Designation: ~~F2374 – 19~~ F2374 – 20

Standard Practice for Design, Manufacture, Operation, and Maintenance of Inflatable Amusement Devices[1]

This standard is issued under the fixed designation F2374; 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 establishes criteria for the Design, Manufacture, Installation, Operation, Maintenance, Inspection, Training, Auditing and Major Modification of commercial use Inflatable Amusement Devices. These devices are made of flexible fabric, inflated by one or more blowers, and rely upon air pressure to maintain their shape. ~~They~~ These devices are designed for patron activities that ~~may~~ include, but are not ~~be limited to: bounce, climb, slide, obstacle course or~~ limited to, bouncing, climbing, sliding, obstacle course running and interactive play.

1.1.1 Amusement devices covered by this standard are used primarily in amusement, entertainment or recreational applications. Such applications include, but are not limited to, amusement parks, theme parks, water parks, family entertainment centers, rental companies, fitness centers, gyms, gymnastics facilities, jump centers, sports facilities, skate parks, camps, schools, shopping centers, temporary special events, carnivals, fairs, festivals and municipal parks.

1.1.2 This practice includes land-based inflatable amusement devices that are designed for dry use, wet use, or a combination of wet/dry use.

1.1.3 Inflatable amusement devices covered by this standard have inflation systems that:

1.1.3.1 Require air to be constantly supplied in order to maintain structure, form, shape or integrity (continuous air inflatable amusement device); or

1.1.3.2 Maintain inflation without the need for constant air supply (captured air inflatable amusement device); or

1.1.3.3 Incorporate both methods of inflation into a single device.

1.1.4 The design and manufacturing requirements in Sections 5 and 6 of this standard shall not apply to inflatable amusement devices manufactured before the publication date of this standard practice.

1.1.5 The modification requirements in Section 5.3 of this standard shall not apply to major modifications performed before the publication date of this standard practice.

1.2 This practice specifically excludes the following types of inflatable devices:

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[1] This practice is under the jurisdiction of ASTM Committee F24 on Amusement Rides and Devices and is the direct responsibility of Subcommittee F24.61 on Adventure Attractions.

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1.2.1 Inflatable devices marketed directly to consumers for private home use by children. Those devices are covered under a separate standard, Consumer Safety Specification F2729.

1.2.2 Inflatable devices that are used for professional exhibition or stunt work; safety and rescue activities; aerial or aviation structures or devices; exhibit floats; or similar inflatable devices.

1.2.3 Inflatables that do not have a floor affixed to the inflatable structure (that is, the ground is exposed inside an inflated perimeter).

1.2.4 Inflatable devices that require a sudden loss of air to perform their intended function (for example, stunt bag style inflatable impact attenuation devices).

1.2.5 Inflatable devices that are designed primarily as floating devices to be installed in or on bodies of water.

1.2.6 Stand-alone captured air inflatable devices that are designed to contain the patron within the elevated pressure space; are designed to be mobile during its intended use; or contain less than 270 ft^3 of air and do not include an anchoring or ballasting system. Examples include, but are not limited to: a water walking ball, a sports ball, a hamster ball, a hill-rolling ball.

1.2.7 Constant air membranes that incorporate a permanent sub-terrain box or pit to form the bottom and sides of the pressure vessel (for example, jumping pillow devices).

1.2.8 Air inflated devices designated to decompress or redistribute foam cubes contained in a trampoline court foam pit.

1.3 This practice includes an annex (mandatory), which provides additional information (for example, rationale, background, interpretations, drawings, commentary, and so forth) to improve the user's understanding and application of the criteria presented in this practice. The annex information shall be interpreted as mandatory criteria.

1.4 This practice includes an appendix (non-mandatory), which provides additional information (for example, rationale, background, interpretations, drawings, commentary, and so forth) to improve the user's understanding and application of the criteria presented in this practice. The appendix information shall not be interpreted as mandatory criteria.

1.5 The text of this standard references notes and footnotes which provide explanatory materials. These notes and footnotes shall not be considered requirements of the standard.

1.6 *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.*

1.7 *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]

D3787 Test Method for Bursting Strength of Textiles—Constant-Rate-of-Traverse (CRT) Ball Burst Test
D5446 Practice for Determining Physical Properties of Fabrics, Yarns, and Sewing Thread Used in Inflatable Restraints
D6951 Test Method for Use of the Dynamic Cone Penetrometer in Shallow Pavement Applications
F355 Test Method for Impact Attenuation of Playing Surface Systems, Other Protective Sport Systems, and Materials Used for Athletics, Recreation and Play
F747 Terminology Relating to Amusement Rides and Devices
F1193-18 Practice for Quality, Manufacture, and Construction of Amusement Rides and Devices
F1292 Specification for Impact Attenuation of Surfacing Materials Within the Use Zone of Playground Equipment
F1772 Specification for Harnesses for Rescue and Sport Activities
F2291 Practice for Design of Amusement Rides and Devices

[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.

F2375 Practice for Design, Manufacture, Installation and Testing of Climbing Nets and Netting/Mesh used in Amusement Rides, Devices, Play Areas and Attractions
F2397 Specification for Protective Headgear Used in Combative Sports
F2729 Consumer Safety Specification for Constant Air Inflatable Play Devices for Home Use

2.2 *ASCE Standards (American Society for Civil Engineers):*[3]
ASCE 7 Minimum Design Loads for Buildings and Other Structures

2.3 *NFPA Standards (National Fire Protection Agency):*[4]
NFPA 70 National Electric Code (NEC)
NFPA 701 Standard Methods of Fire Tests for Flame Propagation of Textiles and Films

3. Terminology

3.1 *Definitions:*

3.1.1 *designer/engineer, n*—party(s) that establishes and describes the configuration of the amusement ride or device, establishes strength and fatigue life, designs and develops electrical/electronic control systems, and defines inspection criteria. **F747**

3.1.2 *major modification, n*—any change in either the structural or operational characteristics of the ride or device which will alter its performance from that specified in the manufacturer's design criteria. **F747**

3.1.3 *serious injuries/illnesses, n*—a personal injury/illness that results in death, dismemberment, significant disfigurement, permanent loss of the use of a body organ, member, function, or system, a compound fracture, or other significant injury/illness that requires immediate admission and overnight hospitalization and observation by a licensed physician. **F747**

4. Significance and Use

4.1 The purpose of this practice is to delineate information regarding the design, manufacture, installation, operation, and maintenance of inflatable amusement devices.

5. Design

5.1 This section establishes information and procedures for the design of inflatable amusement devices and major modifications to inflatable amusement devices.

5.2 Inflatable amusement devices with platforms or play areas higher than 25 ft (7.6 m) above the ground shall also require compliance with the applicable parts of Practice F2291.

5.3 *Parts of the Inflatable Device:*

5.3.1 *Obstacle*—An inflated component that is intended for patrons to climb over, run through, etc., as they progress through the inflatable amusement device.

5.3.2 *Platform*—A horizontally-oriented inflated surface on which a user is permitted to stand or traverse (for example, the transition landing area on a slide).

5.3.3 *Playing Area*—Space in or on the inflatable that is intended for patron play.

5.3.4 *Ramp or Step*—An inclined section or section of intermediate height aiding patrons as they enter and exit the playing area of the inflatable, making the transition between the height of the playing area and the ground.

5.3.5 *Run-out*—Intended deceleration zone at the bottom of a slide.

5.3.6 *Height Measurements:*

[3] Available from American Society of Civil Engineers (ASCE), 1801 Alexander Bell Dr., Reston, VA 20191, http://www.asce.org.
[4] Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169-7471, http://www.nfpa.org.

5.3.6.1 *Playing Area or Platform*—The height of a playing area or platform shall be measured, without load, from the highest point intended to support patrons to the lower bound (see Fig. 1). Typically, this is ground level or the surface of a lower-level inflated playing area or platform.

5.3.6.2 *Containment Wall*—The height of a containment wall shall be measured, without load, from the highest point on the surface of the adjacent platform or playing area to the highest point on the wall (see Fig. 2). For slides, the height measurement is taken at 90° to the slope (see Fig. 1).

5.4 *Drawings, Records and Testing:*

5.4.1 *Drawings and Records*—Records shall be kept in accordance with Subsection 5.6 of Practice F2291.

5.4.2 *Testing*—Document and record the testing performance of inflatable amusement devices in accordance with the tests given in Practice F1193.

5.5 *Structural Integrity and Inflation:*

5.5.1 Inflatable playing areas, platforms, steps, and ramps shall support the weight of the patrons for whom the inflatable is designed.

5.5.2 The inflatable device shall support itself, the maximum total load, and any devices included for which the inflatable is designed.

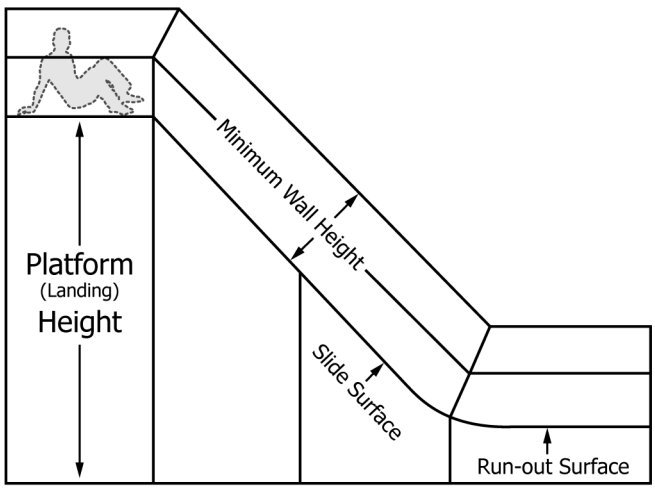
5.5.2.1 The manufacturer shall test the design for structural integrity and stability per Practice F1193 with stated maximum capacity allowed on the device. Where applicable, the test methodology shall consider anticipated areas of uneven loading, such as stairs or transition platforms on inflatable slides.

5.5.3 The weight assigned to each patron, for design purposes, shall be determined as follows:

5.5.3.1 For inflatable devices intended for use by children only, the design weight per patron shall be, at a minimum, the weight specified for a child patron in Subsection 8.6.2 of Practice F2291.

5.5.3.2 For all other inflatable devices, the design weight per patron shall be, at a minimum, the weight specified for an adult patron in Subsection 8.6.1 of Practice F2291.

5.5.4 All inflatables with an inflated floor must pass the applicable Test Methods for Weight Bearing Surfaces in Annex A4.



SIDE VIEW

FIG. 1 Slide Platform and Wall Height Measurements

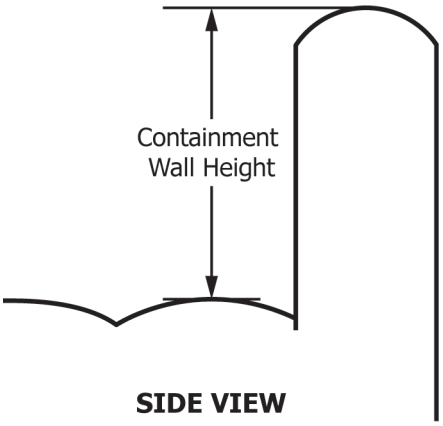


FIG. 2 Containment Wall Height Measurement

5.5.5 The design shall be sufficient to allow for evacuation in the event of deflation during patron use, including, at a minimum:

5.5.5.1 The device shall have a means of egress in case of emergency evacuation.

5.5.5.2 Design elements shall be employed to prevent or minimize risks to patrons when the inflation air supply is interrupted. These shall include, but not be limited to, the following:

(1) A non-return valve or flap shall be fitted to the blower or inflatable device.

(2) The inflation tube shall be placed at the lowest part of the structure.

(3) The structural design shall prevent rapid collapse of elevated platforms or collapse of ceilings and walls onto the patrons.

(4) Inflatable devices with platforms or play areas higher than 8 ft (2.4 m) off the ground shall require a deflation alert system per 5.16.5.

5.5.6 The design shall allow blowers and inflation tubes to be positioned in locations that minimize risk to patrons and will not impede the ingress/egress of the device.

5.5.7 Captured air inflatable amusement devices shall have an air pressure relief valve. When accessible during intended use, protruding parts of the valve shall be rounded and not create entanglement or entrapment points.

5.6 *Anchoring Systems:*

5.6.1 Inflatable amusement devices shall be provided with an anchorage system to prevent unplanned displacement during operation.

5.6.2 Sufficient anchor points shall be provided and located to enable stability and restraint to be maintained under the designer's stated operating conditions including, but not limited to, forces of wind and forces applied by patrons during intended use of the inflatable device. The number of anchor points shall be greater than or equal to four (4).

5.6.3 The design shall specify maximum wind speeds and the type of anchorage. An analysis for determining an acceptable anchorage system shall be performed and stamped by a licensed professional engineer. This analysis shall include calculations and demonstrate that anchoring of the fully inflated device can withstand the stated design wind speed and wind loads (see 5.6.4), and patron loads during operation (see 5.6.5). The stamped wind load calculations shall be retained by the manufacturer in accordance with 5.4.

5.6.4 *Design Wind Conditions:*

5.6.4.1 The design shall assume a maximum allowed operational wind speed of at least 25 mph (11.1 m/s) with highest sustained gusts over a 3-s period. ~~The designer is permitted to allow a~~ A higher operational wind speed ~~as long as~~ shall not be used unless the anchorage ~~is~~ has been verified as sufficient by a professional engineer.

5.6.4.2 Maximum operating wind speed for the device shall be at least 5 mph (2.2 m/s) lower than the wind speed for which anchoring was designed.

5.6.4.3 *Wind Force Calculations*—Select formula from 5.6.4.3*(1)* or 5.6.4.3*(2)* below, based on the dimensions of the inflatable ~~device.~~device for wind force calculations. 5.6.4.3*(1)* shall apply to inflatables with a height not exceeding 10 ft (3 m) and a length not exceeding 2.5 times the width. 5.6.4.3*(2)* shall apply to inflatables that exceed those dimensions. For engineering wind load calculations, the height refers to the dimension measured vertically, the length refers to the longer horizontal dimension of the inflatable; and the width refers to the shorter horizontal dimension.

~~NOTE 1—For engineering wind load calculations only, *height* refers to the dimension measured vertically; *length* is the longer horizontal dimension of the inflatable; and *width* is the shorter horizontal dimension.~~

(1) For inflatables with height ≤ 10 ft (3 m) and length ≤ (2.5 × width), the wind force shall be calculated ~~using:~~using Eq 1:

$$F_{H/V} = C_w \frac{\rho}{2} V^2 A \times S.F. \quad (1)$$

where:

$F_{H/V}$ = force, lbf (N);
~~C_w = wind coefficient (see Note 2);~~
C_w = wind coefficient (see 5.6.4.3*(1)(a)*);
ρ = density of air, 0.002378 slug/ft^3 (1.24 kg/m^3);
V = maximum wind speed with gusts over 3-second period, mph (m/s) (see 5.6.4.1);
~~$A_{H/V}$ = area (see Fig. 3) (see Note 3);~~
$A_{H/V}$ = area (see Fig. 3) (see 5.6.4.3*(1)(b)*);
S.F. = Safety Factor for the purpose of designing the anchor system (≥1.5).

~~NOTE 2—For calculating the horizontal wind force: C_w = 1.5.~~
~~For calculating the vertical wind force: C_w = 0.7.~~

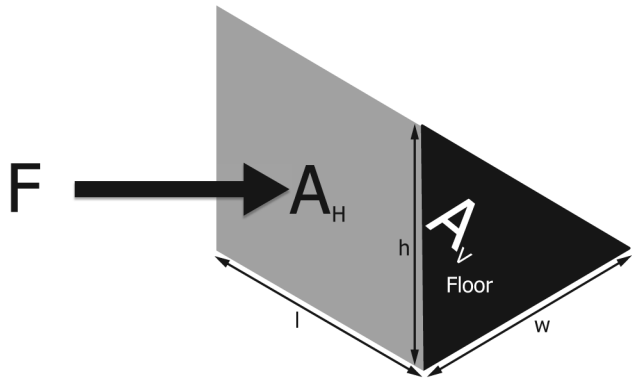
~~NOTE 3—For calculating the horizontal wind force: A_H = area of exposed vertical surface in the wind direction, ft^2 (m^2).~~
~~For calculating the vertical wind force: A_V = plan/surface area of floor, ft^2 (m^2).~~

(a) For calculating the horizontal wind force: C_w = 1.5. For calculating the vertical wind force: C_w = 0.7.

(b) For calculating the horizontal wind force: A_H = area of exposed vertical surface in the wind direction, ft^2 (m^2). For calculating the vertical wind force: A_V = plan/surface area of floor, ft^2 (m^2). For staked anchoring systems, Table X2.1 represents the combination of the simultaneous forces.

(2) For inflatables with height >10 ft (3 m) or with length >(2.5 × width), the wind force shall be calculated ~~using:~~using Eq 2:

$$F_{H/V} = q_w C_{pe} A \times S.F. \quad (2)$$



A_H = Area for Horizontal Wind Calculation

A_V = Area for Vertical Wind Calculation

FIG. 3 Areas of Exposed Surface for Wind Calculation

where:

$F_{H/V}$ = force, lbf (N);
~~$A_{H/V}$ = area (see Fig. 3) (see Note 4);~~
$A_{H/V}$ = area (see Fig. 3);
q_w = velocity pressure, psf (N/m^2);
~~C_{pe} = pressure coefficient; (see Note 5);~~
C_{pe} = pressure coefficient; (see 5.6.4.3*(3)*);
S.F. = Safety Factor for the purpose of designing the anchor system (≥1.5).

~~Note 4—See Note 3.~~

(3) The pressure coefficient, C_{pe}, shall be selected based on the ASCE 7 description. For example: for a square building, the effective Cp shall be 0.8 for the windward wall and –0.5 for the leeward wall or:

$$C_{pe} = 0.8 + 0.5 = 1.3$$

The velocity pressure q_w shall be calculated using the ASCE 7 Exposure category C formula in accordance with Eq 3 or Eq 4, depending on the units:

$$q_w = 0.00256 K_z K_d K_{zt} V^2 \quad \text{(Imperial Units)} \tag{3}$$

$$q_w = 0.613 K_z K_d K_{zt} V^2 \quad \text{(SI Units)} \tag{4}$$

where:

K_z = 0.85; exposure coefficient C, 0 – 4.57 m (15 ft) high;
K_d = 0.85; directionality factor for buildings;
K_{zt} = 1; no topographic effects; and
V = max sustained wind speed with gusts over 3-s period, mph (m/s) (see 5.6.4.1).

~~Note 5—The pressure coefficient, C_{pe}, shall be selected based on the ASCE 7 description For example: for a square building, the effective Cp is 0.8 for the windward wall and –0.5 for the leeward wall or:~~

~~$$C_{pe} = 0.8 + 0.5 = 1.3$$~~

~~*(a)* The velocity pressure q_w shall be calculated using the ASCE 7 Exposure category C formula as follows:~~

~~$$q_w = 0.00256 K_z K_d K_{zt} V^2 \quad \text{(Imperial Units)} \tag{3}$$~~

~~$$q_w = 0.613 K_z K_d K_{zt} V^2 \quad \text{(SI Units)} \tag{4}$$~~

~~where:~~

~~K_z = 0.85; exposure coefficient C, 0 – 4.57 m (15 ft) high;~~
~~K_d = 0.85; directionality factor for buildings;~~
~~K_{zt} = 1; no topographic effects; and~~
~~V = max sustained wind speed with gusts over 3-s period, mph (m/s) (see 5.6.4.1).~~

5.6.4.4 Fig. 4 outlines anchors and how to consider their effectiveness for load calculation purposes.

5.6.5 *Internal Loads:*

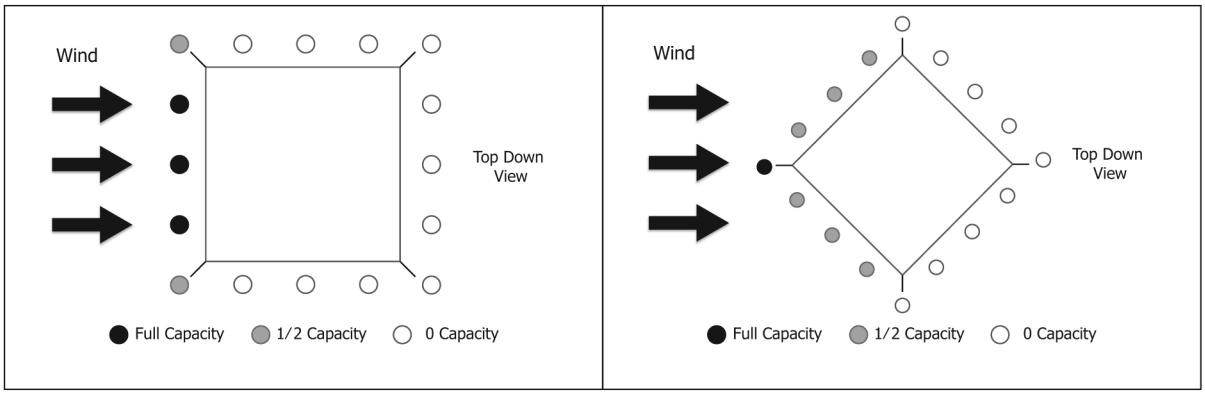


FIG. 4 Anchor Effectiveness

5.6.5.1 When calculating anchoring requirements in the design of an inflatable, F_i = Internal forces due to patron activity or asymmetrical loading must be considered in the design and treated as a separate load.

5.6.6 Anchoring systems for inflatable amusement devices shall be fixed stationary objects, installed or weighted in accordance with the design.

5.6.7 Anchorage points installed near an entrance and exit of an inflatable amusement device shall be connected in such a manner as to minimize the potential for tripping, abrasions, or other injuries.

5.6.8 *Staked Anchoring:*

5.6.8.1 Appendix X2.2 provides staking recommendations and information on pullout capacity for 1 in. diameter straight shaft stakes based on stake length, stake inclination, guy angle, and soil consistency. If the staked anchoring system is designed using other types of stakes, the design shall show how the specified anchors meet the requirements for pullout capacity.

5.6.8.2 Stakes shall have a minimum tensile strength of 36 000 psi.

5.6.9 *Non-staked Anchoring:*

5.6.9.1 Where the inflatable amusement device is secured with means other than ground anchor stakes (for example, ballast bags, sand boxes, water anchor weights, indoor floor anchors), the total anchor system shall be sufficient to resist the loads calculated per 5.6.3.

5.6.10 The manufacturer shall ensure that all ropes and fasteners are capable of meeting the design loads and are suitable for the intended use.

5.6.10.1 Anchoring rings or wire form shall be welded closed or cast (solid), and shall have a minimum working load equal to the calculated vertical, horizontal or combined load. The minimum breaking strength shall be 3 times the working load.

5.7 *Mechanical, Electrical, Hydraulic, Pneumatic and Other Systems or Components Incorporated into Inflatable Amusement Devices:*

5.7.1 This section outlines design requirements for elements that are not typically incorporated into simple inflatable amusement devices, but are integrated into hybrid inflatable attractions (for example, mechanical bulls, inflatable zip lines) or ancillary equipment.

5.7.2 Non-inflated structural elements, mechanical, electrical, hydraulic, pneumatic, and other systems or components covered under Practice F2291, but not addressed in this standard practice, shall be designed in conformance with Practice F2291.

5.8 *Sanitation/Disinfection:*

5.8.1 The atmosphere, material composition and configuration of surfaces, the nature of patron contact, potential for biological growth, disinfection techniques and frequencies, and the information in the disinfectant agent(s) associated Safety Data Sheets shall all be considered in the device analysis.

5.9 *Materials:*

5.9.1 *Material (Fabric) Strength*—Fabrics shall be of adequate tear and tensile strength for the weight of the intended patrons and have sufficient air retention abilities to enable the inflatable amusement device, when pressurized to the levels specified in the operation manual, to resume its intended shape after distortion under normal load.

5.9.1.1 Fabrics used in those parts of the inflatable device that are subject to force or stress as applied by the patrons or the anchorage system shall comply with Practice D5446:

(1) Minimum tear strength of 80 lbf (355 N) warp and 80 lbf weft when tested in accordance with Test Method D3787.

(2) Minimum tensile strength of 440 lbf (1957 N) warp and 440 lbf weft when used in accordance with Test Method D3787.

5.9.1.2 Fabrics used in other applications of the inflatable device shall also be of adequate tear and tensile strength to withstand the design operating pressure to which they are to be subjected.

5.9.1.3 ~~Lower strength fabrics are permitted~~ Fabrics for use in decorative parts that do not come in contact with patrons and are not part of the load path of the anchorage ~~system. Such fabrics shall be of adequate~~system shall comply with 5.9.1.2 ~~tear and tensile strength to withstand the~~but are not required to comply with 5.9.1.1~~design operating pressure.~~.

~~NOTE 6—Cold flex cracking and surface coating adhesions are both measurable parameters that should be considered by the designer as they affect performance of the fabric and must comply with Test Method D3787.~~

5.9.1.4 Fabrics shall comply with the cold flex cracking and surface coating adhesion requirements of Test Method D3787.

5.9.2 *Flammability:*

5.9.2.1 ~~Fabric~~Fabrics used for inflatable amusement devices ~~must~~shall comply with ~~fire testing per~~ the flame propagation performance criteria of NFPA 701 Test Method ~~2, unless~~ 2. If compliance with a different ~~standard~~ fire test is required by local, state or federal ~~law.~~law, additional evidence for compliance with such a fire test shall be provided in accordance with 5.9.2.2.

5.9.2.2 Flammability testing documentation ~~must~~shall be provided by the manufacturer of the materials used in the production of the inflatable amusement device.

(1) Material testing shall be performed by an independent testing facility utilized by the materials manufacturer.

(2) The testing date on the flammability testing documentation shall be within 3 years of the material manufacture date.

5.9.2.3 The inflatable device manufacturer shall maintain flammability test results for material used on the inflatable amusement device per section 5.4.

5.9.3 *Adhesive Bonding:*

5.9.3.1 When adhesive/chemical bonding is used, designer/engineer shall only use in accordance with the manufacturer's instructions and Safety Data Sheet.

5.9.4 *Coatings:*

5.9.4.1 When material coatings are used, designer/engineer shall design for possible degradation due to the environmental conditions.

5.9.4.2 Designer/engineer shall use material coatings in accordance with the manufacturer's instructions and Safety Data Sheet.

5.9.4.3 Painted or printed coated fabric used in the construction of inflatable amusement devices shall comply with the following, unless different standards are required by local, state or federal law:

(1) Concentration of lead shall not exceed 0.009 % (90 ppm).

(2) The following phthalates: DEHP, DBP, BBP, DINP, DIDP and DnOP shall not be used in any amount greater than 0.1 % (1000 ppm), where concentrations are computed for each phthalate individually.

5.9.5 *Netting or Mesh:*

5.9.5.1 Netting or mesh shall not significantly impair the operator/attendant's ability to observe patrons' use of the device.

5.9.5.2 Netting or mesh used to contain patrons shall:

(1) Be strong enough to contain the largest/heaviest user for whom the inflatable is designed;

(2) Meet the requirements for Class 2 Barrier Nets/Mesh in Practice F2375; and

(3) Pass the *Prototype Test Procedure for Maximum Hole Size of No-Hold Netting* in Practice F2375, but using a test rod of 0.315 in. (8 mm) diameter substituted for the test rod size specified in Practice F2375.

5.9.5.3 Climb nets used to form foot and hand holds shall:

(1) Be securely attached to the inflatable at both ends to prevent lifting by patrons;

(2) Meet the criteria for Climb Nets in Section 4 Materials and Manufacture of Practice F2375; and

(3) Pass the *Test Procedure for Nets with Large Openings* in Practice F2375.

5.9.6 *Zippers (Entrance and Deflation Ports):*

5.9.6.1 Zippers shall withstand the air pressure generated within the inflatable amusement device according to manufacturer's designated requirements.

5.9.6.2 Zipper pulls shall be accessible to use from both sides. Zippers for deflation purposes shall have the pull concealed from view by use of a flap or pocket. See example in Fig. 5.

5.10 *Methods of Construction:*

5.10.1 There shall be no hard or sharp angles or edges in any part of the inflatable device that is accessible to patrons (for example, outside seams with a raw edge, square inflated corners, sharp-pointed cones).

5.10.2 Hard objects incorporated into the design of an inflatable amusement device (for example, joust pedestals, mechanical obstacles, log rolling devices, Jacob's Ladder) shall be positioned or padded to mitigate the risk of patron injury when the device is in use or during unintended deflation.

5.10.3 Joints and seams in those parts of the device that are subject to force and stress applied by patrons or are part of the load path of anchorage systems shall be made so they achieve no less than the minimum tensile strength of the fabric used in those parts.

5.11 *Entrapment:*

5.11.1 *Entrapment of the Head and Neck:*

5.11.1.1 Inflatable devices shall be constructed so that any openings do not create head and neck entrapment hazards by either head-first or feet-first passage. Situations in which this type of entrapment occur include the following:

(1) Completely bound openings through which the patron can slide head first or feet first—Accessible completely bound openings with a lower edge more than 24 in. (60 cm) above a platform shall be tested in accordance with Annex A2 test method A2.4.1. The small probe shall not pass through any opening unless it also allows passage of the large probe.

(2) V-shaped openings—The angle of any vertex formed by adjacent components shall be greater than 55°, unless the lower leg is horizontal or projects downwards, or an infill shield is attached to the vertex that prevents a 9 in. (0.23 m) diameter circular template from simultaneously touching components on either side of the vertex. Fig. 6 illustrates recommended angle measurements.

(3) Other openings (for example, sheering or moving openings)—Non-rigid members, such as ropes, shall not overlap if, by doing so, they create openings that do not conform to the requirements for completely bound openings.

5.11.2 *Entrapment of Clothing or Hair:*

5.11.2.1 Spindles and rotating parts shall be constructed so as to prevent entanglement of clothing or hair (for example, by use of suitable coverings or shields).

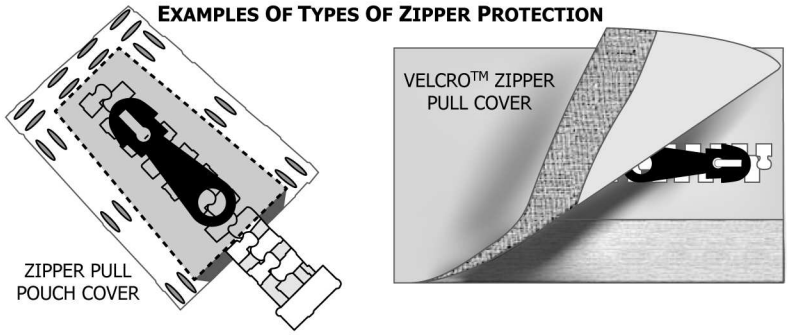
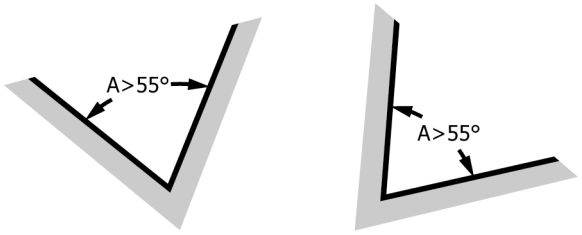
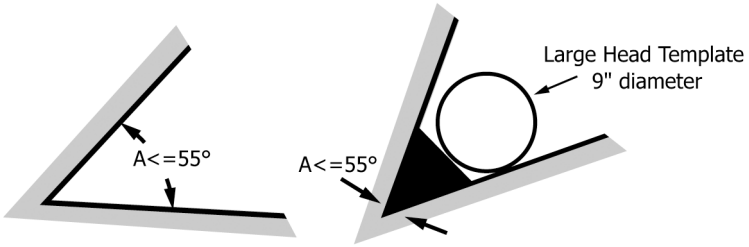


FIG. 5 Examples of Zipper Protection



Angle "A" shall exceed 55 degrees if the V opens upward



Angle "A" may be less than 55 degrees if one leg of the V
is horizontal or slopes downward from the apex,
or if an in-fill shield is used to prevent head entrapment

FIG. 6 Recommendations for Angles on V-shaped Openings

5.11.2.2 Inflatable devices shall be constructed so that there is no exposed hook from a hook-and-loop connection system (for example, Velcro) in areas where patrons play.

5.11.3 *Finger Entrapment:*

5.11.3.1 Inflatable devices shall not have any gaps where fingers can be trapped while the rest of the body is moving or continuing in motion involuntarily (for example, sliding, bouncing).

5.11.3.2 Openings accessible to patrons within the play area, when tested in accordance with Annex A2 test method A2.5, shall conform to one of the following requirements:

(1) A 0.31 in. (8 mm) finger rod (see Fig. A2.2(a)), when applied with a force of 6.75 lbf (30 N), shall not pass through the minimum cross section of the opening and the profile of the opening shall be such that the rod cannot be locked in any position when set in motion as given in Fig. A2.3; or

(2) If the 0.31 in. finger rod passes through the opening, the 1 in. (25 mm) finger rod (see Fig. A2.2), when applied with a force of 6.75 lbf (30 N), shall also pass through the opening.

5.11.4 *Body Entrapment:*

5.11.4.1 Adjacent inflated surfaces shall be more than 4.75 in. (120 mm) apart if the aperture formed is more than 8 in. (200 mm) deep (see examples in Fig. 7). The measurements shall be taken in the unloaded condition (that is, without pressure being applied to push the inflated surfaces farther apart).

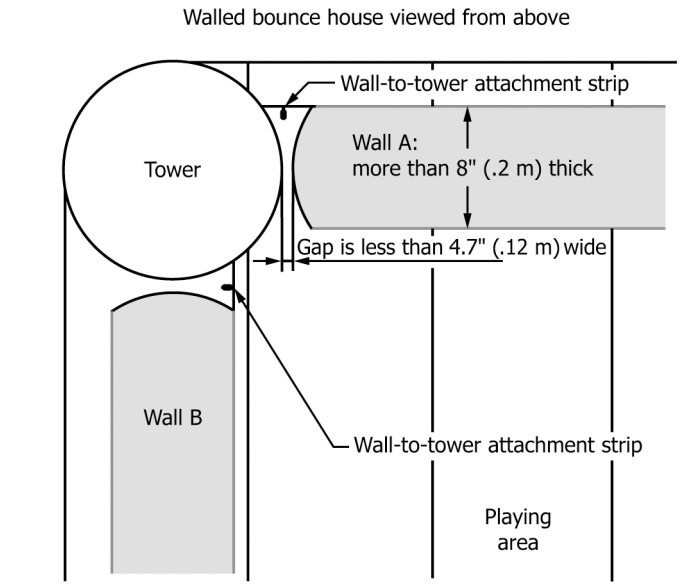
5.11.4.2 Inflatable tunnels shall be open-ended and shall meet the criteria in Table 1.

5.12 *Containment and Impact Attenuation:*

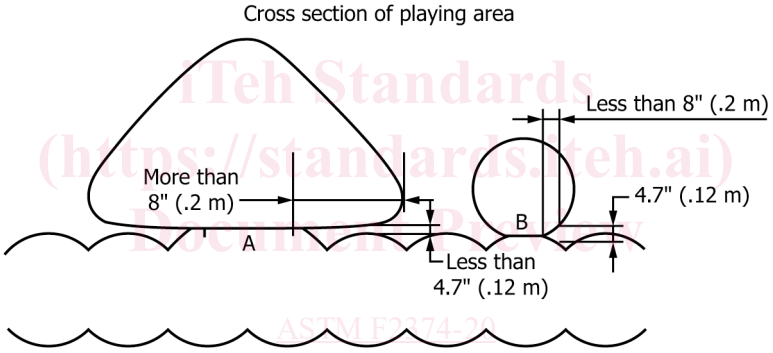
5.12.1 The minimum requirements in this section represent a starting point for containment and impact attenuation system design. Additional factors for consideration include, but are not limited to, the following:

5.12.1.1 Height of the patron routes above the ground.

5.12.1.2 Height of the patron routes above the mattress surface (for example, jousting pedestals, climbable objects).



The wall-to-tower attachment strip on Wall A (positioned to rear of gap) forms an entrapment point. The position of the attachment strip on Wall B guards out the entrapment hazard.



The large slide fixed at A forms an entrapment point.
The ball fixed at point B does not form an entrapment point.

FIG. 7 Body Entrapment Assessment Examples

TABLE 1 Requirements for Tunnels

Tunnel Length	Requirements
≤ 80 in. (2 m)	Internal diameter shall be at least 24 in. (0.6 m)
> 80 in. (2 m)	Internal diameter shall be at least 30 in. (0.75 m)

5.12.1.3 Age and size range of patrons allowed on the device.

5.12.1.4 Slope of the play surface.

5.12.1.5 Patron's body position while using the play area (seated, standing, lying flat, etc.).

5.12.1.6 The intended nature of the amusement device and type(s) of activity patrons are likely to engage in (for example, sliding, running, climbing, horizontal jumping, jumping from object to object).

5.12.1.7 Forces imposed on patrons by intended use of equipment within the device that ~~might~~ affect containment (for example, bungee attachment, mechanical bull, additional elevation obtained from bouncing on the inflated surface).

5.12.2 ~~Alternative design strategies are permitted as long as they~~ Any alternative design strategies used shall provide equivalent (or better) hazard mitigation. For instance, in some cases, it is acceptable to lower perimeter walls or replace them when supplemented by additional containment features, an impact attenuation system, or both.

5.12.3 *Containment System Design:*

5.12.3.1 The perimeter (that is, outermost inflated edges) of an inflatable amusement device shall include a patron containment system, except in areas protected by impact attenuation materials in accordance with 5.12.7.

5.12.3.2 The containment system design shall include elements that singly, or in combination, contain patrons within the designated routes while the inflatable amusement device is being operated in the manner for which it was designed. These elements include, but are not limited to: walls, bumpers, covers over play areas; and harnesses worn by patrons.

5.12.3.3 Any system or systems used to support and contain the patron(s) shall be securely fixed to the structure of the device and shall have adequate strength for the intended forces produced by the device and the reasonably foreseeable actions of the patron(s).

5.12.4 *Containment Walls:*

5.12.4.1 Supporting containment walls ~~are permitted to be either~~ shall either be inflated or shall be enclosed with netting or mesh per 5.9.5.

5.12.4.2 Minimum height for containment walls shall be as follows.

(1) Inflatable bounce houses and combination devices with a bounce house element—1.25 × the maximum patron height requirement for the device.

(2) Inflatable slides and exterior slides on combination units—28 in. (0.7 m) for devices with maximum patron height up to and including 60 in. (1.5 m); 36 in. (0.9 m) for devices with maximum patron height greater than 60 in. (1.5 m). This corresponds approximately to the sitting height of the tallest patron allowed on the device.

(3) All other inflatable amusement devices with an inflated mattress (for example, obstacle courses, games)—36 in. (0.9 m) above mattress height.

NOTE 1—This is a minimum requirement applied to a broad range of inflatable amusement devices; the containment analysis may indicate higher walls for some devices in this category.

5.12.5 *Protective Covers:*

5.12.5.1 Inflatable slides and exterior slides on combination devices shall include design features to prevent patrons from standing, jumping, or diving down the slope, such as a protective cover over the top of the slide and climb areas and the associated transition platform as shown in Fig. 8.

(1) Protective covers shall extend at least ⅓ the slope length of the slide as measured from the top of the sliding surface.

(2) Minimum distance between the play surface and the underside of the protective cover, illustrated in Fig. 9, shall be the same as the minimum containment wall height for the slide defined in 5.12.4.2(2).

5.12.5.2 Inflatable obstacle courses shall include design features such as protective covers over elevated landings to prevent patrons from standing in those areas.

5.12.6 *Activity-related Containment:*

5.12.6.1 If an inflatable game or other device has a play area where the patron is elevated on an object above the mattress surface, the designer shall evaluate the need for higher containment walls, an impact attenuation system, or other mitigation strategy for potential fall hazards.

5.12.7 *Ingress/Egress and Device Landing Surfaces:*

5.12.7.1 The landing surfaces are the areas beneath and directly adjacent to the ingress and egress areas of the inflatable amusement device and any uncontained perimeter area, where a user would land when exiting or falling from the device.