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.

Designation: F2374 – 21a

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. These devices are designed for patron activities that include, but are not 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:

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 F2729-18.

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,

[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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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/D6951M 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 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

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 Association):*[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 For terms associated with amusement rides and devices, the definitions are in accordance with Terminology F747-15. The terms in this section are contained in that terminology standard.

3.2 *Definitions:*

3.2.1 *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.

3.2.2 *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.

3.2.3 *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.

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 F2291-20.

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

[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 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.

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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:*

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 F2291-20.

5.4.2 *Testing*—Document and record the testing performance of inflatable amusement devices in accordance with the tests given in Practice F1193-18a.

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 F1193-18a 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 F2291-20.

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 F2291-20.

5.5.4 All inflatables with an inflated floor must pass the applicable Test Methods for Weight Bearing Surfaces in Annex A5.

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.

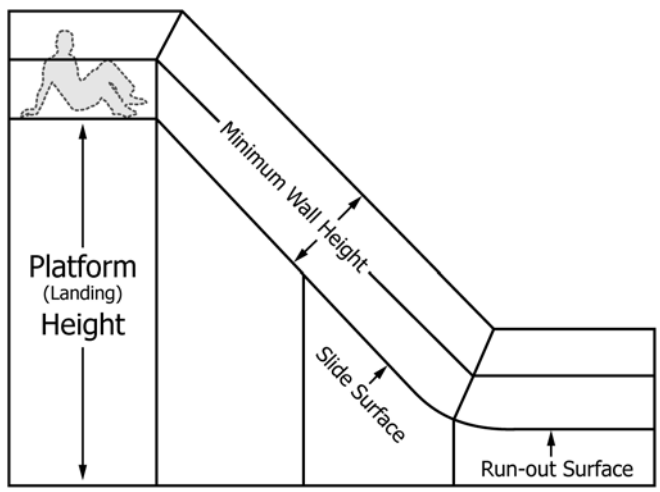
(3) The structural design shall prevent rapid collapse of elevated platforms or collapse of ceilings and walls onto the patrons.

(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:*



SIDE VIEW

FIG. 1 Slide Platform and Wall Height Measurements

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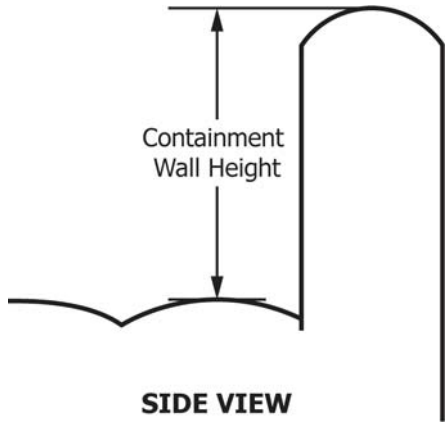

FIG. 2 Containment Wall Height Measurement

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. A higher operational wind speed shall not be used unless the anchorage 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 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.

(1) For inflatables with height ≤ 10 ft (3 m) and length ≤ (2.5 × width), the wind force shall be calculated 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 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 5.6.4.3*(1)(b)*);
$S.F.$ = Safety Factor for the purpose of designing the anchor system (≥1.5).

(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 A2.1 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 Eq 2:

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

where:

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

(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:

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

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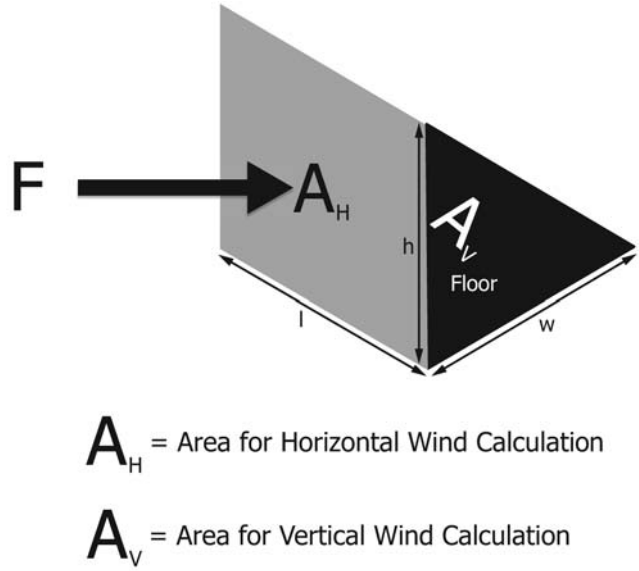

FIG. 3 Areas of Exposed Surface for Wind Calculation

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

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:*

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 A2.2 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

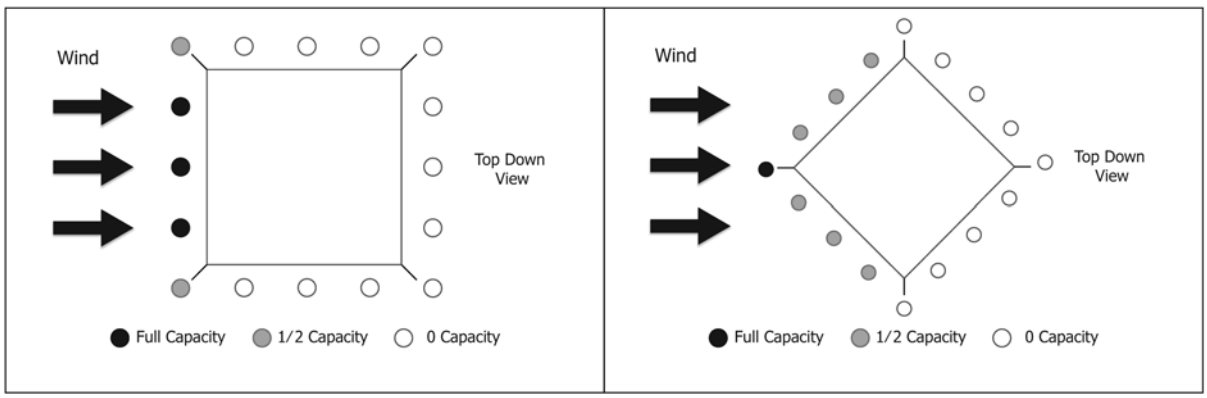

FIG. 4 Anchor Effectiveness

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