Designation: F1951 – 14

An American National Standard

Standard Specification for Determination of Accessibility of Surface Systems Under and Around Playground Equipment[1]

This standard is issued under the fixed designation F1951; 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 need for systematic and consistent means of evaluating the capability of surface systems to provide access to playgrounds has been amplified by the passage of the Federal Americans with Disabilities Act. The goal of this specification is to establish uniform means to measure the characteristics of surface systems in order to provide the potential buyer with performance specifications to select materials for use as an accessible surface under and around playground equipment.

1. Scope

1.1 This specification establishes minimum characteristics for those factors that determine accessibility. This specification applies to all types of materials that can be used under and around playground equipment.

1.2 The material under and around playground equipment that meets this specification must also comply with Specification F1292 if the surface is within the fall zone.

1.3 This specification does not imply that an injury cannot be incurred if the surface system complies with this specification.

1.4 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. (See IEEE/ASTM SI 10.)

1.5 The following precautionary statement pertains only to the test method portions, Sections 6 and 7, of this specification: *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]

IEEE/ASTM SI 10 American National Standard for Use of the International System of Units (SI): The Modern Metric System

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

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

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

F1487 Consumer Safety Performance Specification for Playground Equipment for Public Use

2.2 *U.S. Architectural and Transportation Barriers Compliance Board Document:*[3]

Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities

2.3 *U.S. Consumer Product Safety Commission Document:*[4]

US CPSC Publication No. 325 Handbook for Public Playground Safety (2010)

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

[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 F08.63 on Playground Surfacing Systems.

Current edition approved June 1, 2014. Published July 2014. Originally approved in 1999. Last previous edition approved in 2009 as F1951 – 09b. DOI: 10.1520/F1951-14.

[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 United States Access Board, 1331 F Street, NW, Suite 1000, Washington, DC 20004-1111, http://www.access-board.gov/.

[4] Available from United States Consumer Product Safety Commission, 4330 East West Highway, Bethesda, MD, 20814, http://www.cpsc.gov/.

3.1.1 *camber, n*—the angular position in the vertical direction of the individual main wheel axis.

3.1.1.1 *Discussion*—Zero camber occurs when the wheel axis is parallel to the ground surface.

3.1.2 *loose fill system, n*—a surface system consisting of small independent, movable components.

3.1.2.1 *Discussion*—Examples of movable components include sand, gravel, wood chips, loose rubber, and engineered wood fiber.

3.1.3 *maneuverability, n*—the ability of a surfacing material to allow unencumbered traversing or locomotion of a person with or without prosthetic aids or wheelchair.

3.1.4 *toe, n*—the difference in separation distance between the front of the two main wheels and the rear of the two main wheels of a wheelchair.

3.1.4.1 *Discussion*—Proper toe alignment occurs when the axle is perpendicular to the direction of rolling.

3.1.5 *use zone, n*—area beneath and immediately adjacent to a play structure or equipment that is designated for unrestricted circulation around the equipment and on whose surface it is predicted that a user would land when falling from or exiting the equipment.

3.1.5.1 *Discussion*—The surface area within the use zone shall meet the minimum impact attenuation requirements of Specification F1292 from the maximum fall height.

4. General Requirements

4.1 Playground surfaces represented as complying with this specification shall meet all applicable requirements regarding accessibility specified herein. Anyone representing compliance with this specification shall keep such essential records as are necessary to document any claim that the requirements within this specification have been met.

4.2 Surface systems that are within the use zone of the surrounded playground equipment shall be tested in accordance with Specification F1292 and shall comply with the impact performance requirements of Specification F1292. Thus, surface systems shall exhibit a head injury criterion (HIC) not exceeding 1000 and a value of acceleration recorded during an impact (g-max) not exceeding 200 from a height at or greater than the fall height of the play structure.

NOTE 1—This is consistent with the guidance contained in US CPSC Publication No. 325.

4.3 Accessibility specification certification compliance shall be conducted by an independent accredited testing laboratory.

5. Performance Requirement

5.1 The tests shall be conducted on a surface that is installed per the manufacturers' installation instructions. No additional compaction or other modification shall be permitted, other than what is required for test specimen preparation with Specification F1292.

5.2 *Maneuverability*—When tested in accordance with the test methods described in Sections 6 and 7 of this specification, a surface in place shall have average work per foot (work per meter) values for straight propulsion and for turning less than the average work per foot (work per meter) values for straight propulsion and for turning, respectively, on a hard, smooth surface with a grade of 7.1 ± 0.2 % (1:14).

6. Wheelchair Work Measurement Method—Straight Propulsion

6.1 *Test Equipment and Setup:*

6.1.1 *Test Wheelchair*—A 16-in. (40.64-cm) width rehabilitation wheelchair with pneumatic rear tires, front wheels with pneumatic tires, and a total weight of 31 ± 4.4 lb (14 ± 2 kg) shall be used as the test wheelchair. The rear wheels shall be identical with 24 by 1.375-in. (61 by 3.5-cm) pneumatic tires and pushrim diameters of 20 in. (50.8 cm). The front wheels with pneumatic tires shall be identical with 8 by 1-in. (20.3 by 2.54-cm) wheels with pneumatic tires. One main rear wheel shall be capable of measuring the forces applied to the pushrim that are tangential to the pushrim and parallel to the direction of travel. The wheelchair shall be adjusted such that there is minimal toe and minimal camber. Tire pressures shall be set to the maximum pressure specified by the manufacturer ±2 psi.

6.1.2 *Test Wheelchair Rider*—A165 +11, –4.4-lb (75 +5, –2 kg) test wheelchair rider shall propel the wheelchair during testing.

6.1.3 *Weight of Total System*—The total weight of the wheelchair-rider system, including any distance measurement or data acquisition equipment residing on the wheelchair, shall be a minimum of 187.2 lb (85 kg) and a maximum of 255 lb (116 kg).

6.1.4 *Weight Distribution*—The wheelchair rider shall be seated in the wheelchair such that 40± 2 % of the total weight is supported by the front casters and the rear wheels support the remaining 60 ± 2 % when measured in a static position with the wheelchair rider's hands placed on the rear wheel pushrims in the topmost position.

6.1.5 *Distance Measurement*—A method to measure the total distance that the wheelchair has been propelled must be present. This distance shall be 6.56 +0.66 / –0 ft (2.0 +0.20 / –0 m) from its starting, measured to an accuracy of ± 0.79 in. (2 cm).

6.1.6 *Wheel Angular Displacement Measurement (Optional)*—A method to measure the angular displacement of the pushrim force measuring wheel can be used. It shall have an accuracy of at least ± 0.5°.

6.1.7 *Data Acquisition*—A data acquisition system shall be used to record the forces applied to the pushrim and the end of the trial at a minimum frequency of 50 Hz.

6.2 *Test Specimen:*

6.2.1 An installed site of playground surfacing shall be used as the test specimen. The minimum test specimen size shall be 4 ft (1.22 m) wide by 8 ft (2.44 m) in length.

6.2.2 The surface shall be level and free of surface dirt, ice, or contaminants.

6.2.3 Testing shall be conducted when surface temperature, as measured by a temperature probe, is between 40 and 100°F (4 and 38°C).

6.3 *Test Procedure:*

6.3.1 Starting from a stationary position with the wheelchair casters in the trailing position, the test wheelchair rider shall

propel the wheelchair across the test surface a distance of 6.56 +0.66 / –0 ft (2.0 +0.20 / –0 m) using four uniform pushes. The distance the wheelchair actually rolls shall be recorded to an accuracy of ± 0.79 in. (± 2 cm). The wheelchair rider shall contact the pushrims only during the trial and shall maintain the same posture assumed during weight distribution measurement. The wheelchair shall be propelled in a straight path. At least three of the wheelchair wheels shall be in contact with the test surface during the trial. Each trial shall be completed in 7.0 ±1.0 s.

6.3.2 Record the forces applied to the pushrim to an accuracy of ± 0.15 ft × lbf (± 0.2 N × m), at a minimum frequency of 50 Hz.

6.3.3 Consider the trial acceptable if it meets the following criteria:

6.3.3.1 Pushrim torque values below –3.69 ft × lbf (–5.0 N × m) (reverse torque) do not occur;

6.3.3.2 One or more wheels do not slip on the surface creating torque values above 7.38 ft × lbf (10 N × m) with no forward movement of the wheelchair;

6.3.3.3 The time to complete the 6.56-ft (2.0-m) distance is 7.0 ± 1.0 s;

6.3.3.4 The torque applied to the wheelchair pushrim is zero or decreasing at the end of the trial;

6.3.3.5 The four propulsion strokes cause the wheelchair to travel a total distance of 6.56 +0.66 / –0 ft (2.0 +0.20 / –0 m).

6.3.4 Repeat 6.3.1 – 6.3.3 until a total of five acceptable trials are recorded. Use a leveled surface for each trial. If testing cannot be completed successfully on the test surface, document the reasons.

6.3.5 Repeat 6.3.1 – 6.3.4 with the same test wheelchair rider on a hard, smooth surface with a grade of 7.1 ± 0.2 % (1:14) and a cross slope of 0 ± 0.5 %.

6.4 *Calculation:*

6.4.1 Calculation of work per foot (work per meter):

6.4.1.1 For each trial, calculate the average torque by integrating the area under the torque-time curve and dividing by the time to complete the trial.

6.4.1.2 Calculate the total work required for each trial by multiplying the average torque value by the total wheel angular displacement. If the test wheelchair was instrumented with only one pushrim force measuring wheel, multiply this value by two.

6.4.1.3 For each trial, normalize the total work required to work per foot (work per meter) by dividing by the length of the trial.

6.4.2 Alternative method for calculating work per foot (work per meter):

6.4.2.1 For each trial, calculate the average work per foot (work per meter) by integrating the area under the torque-angular displacement curve or the torque-distance curve, and then dividing by the total angular displacement or length of the trial, respectively. If the test wheelchair was instrumented with only one pushrim force measuring wheel, multiply this value by two.

6.4.3 Discard the low and high work per foot (work per meter) values and average the remaining three trials to determine the average work per foot (work per meter) required to negotiate the test surface and the hard, smooth surface with a grade of 7.1 ± 0.2 % (1:14).

6.5 *Report*—Report the following information for the straight propulsion test:

6.5.1 A reference to this specification.

6.5.2 Complete identification of the playground surface system tested, including manufacturer, type, manufacturer's lot number, if appropriate, thickness, and any other pertinent information.

6.5.3 Details of the manufacturers' installation instructions. No modification or compaction of the surface is permitted beyond what is stated in the manufacturer's installation instructions other than what is required for test specimen preparation within Specification F1292.

6.5.4 Complete identification of the test wheelchair used, including name of manufacturer, model, identification number, and weight.

6.5.5 Weight of the test wheelchair rider, total weight and front-to-rear weight distribution of the wheelchair-rider system.

6.5.6 Optional additional helpful information includes any other relevant information, including photographs of the test site and of the wheelchair.

6.5.7 Date of tests.

6.5.8 The name and address of the test institution.

6.5.9 Pushrim torque versus time graphs for each trial.

6.5.10 Work per foot (work per meter) values to the nearest 0.1 ft × lbf (0.1 N × m) and total trial times for all five trials on the test surface and on the hard, smooth surface with a grade of 7.1 ± 0.2 % (1:14).

6.5.11 Average work per foot (work per meter) to the nearest 0.1 ft × lbf (0.1 N × m) for the test surface and for the hard, smooth surface with a grade of 7.1 ± 0.2 % (1:14). If testing could not be successfully completed on the test surface, the report must state this, as well as the reasons why testing could not be performed according to the test procedure. If the wheelchair continued to roll and could not stop at the specified distance, the work per foot (work per meter) required to negotiate the test surface shall be considered less than on the hard, smooth surface with a grade of 7.1 ± 0.2 % (1:14).

7. Wheelchair Work Measurement Method—Turning

7.1 *Test Equipment and Setup:*

7.1.1 *Test Wheelchair*—A 16-in. (40.64-cm) width rehabilitation wheelchair with pneumatic rear tires, front wheels with pneumatic tires, and a total weight of 31 ± 4.4 lb (14 ±2 kg) shall be used as the test wheelchair. The rear wheels shall be identical with 24 by 1.375-in. (61 by 3.5-cm) pneumatic tires and pushrim diameters of 20 in. (50.8 cm). The front wheels with pneumatic tires shall be identical with 8 by 1-in. (20.3 by 2.54-cm) wheels with pneumatic tires. One main rear wheel shall be capable of measuring the forces applied to the pushrim that are tangential to the pushrim and parallel to the direction of travel. The wheelchair shall be adjusted such that there is minimal toe and minimal camber. Tire pressures shall be set to the maximum pressure specified by the manufacturer ±2 psi.

7.1.2 *Test Wheelchair Rider*—A165 +11, –4.4-lb (75 +5, –2 kg) test wheelchair rider shall propel the wheelchair during testing.

7.1.3 *Weight of Total System*—The total weight of the wheelchair-rider system, including any distance measurement or data acquisition equipment residing on the wheelchair, shall be a minimum of 187.2 lb (85 kg) and a maximum of 255 lb (116 kg).

7.1.4 *Weight Distribution*—The wheelchair rider shall be seated in the wheelchair such that 40± 2 % of the total weight is supported by the front casters and the rear wheels support the remaining 60 ± 2 % when measured in a static position with the wheelchair rider's hands placed on the rear wheel pushrims in the topmost position.

7.1.5 *Turn Guide Test Fixture*—A test-fixture shall be used to guide the wheelchair through the turning maneuver. The test fixture shall be constructed such that it guides the wheelchair through a 90° turn. The turn guide shall be 4.75 ± 0.4 in. (12 ± 1 cm) in height and have a radius of curvature of 12.00 ± 0.05 in. (30.5 ± 0.13 cm) (see Fig. 1). The outside of the 12.0-in. (30.5-cm) turn guide shall by lined with a 0.25 ± 0.02-in. (0.635 ± 0.05-cm) polyethylene strip to provide an antifriction surface; thus, the turn guide with polyethylene strip shall have an outside radius of 12.25 ± 0.07 in. (31.135 ± 0.18 cm). The rear wheel axle location of the test wheelchair shall be tethered to the center of curvature of the turn guide. The length of the tether shall be set such that when taut the lower portion of the wheelchair pushrim is 0.32 ± 0.08 in. (8 ± 2 mm) from the turn guide.

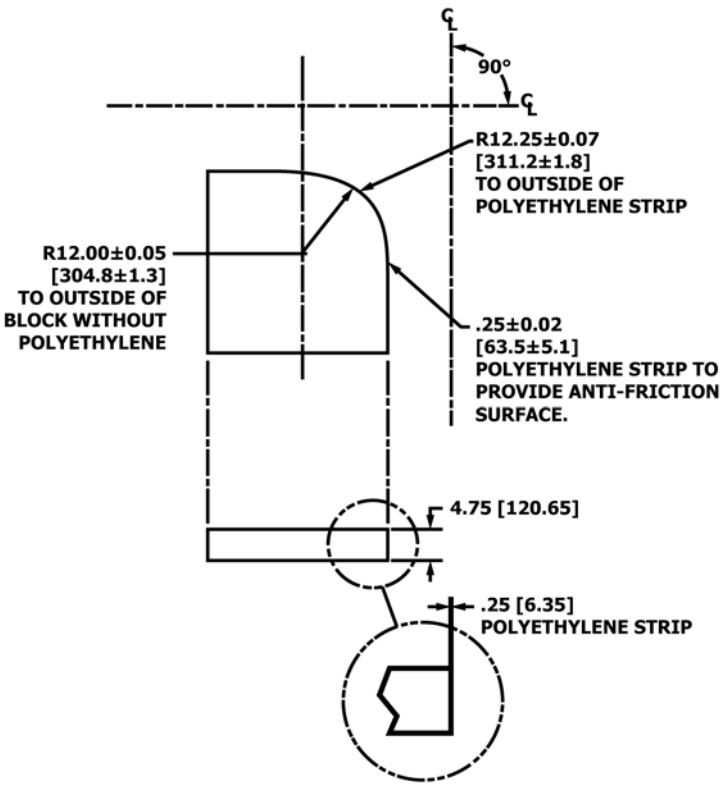

FIG. 1 Turn Guide Test Fixture

7.1.6 *Angle Measurement*—A method to measure the angle that the wheelchair has been turned must be present. This angle shall be 90 +10 / –0° from its starting position, measured to an accuracy of ± 2°.

7.1.7 *Wheel Angular Displacement Measurement (Optional)*—A method to measure the angular displacement of the pushrim force measuring wheel can be used. It shall have an accuracy of at least ± 0.5°.

7.1.8 *Data Acquisition*—A data acquisition system shall be used to record the forces applied to the pushrim and the end of the trial at a minimum frequency of 50 Hz.

7.2 *Test Specimen:*

7.2.1 An installed site of playground surfacing shall be used as the test specimen. The minimum test specimen size shall be 4 ft (1.22 m) wide by 8 ft (2.44 m) in length. The playground surface thickness used for testing shall be the minimum thickness to be used in an actual playground installation.

7.2.2 The playground surface shall be installed in an appropriate location, which is not required to be an actual playground.

7.2.3 The surface shall be level and free of surface dirt, ice, or contaminants.

7.2.4 Testing shall be conducted when surface temperature, as measured by a temperature probe, is between 40 and 100°F (4 and 38°C).

7.3 *Test Procedure:*

7.3.1 Starting from a stationary position with the wheelchair casters in the trailing position, the test wheelchair rider shall propel the wheelchair on the test surface around the turn guide using four uniform pushes until the wheelchair is oriented 90 +10 / –0° from its starting position. The angle the wheelchair actually turns shall be recorded to an accuracy of ± 2°. The wheelchair rider shall contact the pushrim of the wheel that is on the outside of the turn only during the trial and shall maintain the same posture assumed during weight distribution measurement. At least three of the wheelchair wheels shall be in contact with the test surface during the trial. Each trial shall be completed in 7.0 ± 1.0 s.

7.3.2 Record the forces applied to the pushrim to an accuracy of ± 0.15 ft × lbf (± 0.2 N × m), at a minimum frequency of 50 Hz.

7.3.3 Consider the trial acceptable if it meets the following criteria:

7.3.3.1 Pushrim torque values below –3.69 ft × lbf (–5.0 N × m) (reverse torque) do not occur;

7.3.3.2 The wheel on the outside of the turn does not slip on the surface creating torque values above 7.38 ft × lbf (10 N × m) with no forward movement of the wheelchair;

7.3.3.3 The time to complete the entire turn is 7.0 ± 1.0 s;

7.3.3.4 The torque applied to the wheelchair pushrim is zero or decreasing at the end of the turn;

7.3.3.5 The four propulsion strokes cause the wheelchair to be oriented 90 +10 / –0° from its starting position.

7.3.4 Repeat 7.3.1 – 7.3.3 until a total of five acceptable trials are recorded. Use a leveled surface for each trial. If testing cannot be successfully completed on the test surface, document the reasons.

7.3.5 Repeat 7.3.1 – 7.3.4 with the same test wheelchair rider on a hard, smooth surface with a grade of 7.1 ± 0.2 % (1:14) and a cross slope of 0 ± 0.5 %. The wheelchair shall start the turn facing 45° from the uphill direction and be turned toward the uphill direction until it is facing 45° from the uphill direction in the opposite direction that the wheelchair started (see Fig. 2).

7.4 *Calculation:*

7.4.1 Calculation of work per foot (work per meter):

7.4.1.1 For each trial, calculate the average torque by integrating the area under the torque-time curve and dividing by the time to complete the trial.

7.4.1.2 Calculate the work per foot (work per meter) required for each trial by multiplying the average torque value by the estimated, total wheel angular displacement over the length of the test, and then dividing by the length of the test to normalize the work required.

7.4.2 Alternative method for calculating work per foot (work per meter):

7.4.2.1 For each trial, calculate the average work per foot (work per meter) by integrating the area under the torque-angular displacement curve or the torque-distance curve, and then dividing by the total angular displacement or length of the trial, respectively.

7.4.3 Discard the low and high work per foot (work per meter) values and average the remaining three trials to determine the average work per foot (work per meter) required to negotiate the test surface and the hard, smooth surface with a grade of 7.1 ± 0.2 % (1:14).

7.5 *Report*—Report the following information for the turning test:

7.5.1 A reference to this specification.

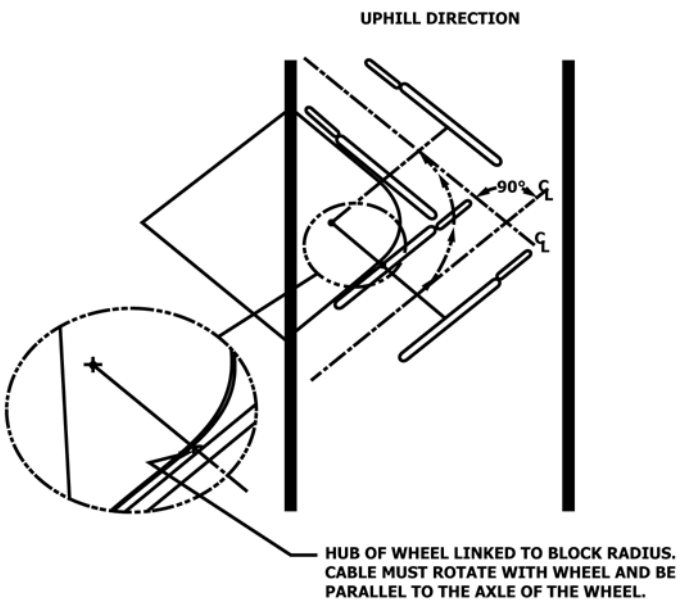

FIG. 2 Turning on Hard, Smooth Surface With Grade of 7.1 ± 0.2 % (1:14)

7.5.2 Complete identification of the playground surface system tested, including manufacturer, type, manufacturer's lot number, if appropriate, thickness, and any other pertinent information.

7.5.3 Details of the manufacturers' installation instructions. No modification or compaction of the surface is permitted beyond what is stated in the manufacturer's installation instructions other than what is required for test specimen preparation within Specification F1292.

7.5.4 Complete identification of the test wheelchair used, including name of manufacturer, model, identification number, and weight.

7.5.5 Weight of test wheelchair rider, total weight and front-to-rear weight distribution of the wheelchair-rider system.

7.5.6 Optional additional helpful information includes any other relevant information, including photographs of the test site and of the wheelchair.

7.5.7 Date of tests.

7.5.8 The name and address of the test institution.

7.5.9 Pushrim torque versus time graphs for each trial.

7.5.10 Work per foot (work per meter) values to the nearest 0.1 ft × lbf (0.1 N × m) and total trial time for all five trials on the test surface and on the hard, smooth surface with a grade of 7.1 ± 0.2 % (1:14).

7.5.11 Average work per foot (work per meter) to the nearest 0.1 ft × lbf (0.1 N × m) for the test surface and for the hard, smooth surface with a grade of 7.1 ± 0.2 % (1:14). If testing could not be successfully completed on the test surface, the report must state this, as well as the reasons why testing could not be performed according to the test procedure. If the wheelchair continued to roll and could not stop at the specified distance, the work per foot (work per meter) required to negotiate the test surface shall be considered less than on the hard, smooth surface with a grade of 7.1 ± 0.2 % (1:14).

8. Precision and Bias

8.1 *Potential Sources of Error or Deviations:*

8.1.1 Variations in weight distribution during wheelchair propulsion due to changes in test wheelchair rider positioning;

8.1.2 Variations in pneumatic tire pressure caused by temperature differences;

8.1.3 Variations in surface characteristics caused by changes in moisture and temperature; and

8.1.4 Variations in friction between the pushrim of the wheelchair and the polyethylene strip of the turn guide test fixture, brought about by subtle differences in the position of the chair with respect to the turn guide.

8.2 *Precision*—Preliminary interlaboratory test results have been obtained and are shown in 8.3.

8.3 A preliminary interlaboratory study of wheelchair work for straight propulsion and turning was conducted based upon Practice E691, using six laboratories and six materials, with each laboratory obtaining two test results for each material.

8.3.1 *Repeatability and Reproducibility Conditions*—All six laboratories conducted testing at the same test site and with the same equipment over a period of three months. Testing was conducted outdoors under various environmental conditions.

Each laboratory used a different test wheelchair rider. The data acquisition equipment was powered down between the two sets of trials on each material.

the work ratios are as shown in Table 1. The terms repeatability standard deviation (within a laboratory) and reproducibility standard deviation (between laboratories) are used as specified

TABLE 1 Typical Standard Deviations for Work Ratios

Wheelchair Work Measurement Method—Work Ratios	Straight Propulsion	Turning
95 % repeatability standard deviation (within laboratories)	0.0914	0.1148
95 % reproducibility standard deviation (between laboratories)	0.1942	0.1490

TABLE 2 Wheelchair Work Measurement Method—Straight Propulsion[A]

Material	Avg. Work Ratio	Repeatability Std Dev.	Reproducibility Std Dev.	Repeatability Limit	Reproducibility Limit
A	0.422	0.0268	0.0741	0.0750	0.2074
B	0.899	0.0320	0.0320	0.0896	0.0896
D	0.914	0.0299	0.0456	0.0836	0.1277
C	0.973	0.0440	0.1066	0.1231	0.2986
E	1.149	0.0310	0.0946	0.0867	0.2649
F	1.330	0.0324	0.0632	0.0907	0.1770

[A]A = accessible carpet.
B = inaccessible carpet.
C = 1:16 ramp.
D = cedar chips.
E = 1:12 ramp.
F = 1:10 ramp.

TABLE 3 Wheelchair Work Measurement Method—Turning[A]

Material	Avg. Work Ratio	Repeatability Std Dev.	Reproducibility Std Dev.	Repeatability Limit	Reproducibility Limit
A	0.505	0.0208	0.0254	0.0583	0.0712
B	0.774	0.0366	0.0527	0.1026	0.1475
D	0.882	0.0505	0.0610	0.1414	0.1708
C	0.977	0.0534	0.0607	0.1495	0.1699
E	1.113	0.0385	0.0385	0.1078	0.1078
F	1.290	0.0462	0.0809	0.1293	0.2266

[A]A = accessible carpet.
B = inaccessible carpet.
C = 1:16 ramp.
D = cedar chips.
E = 1:12 ramp.
F = 1:10 ramp.

8.3.2 *Test Result for This Study*—For purposes of this study, a work ratio was calculated by dividing the average work per foot (work per metre) for the test surface by the average work per foot (work per metre) for the hard, smooth surface with a grade of 7.1 ± 0.2 % (1:14), as shown in Eq 1.

$$\text{work ratio} = \frac{\text{average work per foot for test surface}}{\text{average work per foot for 7.1 \% ramp}} \quad (1)$$

8.3.3 *Preliminary Estimate of Repeatability and Reproducibility*—On average, the typical standard deviation for in Practice E177. See Table 2 and Table 3 for more detail. The terms repeatability limit and reproducibility limit are used as specified in Practice E177.

8.4 *Bias*—These methods have no bias because surface accessibility is defined only in terms of these test methods.

9. Keywords

9.1 playground surface accessibility; playground surfacing; wheelchair maneuverability

APPENDIX

(Nonmandatory Information)

X1. RATIONALE

X1.1 The need to have playground surfaces that are firm and stable and, if within the use zone, resilient, thereby enabling use by people with mobility impairments, has been acknowledged by the U.S. Architectural and Transportation Barriers Compliance Board (United States Access Board) in its Americans with Disabilities Act document, which was published in the Federal Register on July 23, 2004. In addition, the Board understands that playground owners and operators, as well as manufacturers of playground surfacing, desire quantifiable measurement methods to determine the accessibility of playground surfacing systems. This specification has been developed to address this need for quantifiable measurement of accessibility for persons with mobility impairments that do or do not use assistive mobility devices, including but not limited to wheelchairs, crutches, and walkers. The test methods in this specification address access not only for children but also for adults who may traverse the surfacing to aid children who are playing.

X1.2 Testing was conducted to evaluate the firmness of playground surfaces using both wheelchair casters and standard crutch tips. The wheelchair maneuverability test procedures in this specification are more reliable and more stringent than currently available crutch tip penetration measurement methods. Testing showed that surfaces that failed the crutch tip penetration tests also failed the wheelchair maneuverability tests. A test procedure for crutch tip penetration does not presently provide any additional information.

X1.3 The type of adaptive equipment (for example, wheelchair, crutch, walker) used by a person with a mobility limitation will affect the work required to negotiate a surface. The wheelchair configuration will also affect the work required to maneuver across a surface. A wheelchair with smaller diameter or narrower width wheels will require more work to cross a surface than a wheelchair with larger diameter or wider width wheels. The wheelchair maneuverability test procedures are performed with a rehabilitation type wheelchair with main wheel and caster wheel sizes that are typically found on everyday wheelchairs that are most commonly used by persons with mobility limitations that use a wheelchair for all activities of daily life. Persons using a hospital-type wheelchair with narrow, solid tires are not generally using this type of wheelchair in outdoor environments.

X1.4 The weight of a person with a mobility limitation using adaptive equipment will affect the work required to traverse a surface and up a ramp. A heavier person will require more work and a lighter person will require less work on both a level surface and up a ramp. All wheelchair maneuverability testing is performed with a standardized 165-lb (75-kg) test mass commonly used for wheelchair testing. A 165-lb (75-kg) test wheelchair rider corresponds to a 50th percentile male adult. This weight provided the most repeatable results when testing on various surfaces and ramp angles.

X1.5 US CPSC Publication No. 325 (Public Playground Safety Handbook, November 2010) contains guidance on impact requirements. The handbook explains the following. The surfacing under and around playground equipment is one of the most important factors in reducing the likelihood of life-threatening head injuries. A fall onto a shock absorbing surface is less likely to cause a serious head injury than a fall onto a hard surface. However, some injuries from falls, including broken limbs, may occur no matter what playground surfacing material is used. The most widely used test method for evaluating the shock absorbing properties of a playground surfacing material is to drop an instrumented metal headform onto a sample of the material and record the acceleration/time pulse during the impact. Field and laboratory test methods are described in Specification F1292. Specification F1292 includes means to assess the maximum acceleration (shock) produced by an impact (expressed as g-max) and a measure of impact severity (expressed as a Head Injury Criterion or HIC).