Designation: F 1551 – ~~94~~03

An American National Standard

Standard Test Methods for Comprehensive Characterization of Synthetic Turf Playing Surfaces and Materials[1]

This standard is issued under the fixed designation F 1551; 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 These test methods establish a recommended list of test methods to be used for the identification of physical property characteristics and comparison of the performance properties of synthetic turf systems or components for athletic and recreational uses, or both.

1.2 The test procedures included in these test methods apply as a group to the description of synthetic turf playing surfaces.

1.3 Some of the test procedures are specific for components of the synthetic turf system, and others apply to the complete synthetic turf playing surface.

1.4 Some of the test procedures are suitable only for the laboratory characterization of either components or the complete system; others are suitable for tests on installed sports fields; and some tests may be applied in both the laboratory and the field.

1.5 Reference to the methods for testing the synthetic turf playing surface and its components contained herein should state specifically the particular test or tests desired and not necessarily refer to these test methods as a whole.

1.6 This is a physical property characterization standard, and it shall not be construed as a safety standard.

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

1.8 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

2.1.1 *Pile Fiber:*

[1] These test methods are under the jurisdiction of ASTM Committee F08 on Sports ~~Equipment, Surfaces,~~ Equipment and Facilities and are the direct responsibility of Subcommittee F08.65 on ~~Playing~~ Artificial Turf Surfaces and ~~Facilities.~~ Systems.

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D 789 Test Methods for Determination of Relative ~~Viscosity, Melting Point,~~ Viscosity and Moisture Content of Polyamide (PA)[2]
D 792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement[2]
D 1577 Test Methods for Linear Density of Textile Fibers[3]
D 2256 Test Method for Tensile Properties of Yarns by the Single-Strand Method[3]
2.1.2 *Fabric:*
D 418 Methods of Testing Pile Yarn Floor Covering Construction[4]
D 1335 Test Method for Tuft Bind of Pile Yarn Floor Coverings[3]
D 1682 Test Methods for Breaking Load and Elongation of Textile Fabrics[5]
D 1776 Practice for Conditioning ~~Textiles for~~ and Testing Textiles[3]
D 2859 Test Method for ~~Flammability~~ Ignition Characteristics of Finished Textile Floor Covering Materials[6]
D ~~4158 Test Method~~ 4158 Guide for Abrasion Resistance of Textile Fabrics (Uniform ~~Abrasion Method)~~[5] Abrasion)[8]
D 5251 Practice for the Operation of the Tetrapod Walker Drum Tester[7]
E 648 Test Method for Critical Radiant Flux of Floor-Covering Systems Using a Radiant Heat Energy Source[6]
F 1015 Test Method for Relative Abrasiveness of Synthetic Turf Playing Surfaces[9]
2.1.3 *Shock Absorbing Cushion Underlayment:*
D 395 Test Methods for Rubber Property—Compression Set[10]
D 412 Test Methods for Vulcanized Rubber and Thermoplastic ~~Rubbers and Thermoplastic~~ Elastomers—Tension[9]
D 624 Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers[9]
D 1667 Specification for Flexible Cellular Materials—Vinyl Chloride Polymers and Copolymers (Closed-Cell Foam)[2]
D 1876 Test Method for Peel Resistance of Adhesives (T-Peel Test)[11]
D 2126 Test Method for Response of Rigid Cellular Plastics to Thermal and Humid Aging[2]
D ~~3574 Methods of Testing~~ 3574 Test Methods for Flexible Cellular Materials—Slab, Bonded, and Molded Urethane Foams[12]
D 3575 Test Methods for Flexible Cellular Materials Made From Olefin Polymers[11]
D 3936 Test Method for Resistance to the Delamination ~~Strength~~ of Secondary Backing of Pile Yarn Floor Covering[7]
F 355 Test Method for Shock-Absorbing Properties of Playing Surface Systems and Materials[8]
2.1.4 *Turf Systems:*
D 1667 Specification for Flexible Cellular Materials—Vinyl Chloride Polymers and Copolymers (Closed-Cell Foam)[2]
F 355 Test Method for Shock-Absorbing Properties of Playing Surface Systems and Materials[8]
F 1015 Test Method for Relative Abrasiveness of Synthetic Turf Playing Surfaces[8]
F 1936 Specification for Shock-Absorbing Properties of North American Football Field Playing Systems as Measured in the Field[8]
2.2 *Other Standards:*
2.2.1 *Turf Systems:*
AT 030 Sports Shoe Traction
DIN 18-035 Part 6—Water Permeability of Synthetic Turf Systems and Permeable Bases

NOTE 1—AstroTurf® Industries internal test procedures are suitable as bases for new ASTM test methods as follows: (*1*) Water Permeability of Synthetic Turf (DIN 18-035, Part 6); and (*2*) Ball Bounce and Ball Rebound.

3. Terminology

3.1 *Definitions*—Terms are as defined in the referenced ASTM procedures comprising these test methods.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *fabric construction*—the method of assembly of pile ribbon and backing yarns that produces the fabric, usually tufting, knitting, or weaving.

3.2.2 *lengthwise direction*, *n— in textiles*, the direction in a machine-made fabric parallel to the direction of movement the fabric followed in the manufacturing machine.

3.2.3 *matting*—the extent of change of the apparent synthetic turf pile thickness from the original value due to permanent compression of the pile from sports use.

3.2.4 *pile*, *n—for pile ribbon turf surfacing*, the texture surface composed of many tuft legs bound to backing fabric in an orderly and repetitive array.

3.2.5 *pile lay*—the direction in which most of the pile fibers lean in the original, uncrushed fabric.

3.2.6 *secondary backing*—a material adhered to the backing side of a pile turf fabric.

3.2.7 *sports shoe traction*—a measure of the static or sliding coefficient of friction between a weighted sports shoe and the turf pile surface, horizontal motion.

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[2] *Annual Book of ASTM Standards*, Vol 08.01.
[3] *Annual Book of ASTM Standards*, Vol 07.01.
[4] *Discontinued*—See 199~~1~~7 *Annual Book of ASTM Standards*, Vol 07.01.
[5] *Discontinued—*See 1990 *Annual Book of ASTM Standards*, Vol 07.0~~2~~1.
[6] *Annual Book of ASTM Standards*, Vol 04.07.

3.2.8 *sports shoe traction differential*—a measure of difference in sports shoe traction in two or more directions along the turf pile surface.

3.2.9 *synthetic turf system*—(all except bases and sub-bases) includes turf fabric, with attached or detached under cushion.

3.2.10 *synthetic turf system components*—the separate components such as turf fabric, shock-absorbing pad, and adhesives that comprise the synthetic turf playing surface when assembled; the subcomponents such as pile ribbon and backing yarns that comprise the turf fabric.

3.2.11 *texture*—the detailed configuration of loops, cut pile ends, and individual fibers in the pile layer.

3.2.11.1 *Discussion*—Texture is the detailed appearance of the pile that changes by matting, crushing, flattening, fuzzing, untwisting, etc. during exposure to service. The texture should be distinguished from the construction, that is, the specifications of kinds of yarns, yarn sizes, and the mode of combination.

3.2.12 *water permeability*—the rate at which water of a specified head flows vertically through synthetic turf or other components of the system.

4. Summary of Test Methods

4.1 The purpose of these test methods is to provide a comprehensive characterization of synthetic turf playing surfaces through reference to existing ASTM procedures.

4.2 Specific conditions of the referenced ASTM procedures are recommended to encourage uniform application of these test methods.

4.3 Table 1 contains a list of all the assigned suffix letters that may be used for describing the system and components of these test methods.

5. Significance and Use

5.1 These test methods constitute a standard for obtaining data in research and development, quality control, acceptance and rejection under specifications, and for special purposes.

5.2 The data obtained from use of these test methods are applicable to the system and its components under conditions of the particular test procedures and are not necessarily the same as the data that might be obtained in other environments or use conditions.

5.3 The selection of test methods or tests should be limited to those necessary to achieve design of the system.

6. Conditioning of Materials

6.1 Conduct laboratory tests under known conditions of temperature and humidity as specified in the individual test procedures. In the absence of specified conditions, tests must be conducted under the standard laboratory conditions of 23 ± 2°C (73.4 ± 3°F) and 65 ± 5 % relative humidity. Materials must be conditioned, undeflected, and undistorted at the temperature and humidity of test for at least 24 h prior to testing.

6.2 Conduct field tests on installed, indoor or outdoor synthetic turf playing surfaces at ambient temperature and humidity conditions. Measure and record the temperature of the synthetic turf surface, shock-absorbing pad, or other specific components being characterized by the particular test.

7. Sampling

7.1 For laboratory tests, select representative samples of components, in accordance with specific sampling instructions of the test procedure, when provided.

7.2 For field tests, specify locations on the synthetic turf playing surface where tests are conducted.

8. Application of Test Procedures

8.1 References to the ASTM test procedures stated in Section 9 are to be followed with regard to the apparatus, preparation of specimens, procedures, calculations, and reporting of results, except when different conditions are noted specifically in these test methods.

8.2 Precision and bias statements are given for each test procedure in the respective test methods.

8.3 Specific conditions of the referenced ASTM test procedures are recommended in each case, except where specified in these test methods.

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[8] *Annual Book of ASTM Standards*, Vol ~~15.07.~~ 07.02.

[9] *Annual Book of ASTM Standards*, Vol ~~09.01.~~ 15.07.

[10] *Annual Book of ASTM Standards*, Vol ~~15.06.~~ 09.01.

[11] *Annual Book of ASTM Standards*, Vol ~~08.02.~~ 15.06.

~~[12] Available from NAEF Press & Dies, Inc., Bolton Landing, NY 12814.~~

[12] *Annual Book of ASTM Standards*, Vol 08.02.

TABLE 1 Suffix Letter Designations: Performance Test Methods for Synthetic Turf Surfaces

ASTM Test Method	Test Method Suffix	Pile Fiber	Section
D 789		melting point	9
D 792		density (specific gravity)	10
D 1577	A	linear density of textile fibers (denier)	11
D 2256	A-1	breaking strength and elongation	12
		Fabric	
D 418		pile fiber construction	13
D 418		pile height	13
D 1335		resistance to tuft pullout	14
D 1682	G-T	grab tear strength	15
D 4158		abrasion resistance (uniform abrasion method)	16
D 2859		flammability of pile floor covering (methenamine tablet test)	17
E 648		flammability of synthetic turf (flooring radiant panel test)	18
F 1015		relative abrasiveness of synthetic turf surfaces	19
D 5251		resistance to matting (tetrapod method)	32
		Shock Absorbing Pad Component	
D 395	compression set under constant load	20	
D 624	Die C	tear resistance	21
D 1667	D	compression resistance	22
D 1876		T-peel strength of secondary pad	23
D 2126		hydrolytic stability	24
D 3574	E	tensile and elongation	25
D 3936		delamination strength of secondary backing	26
F 355		shock absorbency of playing surface systems and materials	27
D 3575	L	water absorption (% weight gain)	28
		Turf Systems	
F 1015		relative abrasiveness of synthetic turf surfaces	19
D 1667	D	compression resistance (modified method)	22
F 1936	A	shock absorbency of playing surface systems in the field	27
~~F 355~~	~~A~~	~~shock absorbency of playing surface systems and materials~~	~~27~~
F 355		shock absorbency of playing surface systems and materials	28
~~MTP-0030~~		~~sports shoe traction and traction differential (coefficient of friction)~~	~~29~~
MTP-0030		sports shoe traction and traction differential (coefficient of friction)	30
~~DIN 18-035~~		~~water permeability of synthetic turf system~~	~~30~~
DIN 18-035		water permeability of synthetic turf system	31
		~~ball bounce—ball rebound~~	~~31~~
		ball bounce—ball rebound	32

TEST PROCEDURES

9. Suffix A—Test Methods D 789, Determination of Relative Viscosity, Melting Point, and Moisture Content of Polyamide (PA)

9.1 *Scope*:

9.1.1 These test methods describe several techniques for the characterization of polyamides, polypropylene, and other fibers.

9.1.2 The applicable part of this test procedure is that describing the measurement of melting point for polyamide fibers and other fibers used in constructing synthetic turf fabrics.

9.2 *Test Method Specific Conditions* :

9.2.1 A temperature rise of 2°C/min with the Fisher-Johns melting point apparatus is recommended.

9.2.2 Acceptable alternatives for the measurement of melting point are the use of differential thermal analysis (DTA) or differential scanning calorimetry (DSC) instruments. Follow Test Methods D 789 where applicable. Report the temperature rise and other pertinent experimental conditions used with DTA or DSC.

10. Suffix W—Test Method 792, Specific Gravity (Relative Density) and Density of Plastics by Displacement

10.1 *Scope*:

10.1.1 This test procedure describes measurement of the specific gravity of fibers and filaments.

10.1.2 This test is appropriate and applicable to the pile ribbon component of synthetic turf fabrics before the product is made.

11. Suffix W—Test Methods D 1577, Linear Density of Textile Fibers

11.1 *Scope*:

11.1.1 This test procedure describes measurement of the linear density (denier, tex) of textile fibers and filaments.

11.1.2 The test is appropriate and applicable to the pile ribbon component of synthetic turf fabrics before the product is made.

11.2 *Test Method Specific Conditions* :

11.2.1 *Test Method A*—The direct weighing method is recommended.

11.2.2 The linear density of finish-free fiber is the recommended measurement; see 12.1 of Test Methods D 1577.

12. Suffix T—Test Method D 2256, Tensile Properties of Yarns by the Single-Strand Method

12.1 *Scope*:

12.1.1 This test procedure describes measurement of the tensile properties strength, elongation, and (optionally) modulus for textile fibers and filaments.

12.1.2 The test is appropriate and applicable to the pile ribbon component of synthetic turf fabrics before the product is made.

12.2 *Test Method Specific Conditions* :

12.2.1 Option A1, standard-conditioned, straight fiber or filament is recommended.

12.2.2 Horn grip clamps are recommended.

12.2.3 The recommended gage length is 15.2 cm (6 in.).

12.2.4 The recommended cross-head speed is 25.4 cm/min (10 in./min).

12.2.5 The tangent method is recommended if the modulus is calculated (Appendix, Test Method D 2256).

12.2.6 The measurement of strength and elongation may be conducted on monofilaments or multifilament yarns; specify which.

13. Methods D 418, Testing Pile Yarn Floor Covering Construction

13.1 *Scope*:

13.1.1 The test methods are designed for the characterization of pile materials such as carpets.

13.1.2 This test procedure describes several methods appropriate and applicable for characterizing synthetic turf fabrics by pile thickness, tuft height (blade length), and suitable measurements of fabric weight.

13.1.3 Some of the test procedures, such as tuft height (blade length), are applicable in the field as well as in the laboratory.

13.2 *Test Method Specific Conditions* :

13.2.1 The normally applicable tests of the group are as follows: total mass per unit area (Section 7 of Methods D 418); component masses per unit area (Section 8); pile yarn mass per unit area (Section 9); pile thickness—level pile (Section 10); and tuft height (blade length) (Section 13).

13.2.2 Tests of the group normally not applicable for synthetic turf playing surfaces are as follows: number of bonding sites per unit length (Section 16 of Methods D 418); and tuft length for level loop pile floor covering (Section 15).

14. Suffix T—Test Method D 1335, Tuft Bind of Pile Floor Coverings

14.1 *Scope*:

14.1.1 This test provides a method for measuring the tuft bind in pile fabrics such as carpets.

14.1.2 The test is appropriate and applicable to the pile ribbon component of synthetic turf fabrics.

14.2 *Test Method Specific Conditions* :

14.2.1 Test Method D 1335 is written in the language of fabrics of tufted construction. However, application may be extended to knitted and woven synthetic turf fabrics if the concept of tuft is re-defined suitably.

14.2.2 *Tufted Fabrics*—For the purposes of Test Method D 1335, a tuft has the conventional definition of the two halves of the mono- or multi-filament loop of pile that is inserted between the adjacent yarns of the tufting medium (backing fabric), held in place by a primary coating (adhesive), and not otherwise connected mechanically to the tufting medium (see Fig. 1).

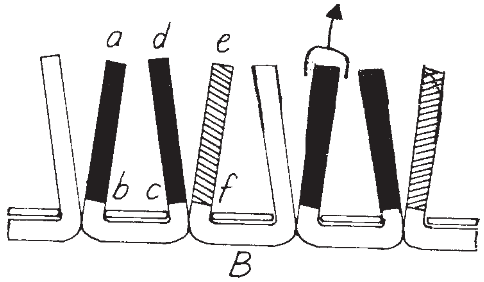
14.2.3 *Knitted Fabrics*—For the purposes of Test Method D 1335, a tuft is comprised of the adjacent legs of two loops of pile. Each loop passes under a yarn of fabric backing, but adjacent legs are not restrained mechanically, thereby permitting pullout without rupture of the backing yarns (see Fig. 2).

14.2.4 *Woven Fabrics*—For the purposes of Test Method D 1335, a tuft is defined suitably as in the case of knitted fabrics (14.2.3) to avoid rupture of the backing yarns when determining tuft pullout (see Fig. 3).

14.3 The specified cross-head speed for the measurement of tuft bind with all fabrics is 30.5 ± 1.0 cm/min (12 ± 0.05 in./min).

15. Suffix T—Test Methods D 1682, Breaking Load and Elongation of Textile Fabrics

15.1 *Scope*:



ad	= cut pile tuft element
ab, cd, ef	= tuft legs
cd, ef	= cut pile tuft leg pair
B	= one bonding site

FIG. 1 Cross Section of Tufted Pile

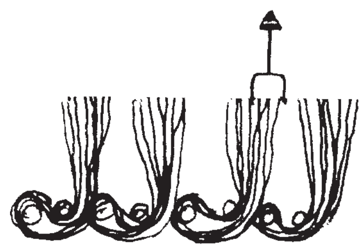


FIG. 2 Cross Section of Knitted Pile

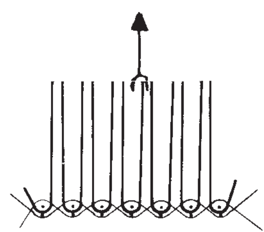


FIG. 3 Cross Section of Woven Pile

15.1.1 This test provides methods for determining the breaking strength and elongation of textile fabrics.

15.1.2 Of the various test methods described in Test Methods 1682 for measuring the strength of textile materials, the grab test (Section 16) is recommended for use with synthetic turf fabrics.

15.2 *Test Method Specific Conditions* :

15.2.1 The recommended instrument type for the tensile testing is a constant rate of extension (CRE) tensile testing machine.

15.2.2 The recommended sample size is 10.2 by 15.2 cm (4 by 6 in.). The sample elongation is in the longer dimension.

15.2.3 The recommended clamps (top and bottom) are 2.54 by 2.54 cm (1 by 1 in.) on one side and 2.54 by 5.08 cm (1 by 2 in.) on the other side. The shorter side of the clamp is oriented in the direction of sample elongation.

15.2.4 The recommended gage length is 7.6 cm (3 in.).

15.2.5 The recommended cross-head speed is a uniform 30.5 cm/min (12 in./min).

15.2.6 The test method is applicable to knitted fabrics. (~~**Caution—**Higher~~**Warning—**Higher strengths and elongation than anticipated could result.)

16. Suffix J—Test Method D 4158, Abrasion Resistance of Textile Fabrics (Uniform Abrasion Method)

16.1 *Scope*:

16.1.1 This test describes the Schiefer and Krasny method for determining the resistance of fabrics to abrasion.

16.1.2 The test is useful for characterizing the abrasion resistance of synthetic turf fabrics.

16.2 *Test Method Specific Conditions* :

16.2.1 The type of abradant wheel used must be specified when reporting the results.

16.2.2 The spring steel blade abradant is the recommended standard.

16.2.3 The counterweight used must be specified when reporting the results.

16.2.4 The 4.536-kg (10-lb) counterweight is the recommended standard.

16.2.5 The standard abrading wheel r/min is 260.

17. Suffix Test Method D 2859, Flammability of Finished Textile Floor Covering Materials

17.1 *Scope*:

17.1.1 This test covers determination of the flammability of finished textile floor covering materials using the methenamine tablet method.

17.1.2 This test method should be used for measuring and describing the properties of materials or assemblies in response to heat and flame under controlled laboratory conditions. It should not be used for describing or appraising the fire hazard or fire risk of materials, products, or assemblies under actual fire conditions.

17.2 *Test Method Specific Conditions* :

17.2.1 This test method involves the exposure of conditioned and oven-dried samples to a methenamine tablet ignition source in a draft-protected environment and measurement of the resulting char length.

17.2.2 The test method may be used for assessing the effect of a specific underlay or cushion in combination with a floor covering.

17.2.3 Condition the samples as directed in Practice D 1776.

17.3 *Sampling and Test Specimens* :

17.3.1 Cut eight specimens from each lot fabricated for each playing surface or field.

17.3.2 This test is applicable for new, non-used, synthetic turf surfaces and materials.

17.4 *Procedure, Results, and Report*— Test Method D 2859 applies as written for synthetic turf fabrics and surfaces.

18. Suffix M—Test Method E 648, Critical Radiant Flux of Floor Covering Systems Using a Radiant Heat Energy Source

18.1 *Scope*:

18.1.1 This test describes the apparatus and technique for determining the critical radiant flux (CRF), a measure of the flammability resistance of fabrics using the flooring radiant panel method.

18.1.2 The test is applicable to synthetic turf fabrics.

18.2 *Test Method Specific Conditions* :

18.2.1 The test method applies as written to synthetic turf fabrics.

18.2.2 The results for CRF will differ, depending on whether the fabric tested also has its shock-absorbing pad placed under it during the test.

NOTE 2—Test Method E 648 is applicable to floor-covering system specimens that follow or simulate accepted installation practices. Tests on the individual elements of a floor system are of limited value and are not valid for evaluation of the flooring system.

18.2.3 Run tests with and without the undercushion, and report the results of both tests.

19. Test Method F 1015, Relative Abrasiveness of Synthetic Turf Playing Surfaces

19.1 *Scope*:

19.1.1 This test was designed specifically for use with synthetic turf fabrics.

19.1.2 This test is applicable to both laboratory and field measurement.

19.1.3 The test also may have use for natural grass playing surfaces.

19.2 *Test Method Specific Conditions*— The test method applies as written to synthetic turf fabrics and surfaces.

20. Suffix B—Test Methods D 395, Rubber Property—Compression Set

20.1 *Scope*:

20.1.1 This test method covers the testing of shock-absorbing pad components intended for use in applications in which the pad will be subjected to compressive stresses in air or liquid media.

20.1.2 This test is appropriate and applicable to the shock-absorbing pad component of synthetic turf playing surfaces.

20.2 *Test Method Specific Conditions* :

20.2.1 *Test Method A*—Compression set under constant force in air is to be used.

20.2.2 The test specimens are to be 5.08 by 5.08 cm (2 by 2 in.) by gage of the cushion underlayment to be used.

20.2.3 The compression load is to be 1.8 kN (400 lb or 100 psi) for 22 h.

20.2.4 The compression set is calculated after 24 h recovery.

21. Suffix G—Test Method D 624, Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomer

21.1 *Scope*:

21.1.1 This test describes a characterization of rubber or foam samples by tear resistance.

21.1.2 The test applies to the shock-absorbing pad component of synthetic turf playing surfaces.

21.2 *Test Method Specific Conditions* :

21.2.1 The sample is an unnicked, 90° angle specimen cut with ASTM Die C.

21.2.2 The specified cross-head speed is 50.8 cm/min (20 in./min).

22. Suffix D—Specification D 1667, Flexible Cellular Materials—Vinyl Chloride Polymers and Copolymers (Closed-Cell Vinyl)

22.1 *Scope*:

22.1.1 This specification applies to the shock-absorbing pad component.

22.1.2 This test consists of measuring the force necessary to produce a 25 % deflection on a round 6.45-cm^2(1-in. ^{2}) test specimen.

22.1.3 This test method is recommended for polyvinyl chloride (PVC) foams or copolymer thereof, polyolefin foams, and other pads.

22.2 *Test Method Specific Conditions* :

22.2.1 Test to Specification D 1667 Suffix D (compression deflection test) with the following deviations:

22.2.2 *Compression Force Deflection Test (CFD)*—A round 2.87-cm (1.129-in. diameter) sample is prepared using a rotary die cutter. Use an ASTM D75 – 83 cutting tool (1.129 in. diameter) for the drill press.[13] Use a flat compression foot that is larger than the specimen to compress the sample. Cut three specimens for testing and averaging the results.

22.2.3 *Indention Force Deflection Test (IFD)*—This test method is required for uneven surfaced pads, that is, convoluted, etc., where a 6.4515-cm^2 (1.0-$in.^2$) specimen is not representative of the sample.

22.2.3.1 Cut a 25.4-cm^2 (10-$in.^2$) specimen. Use a 15.24-cm (6-in.) diameter compression foot plate, which is smaller than the specimen, to compress the sample.

22.2.4 Using a CRE (compression) instrument, deflect the specimen 25 % of its original height. (The specimen gage will be 75 % of its original gage at 25 % deflection.)

22.2.5 Record the force on a strip chart, and read the force from the chart at 25 % deflection, or record the value if the machine compresses the specimen 25 % automatically and provides the value. This is an immediate reading, not a 60 s hold and read value.

22.2.6 The cross-head speed is to be 5.1 cm/min (2.0 in./min).

22.2.7 The test specimen gage is the shock-absorbing pad component gage used in the final product. Measure the pad thickness as described in Section 15 of Specification D 1667.

22.3 *Calculation*:

$$CFD \text{ at } 25\ \% = \text{report force direct as determined in 22.2.2} \quad (1)$$

$$IFD \text{ at } 25\ \% = \frac{\text{total force required at 25 \% compression deflection}}{28.26} \quad (2)$$

where:

28.26 = $in.^2$ of specimen compressed under the 6-in. diameter compression foot plate.

22.4 *Report*:

22.4.1 Report the following data:

22.4.1.1 Average unit force required, expressed in kPa or psi.

22.4.1.2 CFD at 25 % or IFD at 25 %, depending on the method used.

22.4.1.3 Diameter of the compression foot used.

22.4.1.4 Compression or cross-head speed.

22.4.1.5 Sample temperature at the time of testing.

23. Suffix K—Test Method D 1876, Peel Resistance of Abrasives (T-Peel Test)

23.1 *Scope*:

23.1.1 This test is designed for determination of the peel resistance of adhesive bonds, primarily between flexible adherents, by means of a T-type specimen.

23.1.2 The applicability to synthetic turf playing surfaces primarily is to characterize the adhesive bond between the turf component and the (adhesively attached) shock-absorbing pad component.

23.2 *Test Method Specific Conditions* :

23.2.1 Section 4.2 of Test Method D 1876 is modified to accommodate 5.08-cm (2-in.) wide test specimens instead of 2.54-cm (1-in.) wide specimens.

23.2.2 Section 5 of Test Method D 1876 may be modified to shorter periods of specimen conditioning. (Specify the periods used.)

23.2.3 The recommended cross-head speed is 30.5 cm/min (12 in./min).

24. Suffix S—Test Method D 2126, Response of Rigid Cellular Plastics to Thermal and Humid Aging

24.1 *Scope*:

~~[13] See Prins and Hermans, *Journal of Physical Chemistry*, Vol 63, 1959, p. 716.~~
[13] Available from NAEF Press & Dies, Inc., Bolton Landing, NY 12814.

24.1.1 This series of tests specifies procedures for measuring the effect of various combinations of temperature and relative humidity on specimen physical dimensions.

24.1.2 This test is used to determine aging effects on the shock-absorbing pad component for the purposes of characterizing synthetic turf playing surfaces.

24.1.3 The test applied to the shock-absorbing pad components is also extended to include nonrigid as well as rigid cellular plastics that may be used in their construction.

24.2 *Test Method Specific Conditions*— Test Method D 2126, 70°C (158°F) at 97 % relative humidity, is recommended for the shock-absorbing pad component of synthetic turf playing surfaces.

25. Methods D 3574, Testing Flexible Cellular Materials—Slab, Bonded, and Molded Urethane Foams

25.1 *Scope*:

25.1.1 This test describes a series of material characterizations selected particularly for polyurethane foams.

25.1.2 When applicable to synthetic turf playing surfaces, the test will be applied to the shock-absorbing pad component made from polyurethane or other foams.

25.1.3 Of particular interest among the test methods listed is that for tension, Test E—Tension Test, Section 45 of Methods D 3574.

25.1.4 The material characterizations other than the tension test of Methods D 3574 are supplemental to other, analogous tests listed in these test methods.

25.1.5 When overlap of the tests is evident, preference is to be given to the more general tests listed in these test methods.

25.2 *Test Method Specific Conditions* :

25.2.1 Die A of Test Methods D 412 is specified (the die of Fig. 1, Methods D 3574) for the tension test.

25.2.2 The recommended gage length is 8.9 cm (3.5 in.).

25.2.3 The recommended cross-head speed is 50.8 cm/min (20 in./min) for the tension test.

26. Suffix K—Test Method D 3936, Delamination Strength of Secondary Backing of Pile Floor Covering

26.1 *Scope*:

26.1.1 This test measures the delamination strength of the adhesive bond between the primary and secondary portions of a pile floor covering.

26.1.2 The applicability to synthetic turf playing surfaces is for those representatives of the turf pile fabric component that use secondary backings, usually, but not restricted to, fabrics of tufted construction.

26.2 *Test Method Specific Conditions*— The test method is applicable as written to the turf pile fabric of synthetic turf playing surfaces.

27. Suffix ~~CC—Test Method F 355, Shock Absorbing~~ CC—Specification F 1936, Shock-Absorbing Properties of North American Football Field Playing ~~Surface Systems and Materials~~ systems as Measured in the Field

27.1 *Scope*:

27.1.1 This ~~test~~ specification was designed specifically for ~~playing~~ all North American football field surface systems.

27.1.2 Theis test is applicable to ~~both laboratory and~~ field measurement.

27.2 *Test Method Specific Conditions* :

~~27.2.1 Procedure A, 3.2.1 of Test Method~~

27.2.1 This specification employs the F 355 ~~is recommended.~~

~~27.2.2 An~~ procedure A missile with an impact velocity of 3.43 ± 0.17 ~~m/s is required.~~ m/s. (This velocity corresponds to a theoretical drop height of 0.61 m (24 in.) at sea level.)

27.2.32 This specification states a ~~physical property characterization standard, and it shall not be construed as~~ minimum of 6 predetermined test points.

27.2.3 The procedure produces a ~~safety standard.~~ test report that states which points met or did not meet the requirement of under 200 average G_{max}.

28. Suffix ~~L—Test Methods D 3575, Flexible Cellular Materials Made From Olefin Polymers~~ CC—Test Method F 355, Shock Absorbing Properties of Playing Surface Systems and Materials

28.1 *Scope*~~—~~:

28.1.1 This test ~~method covers measurement of the water absorbed by the shock-absorbing pad component material during submersion under pressure and~~ was designed specifically for playing surface systems.

28.1.2 The test is applicable to ~~other pads or cushions.~~ both laboratory and field measurement.

28.2 *Test Method Specific Conditions* :

28.2.1 Procedure A, 3.2.1 of Test Method F 355 is recommended.

28.2.2 An impact velocity of 3.43 ± 0.17 m/s is required. (This velocity corresponds to a theoretical drop height of 0.61 m (24 in.) at sea level.)

28.2.3 This is a physical property characterization standard, and it shall not be construed as a safety standard.

29. Suffix L—Test Methods D 3575, Flexible Cellular Materials Made From Olefin Polymers

29.1 *Scope*—This test method covers measurement of the water absorbed by the shock-absorbing pad component material during submersion under pressure and is applicable to other pads or cushions.

29.2 *Test Specimens*—Test specimens shall be 10 by 10 cm (4 by 4 in.) by the thickness of material being supplied. The specimen may or may not have natural skins on top or on bottom or on both surfaces.

289.3 *Number of Specimens*—Test three specimens for each sample. The values reported shall be the mean of those observed. Test two additional specimens and report the mean for all five values if any value deviates more than 20 % from this mean.

289.4 *Procedure*:

289.4.1 Measure the area of the cut surfaces in accordance with Section 8, and calculate the area of the cut surfaces.

289.4.2 Weigh the specimens and submerge them under a 3-m (10-ft) head of water equal to 30 kPa (4.35 psi) at room temperature, 18 to 29°C (65 to 90°F), for 48 h. Then place the specimens in an air stream for the minimum time required to remove visible water from the surfaces and reweigh.

289.5 *Calculation*—Calculate the water absorption, expressed in kg/m^2 (lb/ft^2) of cut surfaces (surfaces without skin or rind), as follows:

$$\text{water absorption} = \frac{W_2 - W_1}{A} \quad (3)$$

where:

W_1 = specimen mass before immersion, kg (lb),
W_2 = specimen mass after immersion, kg (lb), and
A = area of cut surface, m^2 (ft^2).

289.6 *Report*—Report the average water absorption in kg/m^2 (lb/ft^2) of the three specimens tested, except as noted in 27.3.

29.

30. Suffix AT-030—Sports Shoe Traction (Coefficient of Friction) and Traction Differential

29.1

30.1 *Scope*—This test method is applicable to determination of the shoe traction (coefficient of friction) between shoes and playing surfaces in both the laboratory and the field under various conditions. The shoe traction on a playing surface is determined by dividing the horizontal force required for motion of the shoe by the sum of weight of the shoe and any weight placed on the shoe.

29.2

30.2 *Terminology*:

2930.2.1 Shoe traction is defined herein as the coefficient of friction between a weighted shoe and a playing surface, where the horizontal force, *F*, required to move the shoe in a horizontal direction is divided by the vertical force, *N* applied by the shoe.

$$ST = \text{shoe traction} = F/N \quad (4)$$

If the force, *F*, is just sufficient to initiate motion, the coefficient of static friction is being measured. If *F* sustains motion at constant velocity, however, the coefficient of dynamic friction is the relevant quantity.

2930.2.2 The vertical force, *N*, is equal to the weight of the shoe plus any weight placed on the shoe.

2930.2.3 Shoe traction is normally calculated from the minimum force required to initiate horizontal movement of the shoe over the surface, as this is related to the maximum force a player can exert in stopping or turning without slipping (coefficient of static friction).

2930.2.4 In addition to shoe traction, ST, two other derived traction indices are useful: traction level, TL, and differential traction, DT. TL is the average of the four ST values normally measured (see 29 30.2.3). If ST_i is one of these four values, then, mathematically,

$$TL = 1/4 \sum_{i=1}^{4} ST^{i} \quad (5)$$

DT is defined as the average value of the absolute deviation of the four ST values from their mean (TL), that is,

$$DT = 1/4 \sum_{i=1}^{4} |ST_i - TL| \quad (6)$$

where each difference in absolute values is always considered to be a positive quantity. DT is a useful index of perceived directionality on the playing surface, that is, a difference in friction depending on the direction of measurement. A uniform sports surface would ideally have DT = 0.

29.3

30.3 *Test Design*:

2930.3.1 A barbell weight is placed on top of a shoe with the front edge of the weight on the toe of the shoe approximately 3.8 cm (1½ in.) from the front end of the shoe and the back of the weight on the counter of the shoe. Additional weights may be placed on top of this weight, if desired. Care must be taken to ensure that the weights are balanced properly to prevent them from dragging on the surface during testing. An alternative test device is a sports shoe sole, with the uppers cut off, adhered permanently to a weight such as to provide a flat sole surface.

2930.3.2 Measurements are made by placing a nylon belt around the back of the shoe, as close to the bottom of the sole as possible, and a push-pull gage at the other end of the belt, and then pulling the gage slowly but steadily in a horizontal plane, parallel to the playing surface. The minimum force required either to initiate sliding of the shoe over the turf surface or to maintain movement (dynamic friction) is recorded.

2930.3.3 Two shoes must be tested in four directions at three locations on a field. Each direction is at a 90° angle to the previous direction tested. The four directions for an artificial surface are with the pile lay, across the pile lay in Direction A, against the pile lay, and across the pile lay in Direction B, 180° from Direction A. The shoe traction test setup is shown in Figs. 4 and 5. Directions of testing are illustrated in Fig. 6.

NOTE 3—The same shoes must be used to compare different artificial turfs for shoe traction and traction differential.

29.4

30.4 *Apparatus*:

2930.4.1 *Continuous Loop Nylon Strap or Belt*, modified 2.54-cm (1-in.) wide, 183 cm (72 in.). Modifications are shown in Fig. 7.

2930.4.2 *Barbell Weight*, 11.34 kg (25 lb), approximately 27.9 cm (11 in.) in diameter with 1-cm (0.375-in.) vinyl foam attached to one side.

2930.4.3 *Chatillon Model DPPH-50 Push-Pull Gage*, with a maximum force pointer or an equivalent scale.

2930.4.4 *Shoes*, two different types, size 11.

2930.4.5 *Relative Humidity Meter*.

2930.4.6 *Three Dial Thermometers*, with 12.7-cm (5-in.) spiked probes.

29.5

30.5 *Setup*:

2930.5.1 Surfaces may be tested in either the laboratory under controlled conditions or the field under prevailing conditions. The assumptions are as follows: that the test shoe and test surface are exposed to the same conditions (for example, wet surfaces are tested with wet shoes), the surfaces are anchored down in a manner indicative of their end-use applications (that is, samples do not move during testing), and the conditions under which the surfaces are tested can be recorded. The minimum recommended sample size is 1 by 1 m; the minimum usable sample size is 23 by 76 cm (9 by 30 in.) in the direction of the test (that is, the direction in which the shoe is pulled).

2930.5.2 If the samples have a tendency to move, they may be held firmly to the subsurface by having an individual stand on the test surface directly behind the test shoe with his or her feet, one behind the other, on a line perpendicular to the direction of testing. Weights may be placed on the test surface when necessary, allowing a single operator to make the shoe traction measurements. Having an assistant greatly improves the efficiency of performing the evaluations in all cases since the assistant can record the measurements as they are made, read aloud, and, by handling the weights placed on the test shoe, greatly reduce the physical strain that would be put on a single operator.

2930.5.3 Surfaces may be tested both indoors and outdoors at other than ambient conditions, provided that the samples are conditioned at the desired environment. Care must be taken to condition the shoe and surface under as similar environments as

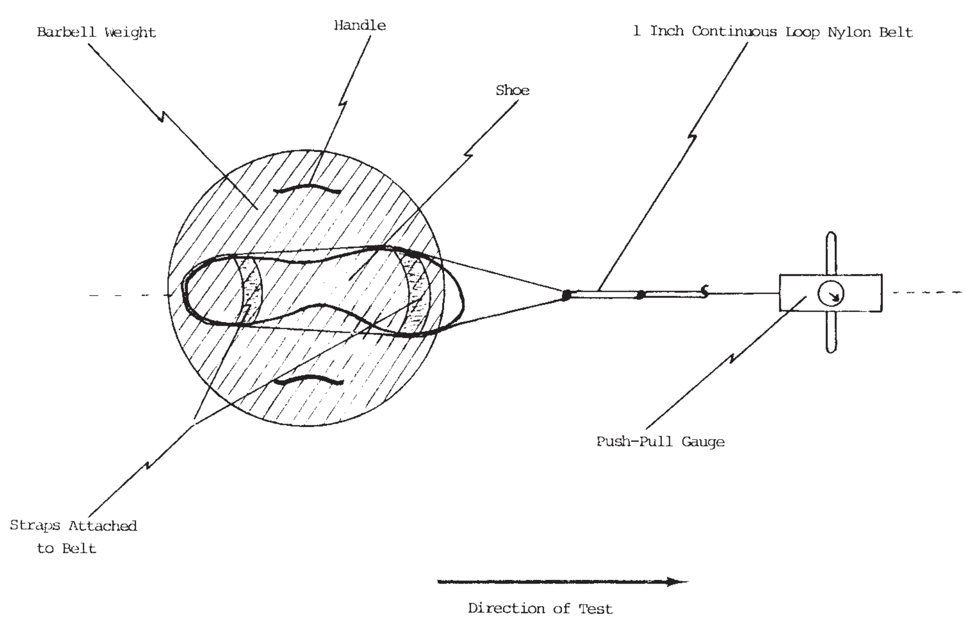


FIG. 4 Shoe Traction Setup (Top View)

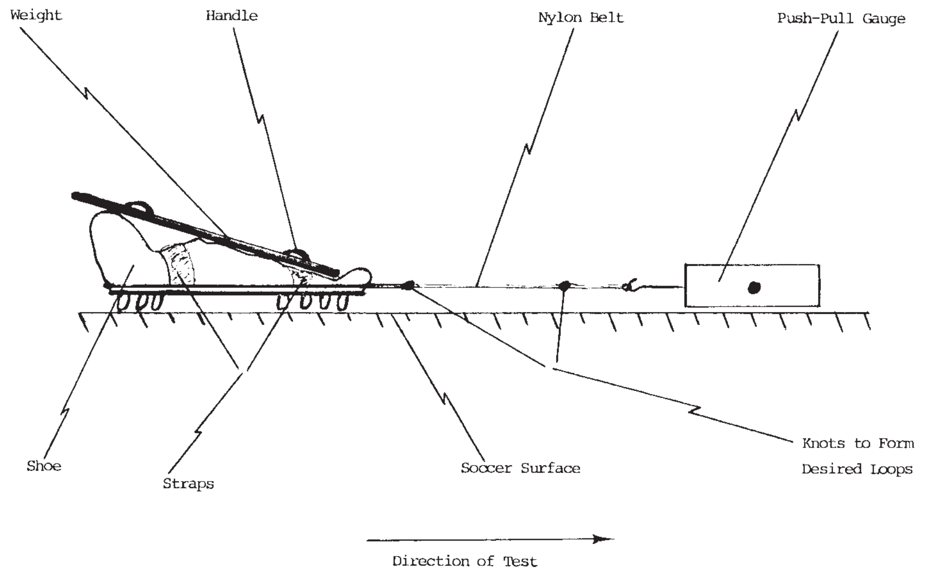


FIG. 5 Shoe Traction Setup (Side View)

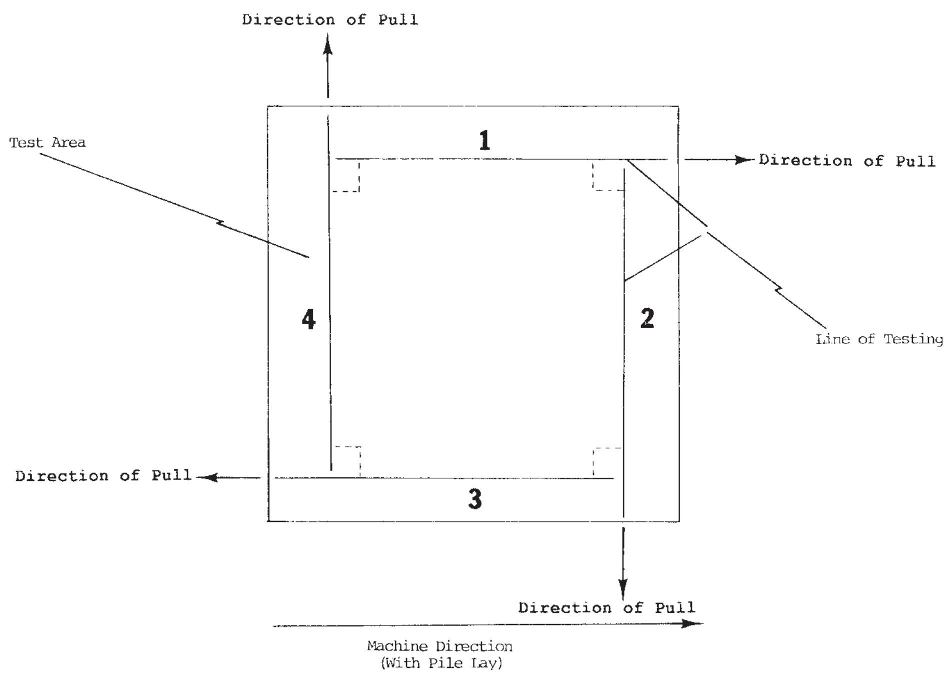


FIG. 6 Directions of Testing

possible. For example, it may be necessary to wet the test shoe more frequently than the test surface when testing wet turf under dry weather conditions since shoe soles generally dry faster than turf surfaces.

~~29.6~~

30.6 *Procedure*:

~~29~~30.6.1 The following procedure is intended as a guide for developing good techniques when setting up for routine shoe traction testing and is outlined to key in on some important factors that could significantly affect the evaluation of raw data obtained by the procedure.

~~29~~30.6.2 Choose a test area (or sample) indicative of the total system to be evaluated. It should not be more soiled, more matted, wetter, muddier, etc. than the total system unless that specific condition is being evaluated.

~~29~~30.6.3 Condition the samples. If the playing surface is to be tested at other than ambient conditions, expose both the surface and the shoes to the test environment for a minimum of 2 h.

NOTE 4—Specific test designs may preclude this requirement (for example, simulating conditions existing immediately following a brief shower).

~~29~~30.6.4 Place one dial thermometer, probe up, on the test surface to measure the air temperature. Insert the probe of a second thermometer horizontally through the turf or grass cover to measure the turf temperature. The subsurface temperature is measured

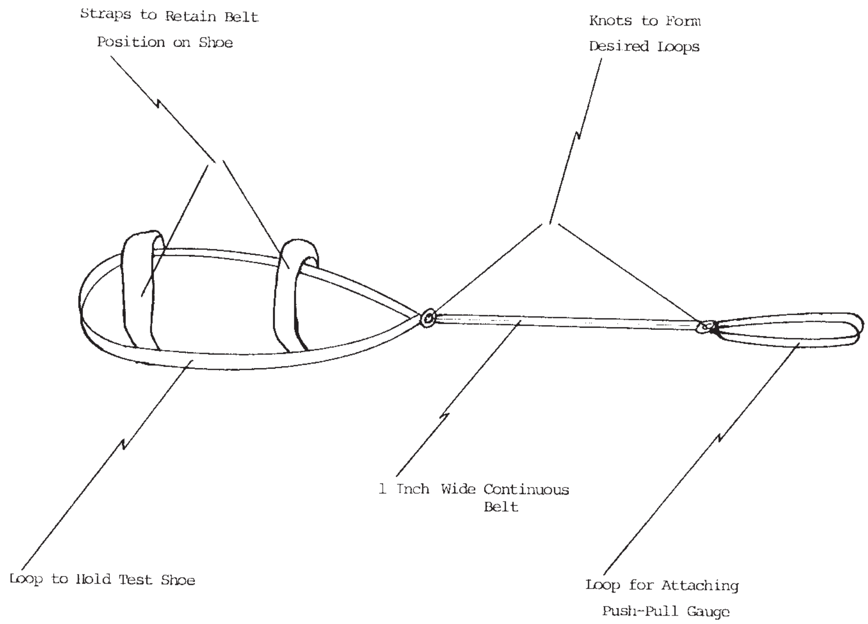


FIG. 7 Belt Modifications

by inserting the probe of a third thermometer into the ground for natural systems or halfway through the pad for artificial systems. Care must be taken not to shade any of the thermometers. (This step may be omitted when testing under controlled environments.) Actual temperature measurements are made in 28.7.5.

~~29~~30.6.5 Record the sample identification and test conditions. In field testing particularly, it is not always possible to control the condition of the sample or environment during or just prior to making an evaluation. It is therefore very important to note, in as much detail as possible, the conditions under which the surface is evaluated.

~~29.7~~

30.7 *Measurements*:

~~29~~30.7.1 Standard procedure includes making measurements in four directions (namely, each direction is at a 90° angle to the preceding direction of testing, and with artificial surfaces the directions are specifically with the pile lay, across the pile lay (A), against the pile lay, and across the pile lay (B) as illustrated in Fig. 7); at three locations on the field (for example, a high-use area, moderate-use area, and low-use area); and on two different shoes. The following procedure details the evaluation of a given test area with a single shoe.

~~29~~30.7.2 Place a sports shoe on the test area such that the direction of testing is parallel to a line passing through the centers of the heel and toe of the shoe and the toe of the shoe is in advance of the heel, as is demonstrated in Fig. 4.

~~29~~30.7.3 Position the modified belt (Fig. 7) on the shoe such that the belt falls on a line parallel to the line of testing. (See Fig. 4.) The strap should be adjusted to maintain the belt horizontal to the test surface during pulling (Fig. 5).

~~29~~30.7.4 Place a barbell weight on top of the shoe, with the front edge of the weight on the toe of the shoe approximately 3.8 cm (1.5 in.) from the front end of the shoe and the back of the weight on the counter of the shoe. Care must be taken that the weight is balanced properly to prevent it from dragging on the surface during testing. The foam-covered side of the weight is placed in contact with the shoe to prevent the weight from slipping. (Bolting two cabinet handles to the top of the weight facilitates handling of the weight greatly.) The Chatillon Model DPPH-50 push-pull gage has a maximum force limitation of 22.7 kg (50 lb), but it is adequate with most shoes for evaluating playing surfaces under a wide variety of weather conditions when the weight on the shoe is limited to a maximum of 11.4 kg (25 lb).

~~29~~30.7.5 Make the measurements. Attach the push-pull gage to the forward most loop of the belt and slowly (approximately 7.6 cm (3 in./s)) but steadily pull in a horizontal plane, parallel to the playing surface, on a line passing through the horizontal centers of the heel and toe of the shoe. The shoe should be pulled a minimum of 30.5 cm (12 in.). The measurement should be made immediately after the weight has been placed on the shoe. (Allowing the weighted shoe to rest on the surface could result in the subsurface taking a temporary compression set.) Record the temperature(s) at the time of measurements.

~~29~~30.7.6 Record the data. Record the minimum force (*F*) required to initiate movement of the shoe over the playing surface. If stick-slip conditions are encountered; record both the maximum force and the sustaining force, using these separately to calculate the static and dynamic shoe tractions, respectively. (That is, the shoe stops and remains stationary and the horizontal force increases, which causes the shoe to move forward; the force decreases until the shoe stops, and the process is repeated.)

~~29~~30.7.7 Test the remaining three directions. Remove the weight from the shoe, and place the shoe and strap to the right of, but perpendicular to, the last direction of testing as shown in Fig. 6. Repeat the steps given in ~~29.7.2-29.7.5~~ 30.7.2-30.7.5 three times to complete the test series for a given test area with one shoe.

~~29.8~~

30.8 *Calculations*:

~~29~~30.8.1 Calculate the shoe traction, ST, for each measurement made in each direction of testing, where:

$$ST = \text{shoe traction} = F/N \tag{7}$$

N = vertical force on the surface (namely, total weight of the shoe and any weight placed on it), and
F = horizontal force required to cause movement of the shoe over the surface.

~~29~~30.8.2 Calculate the traction level,

$$TL = 1/4 \sum_{i=1}^{4} ST_i \text{ (see 29.2)} \tag{8}$$

$$TL = 1/4 \sum_{i=1}^{4} ST_i \text{ (see 30.2)} \tag{8}$$

~~29~~30.8.3 Calculate the differential traction,

$$DT = 1/4 \sum_{i=1}^{4} | ST_i - TL | \text{ (see 29.2)} \tag{9}$$

$$DT = 1/4 \sum_{i=1}^{4} | ST_i - TL | \text{ (see 30.2)} \tag{9}$$

~~29.9~~

30.9 *Report*—Include the following information in the report for each test series:

~~29~~30.9.1 Sample identification and location;

~~29~~30.9.2 Date and time of testing;

~~29~~30.9.3 Type of size 11 shoe(s) used, including the sole configurations, cleat composition, and size and length of the cleat;

~~29~~30.9.4 Total vertical force, *N*, applied to the test surface;

~~29~~30.9.5 Prevailing weather conditions;

~~29~~30.9.6 Environmental conditions during testing (for example, ambient, wetted, washed, length of exposure, etc.);

~~29~~30.9.7 Surface or sample conditions (for example, clean, dirty, matted, new, worn, wet, dry, damp, muddy, soft, hard, long grass, short grass, smooth, level, irregular, etc.)

~~29~~30.9.8 Air, turf, and subsurface temperatures;

~~29~~30.9.9 Relative humidity;

~~29~~30.9.10 Traction level and standard deviation for the shoe traction values calculated in 28.8.1;

~~29~~30.9.11 Differential traction; and

~~29~~30.9.12 Any deviations from the recommended procedure.

3~~0~~1. Suffix—DIN 18-035, Part 6—Water Permeability of Synthetic Turf Systems and Permeable Bases

3~~0~~1.1 *Construction*—PVC tubing, 27.3-cm (10.75-in.) outside diameter, 25.4-cm (10.00-in.) inside diameter, 10-cm (0.375-in.) wall, 20.32-cm (8-in.) length, fused to a 6.35-cm (2.5-in.) PVC flange; a machined index ring marking overall 15.24 cm (6 in.) of flow head 7.57 L (2.00 gal). A gasket seal, same size as the flange, cut from 2.54-cm (1-in.) thick, 1-PCF polyurethane upholstery foam. The total weight of the unit is approximately 4.5 kg (10 lb).

3~~0~~1.2 *Procedure*—Position the tester on the permeable system or base (asphalt) with the wetted gasket in place, and create a seal by having one operator stand on the flange along a diameter. The second operator is to fill the vessel to a level above the index ring by using a hose or pouring water into the tester from a bucket. Start timing when the falling water level reaches the 15.24-cm (6-in.) index mark. Stop timing when the highest spots on the surface are exposed above the water level.

3~~0~~1.3 *Calculation of Rainfall Capacity* :

3~~0~~1.3.1 It will be sufficient for most purposes to report that the total flow time in the test (or average of flow times at various positions) does not exceed 600 s (10 min). This time is the minimum calculated for base (asphalt) thickness in the range of 7.62 to 15.24 cm (3 to 6 in.) when corrections to the observed drain time are applied (see below), to meet the specification of 25.4 cm/h (10 in./h) rainfall capacity. Flow times will usually be 1 to 2 min.

3~~0~~1.3.2 The first correction required is that for the variable flow during the test due to the falling head. The relation between the rainfall capacity provided by this test, *V* in./h, and the observed flow time, *t* s, is as follows:

$$t = 8290 \, (d/V) \log \, (1 + 6/d) \tag{10}$$

where:
d = thickness of the base (asphalt), in.

3~~0~~1.3.3 The rainfall capacity provided by this test, *V* in./h, is somewhat optimistic in terms of the true base (asphalt) permeability because the cross-sectional area of base (asphalt) available for flow increases as the water penetrates. The true permeability, V^* in./h, as, for example, that which one would find in the laboratory with a Marshall plug confined in a pipe section, is related to V by the following:[14]

$$V^* = V/(1 + 0.236d) \quad (11)$$

301.3.4 Combination of the two corrections given yields the following:

$$V^* = 8290d \log (1 + 6/d)/(1 + 0.236d)t \quad (12)$$

When required, calculate V^* in in./h from the above equation (see also the graph in Fig. X2.2). For example, d = 3 in., t = 100 s, log (1 + 6/ d) = 0.477, V^* = 69 in./h.

312. Suffix ASTM—Turf System Ball Bounce and Ball Rebound

312.1 *Scope*:

312.1.1 A general investigation of sports ball and playing surface interaction might include measurement of the coefficient of restitution in vertical ball drops, vertical and horizontal components of the ball bounce and friction at surface contact in non-vertical trajectories, coefficients of rolling friction and directionality in the movement of sports balls across the surface, transfer of the ball spin on surface contact, and other phenomena.

312.1.2 This test method addresses only the basic, and useful, sports ball and playing surface interaction of the coefficient of restitution on vertical impingement.

312.1.3 The coefficient of restitution is of practical value for characterizing playing surfaces, for example, with regard to the bounce height of driven baseballs, where certain limits are considered optimal.

312.1.4 Results of the coefficient of restitution for some sports balls, for example, soccer balls, are critically dependent on characteristics of the ball, notably inflation pressure. Contribution to the apparent coefficient of restitution from the ball spin before impact, for all sports balls, should be minimized by good experimental techniques.

312.1.5 Measurements covered by this test method apply to laboratory and field samples.

312.2 *Terminology*:

312.2.1 The coefficient of restitution is defined as the ratio of the vertical components of ball velocity V just after ($V2$) and just before ($V1$) impact, that is, V_2/V_1.

312.2.2 Since this test method concerns only vertical drops, the vertical velocity components of 312.2.1 are also the actual velocities observed.

312.2.3 With neglect of air resistance, free-fall velocity equals $(2gh)^{1/2}$; thus, the coefficient of restitution is given by the formula $(h_2/h_1)^{1/2}$, where h is the vertical height from the surface, with (h_1) referring to the selected drop height and (h_2) to the maximum height reached on rebound from the surface. Here, g is the acceleration due to gravity, approximately 980 cm/s^2 (32 ft/s^2).

312.3 *Test Design and Measurements* :

312.3.1 In general, the basic method for the coefficient of restitution in vertical drops is to release the ball from a specified height above the surface, taking care to initiate the free fall without ball rotation, and to record the height to which the ball rebounds.

312.3.2 Initial drop heights are optional. Useful selections are as follows: 1, 2, or 10 m for baseballs, or some combination thereof; and 2 or 10 m, or both, for soccer balls. For other sports balls, select heights in the range of applicability for the sport.

312.3.3 A visual method, using a vertical meter stick as the measuring device, and two participants, is usually adequate. The heights must be measured from a given reference point on the ball, such as the bottom surface.

312.3.4 Videocam, cinematrographic, or single frame and strobe cameras may be used for measuring heights under suitable conditions. They also may be used for measuring the impact and rebound velocities directly, in which case the velocity ratio definition of the coefficient of restitution applies (see 312.2.1). If velocities are measured, the distance from the rebounding surface and the distance over which the velocities are determined should be specified, for example, within 15 cm (6 in.) of the surface over a distance of 5 cm (2 in.). The minimum frame rate of the video or film camera should also be specified.

312.4 *Results and Report*:

312.4.1 Average the results from ten drops at a given drop height for each sports ball and surface examined. Each drop should be performed on a fresh portion of the surface. Specify the drop height(s).

312.4.2 If the visual method is used, calculate and report the average ratio $(h_2/h_1)^{1/2}$ (see 312.2.3).

312.4.3 If electronic or photographic measurements are read, and if used to determine the velocities directly, report the ratio of the average values V_2/V_1(see 312.2.1).

312.4.4 In the report, list the temperature and relative humidity and any other conditions that might qualify the sports ball and surfaces involved.

323. Suffix Practice D 5251, Operation of the Tetrapod Walker Drum Tester

323.1 *Scope*:

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[14] The Tetrapod Walker can be purchased from Lawson Hemphill Sales Inc., P.O. Box 6388, Spartanburg, SC; or Machine Control B.A.A. Canada Inc., 701 Ave. Meloche, Dorval, Quebec.

[14] See Prins and Hermans, *Journal of Physical Chemistry* , Vol 63, 1959, p. 716.

323.1.1 This practice describes the equipment and operation of the Tetrapod Walker for testing synthetic turf surfaces for resistance to matting.

323.1.2 This practice may be used upon mutual agreement between the purchaser and the supplier to set purchasing specifications.

323.1.3 The values stated in inch-pound units are to be regarded as the standard for all measurements except mass. The SI values are provided for information only for all measurements except mass.

323.2 *Summary of Practice*—The specimen is secured as the lining of a rotatable drum with the pile surface exposed. A four-legged metal casting (tetrapod) walks on the pile surface as it is tumbled in the drum, which is rotated about its longitudinal axis for a specified number of revolutions.

323.3 *Significance and Use*:

323.3.1 This equipment may be used to bring about the changes in texture on the surface of pile turf surfacing caused by mechanical action.

323.3.2 The acceptance criteria of this practice shall be set by mutual agreement between the purchaser and the supplier.

323.4 *Apparatus and Reagent Tetrapod Walker*[15] *Tester:*

323.4.1 *Driving System*, which cradles a drum on rollers and keeps the axis of the drum level, rotates at 5.2 ± 0.2 rad/s (50 ± 2 r/min), and has a counter that can be preset to stop the drum after any number of revolutions. Drive systems that do not reverse shall have the direction of rotation shown on the drum.

323.4.2 *Drum*, constructed of a rigid material and capped by a lid that is secured firmly. Each drum is equipped with two springs to hold the test specimen in place during testing. The inner dimensions of the drum are as follows: diameter, 205 ± 5 mm (8.0 ± 0.2 in.); and height, 190 ± 5 mm (7.6 ± 0.2 in.).

323.4.3 *Tetrapod*—A metal casting tetrahedral in shape with four legs placed equidistant from one another. That is, the outer most points correspond to the points on an equilateral tetrahedron, and the large angle between any two legs is 109.5°. Each leg shall have a replaceable plastic foot at the end. The free standing height of the tetrapod with three of the four plastic feet in one plane is 125 ± 2 mm (5 ± 0.1 in.). The total mass of the tetrapod, including the feet, is 1000 ± 2.5 g.

323.4.4 *Reagent Solvent*—Ethyl or isopropyl alcohols are suitable. Do not use cellosolve, chlorinated, or ketone solvents.

323.5 *Preparation of Specimen*:

323.5.1 *Marking the Specimen*—Before cutting out the test specimen, mark the direction of the pile lay and direction of the tetrapod walk on the secondary backing of each specimen.

323.5.2 *Size of Specimen*—Cut the specimen 61 by 20.5 cm (24 by 8 in.). The long dimension shall be parallel to the lengthwise direction of the carpet. Take no specimen within 10 cm (4 in.) of the trimmed edge.

323.6 *Conditioning*—Bring the specimen to moisture equilibrium for testing in the standard atmosphere for testing textiles, having a relative humidity of 65 ± 2 % at 21± 1°C (970 ± 2°F). Condition for a minimum of 12 h.

323.7 *Procedure*:

323.7.1 Test the conditioned specimen in a standard atmosphere at 65 ± 2 % relative humidity at 21 ± 1°C (70 ± 2°F).

323.7.2 Ensure that the inside of the drum and feet of the tetrapod are clean, smooth, and free from any contamination. Wipe the tetrapod tumbler and inside of the drum with a clean, lint-free tissue and one of the recommended reagents.

323.7.3 Inspect the tetrapod feet for signs of wear or damage, and replace as necessary.

323.7.4 Place the specimen in the drum, with the lay of the pile and drum rotation in the same direction.

NOTE 5—Some testers have the capability of reversing their direction of rotation intermittently.

323.7.5 Place the specimen in the drum with the pile yarn exposed.

323.7.6 Carefully fit one spring over the specimen at the closed end of the drum and the second spring at the open end. The solid part of the springs should bridge any carpet seams.

323.7.7 Place the tetrapod tumbler in the drum on the carpet surfaces.

323.7.8 Secure the lid to the drum, and then position the drum on the rollers of the drive mechanism and ensure that the drum is level.

323.7.9 Set the counter for 50 000 revolutions unless otherwise specified.

323.7.10 Remove the specimen from the drum at the end of the specified revolutions.

323.8 *Report*:

323.8.1 State that the test was conducted as directed in Practice D 5251.

323.8.2 Identify the tested specimen.

323.8.3 Report the atmospheric conditions.

323.8.4 Report whether the drum rotation reverses.

323.8.5 Report the number of revolutions.

323.8.6 Report the appearance (texture) rating versus standard matting sample Numbers 1 through 5 or provide photographs of

[15] These test methods are under the jurisdiction of ASTM Committee F08 on Sports Equipment and Facilities and are the direct responsibility of Subcommittee F08.65 on Artificial Turf Surfaces and Systems.

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the matted samples versus photographs of a control matted turf sample.

3~~3~~4. Keywords

3~~3~~4.1 artificial turf; football surface; synthetic turf; turf system

APPENDIXES

(Nonmandatory Information)

X1. RATIONALE

X1.1 Over the past several years, there have been several test methods established for various components of, or synthetic turf systems, or both. These test methods define the key test methods currently in use, categorizing the tests into five main areas: fiber, fabric, pad, miscellaneous components, and the entire system; and dividing the tests into the performance of property tests. These test methods do not establish minimum requirements, only standard test methods.

X1.2 For various synthetic turf systems or components, or both, to be compared uniformly, a recommended performance test method guide is necessary. These test methods establish the recommended test methods for various performance properties as well as defining why these tests are applicable to the performance of the system.

X2. ASPHALT PERMEABILITY TESTER

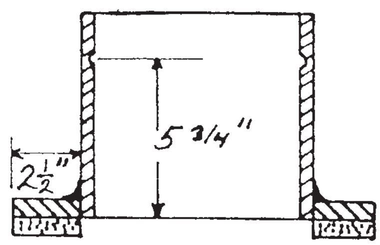

FIG. X2.1 Test Vessel Design

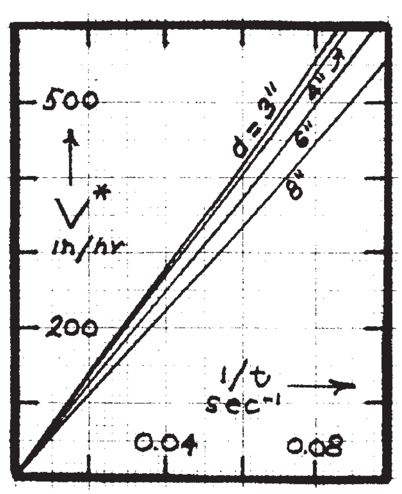

FIG. X2.2 Graphical Relationship of True Permeability, *V (in./h), to Test Flow Time, *t* (s)**