Designation: FXXXX – New Standard

Item 2

Rationale for Turf Playing system test using and E missile to measure impact attenuation in values of G and HIC

Currently there is ASTM F1936 for measuring impact attenuation of sports turf systems using the ASTM F355 A procedure and reporting results in g. The A missile is a 20lb flat missile with a surface area of 20 inches$_2$ and dropped with a velocity of 11.35 ft/s which is achieved with a drop from 24". The threshold for compliance to ASTM F1936 is the g value shall not exceed 200.

For a number of years and within the context of the publicity and awareness of traumatic brain injuries in sport, including impact with the sports field surfaces, there has grown a need to review the missile being used, the threshold for g and the inclusion of HIC that the change of missile allows. To this end FieldTurf has funded research by Biokinetics & Associates Inc. into the selection of the E missile and a discussion of the values of g and HIC that should become the thresholds. Data was presented to validate the use of the E missile through comparisons with the Hybrid III headform. ASTM F1292 Appendix X1.4 stipulates that the rigid E missile is not biofidelic and will produce somewhat higher scores for HIC and "the criteria established by this specification are more conservative than if a lifelike headform were used." This is important as it allows for head injury data available to be used in the development of g and HIC thresholds for this specification.

Data was presented to the F08.65 sub-committee on the risk of injuries at various values of g and HIC. A 50% risk of concussion in the NFL study as established at 80g in 2003, while later data from 2011 indicates concussions occurring at 105g ±27g. Automotive data indicates that values for skull fracture for the mid-sized adult male have a 5% risk at 180g, a 50% risk at 260g and 75% risk at 300g. For HIC, a value of 1000 is a 16% risk of AIS>4, severe, life-threatening with survival probable, while a value of 700 would result in a 5% risk of AIS>4 and 55% risk of AIS>3, serious injury. Scaling of the of the data to relate to all age groups to a 5% risk of AIS>4 would be 3 year old, 568 HIC and 175g, 6 year old, 723 HIC and 189g, 10 year old, 741 HIC and 189g, small female, 779 HIC and 193g, Mid-size male, 700 HIC and 180g, and large male 670 HIC and 175g.

The threshold that was selected by the task group for a field surface being compliant to this Standard was not to exceed 180g and 700 HIC.

The severity of the injury will be influenced by the velocity of the impact or the height from which the missile is dropped. This should be representative of the height or velocity from which a user of the turf is likely to impact the surface. Currently ASTM F1936 drops the A missile from a height of 24", resulting in a velocity of 11.35 ft/s. The task group has selected the 24" drop height as being the velocity for dropping the E missile.

Currently the ASTM F1936 requires the dropping of the A missile 3 times from the same height to the same location. This is consistent with other standards such as pole vault, wrestling mats, playground surfaces (ASTM F1292 and EN1177), etc. There is evidence that the rounded missile may cause the displacement of the infill or

loose materials in subsequent drops to the same location. Typically when three drops are performed at the same test point, the first drop is a conditioning drop and the second and third drops are averaged to provide a result that indicates a field in use, getting older or poorly maintained. The task group has decided for this Standard the test location should be selected and the actual test points would be within a 20" circle and at least 12" apart.

One facet of the research was to have ten testing laboratories owning an E missile to test fields with the E missile in predetermined locations and at heights ranging from 25cm to 175cm, moving the test point with each drop and there was only a single drop at test point. There was no comparison testing between the A and E missiles. There were both natural and synthetic surfaces tested during this process and there was an assumption that since the fields being tested were currently in use that they would have been acceptable and presumably met ASTM F1936. Since no F1936 testing was done, this cannot be confirmed. The results did indicate that natural turf fields that were in use performed significantly better for impact attenuation than the synthetic fields tested at all drop heights. It was determined that all natural turf fields would be under the 700 HIC up to a drop height of 150cm, while all synthetic fields where below the 700 HIC at 60cm and approximately 50% were below the 700 HIC at 75cm drop height and approximately 30% at 100cm drop height. For the g value of 180 the percentage passing was similar.

You are being presented with a first draft of a new standard to determine impact attenuation of turf playing systems, natural or synthetic for the sports of American Football, Soccer, Lacrosse, and Baseball and should provide an indication of the 5% risk of head injury at the AIS>4 level. There is also a test configuration for fields that are not lined. The missile (E) is smaller and less mass, dropped from the same height as the A missile and only once at each location. The g value has been reduced from F1936 from 200 to 180 and the threshold of 700 HIC has been added. We welcome your comments and trust this standard will move through the consensus process provided by ASTM and become a Standard in its own right and provide protection to the users of sports fields.

Date: September 1, 2016

To: Subcommittee F08.65

Tech Contact: Rolf Huber - rolf@everplay.com

Work Item #: WK55841

Ballot Action: New Standard ballot

Rationale: Following a number of years of research and consideration of the issues of head injury in sports fields and the need to have appropriate injury prevention it was determined that a specification was required to perform testing of the surface using an E missile as defined in ASTM F355-16. Inclusive in the specification is the establishment of a peak g value and HIC value for drops at a velocity that reflects the sport activity on the field

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

An American National Standard

This standard is issued under the fixed designation FXXXX; 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*. Since the mid-1990s the issue of prevention of head injuries have been a consideration in the protection of athletes. To this end research has been conducted to assist in the prevention of debilitating head injuries. To this end it is the objective of this specification to reduce the impact values that result from impacts with the surface as a result of play. In applying this specification the user must consider the age of the user of the field, the physical development and the intensity of play they will experience. Owners are encourage to use this information in the development of specifications, maintenance and end of life decisions. This specification can be used on synthetic and natural field surfaces and 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 The use of this specification is to limit the frequency and severity of serious or debilitating head injuries sustained when the upper body or head impacts with the playing surface to the extent possible taking into consideration body type, age, skill level, body orientation, etc. that could lead to an injury.

1.1.2 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 expects to encounter impact attenuation performance that complies with this specification.

1.1.3 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 and HIC performance requirement.

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[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..

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

2.2 *ISO Standard:*

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

ISO TR20183 Sports and other recreational facilities and equipment – Injury and safety definitions and thresholds – Guidelines for their inclusion in standards

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 three drops divided by three 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 *debilitating injury* – injury that diminishes or weakens the human body and has a legacy of greater than one month and that could be categorized as *abbreviated injury scale (AIS)* of 3 (serious, but not life-threatening) and would include injuries requiring surgery or concussions that require removal from play to medical attention.

3.1.5 *drop test*—a set of three successive drops of the impact missile around a test point from the same prescribed height, where each drop has been performed and recorded in accordance with prescribed requirements.

3.1.6 *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.

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

3.1.8 *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.

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

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

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

3.1.12 *serious injury* – acute physical injury requiring medical or surgical treatment or under the supervision of a qualified doctor or nurse provided in a hospital or clinic and includes injuries such as burns, fractures, lacerations, internal injury, injury to organ, concussion, internal bleeding, etc.

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

3.1.13 *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).

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

3.1.15 *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 E. A minimum theoretical drop height of 24 in. (61 cm), as measured from the bottom of the missile 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 3 impact sites shall be within a 20 in. (51cm) diameter circle and each drop of the series shall not be closer than 12 in. (30.5 cm) from each other. The *g*-max and HIC values for each drop are recorded and reported. Following the third drop, the average *g*-max and HIC value for the test point is calculated by averaging all three drops 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 180 *g*'s and the average HIC value shall be less than 700.

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 180 *g*'s or the average HIC value exceeds 700, the turf playing system shall be brought into compliance and shall 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 by lowering the impact values for g or HIC or increasing the drop height. 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 the "E" missile as described in the ASTM F355-16. The procedure for preparation, calibration and procedures to be performed prior to the commencement of a field test shall be as required in ASTM F355-16, E.

7.2 This is a hemispherical missile and for certain infills can displace the infill upon impact. Should this displacement occur the infill shall not be redistributed between drops.

7.3 The test equipment shall have sufficient stability to ensure that the three drops are performed from the identical height to the three positions on the turf. The system shall have the ability to ensure that the missile is suspended at the height specified.

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).

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

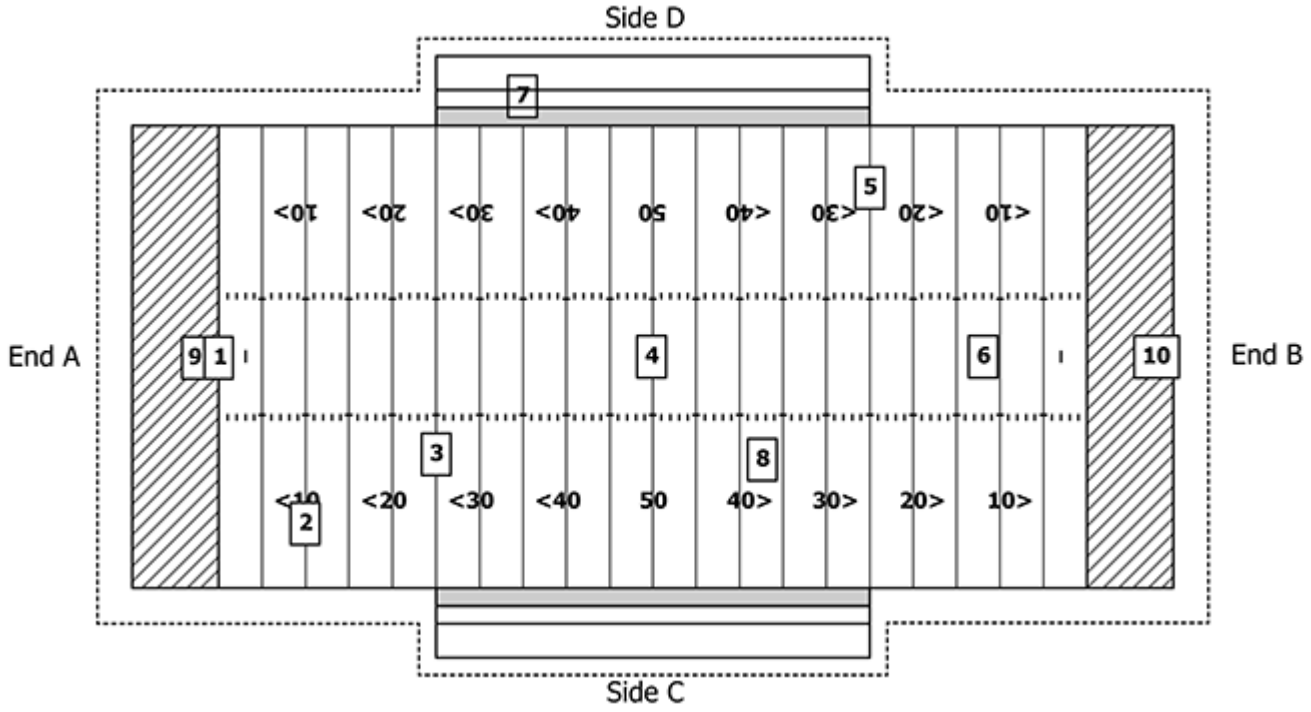
8.1 The following sections describe suggested test point locations for each listed field configuration. The descriptions are supplemented by accompanying illustrations. The number of test points listed for each field configuration constitutes a minimum requirement. As noted in 8.11, additional points 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 are 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 and Canadian football) (see* Fig. 1*):*



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

8.2.1 *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;

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.

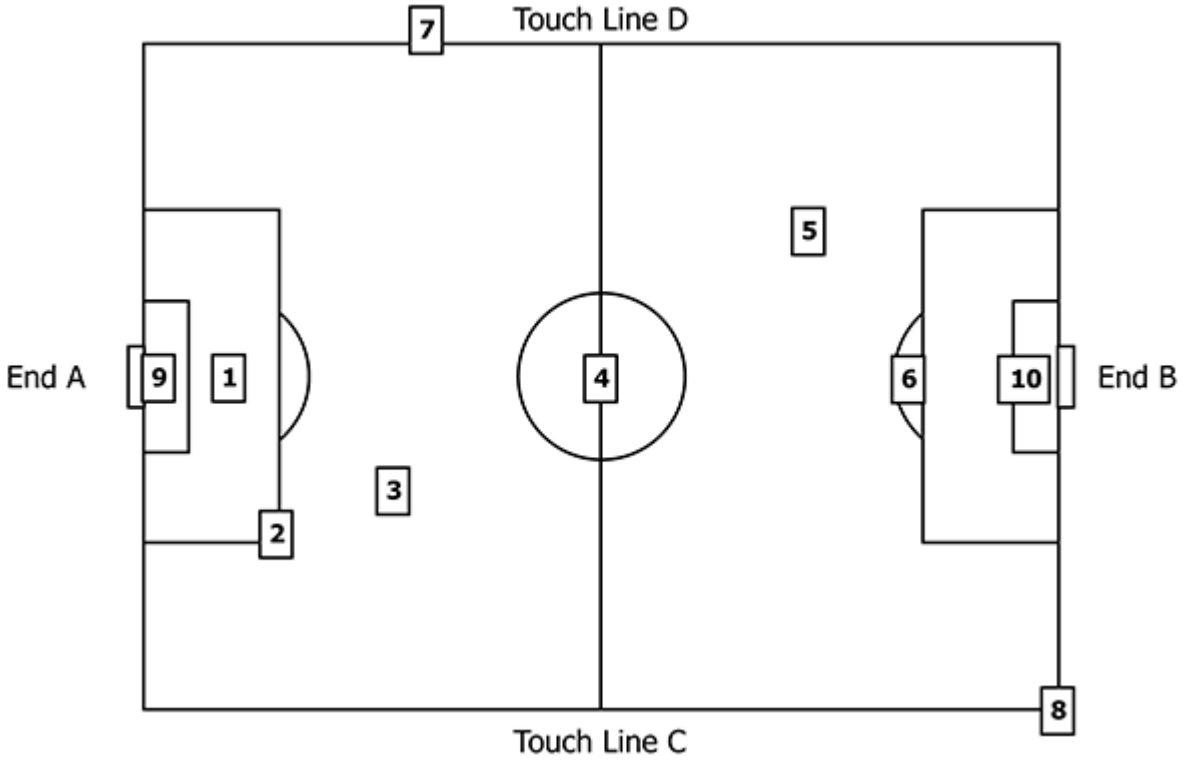
8.2.8 *Point 8*—A test point selected by the tester, with the objective of identifying and testing an area within the limit lines (to include the in-bounds area) that may have different impact attenuation performance than points previously tested;

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.

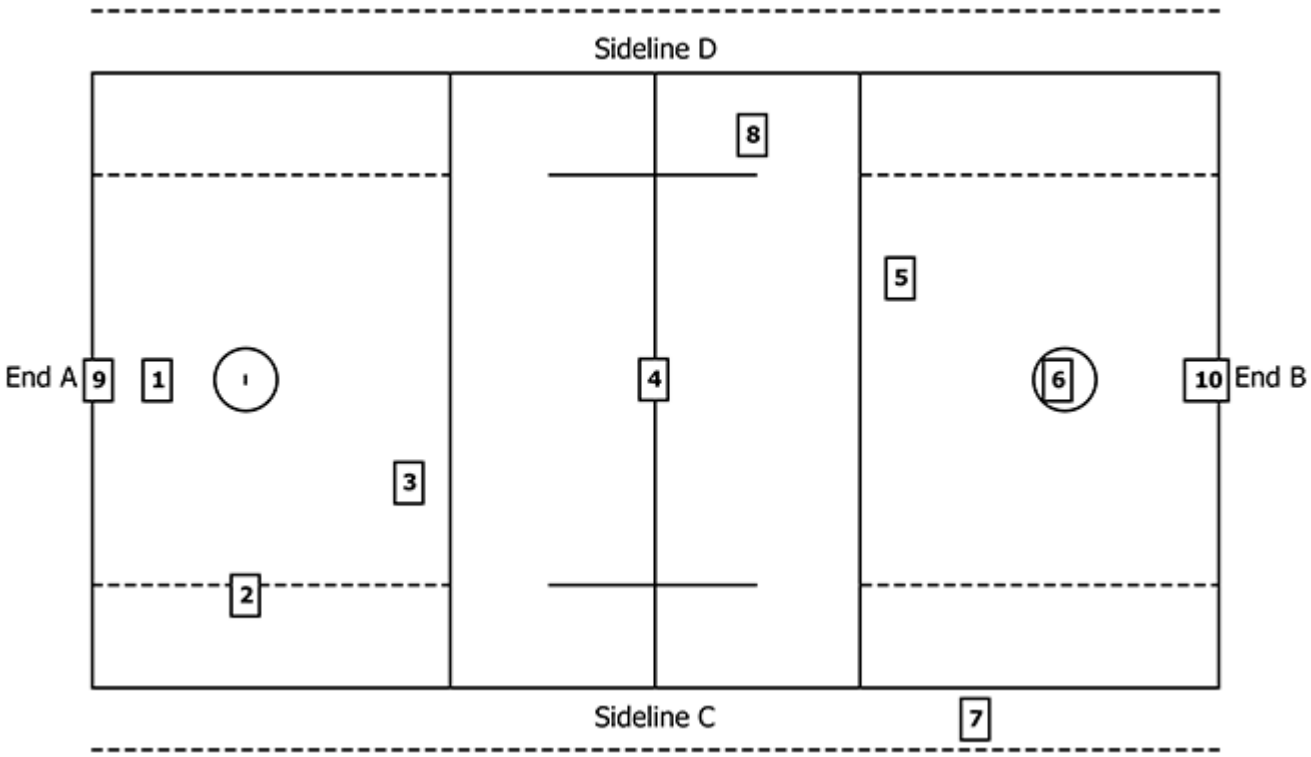
8.3 *Soccer (see* Fig. 2*):*



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

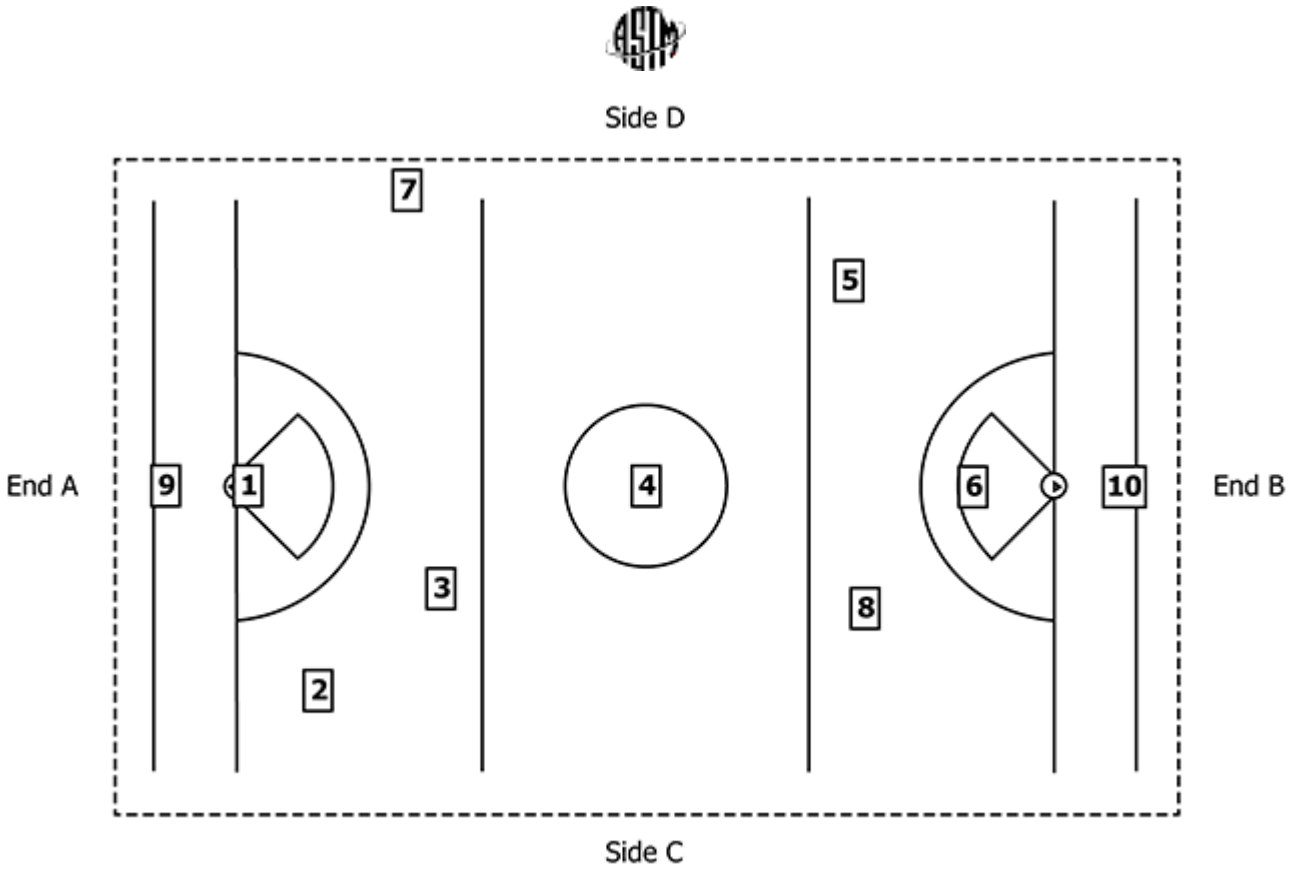
8.3.1 *Point 1*—Penalty Mark, End A, center of field;
8.3.2 *Point 2*—Corner of Penalty Area at End A and closest to Touch Line C;
8.3.3 *Point 3*—75 ft from Halfway Line to End A, 40 ft from center of field to Touch Line C;
8.3.4 *Point 4*—Center Mark;
8.3.5 *Point 5*—75 ft from Halfway Line to End B, 63 ft from center of field to Touch Line D;
8.3.6 *Point 6*—$^{1}/_{2}$ 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*):*



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

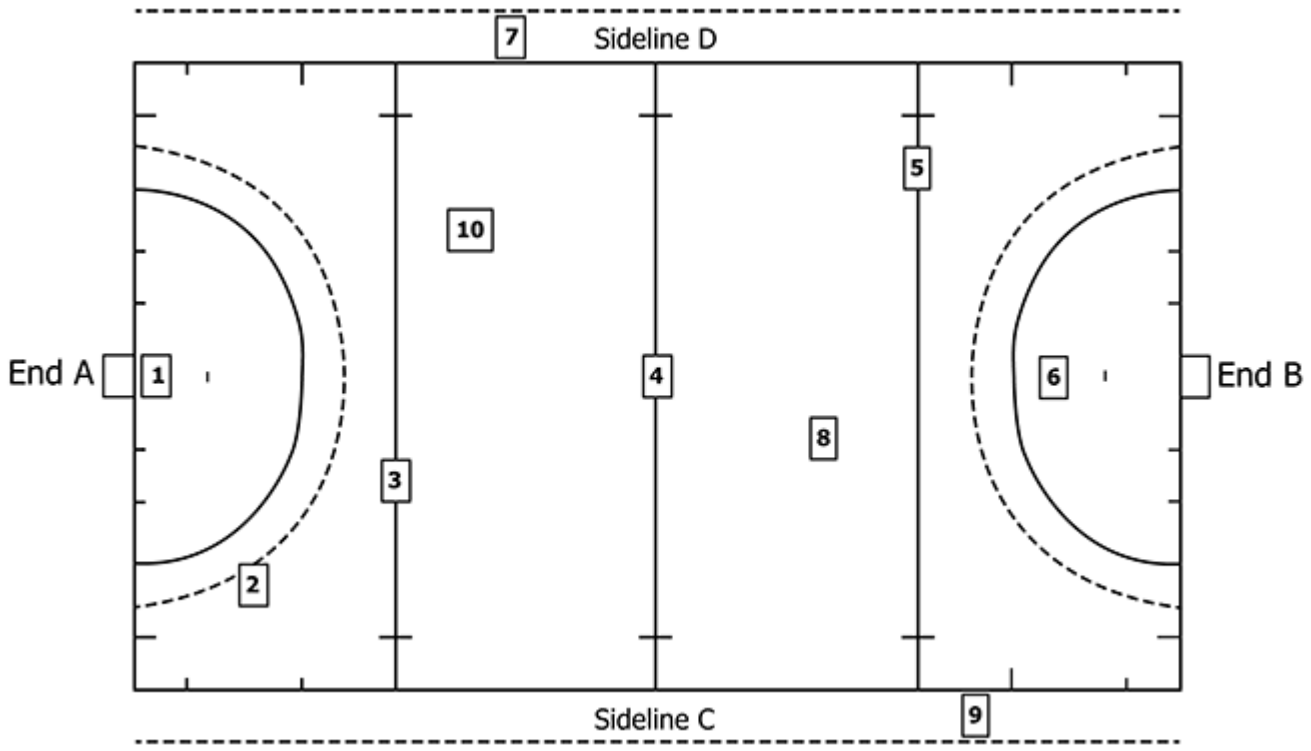
8.4.1 *Point 1*—25 ft from Goal Line to End Line, End A, center of field;
8.4.2 *Point 2*—63 ft from mid-point of Goal Line to Sideline C, End A;
8.4.3 *Point 3*—75 ft from Center Line to End A, 40 ft from center of field to Sideline C;
8.4.4 *Point 4*—Center of the field;
8.4.5 *Point 5*—75 ft from Center Line to End B, 63 ft from center of field to Sideline D;
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*):*



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

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*):*



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

8.6.1 *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;

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;

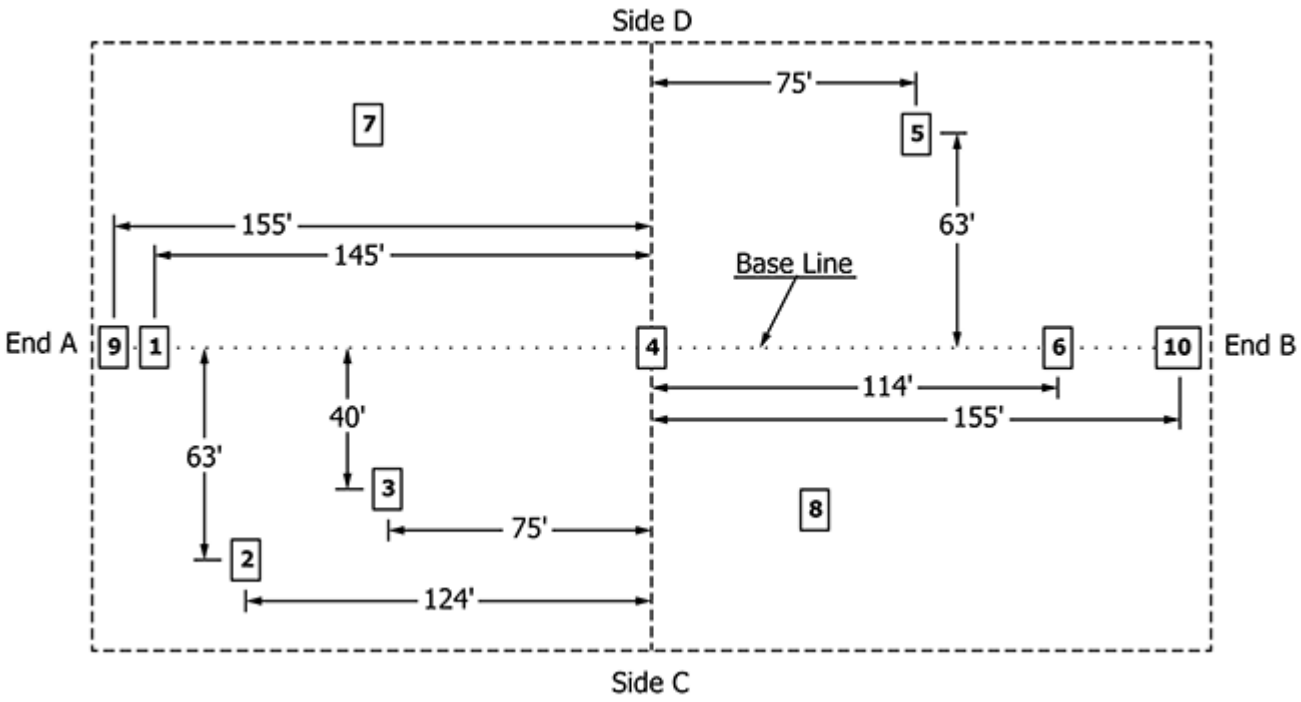
8.6.7.1 Limit lines are 15 ft outside the in-bounds lines on field hockey fields.

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.

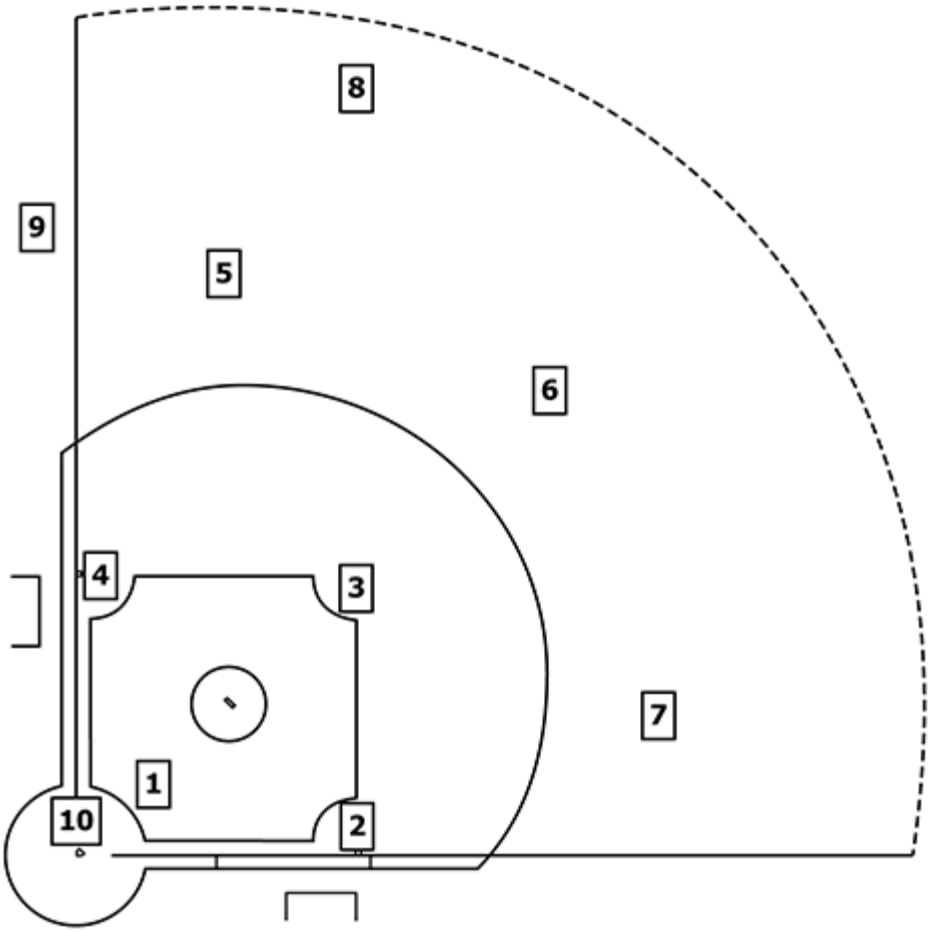
8.7 *Unlined Fields (see* Fig. 6*):*



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

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):*



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

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 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 $^{1}/_{2}$ 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 $^{1}/_{2}$ 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 $^{1}/_{4}$ 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, the test device will be prepared as prescribed in ASTM F355, E. 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 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) shall 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 a three prong infill depth gauge or probe with a fixed shoe or plate, having a contact area with the turf system of not less than 7 inches^2 (45 cm^2), placing no more than 2.0 psi (138.0 millibars) of pressure and 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 If testing a field with an energy absorbing material under the backing of the turf system, record the depth of the underlayment at each test point. (This data can be collected prior to or during testing and at the same time as the measuring of the infill depth.)

9.4.1 The underlayment depth shall be measured using a 3 prong depth tester with a fixed shoe or plate, having a contact area with the turf system of not less than 7 inches^2 (45cm^2), placing no more than 2.0 psi (138.0 millibars) of pressure and capable of measuring to the nearest $^1/_{32}$ in. or 1 mm. The 3 prongs shall be of sufficient strength to ensure penetration of the turf backing and penetration of the underlayment.

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

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

9.6.1 Make three consecutive drops of the missile, at intervals of 1.0 ± 0.5 min (60 ± 30 s), at each test point location. The test equipment is set up to ensure the drops are at the identical height and inside the 20 in. (51cm) diameter circle and not closer than 12 in. (30.5cm) to each other. Record the data where:

H = drop height in ft (cm),
V = velocity, ft/s (cm/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. (12.7 mm) 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. (12.7 mm) 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 E, 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, 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 all drops, then divide the sum by three and round the result to the nearest whole number.

10.3 *Average HIC* – After determining the HIC for the third drop at each test point, calculate the sum of the HIC from the all drops, then divide the sum by three and round the result to the nearest whole number.

11. Report

11.1 Report the following information:

[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.

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 centimeters per second), and *g*-max and HIC value for each drop at each test point,
11.1.14 The average *g*-max and HIC 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 <180 average *g*-max and HIC <700, when tested in accordance with this specification; or that all test points met the requirement of <180 average *g*-max and HIC <700 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. Precision and Bias

12.1 For precision statistics, refer to F1292.

13. Keywords

13.1 average *g*-max; HIC; 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

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