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An American National Standard

Standard Test Method for Impact Attenuation of Playing Surface Systems and Materials[1]

This standard is issued under the fixed designation F355; 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 covers the measurement of certain shock-absorbing characteristics, the impact force-time relationships, and the rebound properties of playing surface systems. This test method is applicable to natural and artificial playing surface systems and to components thereof. Typical playing surfaces are wrestling mats, football fields, soccer fields, playgrounds, and so forth.

NOTE 1—This test method may also be used to measure the shock-attenuation properties of materials used as protective padding, such as the padding on trampoline frames, football goal posts, gymnasium wall, shoulder pads, body padding, and so forth. It should not be used, without some modifications, to test the finished products.

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

1.3 *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]

D1596 Test Method for Dynamic Shock Cushioning Characteristics of Packaging Material

E105 Practice for Probability Sampling of Materials

E122 Practice for Calculating Sample Size to Estimate, With Specified Precision, the Average for a Characteristic of a Lot or Process

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

F1292 Specification for Impact Attenuation of Surfacing Materials Within the Use Zone of Playground Equipment

F2650 Terminology Relating to Impact Testing of Sports Surfaces and Equipment

2.2 *SAE Standard:*

SAE J211/1 Instrumentation for Impact Tests - Part 1 - Electronic Instrumentation (rev. July 2007)[3]

3. Terminology

3.1 *Definitions:*

3.1.1 Definitions of terms related to impact testing of sports surfaces equipment can be found in Terminology F2650.

4. Summary of Test Method

4.1 A test specimen is impacted at a specified velocity with a missile of given mass and geometry. An accelerometer mounted in the missile is used to record the acceleration-time history of the impact and the peak acceleration is used as a measure of impact severity. Optionally, the displacement history of the impact may also be recorded.

4.2 This test method defines three missiles for use in playing surface impact tests:

4.2.1 *Missiles A and D* are both cylindrical, with specified mass and geometry and a circular, flat, metal impacting surface. These missiles are used with a guidance mechanism.

4.2.2 *Missile E* has a hemispherical impacting surface of specified mass and geometry and may be used with a guidance system or, if equipped with a triaxial accelerometer, without guidance ("free-fall").

4.2.3 The specific masses and geometries of the missiles are detailed in 6.2.

5. Significance and Use

5.1 The results of this method quantify the impact attenuation of playing surface and system specimens under the specific test conditions.

5.2 The test method measures the outcome of impacts performed under specific conditions. It does not quantify the intrinsic material properties of the tested specimens.

5.3 Test results from different specimens obtained under the same conditions (that is, the same missile mass and geometry,

[1] This test method is under the jurisdiction of ASTM Committee F08 on Sports Equipment and Facilities and is the direct responsibility of Subcommittee F08.52 on Miscellaneous Playing Surfaces.

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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 SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001, http://www.sae.org.

drop height, etc.) may be used to compare impact attenuation under those conditions.

5.4 Test results obtained under different conditions are not comparable. Specifically obtained with different missiles are not equivalent and cannot be directly compared. Similarly, test results obtained using the same missile, but using different drop heights, are not directly comparable.

6. Apparatus

6.1 *Anvil*—For tests performed on surface samples in a laboratory, the surface sample shall be mounted on a rigid anvil or base having a mass at least 100 times that of the missile.

6.2 *Impact Test System*—A device or system for performing an impact test in which an instrumented missile is dropped onto a playing surface or surfacing material from a predetermined drop height.

6.2.1 *Missile*:

6.2.1.1 The missile shall have one of the combinations of mass and geometry specified in Table 1. (See also Fig. 1.)

6.2.1.2 The missile may include cavities and additional components required to accommodate the attachment of sensors or to attach a supporting assembly. The form of any cavities or additional components shall be generally symmetrical about the Z-axis of the level missile such that center of mass lies within 0.08 in. (2 mm) of the Z-axis and the moments of inertia about any two horizontal axes do not differ by more than 5 %.

6.2.1.3 A supporting assembly (for example, a handle or ball arm) may be rigidly attached to the missile as a means of connecting it to an external guidance system. The total mass of the drop assembly, which is the combined mass of the missile, accelerometer and supporting assembly shall be that defined in Table 1. The mass of the supporting assembly alone shall not exceed 30 % of the total mass.

6.2.2 *Guidance Mechanism for Guided Impact Tests*—For guided impact tests; the missile may be connected to low-friction guides (such as a monorail, dual rails, or guide wires) using a follower or other mechanism in order to constrain the fall trajectory of the missile to a vertically downward path. Missile A and D may be guided using a ventilated tube. The guidance system must allow the missile to be leveled prior to a drop and must maintain the missile in a level (±5°) attitude during the drop. The guidance mechanism shall be constructed in a manner that that does not impede the trajectory of the missile during its fall or during its contact with the surface being tested; other than necessary impedance caused by friction in the guidance mechanism.

6.2.3 *Support Structure for Free-Fall Impact Tests*—For free-fall impact tests, a support structure (for example, a tripod) shall be used to ensure repeatable drop height and location. The support structure shall be sufficiently rigid to support the weight of the missile without visible deformation. The support structure shall be erected in a manner that does not impede the trajectory of the missile during its fall or during its contact with the surface being tested.

6.2.4 *Drop Height Control Mechanism*—The guidance mechanism of 6.2.2 or the support structure of 6.2.3 shall incorporate a means of repeatedly positioning the missile at a predetermined drop height.

6.2.5 *Release Mechanism*—The operation of any release mechanism provided as a means of initiating a drop of the missile shall not influence the fall trajectory of the missile following release.

6.3 *Acceleration Measurement System*—A transducer or transducers and associated equipment for measuring and recording the acceleration of the missile during an impact with an accuracy of within ±1 % of the true value.

6.3.1 *Accelerometers*—An accelerometer shall be rigidly attached at the center of mass of the missile. The sensing axis or axes of the accelerometer shall pass through the center of mass of the missile.

6.3.1.1 For a free-fall test, a triaxial accelerometer is required.

6.3.1.2 For a guided test, a single uniaxial accelerometer may be used. The accelerometer shall be rigidly attached at the center of mass of the missile (±2 mm) with its axis of sensitivity aligned (±5°) with the missile's Z axis and passing through the center of mass of the missile.

6.3.2 Accelerometers shall have a minimum sensitive range of ±500 g and be capable of tolerating accelerations of at least 1000 g along any axis.

6.3.3 *Accelerometer Calibration*—Accelerometers shall be calibrated by reference to a National Institute of Standards and Technology (NIST) traceable standard using a shaker table to excite a range of frequencies and amplitudes determined suitable by the accelerometer manufacturer. The calibration procedure shall include, as a minimum, the range of frequencies from 2 to 2000 Hz.

TABLE 1 Missile Mass and Geometry

Missile	Impacting Surface Shape	Mass	Geometry
A	Cylindrical	9.1 ± 0.050 kg (20.0 ± 0.11 lb)	Circular face with an area of 129 ± 2.0-cm^2(20 ± 1.0-in.^{2}) and a circumference-relieved radius of 2 ± 0.25 mm (0.08 ± 0.01 in.) to eliminate sharp edges
D	Cylindrical	2.25 ± 0.050 kg (4.95 ± 0.011 lb)	Circular face with a diameter of 50 ± 0.1 mm (1.97 ± 0.04 in.) and a circumference-relieved radius of 0.75 ± 0.25 mm (0.03 ± 0.01 in.) to eliminate sharp edges
E	Hemispherical	4.6 ± 0.02 kg (10.1 ± 0.05 lb)	Hemispherical face with a diameter of 160 ± 2 mm (6.3 ± 0.1 in.)

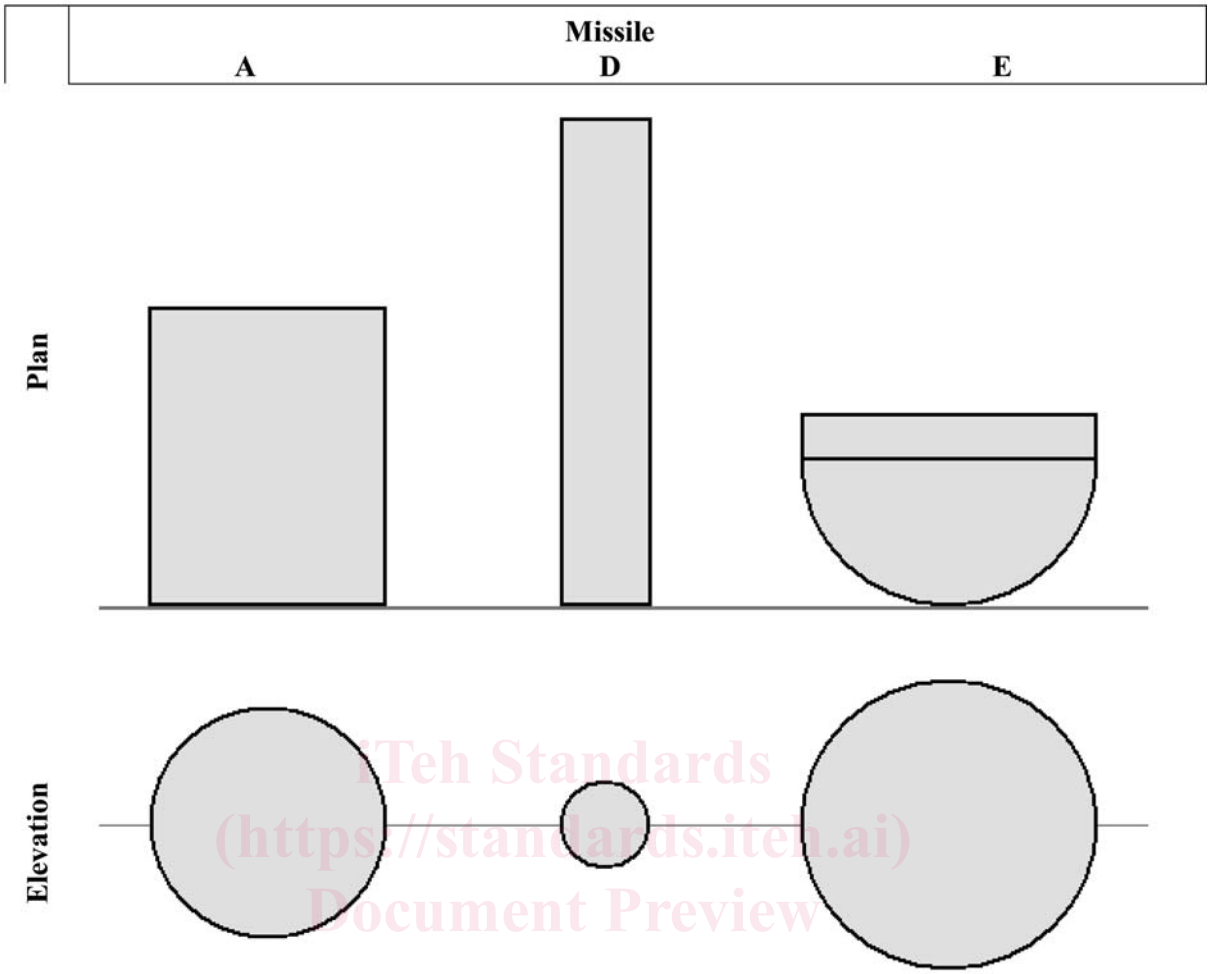

FIG. 1 Schematics Showing Approximate Relative Geometries of the A, D, and E Missiles

NOTE 2—Accelerometer calibration is usually performed by the manufacturer.

6.3.4 Accelerometers shall be recalibrated at a time interval recommended by the equipment manufacturer or every two years, which ever is the lesser time interval.

6.3.5 *Accelerometer Connections*—The means of providing power and signal connections to the accelerometer (for example, a cable) shall be constructed in a manner such that the connecting devices do not influence the trajectory of the missile before or during the impact test.

6.3.6 *Accelerometer Signal Conditioning*—Any signal conditioning of amplifying electronics required for proper operation of accelerometers shall be of a type recommended by the accelerometer manufacturer and shall have impedance and frequency response characteristics that are compatible with the accelerometer.

6.3.7 *Accelerometer Signal Filtering*:

6.3.7.1 *Anti-Aliasing Filter*—To prevent aliasing in the digitized acceleration data, the acceleration signals shall be filtered with an analog low pass filter prior to digitization. The anti-aliasing filter shall have a corner frequency of 5000 ± 500 Hz or a maximum of 0.25× the single channel sampling rate.

6.3.7.2 *Data Channel Filter*—Digitized data shall be filtered in accordance with the specification for an SAE Channel Class 1000 data channel, using a 4th order Butterworth. An analog filter may be substituted provided it has 4-pole characteristics and conforms to the data channel specification.

6.3.8 *Recording Device*—A digital recording device such as a digital storage oscilloscope, a dedicated waveform analyzer of a computer equipped with an analog to digital converter shall be used to capture the acceleration time signal produced during an impact. Analog oscilloscopes and other analog recording devices shall not be used.

6.3.9 *Resolution*—The conversion from analog accelerometer signal to digital data shall be accomplished with a digitizer having a resolution of 0.25 g or less. (For example, a twelve bit digitizer spanning the range ±500 g has a resolution of 0.244 g.)

6.3.10 *Sample Rate*—The minimum sampling rate of the recording device shall be 10.0 kHz per accelerometer channel. When a triaxial accelerometer is used, three individual digitizers (one per accelerometer axis), each with a minimum sampling rate of 10 kHz are required.

6.3.11 *Capacity*—The digitizer shall be capable of recording and storing data continuously for a minimum of 50 ms, beginning at least 5 ms before onset of the impact and ending no earlier than 5 ms after the cessation of the impact.