Designation: F1702 – 10

An American National Standard

Standard Test Method for Measuring Impact-Attenuation Characteristics of Natural Playing Surface Systems Using a Lightweight Portable Apparatus[1]

This standard is issued under the fixed designation F1702; 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 is used to determine the impact-attenuation characteristics of natural turfgrass and soil playing surface systems with a lightweight portable apparatus. This test method can be used to compare the impact attenuation characteristics of natural playing surface systems, as well as assessing the effects of management practices on the impact attenuation characteristics. This test method also can be used to assess the compactibility of natural playing surfaces by recording *g*-max values or penetration of successive impacts, or both.

1.2 This test method provides a procedure for assessing impact attenuation characteristics in the field, on both actual playing surfaces and research plots. Numerical data will not be comparable to data obtained using a different missile mass or geometry, different drop height, or different standard method, for example, Test Method F1936.

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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D5874 Test Method for Determination of the Impact Value (IV) of a Soil

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

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

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

F355 Test Method for Impact Attenuation of Playing Surface Systems and Materials

F1936 Specification for Impact Attenuation of Turf Playing Systems as Measured in the Field

F2650 Terminology Relating to Impact Testing of Sports Surfaces and Equipment

F2651 Terminology Relating to Soil and Turfgrass Characteristics of Natural Playing Surfaces

3. Terminology

3.1 *Definitions*—Except as noted, definitions in this standard are in accordance with Terminologies F2650 and F2651.

4. Summary of Test Method

4.1 A 2.25-kg missile is dropped from a specific height, through a guide tube, onto a playing surface. A linear accelerometer mounted on the missile monitors the acceleration and time history of the impact. The maximum acceleration during the impact (relative to gravity) is recorded and reported as *g*-max. Reporting the time history of the impact is optional. Depth of penetration from successive drops may also be recorded optionally as an indication of soil compactibility.

NOTE 1—This test method is based on an impact tester developed by Clegg (**1,2**).[3] See Test Method D5874. Such impact testers are commercially available. Commercially available Clegg Impact Soil Testers display results in impact value units, where one impact value equals 10 *g*-max units (Test Method D5874), and typically do not display tenths of an impact value unit. For use in this standard, the display should be altered by the manufacturer or authorized personnel to indicate tenths of an impact value or 1 *g*-max unit. Also, other suitable recording equipment can be used to obtain resolution to 1 *g*-max. A 4.5-kg missile has been used to evaluate road base surfaces (**1,2**). A 0.5-kg poly(vinyl chloride)

[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 F08.64 on Natural 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] Numbers in parentheses refer to the list of references at the end of this test method.

missile has been utilized to relate field surfaces to ball bounce (3-6), player response (7), and performance including injury potential (8).

5. Significance and Use

5.1 The *g*-max values obtained by these procedures are indicative of the impact attenuation characteristics of playing surfaces used for sports such as American football, soccer, baseball, lacrosse, rugby, etc. Optional time history data can be used to further describe these properties.

6. Apparatus

6.1 *Missile*—Construct the 2.25 ± 0.05-kg missile from metal with a hardened steel impacting surface that is flat and round with a 5.0 ± 0.1-cm diameter and a rounded or beveled edge of 0.5 to 1.0 mm. Include a T-shaped handle or other appropriate means for lifting the missile prior to dropping. The handle and accelerometer (rated at not less than 5000 *g*) constitute a portion of the missile mass. The missile should be marked around the circumference to obtain a reference point to the guide tube top, which will indicate drop height.

6.2 *Guide Tube*—Construct the vented guide tube from pipe having a smooth inside surface and a nominal inside diameter of 5.4 cm (2.125 in.), such as not to restrict a free fall of the missile. The length of the pipe typically is approximately 61 cm (24 in.). A bull's eye level shall be attached to the guide tube to ensure that the tube is held in a vertical position during measurement. Constructing a circular end flange on the base of the tube helps to improve stability during measurement. The bottom flange shall be milled so that it rests only on its perimeter and vented either with a hole or holes located through the flange top surface or by means of a hole or holes on the side of the guide tube just above the flange, or both, to allow for the escape of air under the compression of the falling missile.

6.3 *Recording Equipment*—Follow the criteria below when using recording equipment:

6.3.1 *g-max*—Ensure that the recording system is capable of measuring impacts of up to a *g*-max of 1000, as measured by an accelerometer mounted on the missile.

6.3.2 *Acceleration-Time*—The acceleration-time history may be recorded optionally using a suitable oscilloscope or computer instrumentation.

6.3.3 The band width of the acceleration measuring instrumentation must be sufficiently large to give good resolution of the peak acceleration (*g*-max). Commercially available devices have a band width of 7 kHz.

7. Test Unit

7.1 The test unit will be either:

7.1.1 An area of a playing surface system that has had similar use and that has similar surface-system characteristics (for example, age, vegetation density, wear, soil moisture content) within its limits, or

7.1.2 An experimental area (plot) subjected to uniform treatment(s) that may or may not affect impact characteristics.

7.2 A test unit on a playing surface system should not exceed approximately 1 m^2.

8. Number of Test Units

8.1 Similar areas of use, wear, etc., may be used to replicate test units on playing surfaces.

8.2 To characterize adequately the surface variability on a natural surface of a sports field, areas having different levels of use, wear, soil compaction, vegetative cover, etc., should be evaluated. If possible, replicate each type of use area.

8.3 Use a minimum of three test units (replications) in research experiments.

8.4 Due to the variable nature of natural surfaces, measure and average at least four locations within a test unit to obtain a test result. To obtain a specific quality assurance level, follow the sampling procedures of Practices E105 and E122.

9. Procedure

9.1 Operate and calibrate all recording equipment as recommended by the manufacturer. Periodically, at least prior to and after each series of impact tests, check the instrumentation output by dropping the missile on a standard surface, for example, a stable synthetic material placed on a rigid concrete or metal surface.

9.2 Place the guide tube on the playing surface and maintain in a vertical position during the drop.

9.3 Lift the missile to obtain a drop height of 45.7 ± 0.3 cm (18.0 ± 0.1 in.) and an approximate impact velocity of 2.85 m/s (9). A mechanical stop may be attached to the top of the guide tube to aid in achieving the exact drop height.

9.4 Release the missile and record the *g*-max value. Lifting the missile to an exact height and then releasing it freely is possible with trained and experienced operators; however, a mechanical holding/releasing mechanism is recommended to insure proper height and release with less-experienced operators. Such a mechanism should not influence the impact velocity to a greater extent than manual operation.

9.5 Make one drop on each location and record the *g*-max value. Soil compaction due to impacting alters natural surface conditions. Successive drops, therefore, will not give results that are indicative of the initial impact characteristics of the test unit. Surface deformation due to successive impacts may be used to give an indication of surface compactibility. Record *g*-max for each drop. A scale, graduated in units of 2.5 mm (0.1 in.) may be placed on the missile handle to determine residual surface penetration. The scale should have at least 20 units, and if deformation (depth of penetration) readings are recorded they shall be taken before and after each drop.

9.6 Record environmental conditions at time of the test, including the soil moisture content.

10. Calculation

10.1 *g-max*—Determine *g*-max to the nearest whole unit by direct readout (a truncated value is acceptable with digital readout equipment) or from the acceleration-time history.

10.2 Additional impact related parameters such as time to *g*-max, impact duration, and penetration depth may be obtained by using appropriate recording equipment.

11. Report

11.1 Include the following information in the report:

11.1.1 Identification of the surface tested, including location and type of surface (turfgrass or soil). Vegetation should be described as to the type(s) and density, and depth of thatch, if present, should be indicated. Soil texture should be given. If the surface is a research plot, treatment(s) should be listed.

11.1.2 Conditions of test, including temperatures, humidity, soil moisture content, and any other pertinent data.

11.1.3 Date of test.

11.1.4 Record type and model of instrumentation used to detect *g*-max/time history.

11.1.5 Record total missile mass (including handle, accelerometer, etc.).

11.1.6 Average *g*-max values from initial impacts on each similar test unit.

11.1.7 Average values from initial impacts on similar test units (replication) for optional results.

11.1.8 If successive impacts are used to characterize compactibility, record successive impact results. If penetration depth measurements are made, record each measurement taken prior to each impact and after the final impact to the nearest 2.5 mm (0.10 in.). Report changes in values with successive impacts for each test unit.

11.1.9 Notate the report to state, "Numerical data with this test method will not be comparable to data obtained using a different missile mass, geometry, drop height, or standard method, for example, Test Method F1936."

NOTE 2—Numerical data collected using this standard method is not directly comparable to data obtained using a different missile mass or geometry, different drop height, or different standard method, for example, Test Method F1936. Research suggests that impact results greater than 100 *g*, measured using the apparatus described herein, may pose a safety hazard (**10,11**). In such instances, corrective management actions may be practiced to reduce impact results. Furthermore, should results exceed 100 *g* using the apparatus described herein, a more accurate evaluation (Test Method F1936) will be required to more precisely assess potential safety hazards.

12. Precision and Bias[4]

12.1 *Interlaboratory Test Program*—Due to the nature of soil and turfgrass surfaces tested by this test method, it is either not feasible or too costly at this time to produce multiple specimens that have uniform mechanical properties. Any variation observed in the data is just as likely to result from specimen variation as from operator or laboratory testing variation. In lieu of natural turf surfaces, six synthetic rubber-composition flooring specimens, giving a range of *g*-max values that are representative of values obtained on natural surfaces of athletic fields, were selected for testing by seven laboratories, using procedures of Practice E691. Six impacting points were marked on each specimen, and average *g*-max values for a specimen were calculated from the six impacts. After a designated waiting period, specimens were retested to obtain a second replication.

12.2 *Test Result*—The precision information given below in the units of measurement (*g*-max) is for two test results, each of which is the average of six test determinations.

12.3 *Precision*—Precision statistics are shown in Table 1. The terms $\bar{x}$ (average), s_r (repeatability standard deviation), s_R (reproducibility standard deviation), r (95 % repeatability limit, within a laboratory), and R (95 % reproducibility limit between laboratories) are used as specified in Practice E177. The temperature of samples influences shock attenuation with lower *g*-max values occurring as temperature increases. Room temperatures among the laboratories ranged from 20 to 23°C and no doubt contributed to the magnitude of the reproducibility limit. Differences in *g*-max at 20°C, however, ranged from 9 to 14 (avg = 11) and at 21°C ranged from 8 to 14 (avg = 11) when all six surfaces are considered. Most of the variability among laboratories, therefore, was due to the operator and test equipment.

12.4 *Bias*—The bias for these measurements is undetermined because there is no reference value available for the materials used.

13. Keywords

13.1 Clegg tester; *g*-max; impact attenuation; impact soil tester; impact test hammer; impact value; natural turf; playing surface system; soil; turfgrass

TABLE 1 G_{max} on Test Surfaces—Precision Statistics

Material	$\bar{x}$	s_r	s_R	r	R
A	50.8	1.134	4.042	3.2	11.3
B	53.8	0.666	4.502	1.9	12.6
C	76.2	1.128	4.911	3.2	13.8
D	88.3	2.390	6.821	6.7	19.1
E	110.6	0.695	5.474	1.9	15.3
F	281.5	3.379	9.010	9.5	25.2

[4] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:F08-1003.

APPENDIX

(Nonmandatory Information)

X1. DIAGRAM OF TEST EQUIPMENT

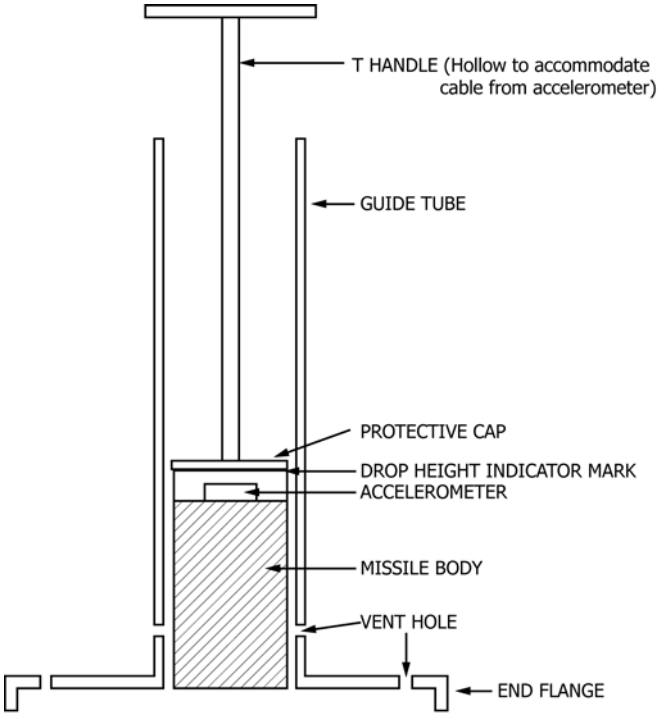

FIG. X1.1 Diagram of Lightweight Portable Apparatus

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