outsole or other abrasion resistant layer, a midsole or other compliant cushioning layer, an insole, insole board, or other material layer overlying the midsole, parts of the upper and heel counter reinforcement which extend beneath the foot, and an insock or other cushioning layer inside the shoe.

1.4 This test method is not intended for use as a test of shoes classified by the manufacturer as children's shoes.

1.5 The type, size or dimensions and thickness of the specimen, and the reference maximum energy applied shall qualify test results obtained by this test method.

1.5.1 Nominal specimen thickness values for this test method are in the range from 10 to 60 mm (0.4 to 2.4 in.). The area of the shoe to be tested must present an approximately circular, flat surface of at least 65 mm (2.6 in.) in diameter for impacting.

1.5.2 The standard value for the reference maximum energy applied by this test method is 5 J (44.2 in.-lbf) for shoes which are subject to moderate impacts during normal use and 7.0 J (61.9 in.-lbf) for shoes which are subject to high impacts during normal use. Other values may be used, if they are stated in the report.

1.6 This test method is not appropriate for measuring the impact response of shoes that are not subjected to moderate impact or high impact in normal use.

1.7 The values stated in SI units are to be regarded as standard.

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.*

2. Referenced Documents

2.1 *ASTM Standards:*

F 1614 Test Method for Shock Attenuating Properties of Materials Systems for Athletic Footwear[2]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *cushioning system*—one or more components of the sole of a shoe intended for the redistribution of force or shock attenuation, or both, including one or more of the insock, insole, midsole, and outsole.

3.1.2 *drop height*—the height from which the falling mass is dropped, being the distance between the top of the specimen and the top of the tup.

3.1.3 *impact*—rapid deceleration of the lower extremity due to collision between the foot and the surface.

3.1.3.1 *low impact*—an impact during which the peak ground reaction force is less than 1.5 body weights and the peak axial deceleration of the lower leg is less than 4 g.

3.1.3.2 *moderate impact*—an impact during which the peak ground reaction force is greater than 1.5 body weights and less than 3 body weights and the peak axial deceleration of the lower leg is greater than 4 g but less than 8 g.

3.1.3.3 *high impact*—an impact during which the peak ground reaction force exceeds 3 body weights or the peak axial deceleration of the lower leg exceeds 8 g.

3.1.4 *maximum energy applied*—the energy applied to the specimen up to the point of maximum compressive displacement.

3.1.5 *shoe upper*—vamp, tongue, heel counters, throat, collar, and other parts of the shoe that do not form part of the cushioning system.

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[1] This test method is under the jurisdiction of ASTM Committee F-8 on Sports Equipment and Facilities and is the direct responsibility of Subcommittee F08.54 on Athletic Footwear.

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[2] *Annual Book of ASTM Standards*, Vol 15.07.

3.1.6 *tup*—leading surface of moving portion of test machine in contact with specimen during the impact cycle.

4. Summary of Test Method

4.1 A test specimen is supported on a rigid foundation and rapidly loaded in compression by a falling mass. The compressive force is applied through the circular flat face of 45-mm (1.8-in.) diameter tup. Force and displacement transducers are employed for continuous measurement of the complete loading and unloading compression cycle. Alternatively, specimen displacement history may be calculated from the force history.

4.2 The maximum energy applied to the test specimen must be within ±10 % of a standard reference value. The reference value is typically 5 J (44.2 in.-lbf) or 7 J (61.9 in.-lbf) but may be varied depending of the type of shoe and whether the heel or forefoot is being tested. Other reference energy values may be used, if they are stated in the report.

4.3 This test method uses the gravity-driven impact of a defined mass as the method for force application. The impact velocity is determined by the drop height. The maximum force and maximum displacement are determined by the cushioning characteristics of the shoe. The maximum energy applied is determined by both the drop height and the cushioning characteristics of the shoe.

5. Significance and Use

5.1 This test method is used by athletic footwear manufacturers and others, both as a tool for development of athletic shoe cushioning systems and as a test of the general cushioning characteristics of athletic footwear products. Adherence to the requirements and recommendations of this test method will provide results that can be compared between different laboratories.

5.2 Data obtained by these procedures are indicative of the shock-attenuating properties of athletic shoe cushioning systems under the specific conditions selected.

5.3 This test method is designed to provide data on the force versus displacement response of athletic footwear cushioning systems under essentially uniaxial compression conditions at load rates that are similar to those of heel and forefoot impacts during different athletic activities.

5.4 The peak or maximum values of force, pressure, displacement, and strain are dependent on the maximum energy applied to the specimen. These values are normalized to provide comparative results for a reference maximum energy applied to the specimen of 5 J (44.2 in.-lbf) or 7 J (61.9 in.-lbf).

5.5 Shock-attenuating characteristics are strongly dependent on specimen size and prior history of force application. Therefore, results should be compared only for specimens of the same nominal shoe size and prior impact conditioning. There are no currently acceptable techniques for normalizing results for specimen thickness variations.

NOTE 1—Shock-attenuating scores determined by this test method, for athletic shoes, may not correlate with the forces experienced by individual users of the shoes.

NOTE 2—There is no research showing a correlation between scores on this test method and the probability of injury among users of a particular athletic footwear product.

6. Test Apparatus

6.1 Test apparatus shall conform to Test Method F 1614, Procedure A.

7. Test Specimen

7.1 *Preparation of Test Specimens*—The cushioning test specimen shall be isolated from the shoe by cutting away the upper. The lower portion of the upper (that which extends 10 ± 5 mm (0.4 ± 0.2 in.) above the top surface of the cushioning system) shall not be removed, providing it does not interfere with the falling mass.

NOTE 3—The retention of a rim of upper materials around the edge of the test specimen prevents disturbance of the cushioning materials during removal of the upper, preserves the attachments between the sole and the upper (which can influence shock attenuation), and serves as a retainer for any loosely attached components of the cushioning system that normally reside inside the shoe (an insock for example).

7.2 *Geometry*—In order for this test method to be applicable, the region of the cushioning system to be tested shall have an approximately flat surface, approximately circular in shape, with a minimum diameter of 65 ± 2 mm (2.6 ± 0.1 in.). The center of this presenting surface shall coincide with the center of the tup of the test apparatus, such that on initial contact between the tup and the test specimen there is a minimum of 10 ± 1-mm (0.4 ± 0.05-in.) clearance between the edge of the tup and the edge of the test specimen, in all directions.

NOTE 4—The geometry of the test specimen will vary with the design of the shoe under test. Since the geometry of the shoe is a factor which influences shock attenuation, the influence of which may be tested with this test method, no standard specimen geometry is defined. The validity for comparisons of results from tests of specimens of different geometries, thicknesses, and sizes has not been determined.

7.3 *Alignment of Test Specimens*—The standard methods of aligning test specimens with the test apparatus are as follows:

7.3.1 *Heel*—For tests of shock attenuation in the heel of a shoe, test specimens shall be aligned with the test apparatus as shown in Fig. 1 such that the center of the tup coincides with a point on the top surface of the shoe that is 12 %± 2 mm (12 % ± 0.08 in.) of the internal length of top surface of the test specimen from the heel end and equidistant from the medial and lateral edges of the test specimen.

7.3.2 *Forefoot*—For tests of shock attenuation in the forefoot of a shoe, test specimens shall be aligned with the test apparatus as shown in Fig. 1 such that the center of the tup coincides with a point on the top surface of the shoe that is 75 % ± 2 mm (75 % ± 0.08 in.) of the internal length of top surface of the test specimen from the heel end and equidistant from the medial and lateral edges of the test specimen.

8. Conditioning

8.1 Condition test specimens in accordance with Test Method F 1614.

8.1.1 Test specimens in accordance with Test Method F 1614, Procedure A, with the following adjustments:

8.1.1.1 Align the test specimen with the test apparatus in accordance with 7.2 of this test method.

8.1.1.2 The maximum energy applied to the test specimen must be within ±10 % of a reference value. The reference

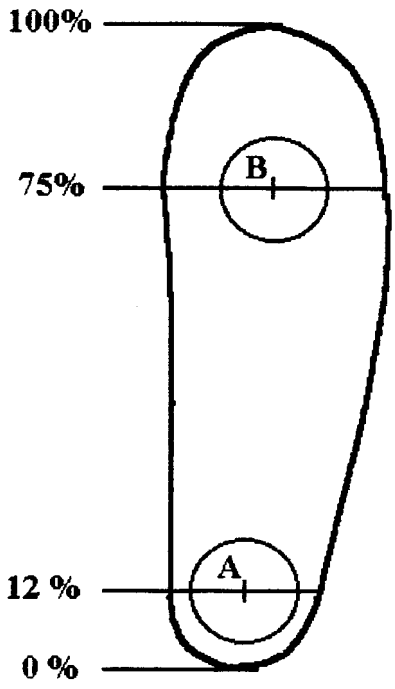

FIG. 1 Plan View of Shoe Sole Sample Showing Alignment of the Tup for (A) Heel and (B) Forefoot Tests

value shall be 5 J (44.2 in.-lbf) for shoes which are subject to moderate impacts during normal use and 7 J (61.9 in.-lbf) for shoes which are subject to high impacts during normal use. Reference energy values other than 5 J (44.2 in.-lbf) or 7 J (61.9 in.-lbf) may be used, if they are stated in the report.

NOTE 5—The goal of the impact test is to simulate the energy inputs, forces, and load rates applied to the shoe cushioning system during normal use. For general purposes, a reference energy of 5 J (44.2 in.-lbf) has been found appropriate for sports shoes. However, the reference energy may be varied depending of the type of shoe and whether the heel or forefoot is being tested. A reference energy of 5 J (44.2 in.-lbf) is recommended for testing shoe cushioning systems which are subjected to moderate impact (see 3.1.3.2) during normal use. These include running shoes (heel) and multipurpose fitness shoes (heel and forefoot). For shoe cushioning systems which are subjected to high impact (see 3.1.3.3) during normal use, a reference energy of 7 J (61.9 in.-lbf) is recommended. These include basketball, tennis, and volleyball shoes. This test method is not recommended for shoes that are not subject to moderate or high impact during normal use. These include shoes intended for exercise walking and for aerobics.

9. Calculation

9.1 In addition to the calculations specified in Test Method F 1614, the following may be calculated:

9.1.1 *Peak G Score*, defined as the peak acceleration of the tup of the falling mass apparatus during an impact, expressed in gravitational units.

$$\text{Peak G score} = A/g \quad (1)$$

where:
A = peak deceleration, and
g = acceleration due to gravity = 9.81 m s^{-2} (33.2 ft s^{-2}).

When a force transducer is used, peak deceleration may calculated as follows:

$$A = -F/M \quad (2)$$

where:
A = peak deceleration,
F = peak force recorded with the force transducer, and
M = mass of the impactor.

10. Report

10.1 Report the following information:

10.1.1 Complete identification of the shoe tested, including type, shoe size or dimensions, source, manufacturer's code number, form, and previous history.

10.1.2 Specimen size and thickness.

10.1.3 Sources and types of test equipment.

10.1.4 Reference maximum energy applied.

10.1.5 For the series of five impact cycles, average value and standard deviation for each of the following properties:

10.1.5.1 Peak force, maximum displacement, time, maximum energy applied, and hysteresis energy ratio in accordance with Test Method F 1614.

10.1.5.2 Peak G score in accordance with 10.1.

11. Precision and Bias

11.1 *Precision*—The precision of this test method for measuring peak force and hysteresis energy ratio are essentially as specified in Test Method F 1614. Peak G score is directly derived as the product of the peak force measurement and a constant. Therefore, Peak G score has precision that is proportionate to that of the peak force measurement.

11.2 *Bias*—A statement on bias cannot be made because no reference samples are available.

12. Keywords

12.1 athletic shoes; cushioning; impact; shock attenuation; sports shoes