Standard Test Method for Impact Attenuation of Athletic Shoe Cushioning Systems and Materials[1]

1. Scope

1.1 This test method describes the use of a gravity-driven impact test to measure certain impact attenuation characteristics of cushioning systems and cushioning materials employed in the soles of athletic shoes.

1.2 This test method uses an 8.5 kg mass dropped from a height of 30-70 mm to generate force-time profiles that are comparable to those observed during heel and forefoot impacts during walking, running and jump landings.

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 outer layer, a midsole of compliant cushioning materials or structures forming an intermediate layer, an insole, insole board, or other material layers overlying the midsole, parts of the upper and heel counter reinforcement which extend beneath the foot, and an insock, sockliner or other cushioning layers, either fixed or removable, inside the shoe.

1.4 This test method may also be employed in to measure the impact attenuation of cushioning system components and cushioning material specimens.

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

1.6 The type, size or dimensions and thickness of the specimen, the total energy input and prior conditioning shall qualify test results obtained by this test method.

1.6.1 The range of tests results is limited by the calibrated range of the test device's force transducer. Combinations of thin specimens, high specimen stiffness and high total energy input may produce forces that exceed the transducer's capacity and are hence not measurable. In practice, the specified force transducer range (10 kN) accommodates more than 99 % of typical shoe soles and cushioning material specimens that are 7 mm or more in thickness at a total energy input of 5 Joules.

1.6.2 The nominal value of the total energy input applied by this test method is 5 J for shoes, such as running shoes, which are subject to moderate impacts during normal use. Total energy inputs of 7.0 J and 3.0 J may be used for shoes (e.g basketball shoes) which are subject to higher impact loads during normal use. Other values of total energy input may be used, if they are stated in the report.

1.6.3 Results from tests performed with different total energy inputs or with different masses are not directly comparable.

1.6.4 Specimen thickness has a significant effect on impact attenuation outcomes. Consequently, results from tests of material specimens of different thicknesses cannot be directly compared.

1.6.5 The impact attenuation of cushioning materials may change over time and with use (e.g. wear or durability testing) or prior conditioning (e.g. from previous tests). Consequently, test results obtained using this test method shall be qualified by the age and prior conditioning of the samples.

1.7 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this 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:*[2]

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

F1614 Test Method for Shock Attenuating Properties of

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

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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.

Materials Systems for Athletic Footwear (Withdrawn 2014)[3]

F2650 Terminology Relating to Impact Testing of Sports Surfaces and Equipment

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this test method, refer to Terminology F2650.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *low impact*—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.

3.2.2 *moderate impact*—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.

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

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

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

4. Summary of Test Method

4.1 The test apparatus consists of a rigid foundation with a support structure that guides the fall of an 8.5 kg, gravity driven missile. The apparatus includes a mechanism for positioning the missile at a predetermined drop height, then cyclically releasing it at a nominal rate of 30 cycles per minute.

4.2 A test specimen is supported by the rigid foundation. The drop height is adjusted to produce a specified total energy input, typically 5 Joules. Specimens are subjected to a series of 30 impacts with a nominal interval of 2.0 s. The first 25 drops used to condition the specimen and the last five drops used for measurements. Force and displacement time histories are measured with appropriate transducers and recorded. The primary outcomes of the test are the peak acceleration during the impact (g-max), time to peak acceleration (t-max), peak compressive displacement (x-max) of the specimen and energy return/loss due to hysteresis.

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, materials and components. Adherence to the requirements and recommendations of this test method will provide repeatable results that can be compared among laboratories.

[3] The last approved version of this historical standard is referenced on www.astm.org.

5.2 Data obtained by these procedures are indicative of the impact attenuation of athletic shoe cushioning systems under the specific conditions employed.

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

5.4 The peak or maximum values of force, acceleration, displacement, and strain are dependent on the total impact energy applied to the specimen. These values are normalized to provide comparative results for a reference value of total energy input.

5.5 Impact attenuation outcomes are strongly dependent on initial conditions (impact mass, impact velocity, contact area, etc.) and on specimen size and the specimen's prior history of compressive loading. Therefore results should be compared only for specimens of the same nominal size and prior conditioning.

NOTE 1—Impact test outcomes have been found to correlate with in-vivo loads (peak ground reaction force, peak plantar pressure, lower extremity acceleration) experienced by runners. Relationships between test outcomes and subjective perceptions of cushioning have also been found. However, there is no direct evidence of 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 The test device (Fig. 1) shall consist of two primary assemblies, the first providing a fixed anvil and structures for the support, alignment and guidance of a second, gravity-driven missile assembly (Fig. 1).

6.2 *Fixed Anvil Assembly,* (Fig. 1(A)) consisting of an effectively rigid anvil having a minimum mass of 170 kg and providing a flat, rigid surface for specimen support. The specimen support surface shall be planar, normal to the vertical direction of missile travel, centered under the tup of the gravity-driven assembly and of sufficient area to support the entire lower surface of the specimen.

6.2.1 *Support and Guidance*—The fixed assembly shall provide linear bearings or other means guidance for a gravity-driven missile such that the motion of the missile is vertical and normal to the plane of the specimen support surface.

6.2.2 *Lift and Drop Mechanism*—A means of lifting the missile above the upper surface of the specimen, repeatably positioning it with an accuracy of ±0.5 mm releasing it to initiate a gravity-driven drop.

6.2.2.1 The testing machine shall be capable of initiating the impact cycle (that is, loading and unloading as one cycle) at a rate of one every 2 ± 1 s.

NOTE 2—The adjustable range of the lift and drop mechanism must accommodate the thickness of the specimen (typically 10 to 50 mm) plus the drop height required to produce the specified total input energy (typically 30 to 70 mm).

6.2.3 *Friction*—The missile assembly shall move freely, with minimum friction between the missile and the bearings or other guidance structure. Any friction shall be such that the measured free-fall velocity, V_0, from a drop height h, shall be