



Designation: F2376 – 21

# Standard Practice for Classification, Design, Manufacture, Construction, and Operation of Water Slide Systems<sup>1</sup>

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 ( $\epsilon$ ) 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.*

<sup>1</sup> 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.

Current edition approved May 1, 2021. Published June 2021. Originally approved in 2006. Last previous edition approved in 2017 as F2376 – 17a. DOI: 10.1520/F2376-21.

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:<sup>2</sup>

**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:<sup>3</sup>

**ACI-318** Building Code Requirements for Structural Concrete

### 2.3 ASCE Standard:<sup>4</sup>

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

### 2.4 EN/ISO Standard:<sup>5</sup>

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

### 2.5 USDA Document:<sup>6</sup>

**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.

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

<sup>3</sup> Available from American Concrete Institute (ACI), P.O. Box 9094, Farmington Hills, MI 48333.

<sup>4</sup> Available from The American Society of Civil Engineers (ASCE), 1801 Alexander Bell Dr., Reston, VA 20191.

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

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

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 *owner/operator*—person or organization that is responsible for the maintenance and operation of a water slide system.

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

3.1.8 *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.

3.1.9 *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<sup>e1</sup>, with the exception that ASCE/SEI 7-16 shall be used.

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.  $L_s = \text{water loads}(L,f) + \text{rider loads}(L,p)$

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).

4.3.4.6 *Rain Load (symbol R)*—The rain load shall be calculated for outdoor slides and incorporated into operational and non-operational load combinations.

4.3.4.7 *Temperature Change Loads (symbol T)*—The temperature change load shall be calculated for outdoor/exposed water slides and incorporated into operational and non-operational load combinations.

4.3.4.8 *Seismic Loads (symbol E)*—The seismic load shall be calculated for all slides and incorporated into load combinations for operational and non-operational load combinations. Seismic loads shall be considered during both operational and non-operational conditions.

4.3.4.9 The environmental loads during operation shall always conform to the minimum requirements within this document and Practice F2291-19<sup>e1</sup> regardless of operational manual limitations. However, when the operations manual dictates operational limits that are higher (or more severe) than this document and Practice F2291-19<sup>e1</sup>, the environmental loads during operations shall be increased to those written within the operations manual.

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

4.3.5.1 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.

4.3.5.2 *Chain Load (symbol L<sub>p</sub>)*—A required overload case where multiple ride vehicles (or single riders) slide down the flume connected. This load case shall be considered regardless of operational limitations. The chain load shall be applied within load combinations as a live load in place of the slide live load, using the same live load factors. Apply the chain load as a moving load that starts at the top of the flume and ends at the flume's bottom. This load is defined as a 1.5 kN/m (103 plf) over a 5.0 m (16.4 ft) length segment.

4.3.5.3 *Jam Load (symbol A)*—An overload case where a ride vehicle or individual rider stops or is stuck on the slide. Subsequent ride vehicles or individual riders accumulate behind the blockage. This load shall be used in place of the slide live load using a 1.0 load factor for service (ASD) combinations, and a 1.3 load factor for ultimate (USD) combinations. The load is defined as a 1.5 kPa (31 psf) over the projected plan area of the entire length of the flume. This load may be omitted where there is a 20 % or more vertical slope.

4.3.6 *Load Combinations*—Shall be calculated according to Practice F2291-19<sup>e1</sup>, Section 8. Engineering calculations may use either service level (ASD) or ultimate level methods (LRFD). Whichever load combination method is used, the subsequent analysis and material resistance calculations shall be performed consistent with the load combination method chosen. Engineering calculations shall consider load conditions and simultaneous occurrence of loads in accordance with generally accepted engineering methods. Calculations shall

consider load combinations when water slide systems are not occupied and may experience extreme (or maximum design) weather.

4.3.6.1 *Operational Load Combinations*—For guidance on operational load combinations refer to Practice F2291-19<sup>e1</sup>, Section 8.

4.3.7 *Metal Structures*—Strength of steel structures under or above noted loads shall be designed in accordance with current AISC, ASCE standards,<sup>4</sup> or equivalent national standards.

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

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

4.3.10 *Plastic and Plastic Composite Structures:*

4.3.10.1 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.

4.3.10.2 Fiberglass reinforced plastic or other composite materials used structurally shall have samples tested for strength with accelerated aging in accordance with Test Methods D570, D638, and D790.

4.3.10.3 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.

4.3.10.4 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.

4.4 *Performance Requirements:*

4.4.1 *General Requirements:*

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

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

4.4.1.3 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.

4.4.2 *Slide Access:*

4.4.2.1 *General*—Fencing, guardrails, and handrails shall be installed in accordance with Section 14, Fencing, Guardrails, Handrails, Gates, and Walkways for Amusement Rides and Devices, of Practice F2291-19<sup>e1</sup>.

4.4.2.2 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 be provided on the platform for slide attendant workspace, signage, and any communication devices needed for operation. Except where a stair or ramp or slide entry joins it, the platform shall be surrounded on all sides by a guardrail

in accordance with Section 14, Fencing, Guardrails, Handrails, Gates, and Walkways for Amusement Rides and Devices, of Practice F2291-19<sup>e1</sup>.

4.4.2.3 Surface of steps, access ramp, and deck shall be slip-resistant and self-draining.

4.4.2.4 Slide entry section should interface with the platform guardrail so that a 4 in. sphere cannot pass between the slide entry component and the adjacent guardrail component.

4.4.3 Open Flume Geometry:

4.4.3.1 Flume cross-section shape shall be configured to contain the rider(s) or vehicle, or both, under all reasonable operating conditions. Total depth of section and shape of cross-section of a flume may be created in a single piece or more than one piece.

4.4.3.2 Open water slide flumes shall be kept clear of obstacles within the water slide clearance envelope as shown in Figs. 1 and 2. Flume riser sections may be added to block access to anything encroaching in the area.

4.4.3.3 Water slides shall have additional sidewall height provided by a flume riser section on the outside part of all horizontal curves to contain the rider. This flume riser shall be concave facing the center of the cross-section. The flume riser may be an integral or separate part from the main flume component.

(1) *Flume Riser Transition*—Flume riser parts shall be transitioned from sections without flume risers to sections with flume risers with a maximum angle of 45° from the horizontal. See Fig. 3.

(2) *Other Additions*—Where a cover, a tube entrance, or a flume riser is fitted other than at the beginning of the slide, the sides of the slide shall have a smooth transition from horizontal

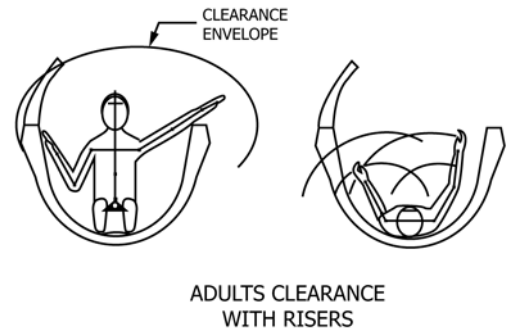
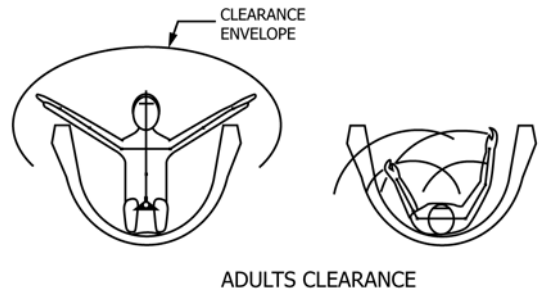


FIG. 2 Water Slide Clearance Envelope

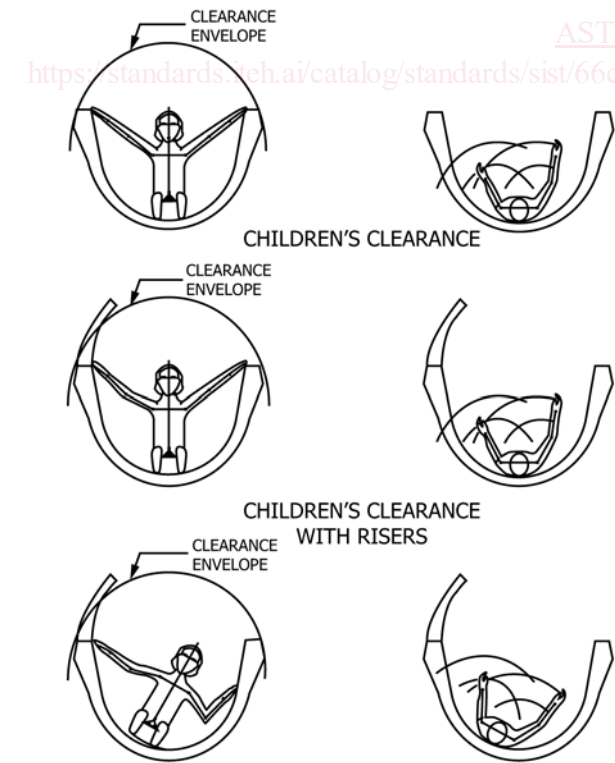


FIG. 1 Water Slide Clearance Envelope

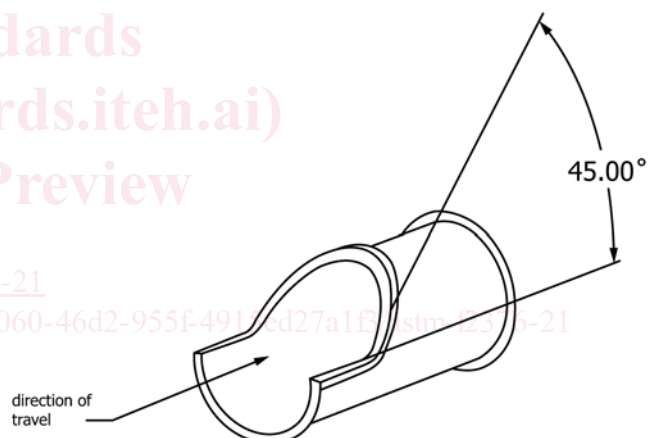


FIG. 3 Flume Riser

to vertical. Maximum angle of transition will be 45°. The inside height of the entrance to the cover or flume riser shall be at least 48 in.

4.4.3.4 Body slides with curved bottom flume sections such that the cross-section of the bottom and the sides are a continuously curving surface shall have:

- (1) Minimum inside width of 30 in., minimum sidewall height of 15 in., and
- (2) The top 1 in. of curved sidewalls shall be within 10° of vertical.

4.4.3.5 Tube slides with flat bottom flume sections shall have:

- (1) Minimum width of 48 in. inside sidewalls,
- (2) Minimum sidewall height of 24 in., and
- (3) Sidewalls that are straight may diverge from vertical a maximum of 2 in. measured at 24 in. from bottom.

4.4.3.6 Tube slides with curved bottom flume sections such that the cross-section of the bottom and the sides are a continuously curving surface shall have:

- (1) Minimum inside width of 52 in.,
- (2) Minimum sidewall height of 26 in., and
- (3) The top 1 in. of curved sidewalls shall be within 10° of vertical.

4.4.3.7 Mat slides that are straight in plan shall have:

- (1) Minimum width of 22 in. inside sidewalls,
- (2) Minimum sidewall height of 16 in.,
- (3) Sidewalls that are straight may diverge from vertical a maximum of 6 in. measured at 16 in. from bottom, and
- (4) The top 1 in. of curved sidewalls shall be within 10° of vertical.

4.4.3.8 *Multiple Parallel Lane Flumes*—Where more than one flume runs in parallel straight-line path (in plan).

- (1) The outermost sections shall have sidewalls a minimum of 24 in. in height.
- (2) Where the flume path runs adjacent, there shall be a dividing barrier a minimum of 8 in. high between the lanes.
- (3) Each lane shall be a minimum of 22 in. inside width.

4.4.3.9 Water slides such as specialty slides that cannot be classified above shall conform to the requirements of 6.3.4.

4.4.3.10 Combination rides may be designed such that sections of the slide conform to the requirements of the respective specifications above.

4.4.4 *Closed Flume Geometry:*

4.4.4.1 The following are minimum requirements and should not be substituted where manufacturer experience suggests more conservative values. Total shape of cross-section of a flume may be created in two or more pieces.

4.4.4.2 Body slides with curved bottom flumes shall have a minimum inside dimension of 30 in.

4.4.4.3 Tube slides with flat bottom closed flume sections shall have a minimum inside dimension of 48 in.

4.4.4.4 Tube slides with curved bottom closed flume sections shall have a minimum inside dimension of 52 in.

4.4.5 *Run Out Lanes:*

4.4.5.1 Run out sections shall be designed to contain, decelerate, and stop riders to allow them to exit the slide.

4.4.5.2 A weir or other device shall regulate the water level in the run out to the correct level given correct flow rate for the ride.

4.4.5.3 To facilitate proper deceleration, a marker shall be provided to indicate the operational water level in the run out, which the slide attendant/lifeguard may verify prior to allowing the next rider entry to the slide.

4.4.6 *Landing Pools:*

4.4.6.1 Landing pools shall be designed to decelerate and stop riders and allow them to exit the water slide without encountering an obstruction.

4.4.6.2 The exit path for riders shall not cross with the landing zone of other slides. The designated pool exit shall be such as to force the riders to move forward and away from the paths of riders from other flumes.

4.4.6.3 Water slides entering a landing pool shall have a landing pool of sufficient length to decelerate and stop riders and minimize the potential for contact with the pool wall or

stationary objects (stair, ladder, railing, and so forth) in the landing pool. Water slides classified as speed slides (rider velocity over 25 ft/s) will require additional pool length.

4.4.6.4 Pool depth in the landing zone for water slides for persons over 48 in. tall shall have a minimum pool depth of 3 ft.

4.4.6.5 Flume geometry at pool entry shall be straight viewed in plan for the last 8 ft of the water slide entering a pool.

4.4.6.6 Landing pools for waterslides with a fall distance greater than 6 in. shall have an increase in pool depth from the 3 ft minimum according to manufacturer recommendation to minimize potential impact with pool bottom.

4.4.6.7 If water supply for the slide(s) is drawn directly from landing pools or other areas accessible to the public, the suction line shall be divided into at least two lines, where connected to the pool, such that one person cannot block more than one suction line. The fittings and piping details shall be designed so that the full volume of water for the slide may be drawn through the remaining fittings at a velocity not to exceed 1 ft/s, assuming one suction fitting is fully blocked.

4.4.7 *Body Slide Landing Pools:*

4.4.7.1 Body slides entering a landing pool shall have a minimum distance between the inside of the widest part of the flume riding surface and the closest pool wall of 5 ft. The place of measurement in the pool shall be at any point from water level to 3 ft below water level and 6 ft in front of the flume termination. The lateral pool wall shall be parallel to or diverge from the axis of the slide. See Fig. 4.

4.4.7.2 Body slides entering a common landing pool should be arranged so as to minimize the potential for riders to come in contact with each other when exiting the flumes of adjacent slides simultaneously.

4.4.8 *Tube Slide Landing Pools:*

4.4.8.1 Tube slides entering a landing pool shall have a minimum distance between the inside of the widest part of the flume riding surface and the closest pool wall of 4.5 ft. The place of measurement in the pool shall be at any point from water level to 3 ft below water level and 6 ft in front of the flume termination. The pool wall shall be parallel to or diverge from the axis of the slide. See Fig. 4.

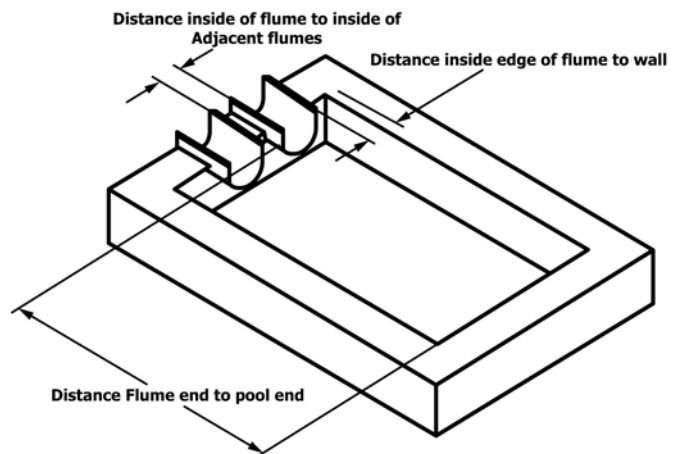


FIG. 4 Body Slide Landing Pool

4.4.8.2 Tube slides entering a common landing pool should be arranged to minimize the opportunity for contact with other riders when exiting the flumes of adjacent slides simultaneously.

4.4.9 *Openings and Apertures in Flume Surfaces:*

4.4.9.1 Openings may be provided in flume surfaces for introduction of water, drains, special effects, light, and other similar purposes. All edges in openings within reach of riders shall be smooth with a minimum radius of  $\frac{1}{8}$  in. Openings shall not present an entrapment risk.

4.4.9.2 Openings at the slide start for the main water supply do not require guards or gratings unless the rider stands, sits, walks, or slides over the face of the opening during normal slide operation, or if the configuration of the opening is such that a rider moving in the usual direction of travel would not become entrapped. Grating shall have a maximum width of slot or hole diameter of  $\frac{1}{2}$  in.

4.4.10 *Seams and Joints:*

4.4.10.1 For the purposes of this section, riding surface shall be taken to mean the part of the flume where the path of riders is expected or found to pass over, for example, the outside half of a curved flume section.

4.4.10.2 Longitudinal joints on the riding surface shall be made tangent.

4.4.10.3 Edges of lateral joints on body slides may have a radius of up to  $\frac{3}{16}$  in. Edges of longitudinal joints in closed flumes may have a radius of up to  $\frac{1}{4}$  in. Edges of longitudinal joints in open flume risers may have a radius of up to  $\frac{3}{8}$  in.

4.4.10.4 Edges of lateral joints on mat and tube slides may have a radius of up to  $\frac{1}{2}$  in.

4.4.11 *Accelerations:*

4.4.11.1 Slide paths shall be designed so riders in seated or prone (laying face down) positions do not experience greater than 2 Gs acceleration from gravity and centrifugal acceleration vectors added together. This limit may be increased to 3 Gs if the duration is less than 1 s.

4.4.11.2 Slide paths shall be designed so that riders in supine (laying face up) positions do not experience greater than 3 Gs acceleration from gravity and centripetal acceleration vectors added together.

4.4.12 *Slide Vehicles:*

4.4.12.1 Slide vehicles shall be constructed to have a cushioning effect for riders who can come into contact with another vehicle during normal operation of the slide.

4.4.12.2 Slide vehicles shall float when used in a landing pool.

4.5 *General Design Criteria:*

4.5.1 General design criteria shall be in accordance with Section 5, General Design Criteria, of Practice F2291-19<sup>e1</sup> with the following revisions:

4.5.1.1 Delete 5.1.1.4 (2) Patron Restraint and Containment Analysis.

4.5.1.2 *Patron Restraint and Containment Analysis*—A patron restraint and containment analysis shall be performed.

4.5.1.3 Delete 5.1.1.4 (3) Patron Clearance Envelope Analysis.

4.5.1.4 *Patron Clearance Envelope Analysis*—A patron clearance envelope analysis shall be performed.

4.5.1.5 Delete 5.5.2.

4.5.1.6 The coordinate system as defined in Terminology F747-15 shall be used as the standard reference for acceleration directions.

4.5.1.7 Delete 5.6.4.1.

4.5.1.8 General drawings or diagrams in plan, elevation, and section views showing the general arrangement of components, including side clearance envelope as described in 4.4.3.2.

4.5.2 The ride analysis shall include assessment and mitigation of potentially hazardous conditions associated with the design rider path and rider path variations.

4.5.3 If systems or devices are used to affect the speed of the rider or ride vehicle in order to mitigate a hazard, these systems or devices shall meet the requirements of Practice F2291-18, Section 5.2 Hazard Mitigation.

4.6 *Pneumatics*—Pneumatics shall be designed in accordance with Section 10, Pneumatic Systems and Components, of Practice F2291-19<sup>e1</sup>.

4.7 *Safety Related Control Systems*—Safety Related Control Systems shall be designed in accordance with Section 11, Safety Related Control Systems, of Practice F2291-19<sup>e1</sup>.

4.8 *Mechanical Systems and Components*—Mechanical Systems and Components shall be designed in accordance with Section 13, Mechanical Systems and Components, of Practice F2291-19<sup>e1</sup>.

4.9 *Fasteners*—Fastened connections shall be designed in accordance with Section 16, Fasteners, of Practice F2291-19<sup>e1</sup>.

## 5. **Manufacture**

5.1 *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.

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

5.1.2 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.

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

5.1.4 Support material shall be demonstrated as strong enough to support specified loads as defined in 4.3.

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

5.2 *Notification Requirement*—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.

5.2.1 Such manufacturer notification shall be a bulletin as specified in Section 8, Manufacturer Supplemental Bulletin Requirements, of Practice F1193-18a.

5.3 *Manufacturer Responsibilities:*

5.3.1 The following instructions outline requirements under Practice F1193-18a as applicable to water slides and include