



Designation: ~~F 2376-07~~ Designation: F 2376 – 08

Standard Practice for Classification, Design, Manufacture, Construction, and Operation of Water Slide Systems¹

This standard is issued under the fixed designation F 2376; 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, 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.

1.2 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, and

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 Section 3.1.26 of Practice F 2291, and the manufacturer provides:

1.4.1 A historical summary of the water slide, or major modification as defined in Terminology F 747, 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 78.

1.5 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are for information only.

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 and health 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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2. Referenced Documents

2.1 *ASTM Standards:*²

- D 570 Test Method for Water Absorption of Plastics
- D 638 Test Method for Tensile Properties of Plastics
- D 790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
- F 698 Specification for Physical Information to be Provided for Amusement Rides and Devices
- F 747 Terminology Relating to Amusement Rides and Devices
- F 770 Practice for Ownership and Operation of Amusement Rides and Devices
- F 846 Guide for Testing Performance of Amusement Rides and Devices
- F 853 Practice for Maintenance Procedures for Amusement Rides and Devices
- F 893 Guide for Inspection of Amusement Rides and Devices
- F 1193 Practice for Quality, Manufacture, and Construction of Amusement Rides and Devices
- F 1305 Guide for Classification of Amusement Ride and Device Related Injuries and Illnesses
- F 2291 Practice for Design of Amusement Rides and Devices

2.2 *ACI Standard:*³

- ACI-318 Building Code Requirements for Structural Concrete

2.3 *ASCE Standard:*⁴

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

2.4 *USDA Document:*⁵

- USDA-72 The Wood Handbook

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

- 3.1.1 *closed flume*—flume that encloses the rider in a pipe-like cross-section.
- 3.1.2 *fall distance*—vertical distance between the terminus of the slide surface and the water surface of the landing pool.
- 3.1.3 *flow meter*—device used to measure the water flow for a water slide.
- 3.1.4 *flume*—that part of the water slide that contains the rider(s) and defines the path of the water slide within which sliding takes place.
- 3.1.5 *flume riser (splashguard)*—extension of the sidewall of an open flume to contain riders or water and is capable of use as a riding surface.
- 3.1.6 *instructional signage*—signage displayed in public view prior to the entrance of the ride with information provided to the rider, which informs them of instructions for proper use, riding position, and expected rider behavior.
- 3.1.7 *landing pool*—pool intended to receive riders from a water slide.
- 3.1.8
- 3.1.2 *landing zone*—area in a landing pool intended for receiving riders from a particular slide.
- 3.1.9
- 3.1.3 *lifeguard*—individual specially trained in lifesaving and emergency procedures, responsible for monitoring patrons and responding to aquatic and other emergencies.
- 3.1.10 *mat*—flexible sheet usually made of plastic or foam, suitable for use as a vehicle in a water slide flume to carry a rider.
- 3.1.11 *multiple dispatch slide*—slide that is designed for the slide attendant to dispatch or allow two or more individual riders or vehicles in the flume at one time.
- 3.1.12 *open flume*—flume that does not completely encircle or enclose the rider.
- 3.1.13
- 3.1.4 *owner/operator*—person or organization that is responsible for the maintenance and operation of a water slide system.
- 3.1.14 *rider*—any person who is in the act of entering the flume, using the flume, or getting off of the flume.
- 3.1.15 *rider oscillation*—repeated movement of rider or vehicle, or both, back and forth across the width of a water slide flume.
- 3.1.16 *run-out section*—flume surface of a water slide where riders are intended to decelerate or come to a stop, or both.
- 3.1.17 *sign*—display of symbols or language reasonably calculated to communicate information to riders or their parents or guardians, including placards, stickers, pictures, pictograms, guidebooks, brochures, video, and visual signals.
- 3.1.18 *slide attendant*—individual trained in facility and ride-specific emergency procedures, slide operating procedures, and responsible for dispatching and controlling rider intervals as they enter and exit on water slides and attractions.
- 3.1.19 *safety sign*—signage displayed in public view, prior to the entrance of the water slide, with information provided to the rider, which includes restrictions, warnings, and instructions.

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

3.1.20 *single dispatch slide*—slide that is designed for the slide attendant to dispatch or allow only a single rider or vehicle in the flume at one time. The rider or vehicle must clear a specific exit point before the slide attendant dispatches the next rider or vehicle.

3.1.21 *slide entry section*—that part of the water slide where riders enter the flume from the starting platform.

3.1.22 *slide exit section*—that part of the water slide where riders leave the flume to come to a stop in a landing pool.

3.1.23 *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.

3.1.24 *slide length*—total length of the geometric invert of the flume from the slide exit to the slide entry.

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

3.1.26 *slide vehicle*—device intended for use on a water slide upon which the rider(s) sits or lays while sliding.

3.1.27 *specialty vehicle*—proprietary vehicle sufficiently different from other vehicles designated by the slide manufacturer as suitable for use in a water slide.

3.1.28 *starting platform*—deck structure, usually of separate construction from the water slide, from which a given water slide starts.

3.1.29 *warning signage*—signage displayed in public view prior to the entrance of the water slide provided to the rider identifying the features the rider will experience such as lighting effects.

3.1.30 *water flow*—water volume per unit time for a given water slide.

3.1.31 *water slide*—see definition in Section 1.

3.1.32 *water slide clearance envelope*—design clearance to minimize the opportunity for contact between the rider and other objects, outside of the flume, where said contact is likely to cause injury. See Figs. 1 and 2.

3.1.33 *water slide system*—see definition in Section 1.

3.1.34 *water slide tube*—inflated vehicle that floats in a stable fashion in a pool intended for rider use on water slides. The vehicle may have a bottom or have a hole intended for seating and contains one or more riders as they ride in the flume; often called a raft, boat, or tube.

3.2 *Slide Classification*—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:

(<https://standards.iteh.ai>)

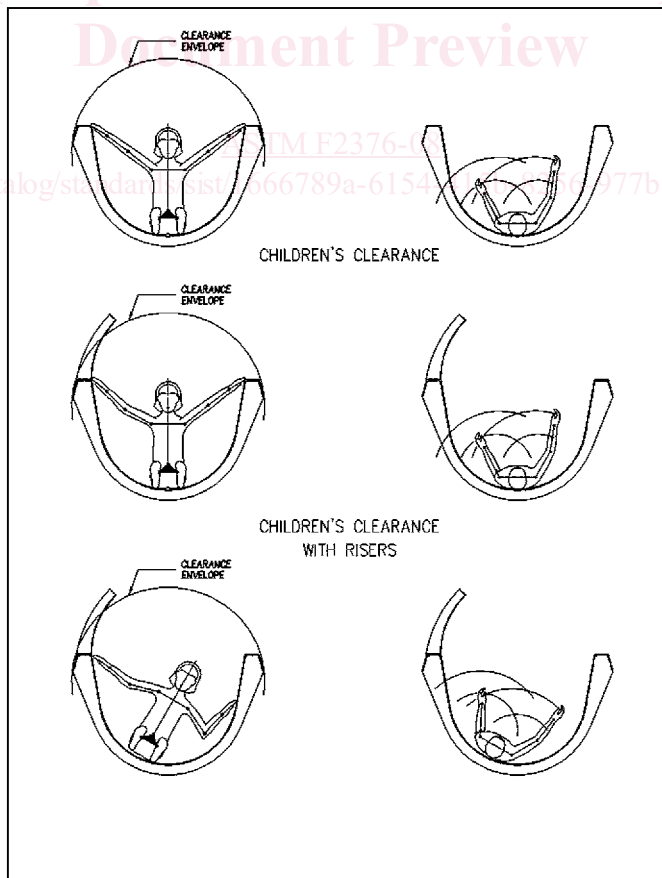


FIG. 1 Water Slide Clearance Envelope

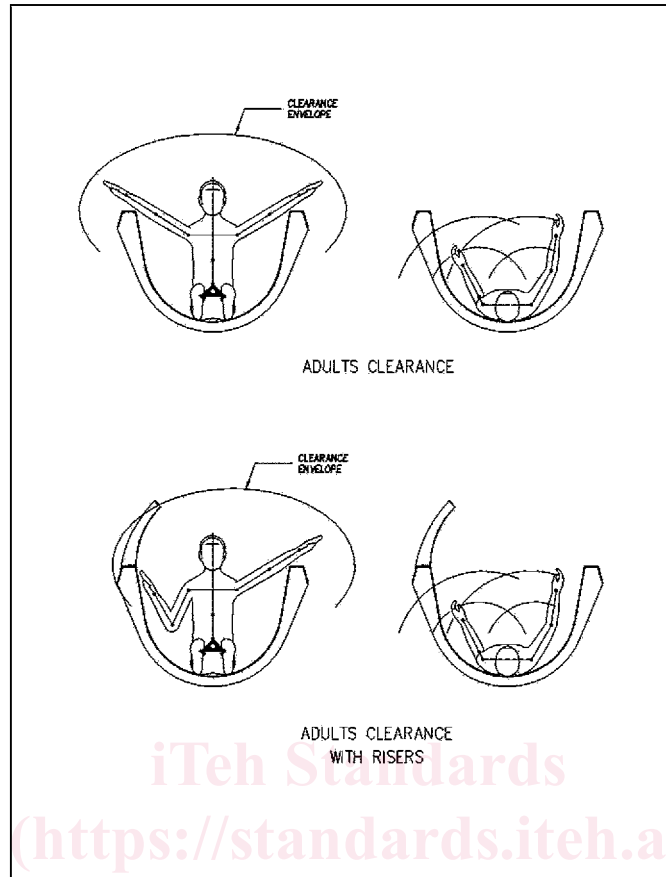


FIG. 2 Water Slide Clearance Envelope

3.2.1 *body slides*

4. Slide Classification

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

3.2.2 *children's slides*

4.1.2 *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.

3.2.3 *mat slides*

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

3.2.4 *serpentine slide*

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

3.2.5 *specialty slides*

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

3.2.6 4.1.6 *specialty vehicle slides*—water slide used with a proprietary vehicle specified by the manufacturer.

3.2.7 *speed slide*

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

3.2.8 *tube slides*

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

4.

5. Materials

4.1

5.1 Flume Material—Any material that has the following basic properties and that meets all other requirements of this practice may be used to construct water slides.

45.1.1 Flumes riding surfaces shall be constructed to be smooth.

45.1.2 Flume material shall be demonstrated as strong enough to support specified loads as defined in Section 78.

45.1.3 Flume components, maintained using the manufacturer's instructions, shall not deteriorate over time in such a way that a hazard will develop.

4.25.2 Support Materials—Any material that has the following basic properties and that meets all other requirements of this practice may be used to construct water slide supports.

45.2.1 Supports for water slides shall be constructed from durable materials such as wood, metal, concrete, or engineered composites.

45.2.2 Supports for water slides fabricated from metal shall be either inherently corrosion resistant, or be finished in such a way as to provide protection from corrosion.

45.2.3 Wood materials shall be finished in such a way to provide protection against deterioration.

45.2.4 Support material shall be demonstrated as strong enough to support specified loads as defined in Section 67.

45.2.5 Supports shall be constructed to accommodate regular inspection and maintenance for structural integrity, material deterioration, or corrosion, or a combination thereof.

5.6. Notification Requirement

5.1A6.1 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.

5.2The6.2 The owner/operator of a water slide shall notify the appropriate manufacturer(s) of any known incident as specified in Guides F 1305 and F 893.

5.3The6.3 The manufacturer shall notify the appropriate owner(s)/operator(s) of similar water slides of an incident that resulted in a serious injury promptly upon the determination by the manufacturer that the incident is significantly repeatable.

56.3.1 Such manufacturer notification shall be a bulletin as specified in Sections 4.1.14.3 through 4.1.14.8 of Practice F 853.

6.

7. Structural Design of Water Slides

6.1This7.1 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.

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

6.37.3 Operational Loads—Forces from water, riders, or vehicles, or a combination thereof, in the ride under normal operations.

6.3.1

7.3.1 Water Load (symbol WL)—In free flowing water slides where water does not collect in pools or streams greater than 2 in. deep, the water load shall be a minimum of 15 lbs/linear ft for every 1000 gal/min of flow. Where the flow is such that water collects in pools or streams greater than 2 in. deep, the actual maximum water load shall be determined and used in calculation, design, or load tests, or a combination thereof.

6.3.2

7.3.2 Rider Load (symbol RL)—The manufacturer shall specify the rider vehicle and the maximum number of riders that are to ride in the flume at one time.

67.3.2.1 For water slides intended for multiple rider use, the weight assigned to each rider shall be, at a minimum, the weight specified for an adult rider in Section 8.6.1 of Practice F 2291.

67.3.2.2 For single rider water slides, the rider weight shall be a maximum of 300 lb.

67.3.2.3 For water slides intended for use by children only, the weight assigned to a child shall be as specified in Section 8.6.2 of Practice F 2291.

67.3.2.4 Ride loads shall be so arranged to cause the greatest realistic operational load to the system.

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

67.3.2.6 If the manufacturer places maximum rider total weight limits on a slide, then that restricted load may be used.

67.3.2.7 The weight of the rider vehicle shall be included in determining rider load.

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

67.4.1 Loads and forces due to environmental conditions shall be in accordance with applicable local code requirements or ANSI/ASCE 7, or other equivalent national standard.

7.4.2 The manufacturer/designer shall clearly indicate the environmental loads the water slide was designed for in the operating and maintenance instructions as specified in the sections on Manufacturer's Responsibility of Practices F 770 and F 853. 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.

6.4.3

7.4.3 Lateral Wind Load (symbol LWL)— For outdoor slides, the minimum wind load for all types of water slides shall be calculated based on 100-mph wind (3-s gust) for non-operational conditions. Lateral wind load may be reduced by an importance factor of less than 1.0, where appropriate, for water slide structures that are unoccupied during extreme weather.

6.4.4

7.4.4 Reduced Lateral Wind Load (symbol RLWL)—For outdoor slides, the minimum wind load for all types of water slides shall be calculated based on Section 8.13.1 of Practice F 2291 for operational conditions.

6.4.5

7.4.5 Other Lateral Loads (symbol OLL)— A minimum lateral load equivalent to 10 % of the dead weight of the structure shall be included.

6.4.6

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

6.5

7.5 Overload—Forces from water, riders, or vehicles, or a combination thereof, under extraordinary operational conditions due to user overload.

6.7.5.1 Calculations for extraordinary operational conditions that consider user overload shall be based on conditions specified by the manufacturer and need not consider any other live load in combination with such overload.

6.7.6 Load Combinations—Engineering calculations may use either allowable stress methods (ASD) or load and resistance factor methods (LRFD). Engineering calculations shall consider load conditions and combinations of loads in accordance with generally accepted engineering methods. Calculations shall consider that water slide systems may not be occupied during extremes of weather.

6.7

7.7 Metal Structures—Strength of steel structures under or above noted loads shall be designed in accordance with current AISC, ASCE standards,⁴ or equivalent national standards.

6.8

7.8 Wood Structures—Strength of timber structures under or above noted loads shall be designed in accordance with current USDA-72, ASCE standards,⁴ or equivalent national standards.

6.9

7.9 Concrete Structures—Strength of concrete structures under above noted loads shall be designed in accordance with current ACI-318 or equivalent national standards.

6.10

7.10 Plastic and Plastic Composite Structures:

6.7.10.1 Strength of plastic structures under above noted loads shall be designed in accordance with generally accepted engineering methods. Assessment shall be performed in a manner suitable for the specific material and structure.

6.7.10.2 Fiberglass reinforced plastic or other composite materials used structurally shall have samples tested for strength with accelerated aging in accordance with Test Methods D 570, D 638, and D 790.

6.7.10.3 Loads from normal operational conditions shall demonstrate a minimum of 5 to 1 factor of safety against rupture for fiberglass reinforced plastic or other composite materials.

6.7.10.4 Calculations for extraordinary operational conditions from user overload shall demonstrate a minimum of 2 to 1 factor of safety against rupture of fiberglass reinforced plastic or other composite materials.

7.8. Performance Requirements

7.1

8.1 General Requirements:

7.1.1 The following are minimum requirements and should not be substituted where manufacturer experience suggests more acrimonious values.

7.1.2 Surfaces in reach by slide attendants and riders shall be made in such a way as to reduce the potential for injury.

7.1.3 A water slide shall be designed and constructed so that forces on riders allow the rider to use the slide in accordance with the rules and instructions under normal operating conditions.

7.2.2 Slide Access:

7.2.1

8.2.1 General—Fencing, guardrails, and handrails shall be installed in accordance with Section 14 of Practice F 2291.

7.2.2 If the water slide system includes a starting platform and the platform is more than 21 in. above surrounding terrain, the platform shall provide at least 36 in. in distance between the slide entry and the top of stairs or ramp. Sufficient space shall