Designation: F2376 – 21a

Standard Practice for Classification, Design, Manufacture, Construction, and Operation of Water Slide Systems[1]

This standard is issued under the fixed designation F2376; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice applies to the classification, design, manufacture, construction, major modification, and operation of water slide systems. Water slide systems shall be defined as rides intended for use by riders in bathing attire where the action of the ride involves possible and purposeful immersion of the rider's body either in whole or in part in water, and uses circulating water to mobilize or lubricate the rider's transportation along a purpose built path. This includes slides used with or without vehicles as defined below. The terms water slides, waterslides, and slides shall be considered equivalent when used in this practice.

1.1.1 Owner/operator requirements of this standard are required of all water slide systems regardless of date of construction.

1.1.2 The design, manufacture and construction of an existing water slide or portions of a water slide system unaffected by a major modification shall meet the standard requirements in existence at the time of the construction.

1.2 For the purposes of this practice, a water slide system includes:

1.2.1 The flume,

1.2.2 The water-circulation system,

1.2.3 The starting platform with associated means of access and egress,

1.2.4 The structural supports,

1.2.5 Vehicles or other aquatic accessories that are part of the water slide as defined by the manufacturer, and

1.2.6 Means of slide termination.

1.3 This practice shall not apply to:

1.3.1 Any water slides installed in private residences,

1.3.2 Water flume amusement rides where contact with water is merely incidental (for example, log flume rides, shoot-the-chutes),

1.3.3 Amusement rides and devices whose design criteria are specifically addressed in another ASTM standard,

1.3.4 Lazy river type attractions operating at constant elevation, constructed in the ground,

1.3.5 Inflatable water slides (constant air supply) that are mounted on land (refer to Practice F2374-19 for the requirements of these types of water slides), and

1.3.6 Inflatable water slides (captured air) that are floating on a body of water (refer to EN/ISO 25649, parts 1 through -7).

1.4 Pre-existing designs manufactured after the effective date of publication of this practice if the design is service proven or previously compliant, as defined in Terminology F747-15, and the manufacturer provides:

1.4.1 A historical summary of the water slide, or major modification as defined in Terminology F747-15, and

1.4.2 A statement that the design is service proven or previously compliant. Water slides and major modifications to water slides may qualify as previously compliant for five years following the date of publication of this practice. Thereafter, water slides and major modifications to water slides must qualify as service proven or meet the requirements of this practice.

1.4.3 Service proven or previously compliant designs shall comply with Section 4.

1.5 The values stated in inch-pound units are to be regarded as standard. No other units of measurement are included in this standard.

NOTE 1—The conversion factor from inch-pound to metric units is 1 in. = 25.4 mm, and 1 lb = 4.4482 N.

1.6 This practice includes an Appendix, which provides additional information to enhance the user's understanding of and application of the criteria presented in this practice, for example, rationale, background, drawings, interpretation, or commentary. The information in the Appendix shall not be considered a mandatory part of this practice.

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

[1] This practice is under the jurisdiction of ASTM Committee F24 on Amusement Rides and Devices and is the direct responsibility of Subcommittee F24.70 on Water Related Amusement Rides and Devices.

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1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D570 Test Method for Water Absorption of Plastics

D638 Test Method for Tensile Properties of Plastics

D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

F747 Terminology Relating to Amusement Rides and Devices

F770 Practice for Ownership, Operation, Maintenance, and Inspection of Amusement Rides and Devices

F1193 Practice for Quality, Manufacture, and Construction of Amusement Rides and Devices

F2291 Practice for Design of Amusement Rides and Devices

F2374 Practice for Design, Manufacture, Operation, and Maintenance of Inflatable Amusement Devices

2.2 *ACI Standard:*[3]

ACI-318 Building Code Requirements for Structural Concrete

2.3 *ASCE Standard:*[4]

ASCE/SEI 7-16 Minimum Design Loads for Buildings and Other Structures

2.4 *EN/ISO Standard:*[5]

EN/ISO 25649 Floating leisure articles for use on and in the water

2.5 *USDA Document:*[6]

USDA-72 The Wood Handbook

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *fall distance*—vertical distance between the terminus of the slide surface and the water surface of the landing pool.

3.1.2 *flume riser (splashguard)*—extension of the side wall of an open flume to contain riders or water and is capable of use as a riding surface.

3.1.3 *landing pool*—pool intended to receive riders from a water slide.

3.1.4 *landing zone*—area in a landing pool intended for receiving riders from a particular slide.

3.1.5 *lifeguard*—individual specially trained in lifesaving and emergency procedures, responsible for monitoring patrons and responding to aquatic and other emergencies.

3.1.6 *run-out section*—flume surface of a water slide where riders are intended to decelerate or come to a stop, or both.

3.1.7 *slide height*—difference in elevation from the centerline of the flume at the slide exit to the centerline of the flume at slide entry, measured at the riding surface.

3.1.8 *slide path*—geometric layout of the flume sections that make up the water slide.

4. Design

4.1 *Slide Classification:*

4.1.1 Water slides are classified by their physical and intended use characteristics. The classification may be a combination of the specific rider vehicle used the type of geometric path, often serpentine or straight, and the designation as a speed slide if the rider's velocity exceeds 25 ft/s. The following are definitions of the types of water slides.

4.1.1.1 *body slides*—water slide used without a vehicle.

4.1.1.2 *children's slides*—Water slides generally intended only for use by persons under the height of 48 in. Water slide has a maximum fall distance of 3 in. from slide exit where the rider enters the water and water depth is no greater than 24 in.

4.1.1.3 *mat slides*—water slide used with a designated mat as a vehicle.

4.1.1.4 *serpentine slide*—curved path as viewed in geometric slide path.

4.1.1.5 *specialty slides*—proprietary water slide design, such as an uphill, half-pipe, or bowl ride, which does not conform to standard classification.

4.1.1.6 *specialty vehicle slides*—water slide used with a proprietary vehicle specified by the manufacturer.

4.1.1.7 *speed slide*—water slide where the rider(s) achieve a velocity of 25 ft/s or more during the course of the ride.

4.1.1.8 *tube slides*—water slide used with a single or multi-person water slide tube.

4.2 *Notification Requirement*—A water slide system shown to comply with this practice shall meet all applicable requirements specified in this practice. Anyone representing compliance with this practice shall keep such essential records as are necessary to document any claim that the requirements within this specification have been met.

4.3 *Structural Design of Water Slides:*

4.3.1 This section defines the loading and strength criteria that shall be used in the structural engineering of water slide flumes and supporting structures. The strength and stability of the water slide system shall be demonstrated by generally accepted engineering methods certified by a professional engineer.

4.3.1.1 Basic load descriptions are provided below and within Appendix X2.

4.3.1.2 In the absence of a recognized national building code, the basic loads defined below shall be combined with guidance provided by Practice F2291-19$^{\varepsilon 1}$, with the exception that ASCE/SEI 7-16 shall be used.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American Concrete Institute (ACI), P.O. Box 9094, Farmington Hills, MI 48333.

[4] Available from The American Society of Civil Engineers (ASCE), 1801 Alexander Bell Dr., Reston, VA 20191.

[5] Available from International Organization for Standardization (ISO), ISO Central Secretariat, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, https://www.iso.org.

[6] Available from U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401.

4.3.1.3 The ASCE/SEI 7-16 and later calculates basic wind loads as ultimate wind loads. This document provides the ultimate wind speeds for use with the load combinations provided in Appendix X2.

4.3.1.4 Basic loads are forces, pressures, movements, etc. defined by a magnitude, direction, and application location. Basic loads are not yet combined with other loads.

4.3.1.5 Basic load case values such as wind, live, and dead shall be combined using pre-defined Load Combinations within ASCE/SEI 7-16 when no other load combination guidance is required by the jurisdiction. Some of these load combinations are provided within Appendix X2 as they appear within ASCE/SEI 7-16. Load combinations are defined for allowable stress design (ASD) and ultimate strength design (USD) methodologies, respectively. The engineer will ensure that load combinations are used consistently with matching resistance levels.

4.3.2 *Dead Loads (symbol D)*—Forces resulting from weight of all components of the ride and includes all loads that do not fluctuate with respect to time.

4.3.2.1 *Ice Loads (symbol D,i)*—Forces resulting from the calculated accumulation of ice on exterior water slide components that correspond to the location's ice risk category.

4.3.3 *Live Loads (symbol L)*—Forces resulting from live load occupancy requirements including, but not limited to egress corridors, public assembly, queuing areas, maintenance platforms or catwalks. Also, forces from water, riders, rider vehicles, or a combination thereof, in the slide system, are defined herein.

4.3.3.1 *Slide Live Load (symbol L,s)*—Forces from water, riders, rider vehicles, or a combination thereof, in the system under its pre-established and defined normal operations. L,s = water loads(L,f) + rider loads(L,p).

4.3.3.2 *Water Load (symbol L,f)*—One component of the slide live load. In free flowing water slides where water does not collect in pools or streams greater than 51 mm (2 in.) deep, the water load shall be a minimum of 0.35 kN/m (22.5 pounds per linear foot) for every 100 liters per second (1500 gallons per minute) of flow. Where the flow is such that water collects in pools or streams greater than 51 mm (2 in.) deep, the actual maximum water load shall be determined and used in calculation, design, or load tests, or a combination thereof.

4.3.3.3 *Rider Load (symbol L,p)*—One component of the slide live load. The manufacturer shall specify the rider vehicle weight and the maximum number of riders that are to slide in the flume at one time to the designer/engineer.

(1) For water slides intended for multiple rider use, the weight assigned to each rider shall be, at a minimum, the weight specified for a rider within 4.3.3.3*(2)*.

(2) Each water slide rider shall be modeled as a 1.33 kN (300 lb) point load rationally distributed by the rider vehicle stiffness, or over a 762 by 762 mm (30 by 30 in.) area for an individual rider with no vehicle.

(3) Rider loads shall be so arranged to cause the greatest realistic stress on each structural element within the water slide system.

(4) Lateral centripetal forces shall be considered in curved sections of flume using live loads. Predicted rider speeds should be used to calculate these forces. If speeds cannot be predicted, then a minimum of 4.6 m/s (15 ft/s) for flumes under 15 % slope and 9.1 m/s (30 ft/s) for all other flumes shall be used.

(5) If the manufacturer allows rider loads in excess of those defined herein, then the designer/engineer shall design for the higher load provided by the manufacturer.

(6) The weight of the rider vehicle shall be added to and included in determining rider load.

4.3.3.4 Live loads are loads produced by the intended use, occupancy, reasonably expected operations, maintenance, and person rescue applied to the water slide structural system. Live loads shall never be less than the loads required within this specification, even if operational limitations may justify a lesser load.

4.3.4 *Environmental Loads*—Forces from environmental conditions of the site such as wind, precipitation, earthquake, and changes in temperature.

4.3.4.1 Loads and forces due to environmental conditions shall be applied consistently in accordance with the applicable building code requirements or guidance provided by this standard.

4.3.4.2 The manufacturer and designer/engineer shall clearly indicate the design environmental loads within the water slide system's operating and maintenance instructions, as specified in the sections on manufacturer's responsibility within Practices F770-18 and F1193-18. In addition to the environmental load information, any restriction, limitations, or special procedures associated with water slides exposed to these environmental loads shall be included.

4.3.4.3 *Wind Load (symbol W)*—For outdoor slides, the minimum wind load for all types of water slides shall be calculated based on the local jurisdiction's minimum wind speed velocity using the following:

- Duration equal to 3-s gust.
- Height equal to (10.06 m) 33 ft above grade.
- Exposure C is defined as open terrain with scattered obstructions.
- The return interval (of 300, 700, and 1700 years) is based on the water slide systems' risk category.

(1) Non-operational in the wind (symbol W,n)—In the absence of a local building code, the wind load shall be calculated based on a minimum 3-s gust, 700-year MRI basic wind speed of 58 m/s (130-mph) during non-operational conditions.

(2) Operational in the wind (symbol W,s)—For outdoor slides the operational wind load for all types of water slides shall be calculated based on a minimum 3-s gust, 700-year MRI wind speed of 25 m/s (60-mph) during operational conditions.

4.3.4.4 *Other Lateral Loads – for example, Notional Loads (symbol N)*—A minimum lateral load equivalent to 10 % of the dead weight and superimposed D of the structure shall be included or minimum notional load required by structural material specifications (whichever is larger).

4.3.4.5 *Snow Load (symbol S)*—The snow load for all types of water slides shall be calculated in accordance with the relevant local ground snow load(s).