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An American National Standard

Standard Specification for Impact Attenuation of Turf Playing Systems as Measured in the Field[1]

This standard is issued under the fixed designation F1936; 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.

INTRODUCTION

The impact attenuation of turf playing systems can be measured in a laboratory, but such tests are often conducted under optimal or tightly controlled conditions. To accurately assess the impact attenuation an athlete will encounter on an installed field, that specific field must be tested *in situ*. That objective was the impetus for the development of this specification. Initially, the stated scope of the specification was limited to measuring the impact attenuation of North American football fields. The scope of the current revision encompasses a broader range of sport-specific field configurations and a protocol for conducting tests on multi-sport fields.

1. Scope

1.1 This specification establishes an *in situ* test method and maximum impact attenuation value for all types of turf playing systems and for a number of sport-specific field layouts. It also includes a protocol for determining test point locations on fields that are lined for multiple sports.

1.1.1 Turf playing systems may be located outdoors or indoors, and typically include field areas within the in-bounds lines and areas outside the in-bounds lines extending to sport-specific limit lines; areas where an athlete should expect to encounter impact attenuation performance that complies with this specification.

1.1.2 Site-specific conditions may exist wherein non-turf surface materials, such as track surfacing and/or covers over subsurface structures, are found within the boundaries of the limit lines. These alternate surface materials are not included in the scope of this specification.

1.2 This specification establishes a method for reporting test results and identifying areas within an existing turf playing system where impact attenuation measurements exceed required threshold values.

1.3 Nothing in this specification is intended to impose limitations on what fields can be tested, or how a particular field can be used. Test providers can adapt the procedures and guidelines contained herein to tests performed on any turf playing system.

1.4 This specification does not imply that an impact-related injury cannot be incurred if a turf playing system complies with its *g*-max performance requirement.

1.5 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.6 *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]

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

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

F1551 Test Methods for Comprehensive Characterization of Synthetic Turf Playing Surfaces and Materials

F1702 Test Method for Measuring Impact-Attenuation Characteristics of Natural Playing Surface Systems Using a Lightweight Portable Apparatus

F2650 Terminology Relating to Impact Testing of Sports Surfaces and Equipment

[1] This specification is under the jurisdiction of ASTM Committee F08 on Sports Equipment, Playing Surfaces, and Facilities and is the direct responsibility of Subcommittee F08.65 on Artificial Turf Surfaces and Systems.

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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.

2.2 *ISO Standard:*
ISO 6587 Paper, board and pulps – Determination of conductivity of aqueous extracts[3]

NOTE 1—Additional references are listed at the end of this specification.

3. Terminology

3.1 *Definitions:* Except as noted, definitions in this standard are in accordance with Terminology F2650.

3.1.1 *abnormal drop*—any drop of the missile which, due to operator or equipment problem(s) or uncertainty, results in a reading which is questionable.

3.1.2 *average g-max*—sum of the *g*-max of the second and third drops divided by two and rounded to the nearest whole number.

3.1.3 *combination turf system*—a turf playing system consisting of a natural turf surface which is enhanced by use of synthetic elements such as synthetic turf substructures, excluding water/drainage systems and single layer mesh fabrics, which are used for the sole purpose of soil stabilization.

3.1.4 *drop test*—a set of three successive drops of the impact missile at a test point, where each drop has been performed and recorded in accordance with prescribed guidelines.

3.1.5 *infill turf system*—a turf playing system having a long pile height and one or more substances in the face of the fabric to provide desired performance properties. Infill materials can include sand, rubber, other substances, or combinations thereof.

3.1.6 *impact velocity*—the velocity of the missile as it impacts the turf playing system.

3.1.7 *limit lines*—limits beyond the in-bounds boundaries that represent the extent to which the out-of-bounds areas should remain free of hazards and obstructions, and where an athlete may anticipate consistent surface characteristics. These limits are defined by the appropriate governing body or regulating standard for each specific sport.

3.1.8 *natural turf system*—a turf playing system which is comprised of living grass or similar plant materials which are rooted in soil.

3.1.9 *pile*—a surface texture composed of many individual thin strands or groups of strands bound to a backing fabric in a repetitive array.

3.1.10 *pile layover*—a horizontal motion of the pile under the influence of impact.

3.1.11 *restraining ring*—a rigid circular device with a smooth or polished surface, creating little or no friction, used to restrict the horizontal movement of the missile at impact.

3.1.12 *synthetic turf system*—a composite of synthetic contact surface material, any fill material used in the contact surface, energy absorbing material, fabric layers, adhesives, if any, and other constructed layers (as applicable to the individual system).

3.1.13 *test point*—a location on the turf playing system at which a series of measurements is taken.

3.1.14 *theoretical drop height*—the drop height (*h*) that, under standard conditions, would result in an impact velocity equal to a missile's measured impact velocity (*Vo*).

4. Summary of Test Method

4.1 Turf playing systems are tested according to this specification and Test Method F355, Procedure A. A theoretical drop height of 24 in. (61 cm), as measured from the bottom of the missile face to the top of the turf playing system, shall be used. At each test point, the impact missile is dropped onto the turf playing system three times, with an interval of 1.0 ± 0.5 min (60 ± 30 s) between successive drops. The *g*-max value for each drop is recorded and reported. Following the third drop, the average *g*-max value for the test point is calculated and reported.

5. Significance and Use

5.1 Data obtained from the use of this specification are indicative of the impact attenuation performance of individual test points on an installed turf playing system. The data may be used to make comparisons between values measured in accordance with this specification and performance requirements herein or elsewhere specified. Data may also be used to determine the need for maintenance and or replacement of the turf playing system.

6. Performance Requirements

6.1 When tested in accordance with this specification, the average *g*-max at each test point shall be less than 200 *g*'s.

6.2 If a turf playing system is tested in accordance with this specification, and the reported average *g*-max of one or more test points is equal to or greater than 200 *g*'s, the turf playing system should be brought into compliance and should not be used in the interim.

6.3 Nothing in this specification is intended to keep an owner, architect, engineer or other specifier from establishing more stringent performance requirements for a turf playing system. However, reports prepared in accordance with this specification shall assess performance per the requirements described in 6.1 and 6.2.

7. Test Apparatus

7.1 The impacting missile shall be cylindrical with a circular, flat, metal, impacting surface. It shall weigh 20 lb (9.1 kg), and have a 20 in.^{2} (129 cm^2) surface face with the impacting edges slightly beveled to eliminate sharp edges. The design of the missile shall provide for mounting the accelerometer within ±1° of the vertical axis of the missile, and allow the missile to achieve a velocity of 11.35 ± 0.56 ft/s (3.46 ± 0.17 m/s) (referenced in Section 27 of Test Methods F1551 as the velocity corresponding to a theoretical drop height of 24 in. (61 cm) at sea level) upon impact from the drop height.

7.2 To restrict the influence of pile layover, the test equipment shall be designed to include a rigid restraining ring with a smooth or polished surface, creating little or no friction,

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

having an interior dimension not to exceed the diameter of the missile by more than 0.039 in. (1 mm). The ring shall be securely mounted horizontal to the surface such that a minimum of ¼ of the missile shall freely pass through it prior to striking the surface, ensuring a vertical impact and precluding the missile's rebound onto the top of the ring. Other guidance systems can be utilized, provided they do not allow lateral movement greater than 0.039 in. (1 mm) upon impact and rebound of the missile.

7.3 The test equipment shall have sufficient stability to eliminate undesirable vibrations in the apparatus which might be recorded on the acceleration-time curve. It shall also allow sufficient vertical fall for the missile to achieve a velocity corresponding to a theoretical drop height of 24 in. (61 cm).

7.4 The signal from the acceleration transducer shall be conditioned with a low pass filter: complying to Channel Class 1000 as specified in Specification F1292 (ISO 6587).

7.5 The acceleration recording system must be capable of accurately resolving the deceleration to a minimum of ±1 % of true value.

7.6 The acceleration transducer must be capable of withstanding impacts of at least 1000 *g* without damage.

7.7 The minimum required system sampling rate is 20 000 Hz.

7.8 The test equipment shall be capable of visually displaying and recording the acceleration-time curve of each drop.

NOTE 2—The Clegg Hammer, as defined in Test Method F1702, is not an appropriate device for testing under this specification. Results obtained with a Clegg Hammer and subsequently adjusted by conversion factors or regression equations are not appropriate for inclusion in a report prepared in accordance with this specification.

8. Test Point Locations

8.1 The following sections describe suggested test point locations for each listed field configuration. The descriptions are supplemented by accompanying illustrations. The number of test points listed for each field configuration constitutes a minimum requirement. As noted in 8.11, additional points may be tested.

8.1.1 On fields lined for multiple sports, the selection of test point locations will be determined by the sport which appears first on the following list: football (American football, Canadian football, and rugby), soccer, men's lacrosse, women's lacrosse, baseball, softball, field hockey.

8.1.2 Actual drop sites may be located anywhere within a 36 in. (91 cm) radius of a described test point location. Deviations that exceed this requirement must be recorded as site abnormalities, per 11.1.15.

8.1.3 This specification cannot anticipate all possible field configurations. Persons using it are expected to select the most appropriate set of test points for the field being tested, from among the options specified below.

8.2 *Football (American football, Canadian football, and rugby) (see* Fig. 1*):*

8.2.1 *Point 1*—Goal Line, End A, center of field;

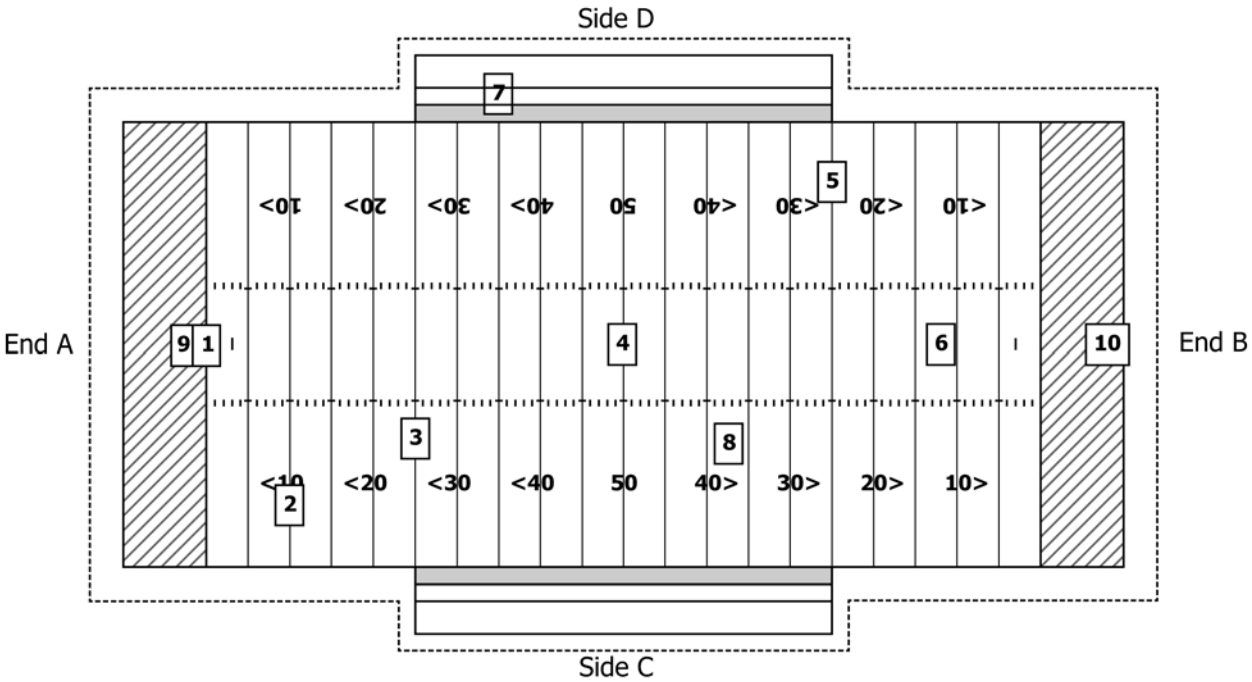
8.2.2 *Point 2*—10 Yard Line, End A, 63 ft from center of field to Side C;

8.2.3 *Point 3*—25 Yard Line, End A, 40 ft from center of field to Side C;

8.2.4 *Point 4*—Center of the field;

8.2.5 *Point 5*—25 Yard Line, End B, 63 ft from center of field to Side D;

8.2.6 *Point 6*—12 Yard Line, End B, center of field;



NOTE 1—Test points 7 and 8 are shown for information purposes only. Actual locations are selected at the time of the test and may vary from those illustrated.

FIG. 1 Test Point Locations for North American Football

8.2.7 *Point 7*—A test point selected by the tester, with the objective of identifying and testing a high-wear area located within the limit lines but outside the in-bounds lines;

8.2.7.1 Football limit lines are typically 12 ft beyond the in-bounds lines.

8.2.8 *Point 8*—A test point selected by the tester, with the objective of identifying and testing an area within the limit lines (to include the in-bounds area) that may have different impact attenuation performance than points previously tested;

8.2.9 *Point 9*—6 ft from the Goal Line to the back of the End Zone, End A, center of field;

8.2.10 *Point 10*—6 ft from the back of the End Zone to the Goal Line, End B, center of field.

8.2.11 If the field is lined for Canadian football or rugby and not for American football, refer to 8.9.1 for instructions regarding test point placement.

8.3 *Soccer (see* Fig. 2*):*

8.3.1 *Point 1*—Penalty Mark, End A, center of field;

8.3.2 *Point 2*—Corner of Penalty Area at End A and closest to Touch Line C;

8.3.3 *Point 3*—75 ft from Halfway Line to End A, 40 ft from center of field to Touch Line C;

8.3.4 *Point 4*—Center Mark;

8.3.5 *Point 5*—75 ft from Halfway Line to End B, 63 ft from center of field to Touch Line D;

8.3.6 *Point 6*—½ the distance from Penalty Arc to leading edge of Penalty Area at End B, center of field;

8.3.7 *Point 7*—A test point selected by the tester, with the objective of identifying and testing a high-wear area located anywhere within the limit lines, but outside the in-bounds lines:

8.3.7.1 Limit lines are 10 ft beyond the in-bounds lines on high school soccer fields, and 20 ft beyond the in-bounds lines on NCAA soccer fields.

8.3.8 *Point 8*—A test point selected by the tester, with the objective of identifying and testing a point within the limit lines (to include the in-bounds area) that may have different impact attenuation performance than points previously tested;

8.3.9 *Point 9*—3 ft from Goal Line to Halfway Line, End A, center of field;

8.3.10 *Point 10*—15 ft from Goal Line to Halfway Line, End B, center of field.

8.3.11 If the field is less than 300 ft in length or less than 120 ft in width, or both, refer to 8.9.2.

8.4 *Men's Lacrosse (see* Fig. 3*):*

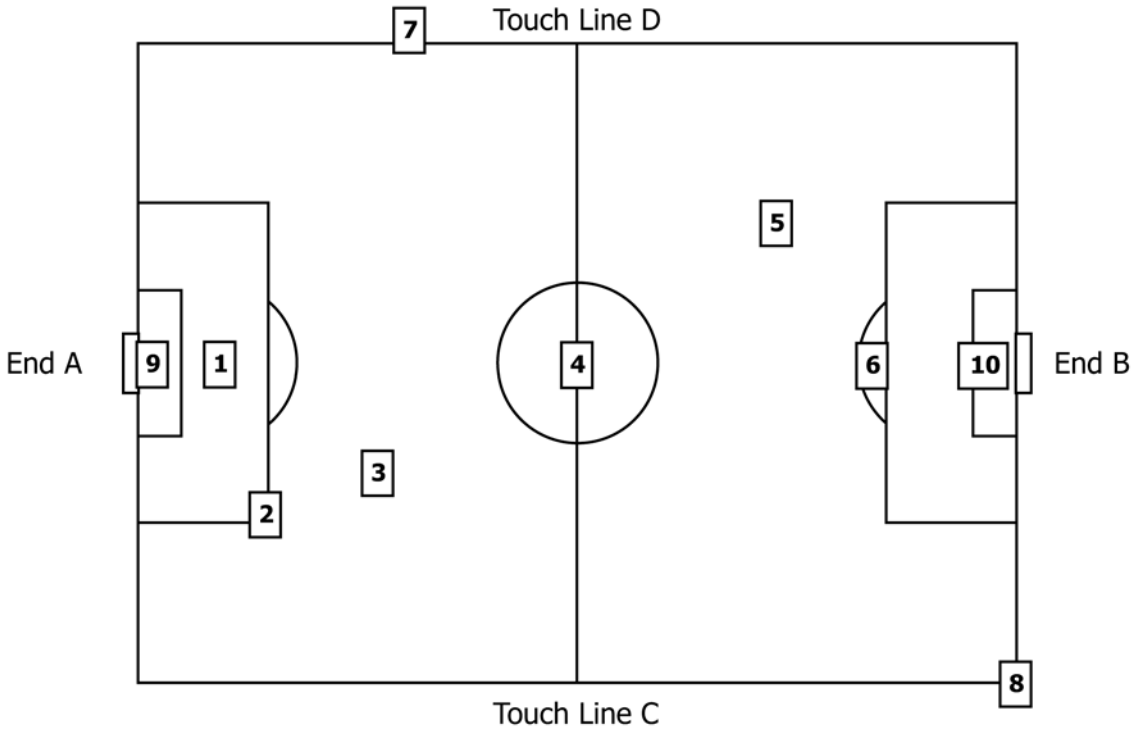
8.4.1 *Point 1*—25 ft from Goal Line to End Line, End A, center of field;

8.4.2 *Point 2*—63 ft from mid-point of Goal Line to Sideline C, End A;

8.4.3 *Point 3*—75 ft from Center Line to End A, 40 ft from center of field to Sideline C;

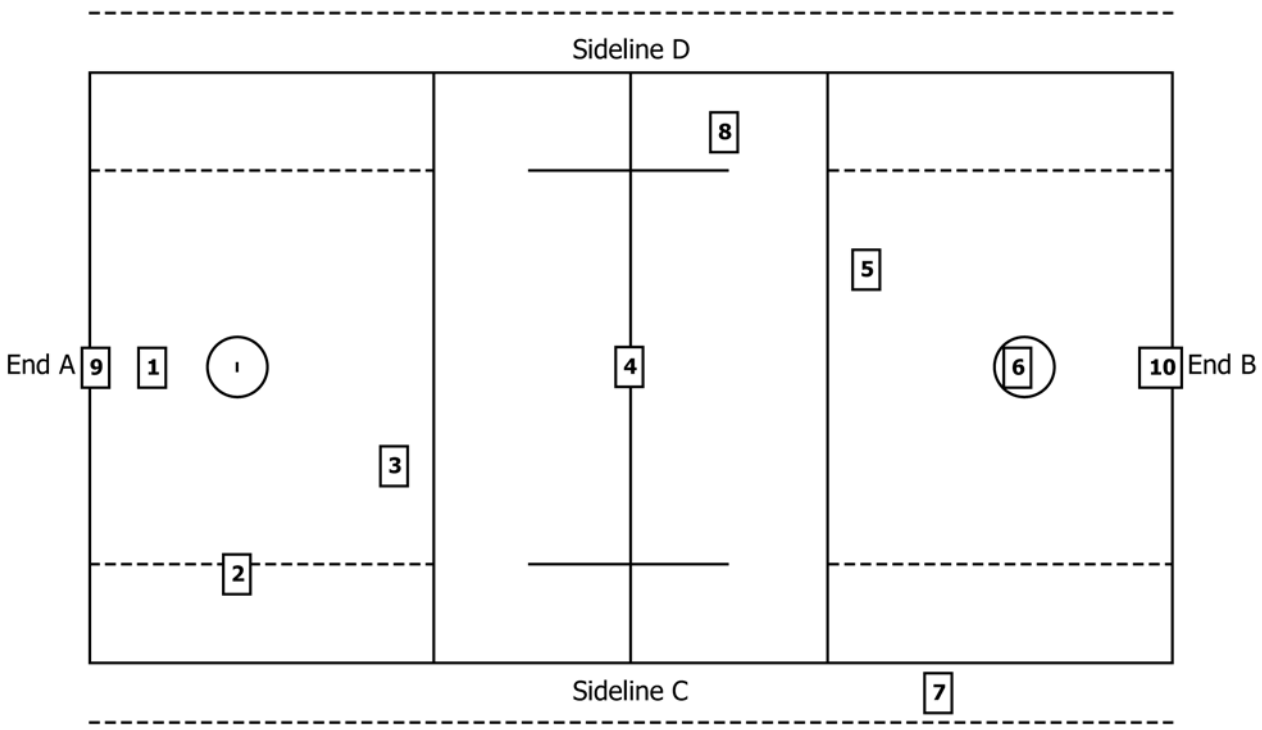
8.4.4 *Point 4*—Center of the field;

8.4.5 *Point 5*—75 ft from Center Line to End B, 63 ft from center of field to Sideline D;



NOTE 1—Test points 7 and 8 are shown for information purposes only. Actual locations are selected at the time of the test and may vary from those illustrated.

FIG. 2 Test Point Locations for Soccer



NOTE 1—Test points 7 and 8 are shown for information purposes only. Their locations are selected at the time of the test.

FIG. 3 Test Point Locations for Men's Lacrosse

8.4.6 *Point 6*—3 ft from Goal Line to Center Line, End B, center of field;

8.4.7 *Point 7*—A test point selected by the tester, with the objective of identifying and testing a high-wear area located anywhere within the limit lines, but outside the in-bounds lines;

8.4.7.1 No limit lines are specified for men's lacrosse fields. Use the 18 ft width of the Coach's Area as the maximum distance from the inbounds lines for test points 7 and 8.

8.4.8 *Point 8*—A test point selected by the tester, with the objective of identifying and testing a point within the limit lines (to include the in-bounds area) that may have different impact attenuation performance than points previously tested;

8.4.9 *Point 9*—3 ft from the End Line to the Center Line, End A, center of field;

8.4.10 *Point 10*—3 ft from the End Line to the Center Line, End B, center of field.

8.5 *Women's Lacrosse (see* Fig. 4*):*

8.5.1 *Point 1*—3 ft from Goal Line to Center Line, End A, center of field;

8.5.2 *Point 2*—30 ft from Goal Line at End A to Center Line, 63 ft from center of field to Side C;

8.5.3 *Point 3*—75 ft from Goal Line at End A to Center Line, 40 ft from center of field to Side C;

8.5.4 *Point 4*—Center of the field;

8.5.5 *Point 5*—75 ft from Goal Line at End B to Center Line, 63 ft from center of field to Side D;

8.5.6 *Point 6*—3 ft from 8-Meter-Arc to Goal Line, End B, center of field;

8.5.7 *Point 7*—A test point selected by the tester, with the objective of identifying and testing a high-wear area located anywhere within the boundary lines but outside the lined area of the field;

8.5.7.1 Limit (boundary) lines on women's lacrosse fields are variable. The location of the limit lines will be determined by conditions at each test site.

8.5.8 *Point 8*—A test point selected by the tester, with the objective of identifying and testing a point within the boundary lines (including the field of play) that may have different impact attenuation performance than points previously tested.

8.5.9 *Point 9*—3 ft from the End Line at End A to Center Line, center of field;

8.5.10 *Point 10*—3 ft from the End Line at End B to Center Line, center of field.

8.6 *Field Hockey (see* Fig. 5*):*

8.6.1 *Point 1*—3 ft from Goal Line to Center Line, End A, center of the field;

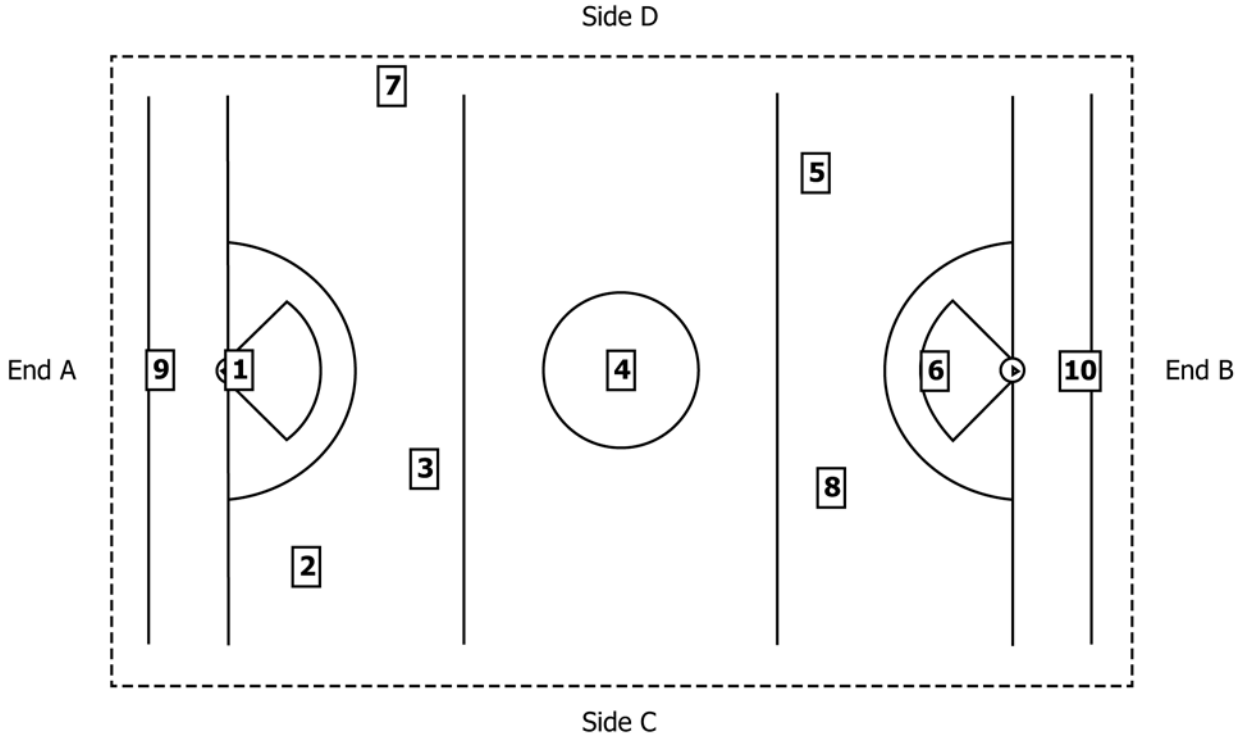
8.6.2 *Point 2*—30 ft from Goal Line at End A to Center Line, 63 ft from center of the field to Sideline C;

8.6.3 *Point 3*—25 Yard Line, End A, 40 ft from center of field to Sideline C;

8.6.4 *Point 4*—Center of the field;

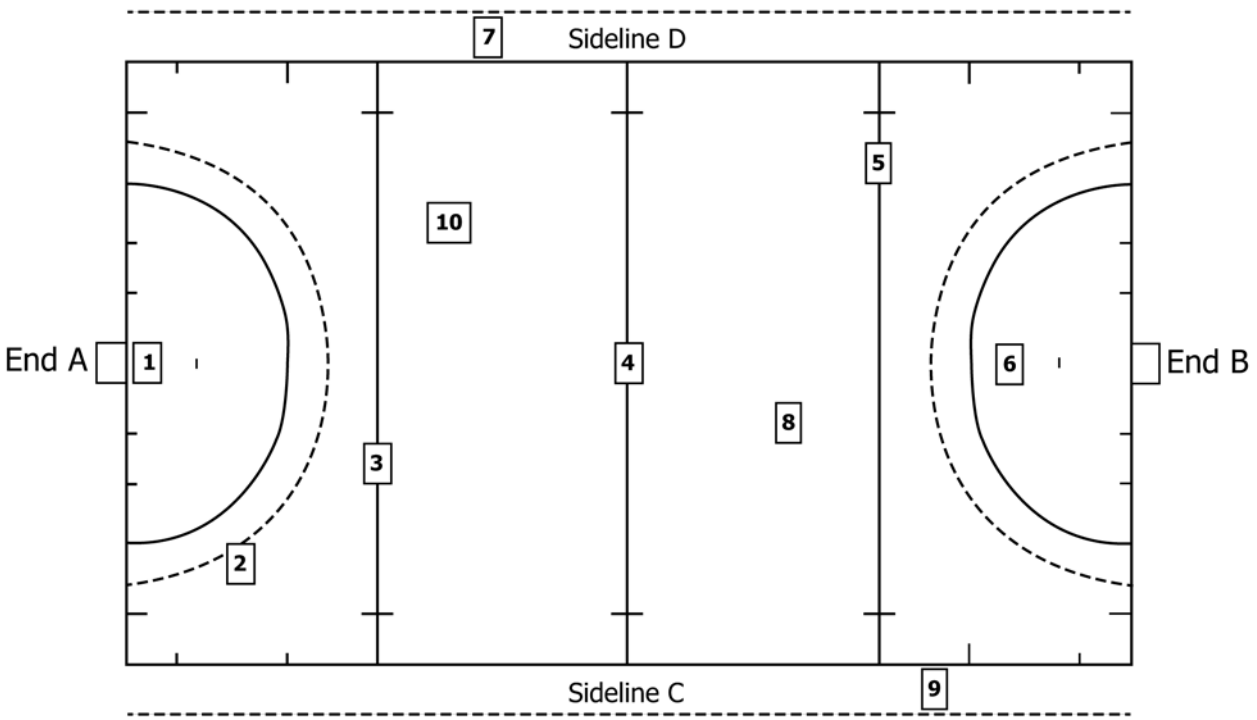
8.6.5 *Point 5*—25 Yard Line, End B, 63 ft from center of field to Sideline D;

8.6.6 *Point 6*—12 ft from edge of Striking Circle to Goal Line, End B, center of field;



NOTE 1—Test points 7 and 8 are shown for information purposes only. Their locations are selected at the time of the test and may vary from those illustrated.

FIG. 4 Test Point Locations for Women's Lacrosse



NOTE 1—Test points 7, 8, 9, and 10 are shown for information purposes only. Their locations are selected at the time of the test and may vary from those illustrated.

FIG. 5 Test Point Locations for Field Hockey

8.6.7 *Point 7*—A test point selected by the tester, with the objective of identifying and testing a high-wear area located anywhere within the limit lines, but outside the in-bounds lines;

8.6.7.1 Limit lines are 15 ft outside the in-bounds lines on field hockey fields.

8.6.8 *Point 8*—A test point selected by the tester, with the objective of identifying and testing a point within the limit lines (to include the in-bounds area) that may have different impact attenuation performance than points previously tested;

8.6.9 *Point 9*—A test point selected by the tester, with the objective of identifying and testing a high-wear area located anywhere within the limit lines, but outside the in-bounds lines;

8.6.10 *Point 10*—A test point selected by the tester, with the objective of identifying and testing a point within the limit lines (to include the in-bounds area) that may have different impact attenuation performance than points previously tested.

8.7 *Unlined Fields (see* Fig. 6*):*

8.7.1 *Point 1*—145 ft from mid-point of base line to End A, on base line;

8.7.2 *Point 2*—124 ft from mid-point of base line to End A, 63 ft from base line to Side C;

8.7.3 *Point 3*—75 ft from mid-point of base line to End A, 40 ft from base line to Side C;

8.7.4 *Point 4*—Mid-point of the base line;

8.7.5 *Point 5*—75 ft from mid-point of base line to End B, 63 ft from base line to Side D;

8.7.6 *Point 6*—114 ft from mid-point of base line to End B, on base line;

8.7.7 *Point 7*—A test point selected by the tester, with the objective of identifying and testing a high-wear area located anywhere within the turf playing system;

8.7.8 *Point 8*—A test point selected by the tester, with the objective of identifying and testing a point within the turf playing system that may have different impact attenuation performance than points previously tested.

8.7.9 *Point 9*—155 ft from mid-point of base line to End A, on base line;

8.7.10 *Point 10*—155 ft from mid-point of base line to End B, on base line.

8.7.11 If the turf playing system is not rectangular, or it is less than 310 ft in length or 126 ft in width, refer to 8.9.6.

8.8 *Baseball and Softball (see* Fig. 7*):*

8.8.1 *Point 1*—25 ft from the tip of Home Plate to the center of the Pitcher's Mound;

8.8.2 *Point 2*—6 ft from 1st Base to 2nd Base;

8.8.3 *Point 3*—3 ft from 2nd Base to 1st Base;

8.8.4 *Point 4*—4 ft from 3rd Base to 2nd Base;

8.8.5 *Point 5*—Perpendicular to the mid-point of 3rd Base Line, half the distance from the Base Line to the Left Field fence or boundary line;

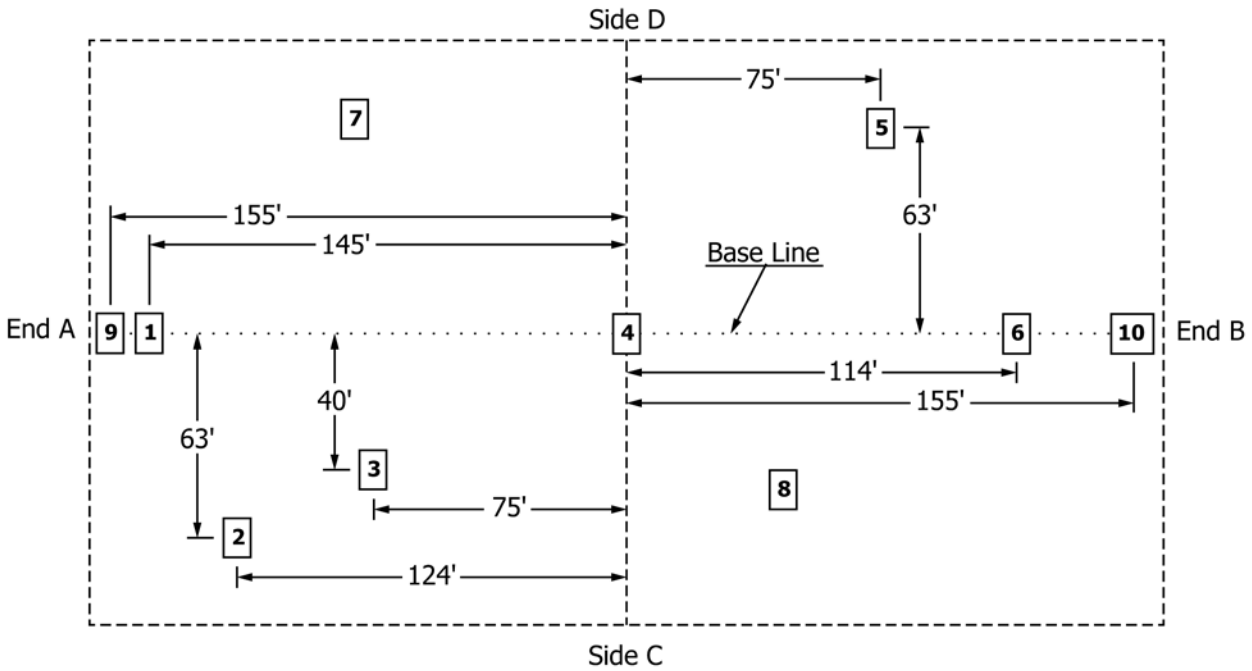
8.8.6 *Point 6*—Halfway from 2nd Base to the Center Field fence or boundary line, in line with Home Plate;

8.8.7 *Point 7*—Perpendicular to the mid-point of 2nd Base Line, half the distance from the Base Line to the Right Field fence or boundary line;

8.8.8 *Point 8*—20 ft from the Left Field fence or boundary line toward 2nd Base, in line with 1st Base;

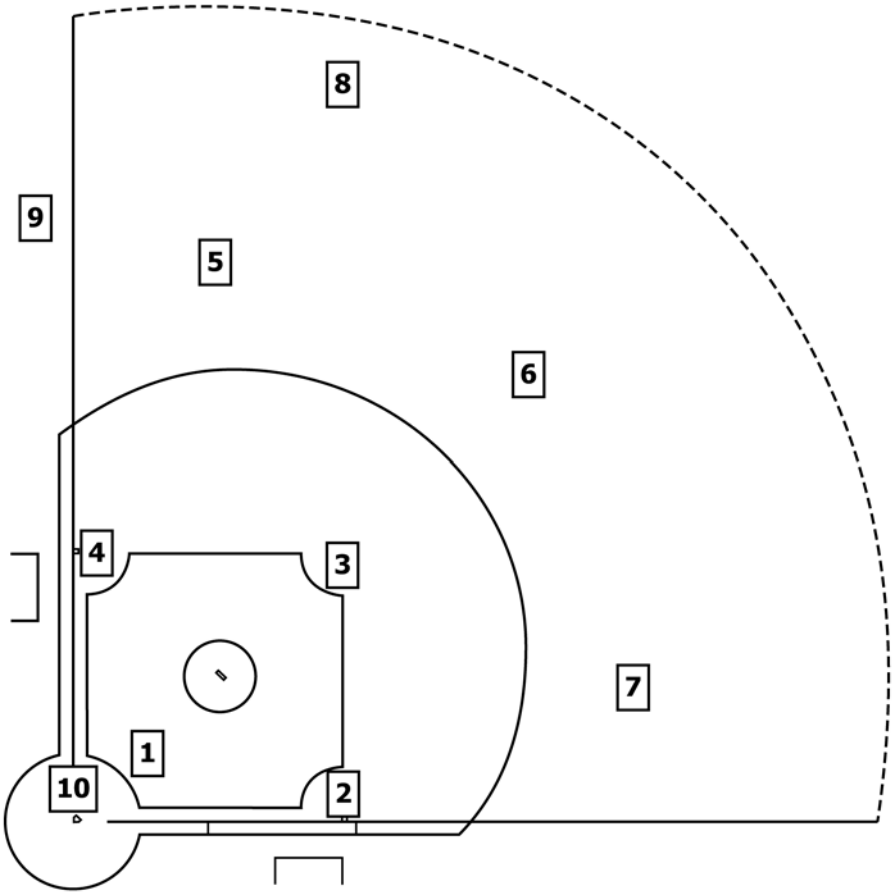
8.8.9 *Point 9*—A test point selected by the tester, with the objective of identifying and testing a high-wear area located anywhere in foul territory (to include infield areas that are outside the Base Lines);

8.8.10 *Point 10*—A test point selected by the tester, with the objective of identifying and testing a point within the turf



NOTE 1—Test points 7 and 8 are shown for information purposes only. Their locations are selected at the time of the test.

FIG. 6 Test Point Locations for Unlined Fields



NOTE 1—Test points 9 and 10 are shown for information purposes only. Their locations are selected at the time of the test and may vary from those illustrated.

FIG. 7 Test Point Locations for Baseball and Softball

playing system that may have different impact attenuation performance than points previously tested.

8.8.11 If any of the test points listed above is located on a "skinned" surface (dirt instead of turf), refer to 8.9.4.

8.8.12 If there is no outfield fence or boundary line, refer to 8.9.5.

8.9 *Exceptions:*

8.9.1 For fields configured exclusively for Canadian football or rugby, or where Canadian football or rugby has the highest relative priority (see 8.1.1), adjust the test point locations in 8.2 as follows:

8.9.1.1 On fields lined for Canadian football, move test points 1, 2, 3, 5, 6, and 9 15 ft toward the Center Line and move test point 10 45 ft toward the Center Line. (Test point 9 will no longer be located in the End Zone.)

8.9.1.2 On fields lined for rugby, position each test point using the dimensions described in 8.2 as applied to an American football field layout. For example, test point 1 will be located 150 ft from the Center Line to End A, center of field.

8.9.2 On soccer fields that are less than 300 ft in length or less than 120 ft in width, or both, make the following adjustments to the test point locations described in 8.3:

8.9.2.1 If the field is less than 300 ft in length, position test point 3 so it is ½ the distance from the Half Way Line to the leading edge of the Penalty Box at End A, and position test point 5 so it is ½ the distance from the Half Way Line to the leading edge of the Penalty Box at End B.

8.9.2.2 If the field is less than 120 ft in width, position test point 2 so that it is ¼ the distance from Touch Line C to center of field.

8.9.3 On baseball or softball fields where there are multiple infield configurations (base path options) the tester will select one of the configurations as the basis for locating the test points. The report will note the configuration selected.

8.9.4 On baseball or softball fields where some or all of the infield is "skinned" (dirt instead of turf) select alternate locations for test points 1, 2, 3 and 4, as appropriate. ("Skinned" surfaces are not included in the scope of this specification.)

8.9.5 On baseball or softball fields where there is no outfield fence or other clear indication of the boundary of the outfield turf, select and record locations for test points 5, 6, 7, and 8 that are appropriate to the site. Note the absence of an outfield boundary as an exception per 11.1.15.

8.9.6 In cases where a field is unlined, the tester will utilize the test points described in 8.7. To facilitate that effort, Fig. 6 depicts the location of each test point relative to a base line that is parallel to the long axis of the field and which bisects the ends of a rectangular field. Locate test point 7 anywhere within

the turf playing system. The fact that the field is unlined will be noted as an exception, per 11.1.15.

8.9.6.1 If the unlined field is not rectangular, situate the base line as appropriate to the configuration of the test site.

8.9.6.2 When using the test points described in 8.7 on a field that is less than 310 ft in length or less than 126 ft in width, or both, adjust test point locations as necessary.

8.9.7 On fields where the area outside the in-bounds lines is inappropriate for testing, test points that are supposed to be outside the in-bounds lines will be positioned within the in-bounds area and noted as exceptions per 11.1.15.

8.10 This specification cannot anticipate all possible exceptions. Persons using the specification are expected to resolve unforeseen exceptions in a manner consistent with the procedures and objectives contained herein.

8.11 Additional test points may be selected by the tester or required by the client. Additional test points within prescribed limit lines shall be tested in accordance with this standard and shall be subject to performance requirements herein or elsewhere specified.

NOTE 3—Test point locations are intended to assess the overall condition and typical "wear points" of a field (see Figs. 1-7).

9. Test Procedure

9.1 Prior to each series of tests, at least one drop test, as defined in 3.1.4, will be performed on a reference surface with known impact attenuation performance. The results of the drop test(s) will be compared to the established value for the reference surface, to ensure that the test equipment is performing within acceptable limits. If the *g*-max value for the drop test(s) varies by more than ±5.0% from the *g*-max value established for the reference surface, the test equipment will not be used until such time as a subsequent drop test shows it is operating within the ±5.0% tolerance limit.

9.1.1 The drop test(s) should be conducted in a controlled setting to ensure that site conditions do not contribute to a "false negative" result. Ideally, the reference surface will always be tested on a smooth, level and dense concrete substrate.

9.2 Record basic data related to the test site and environmental conditions:

9.2.1 Record the general weather conditions for each day of testing (sunny, light rain, gusting wind, etc.).

9.2.2 Record the condition of the field as influenced by the weather (damp, dry, areas of standing water, ice, etc.).

9.2.3 Record test point locations with enough detail that each is fully and uniquely identified.

9.2.4 Record the orientation of the field so that End A can be identified.

9.3 If testing an infill turf system, record infill depth data for each test point. (This data can be collected prior to or during testing. If collected during testing, it should be recorded prior to the actual drop test.)

9.3.1 Infill depth shall be measured using an infill depth gauge or probe with a fixed shoe or plate capable of measuring to the nearest 1/32 in. or 1 mm. Make three measurements at each test point, within or immediately adjacent to the footprint of the test apparatus; calculate and report the average.

9.4 Set up the test apparatus and prepare it for use in accordance with the manufacturer's instructions.

9.5 After ensuring that each test point is free of debris, position the test apparatus and conduct the drop test.

9.5.1 Make three consecutive drops of the missile, at intervals of 1.0 ± 0.5 min (60 ± 30 s), at each test point location. Do not move the test equipment between consecutive drops. Record the data where:

H = drop height in ft (cm),
V = velocity, ft/s (m/s), and
g = acceleration of gravity, 386 in./s/s (9806 mm/s/s)

Display the acceleration time curve for each drop as it occurs. Check the displayed curve for signal abnormalities. (If signal abnormalities are observed, discard the results and determine and correct the cause(s) of the problem.) Should more than three drops be needed, relocate the test point within the allowable tolerance of 36 in. (91 cm) and start over. Disregard the previous drops for this test point.

9.6 Record data specific to each test point during testing:

9.6.1 Record the air temperature in the shade.

9.6.2 Record the playing system temperature. Use the procedure appropriate to the turf system being tested, as indicated in the following subsections:

9.6.2.1 *Synthetic Turf System with Resilient Padding*—Measure the temperature using a temperature probe inserted 0.5 in. (1.27 cm) below the fabric backing of the pile.

9.6.2.2 *Natural Turf System*—Measure the temperature using a temperature probe inserted 0.5 in. (1.27 cm) into the soil.

9.6.2.3 *Combination Turf System*—Measure the temperature per 9.6.2.2, except where a synthetic element prohibits measurement of surface temperature as specified. When this occurs, the measurement of surface temperature shall be made as close to the specified depth as possible and the deviation shall be recorded in the site abnormalities section of the test report.

9.6.2.4 *Infill Turf System*—Measure the temperature using a probe inserted 0.5 in. (1.27 cm) below the upper surface of the infill material.

9.6.3 Note if the test point is located on a line and, if so, the nature of the line (paint, chalk, permanent synthetic material, etc.). (If all lines on the field are of the same type, a single note will suffice.)

9.6.4 For natural and combination turf systems, record an estimate of the percentage of turf cover (50%, 90%, etc.) and the soil's moisture content (dry, damp, wet, saturated, etc.) at each test point.

NOTE 4—It has been reported that on natural turf and soil surfaces, soil compaction from successive impacts (using Test Method F355, Procedure A, and a theoretical drop height of 24 in. (61 cm)) altered *g*-max and depth of penetration.[4] This can also be influenced by soil bulk density, turf cover,

[4] Henderson, R.L., Waddington, D.V., Morehouse, C.A., "Laboratory Measurement of Impact Absorption on Turfgrass and Soil Surfaces" and Schmidt, R.C., et al, "Natural and Artificial Playing Fields: Characteristics and Safety Features," *ASTM STP 1073*, pp. 127-135.

and soil water content. To restrict these influences and the variation that might then occur between natural and artificial systems if an unspecified number of drops in one location were allowed, the number of successive drops permitted at any test point has been limited to three.

10. Calculation

10.1 *g-max*—Following each drop, determine (read) and record the maximum value of " *g*" observed in the time-deceleration history of the impact event.

10.2 *Average g-max*—After determining *g*-max for the third drop at each test point, calculate the sum of the *g*-max from the second and third drops, then divide the sum by two and round the result to the nearest whole number. The *g*-max from the first drop is disregarded.

11. Report

11.1 Report the following information:

11.1.1 Date the report was issued,

11.1.2 Name of the laboratory, company, or individual issuing the report,

11.1.3 Name and location of the test site,

11.1.4 The installation date or age of the turf playing system, if known (if not known, so note),

11.1.5 Date(s) of the test (if more than one day is required, list all dates involved and the reason(s) for the continuance),

11.1.6 Range of surface temperatures and air temperatures in °F (°C), general weather conditions during each day of testing, and overall weather-influenced field conditions as detailed in Section 9,

11.1.7 The sports for which the field is lined at the time of testing,

11.1.8 A general description of the turf playing system, including the type of system and the various layers of which it is comprised,

11.1.9 Name and version of the test method, equipment type, and procedure used,

11.1.10 A means of identifying End A of the field (per 9.2.4),

11.1.11 A detailed description of the location of each test point (per 9.2.3),

11.1.12 The surface temperature, percent of turf cover, soil moisture, and average depth of infill for each test point, as appropriate to the type of playing system being tested (see Section 9),

11.1.13 The drop height, impact velocity (feet per second or metres per second), and *g*-max value for each drop at each test point,

11.1.14 The average *g*-max value for each test point,

11.1.15 Description(s) of site abnormalities such as an unlined field, reduced field size, a flooded area, or any other condition(s) which lead to an out-of-tolerance test point location or deviation from procedures or requirements specified herein. Identify the test point(s) affected by each abnormality, and

11.1.16 *Conclusion*—State if, under the test conditions listed in the report, all test points met the requirement of <200 average *g*-max when tested in accordance with this specification; or that all test points met the requirement of <200 average *g*-max except test point(s) listed.

11.1.17 The test report shall include the following statement:

11.1.17.1 Test results reported herein reflect the performance of the points tested, at the time of testing and at the temperature(s) reported.

12. Keywords

12.1 average *g*-max; baseball; combination field system; drop test; field hockey; field testing; *g*-max; impact; impact attenuation; lacrosse; multi-sport; natural grass field system; North American football; shock absorbing; soccer; softball; synthetic turf field system; test point; infill turf system

APPENDIX

X1. Rationale

X1.1 According to historical data, the value of 200 *g*-max is considered to be a maximum threshold. Values of 200 *g*-max and above are considered values at which life threatening head injuries may be expected to occur.

X1.2 The test method incorporated into this specification (Procedure A of Test Method F355) has been used to test the impact attenuation of athletic fields for over 30 years. The development of the 2-ft fall-height method can be traced back to the Ford and GM crash-dummy tests of the 1960's, medical research papers from the 1960's and 1970's, and a Northwestern University study in which an accelerometer was fixed to the helmet of a middle line backer to measure impacts received during actual play. This study found the typical head-impact to be 40 ft/lb, which is equivalent to the impact generated by dropping a 20 lb missile from a height of 2 ft—the requirement specified in Procedure A of Test Method F355. For comparability and consistency, a set of standard test points was developed based on the experience of the task group in the areas of field testing and systems development. The maximum impact attenuation of <200 average *g*-max, as accepted by the U.S. Consumer Product Safety Commission, was adopted for use herein.

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