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NFPA 102 Standard for Grandstands, Folding and Telescopic Seating, Tents, and Membrane Structures 1995 Edition

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An International Codes and Standards Organization

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NFPA 102

Standard for

Grandstands, Folding and Telescopic Seating, Tents, and Membrane Structures

1995 Edition

This edition of NFPA 102, *Standard for Grandstands, Folding and Telescopic Seating, Tents, and Membrane Structures*, was prepared by the Technical Committee on Tents and Membrane Structures, released by the Technical Correlating Committee on Safety to Life, and acted on by the National Fire Protection Association, Inc., at its Fall Meeting held November 14-16, 1994, in Toronto, Ontario, Canada. It was issued by the Standards Council on January 13, 1995, with an effective date of February 7, 1995, and supersedes all previous editions.

The 1995 edition of this document has been approved by the American National Standards Institute.

Changes other than editorial are indicated by a vertical rule in the margin of the pages on which they appear. These lines are included as an aid to the user in identifying changes from the previous edition.

Origin and Development of NFPA 102

This standard is the result of a committee project inaugurated shortly after the circus fire in Hartford, CT, on July 6, 1944, in which 168 lives were lost.

A committee was organized under the joint sponsorship of the Building Officials Conference of America and the National Fire Protection Association under the procedure of the American Standards Association. As a result of extensive deliberation during the winter of 1944-1945, this committee prepared a draft of a proposed standard, which was submitted at the annual meeting of the National Fire Protection Association in June, 1945. This was then printed and sent to all of the members of the Association, to a representative group of leaders in the outdoor amusement industry, and to all others who filed requests for copies. As a result, numerous constructive suggestions were received, all duly considered by the committee in several meetings, and the 1946 standard was completed by the committee. It was then adopted by the sponsoring organizations, the National Fire Protection Association, and the Building Officials Conference of America, and approved by the American Standards Association as an American Standard on May 22, 1946.

As a result of circulation and use of the 1946 standard, various proposals were made for revision in the interest of clarification. These were considered by the committee and revisions recommended by the committee and circulated to all concerned for comment, further amended, and adopted by the National Fire Protection Association and the Building Officials Conference of America in 1948; the American Standards Association approved the 1948 edition as an American Standard on January 5, 1949.

In 1949 the committee recommended further changes to include the essential features of an earlier standard on grandstands, Z20.1, which covered certain types of grandstands not covered in the 1946-1948 standard, Z20.2, thus making the continuance of the earlier separate standard unnecessary. The 1949 revision, Z20.3, also made the standard applicable to foldable grandstands in buildings that had not been previously covered. After the usual circulation for comment the revisions were adopted in 1949 by the sponsors, and the revised text was approved by the American Standards Association as an American Standard, April 5, 1950.

Revised editions of the standard have been prepared by the committee and adopted by the sponsors in 1957, 1966, and 1967. The 1972 edition was a reconfirmation of the 1967 edition.

The 1978 edition was prepared by the Committee on Tents, Grandstands, and Air-Supported Structures and represented a complete revision of the 1972 edition, complete with a new title, *Standard for Assembly Seating, Tents, and Air-Supported Structures*. The means of egress section was coordinated with the provisions of NFPA *101®*, *Life Safety Code.®*

The 1986 edition further coordinated with the *Life Safety Code*. It was prepared by the Technical Committee on Safety to Life through its Subcommittee on Tents and Membrane Structures. Its scope was extended beyond assembly occupancies to include tents and membrane structures used for any occupancy.

The 1992 and 1995 editions delete all means of egress provisions that are adequately covered by NFPA *101*, *Life Safety Code*, so as to avoid redundancy and inconsistencies between the two documents. This 1995 edition was retitled, *Standard for Grandstands, Folding and Telescopic Seating, Tents, and Membrane Structures*, to reflect more accurately the scope and contents of the document.

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Committee Scope: This Committee shall have primary responsibility for documents on the protection of human life from fire and other circumstances capable of producing similar consequences and for the non-emergency and emergency movement of people.

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This list represents the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in the membership may have occurred.

NOTE: Membership on a Committee shall not in and of itself constitute an endorsement of the Association or any document developed by the Committee on which the member serves.

Committee Scope: This Committee shall have primary responsibility for documents on protection of human life from fire and other circumstances capable of producing similar consequences, and on the nonemergency and emergency movement of people in assembly seating, tents, and membrane structures.

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NFPA 102

Standard for

Grandstands, Folding and Telescopic Seating, Tents, and Membrane Structures

1995 Edition

NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates explanatory material on that paragraph in Appendix A.

Information on referenced publications can be found in Chapter 11 and Appendix B.

Chapter 1 General

1-1* Scope. This standard covers the following:

(a) The construction, location, protection, and maintenance of grandstands and bleachers, folding and telescopic seating, tents, and membrane structures.

(b) Seating facilities located in the open air or within enclosed or semienclosed structures such as tents, membrane structures, and stadium complexes.

1-2 Purpose. The purpose of this standard is to provide for life safety in relation to fire, storm, collapse, and crowd behavior in tents, membrane structures, and assembly seating as covered in Section 1-1.

1-3 Application. This standard applies to new facilities. Where specifically noted, it also applies to existing facilities.

1-4 Referenced Design Standards. The materials, design, fabrication, and construction of structures or devices included within the scope of this standard shall comply with approved standards for safety to life and property as contained herein and in the applicable building code.

1-5 Equivalency Concepts.

1-5.1 Nothing in this standard is intended to prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire resistance, effectiveness, durability, and safety to those prescribed by this standard, provided technical documentation is submitted to the authority having jurisdiction to demonstrate equivalency and provided the system, method, or device is approved for the intended purpose.

1-5.2 The specific requirements of this standard shall be permitted to be modified by the authority having jurisdiction to allow alternative arrangements that will secure as nearly equivalent safety to life from fire as practicable, but in no case shall the modification afford less safety to life than, in the judgment of the authority having jurisdiction, that which would be provided by compliance with the corresponding provisions contained in this standard.

1-5.3 Buildings with alternative fire protection features accepted by the authority having jurisdiction shall be considered to conform with this standard.

Chapter 2 Definitions

2-1 General.

2-1.1 For the purposes of this standard, the following terms shall have the meanings given in this chapter.

2-1.2 Words used in the present tense include the future; words used in the masculine gender include the feminine and neuter; the singular number includes the plural and the plural the singular.

2-1.3 Where terms are not defined in this chapter, they shall have their ordinarily accepted meanings or such as the context implies.

2-2 Definitions.

Air-Inflated Structure. A structure whose shape is maintained by air pressure in cells or tubes forming all or part of the enclosure of the usable area. Occupants of such a structure do not occupy the pressurized area used to support the structure.

Air-Supported Structure.* A structure whose shape is maintained by air pressure and occupants of the structure are within the elevated pressure area.

Approved. Acceptable to the authority having jurisdiction.

NOTE: The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization concerned with product evaluations that is in a position to determine compliance with appropriate standards for the current production of listed items.

Assembly Occupancy. Includes, but is not limited to, all structures or portions of structures used for gathering together 50 or more persons for such purposes as deliberation, worship, entertainment, eating and drinking, amusement, or awaiting transportation.

Authority Having Jurisdiction. The organization, office, or individual responsible for approving equipment, an installation, or a procedure.

NOTE: The phrase "authority having jurisdiction" is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

Bleachers. A grandstand where the seats are not provided with backrests.

Exit.* That portion of a means of egress that is separated from all other spaces of the building or structure by construction or equipment as required to provide a protected way of travel to the exit discharge.

Exit Access. That portion of a means of egress that leads to an exit.

Exit Discharge. That portion of a means of egress between the termination of an exit and a public way.

Fire Resistance Rating. The time in minutes or hours that materials or assemblies have withstood a fire exposure as established in accordance with the test procedures of NFPA 251, *Standard Methods of Fire Tests of Building Construction and Materials*.

Folding and Telescopic Seating. A structure that is used for tiered seating of persons and whose overall shape and size can be reduced, without being dismantled, for purposes of moving or storing.

Grandstand. A structure providing tiered or stepped seating. Where the term "grandstand" is preceded by an adjective denoting a material, it shall mean a grandstand the essential members of which, exclusive of seating, are of the material designated.

Heavy Timber Construction. Type IV (2HH) construction as defined in NFPA 220, *Standard on Types of Building Construction*.

Labeled. Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation that maintains periodic inspection of production of labeled equipment or materials and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

Limited-Combustible. As applied to a building construction material, means a material, not complying with the definition of noncombustible material, that, in the form in which it is used, has a potential heat value not exceeding 3500 Btu per pound (8141 kJ/kg) per NFPA 259, *Standard Test Method for Potential Heat of Building Materials*, and complies with one of the following paragraphs (a) or (b). Materials subject to increase in combustibility or flame spread rating beyond the limits herein established through the effects of age, moisture, or other atmospheric condition shall be considered combustible materials.

(a) Materials having a structural base of noncombustible material, with a surfacing not exceeding a thickness of 1/8 in. (3.2 mm) that has a flame spread rating not greater than 50.

(b) Materials, in the form and thickness used, other than as described in (a), having neither a flame spread rating greater than 25 nor evidence of continued progressive combustion and being of such composition that surfaces that would be exposed by cutting through the material on any plane would have neither a flame spread rating greater than 25 nor evidence of continued progressive combustion.

Listed. Equipment or materials included in a list published by an organization acceptable to the authority having jurisdiction and concerned with product evaluation that maintains periodic inspection of production of listed equipment or materials and whose listing states either that the equipment or material meets appropriate standards or has been tested and found suitable for use in a specified manner.

NOTE: The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

Means of Egress. A continuous and unobstructed way of exit travel from any point in a building or structure to a public way, consisting of three separate and distinct parts: (a) the exit access, (b) the exit, and (c) the exit discharge. A means of egress comprises the vertical and horizontal travel and includes intervening room spaces, doorways, hallways, corridors, passageways, balconies, ramps, stairs, enclosures, lobbies, escalators, horizontal exits, courts, and yards.

Membrane. A thin, flexible, water-impervious material capable of being supported by an air pressure of 1.5 in. (38.1 mm) of water column.

Membrane Structure. A building or portion of a building incorporating an air-inflated, air-supported, tensioned-membrane structure; a membrane roof; or a membrane-covered rigid frame to protect habitable or usable space.

Noncombustible Material. A material that, in the form in which it is used and under the conditions anticipated, will not aid combustion or add appreciable heat to an ambient fire. Materials, where tested in accordance with ASTM E136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*, and conforming to the criteria contained in Section 7 of the referenced standard shall be considered as noncombustible materials.

Permanent. A building or structure that is intended to remain in place for a period of 180 days or more.

Private Party Tent. A tent erected in the yard of a private residence for entertainment, recreation, dining, reception, or similar function.

Professional Engineer. An engineer who is registered or licensed to practice engineering.

Shall. Indicates a mandatory requirement.

Should. Indicates a recommendation or that which is advised but not required.

Temporary. A building or structure that is in place for a period of 180 consecutive calendar days or less.

Tensioned-Membrane Structure.* A membrane structure incorporating a membrane and a structural support system such as arches, columns and cables, or beams wherein the stresses developed in the tensioned membrane interact with those in the structural support so that the entire assembly acts together to resist the applied loads.

Tent. A temporary structure, the covering of which is made of pliable material that achieves its support by mechanical means such as beams, columns, poles, arches, rope, and/or cables. Tent might also include a temporary tensioned-membrane structure.

Weathered-Membrane Material. Membrane material that has been subjected to a minimum of 3,000 hours in a weatherometer in accordance with ASTM G26, *Practice for Operating Light/Exposure Apparatus (Zenon-Arc Type) With and Without Water for Exposure of Non-Metallic Materials*, or approved equivalent.

Chapter 3 Means of Egress

3-1 General.

3-1.1 Means of egress from facilities included within the scope of this standard shall comply with the provisions of NFPA *101®, Life Safety Code®*.

3-1.2 No guy wire or guy rope shall cross any means of egress at a height of less than 7 ft (2.1 m). Tent stakes adjacent to any means of egress from any tent open to the public shall be railed off, capped, or covered so as not to present a hazard to the public.

Chapter 4 Grandstands and Bleachers

4-1 Location. Grandstands shall be erected or otherwise located only where adequate load-carrying capacities exist to safely support the loads.

4-2 Minimum Construction Requirements.

4-2.1 Grandstands and bleachers shall be permitted to be of unlimited area when of Type I or Type II construction.

4-2.2 Grandstands and bleachers shall be permitted to be of Type III, Type IV, or Type V construction when designed in accordance with Section 4-6.

4-3 Design.

4-3.1 The design of grandstands shall be in accordance with accepted structural engineering practice.

4-3.2 Load tests in accordance with accepted engineering practice shall be permitted in lieu of the design analysis for a grandstand unit or a part thereof.

4-3.3 Where required by the authority having jurisdiction, the manufacturer shall submit either calculations verifying the design analysis prepared by a professional engineer or registered architect or a report of load tests conducted by an approved independent testing laboratory and certified by a professional engineer. Where required by the authority having jurisdiction, the manufacturer shall certify that the equipment supplied is in accordance with the design or is essentially identical to the structure tested.

4-3.4 A grandstand shall be designed and assembled so that the maximum expansion, contraction, settlement, or misalignment likely to occur will not cause stresses in excess of those permissible nor jeopardize the structure or its occupants. It shall be designed to remain stable so as not to be overturned either by wind or unequal distribution of live load.

4-3.5 Design Loads.

4-3.5.1 Grandstands shall be designed to support, in addition to their own weight and the weight of added accessories, a uniformly distributed live load of not less than 100 lb/ft^2 (488 kg/m^2) of gross horizontal projection.

4-3.5.2 All seat board and footboard members shall be designed for a live load of not less than 120 lb/linear ft (179 kg/linear m).

4-3.5.3 Grandstands shall be designed to resist a horizontal swaying force applied to the seats, in a direction parallel to the length of the seats, of 24 lb/linear ft (36 kg/linear m) of seats and, in a direction perpendicular to the length of the seats, of 10 lb/linear ft (15 kg/linear m) of seats.

4-3.5.4 Wind Loads.

4-3.5.4.1 Grandstands shall be designed to withstand, with or without live loads, the horizontal and uplift pressures due to wind. Wind pressures shall be derived from ASCE 7, *Minimum Design Loads in Buildings and Other Structures*.

4-3.5.4.2 Horizontal pressures shall be assumed to be acting on the gross vertical projection of the grandstand measured above the average level of the adjoining ground.

4-3.5.4.3 Uplift wind pressures equal in magnitude to those shown in ASCE 7, *Minimum Design Loads in Buildings and Other Structures*, shall be assumed to be acting vertically on the gross horizontal projection of "closed deck" grandstands, the understructure of which is unenclosed. Uplift wind pressures equal to 60 percent of these values shall be assumed to be acting vertically on the gross horizontal projection of "closed deck" grandstands, the understructure of which is enclosed at the perimeter with solid walls.

4-3.5.4.4 Uplift wind pressures equal to 1¼ times those shown in ASCE 7, *Minimum Design Loads in Buildings and Other Structures*, shall be assumed to be acting normal to an unenclosed roof situated over a grandstand.

4-3.5.5 Handrails on grandstands shall be designed and constructed for:

(a) A concentrated load of 200 lb (91 kg) applied at any point and in any direction, and

(b) A uniform load of 50 lb/ft (74 kg/m) applied in any direction.

The concentrated and uniform loading conditions shall not be required to be applied simultaneously.

4-3.5.6 Guards of grandstands shall be designed and constructed for:

(a) A concentrated load of 200 lb (91 kg) applied at any point and in any direction along the top railing member, and

(b) A uniform load of 50 lb/ft (74 kg/m) applied horizontally at the required guardrail height and a simultaneous uniform load of 100 lb/ft (149 kg/m) applied vertically downward at the top of the guardrail.

The concentrated and uniform loading conditions shall not be required to be applied simultaneously.

4-3.5.7 Each of the horizontal forces in 4-3.5.3, 4-3.5.5, and 4-3.5.6 shall not be required to be applied simultaneously with other lateral forces such as wind or seismic loads.

4-3.6 Members in which the stresses are greater under a partial loading of the grandstand than under a full load shall be designed to meet the conditions causing the largest stress.

4-3.7 Stresses permitted in the design standards of the various materials shall be permitted to be increased by 33⅓ percent due to sway or wind loads or by a combination of sway or wind loads and vertical loads, provided that no such increases shall be allowed for stresses due to vertical loads acting alone.

4-3.8 Foundations for permanent grandstands shall be designed to sustain a total load equal to the dead load plus 60 percent of the total of the live load and the transmitted wind or sway load.

4-4 Seating.

4-4.1 The depth of footboards and seat boards in grandstands shall be not less than 9 in. (22.9 cm). Where the same level is not used for both seat foundations and footrests, footrests independent of seats shall be provided.

4-4.2 Seats and footrests of grandstands shall be supported securely and fastened in such a manner that they cannot be displaced inadvertently.

4-4.3 Individual seats or chairs shall be permitted only if secured firmly in rows in an approved manner.

Exception: Seats, if not more than 16 in number, on level floors and within railed-in enclosures, such as boxes, shall not be required to be fastened.

4-4.4 Any opening between the seat board and footboard that is located more than 30 in. (76 cm) above grade shall be provided with intermediate construction such that a 4-in. (10.2-cm) diameter sphere cannot pass.

4-5 Railings or Guards.

4-5.1 Railings or guards not less than 42 in. (107 cm) high above the aisle surface or footrest or 42 in. (107 cm) vertically above the center of the seat board surface, whichever is adjacent, shall be provided along those portions of the backs and ends of all grandstands where the seats are more than 4 ft (1.2 m) above the ground.

Exception: Where grandstands are used adjacent to a wall or fence, railings or guards shall be permitted to be omitted from those portions where such wall or fence affords equivalent safeguard.

4-5.2 Where the front footrest of any grandstand is more than 2 ft (0.6 m) above the ground, railings or guards not less than 26 in. (66 cm) high above such front footrests shall be provided.

4-5.3 Each cross aisle located at the front of the grandstand shall be provided with a rail not less than 36 in. (91 cm) high.

Exception: Railings at the foot of aisles where steps occur shall be not less than 42 in. (107 cm) high for the width of the aisle.

4-5.4 Each cross aisle other than those located at the front of the grandstand shall be provided with a rail not less than 26 in. (66 cm) high.

Exception: Where the backs of the seats in front of the cross aisle project 24 in. (61 cm) or more above the surface of the cross aisle, the rail shall be permitted to be omitted.

4-5.5 Vertical openings between guardrails and footboards or seat boards shall prevent the passage of a 4-in. (10.2-cm) diameter sphere.

4-6 Special Requirements — Wood Grandstands.

4-6.1 No outdoor wood grandstand shall be erected within less than two-thirds of its height but in no case less than 10 ft (3 m) of a building, unless the separation from such building is of not less than 1-hour fire resistance rating and any openings in the separation are protected against the fire exposure hazard created by the grandstand, or unless a protection of not less than 1-hour fire resistance rating is interposed between such grandstand and building.

4-6.2* No outdoor wood grandstand unit shall exceed 10,000 ft^2 (929 m^2) in ground area or 200 ft (61 m) in length. Grandstand units of the maximum size shall be placed not less than 20 ft (6.1 m) apart or shall be separated by walls of 1-hour fire resistance rating. Not more than three such units shall be erected in any one group. Each such group shall be separated from any other group by a wall of 2-hour fire resistance-rated construction extending 2 ft (0.6 m) above the seat platforms or by an open space of not less than 50 ft (15.2 m).

Exception: Where entirely constructed of labeled fire-retardant-treated wood that has passed the standard rain test, ASTM D2898, Test Method for Accelerated Weathering of Fire-Retardant-Treated Wood for Fire Testing, or of members conforming to dimensions for heavy timber construction [Type IV (2HH)], the allowable ground area or length shall be permitted to be doubled.

4-6.3 The highest level of seat platforms of any wood grandstand shall be not more than 20 ft (6.1 m), and of portable grandstands within tents or membrane structures not more than 12 ft (3.7 m), above the ground or the surface at the front of the grandstand.

Exception: Where entirely constructed of labeled fire-retardant-treated wood that has passed the standard rain test, ASTM D2898, Test Method for Accelerated Weathering of Fire-Retardant-Treated Wood for Fire Testing, or of members conforming to dimensions for heavy timber construction [Type IV (2HH)], the allowable height shall be permitted to be doubled.

4-7 Special Requirements — Portable Grandstands.

4-7.1 Portable grandstands shall conform to the requirements of Chapter 4 for grandstands and the following special requirements.

4-7.2 Portable grandstands shall be self-contained, having within all necessary parts to withstand and restrain all forces that might be developed during human occupancy. They shall be designed and manufactured so that if any structural members essential to the strength and stability of the structure have been omitted during erection, the presence of unused connection fittings shall make the omissions self-evident. The construction shall be skillfully accomplished to produce the strength required by the design.

4-7.3 Portable grandstands shall be provided with base plates, sills, floor runners, or sleepers of such area that the allowable bearing capacity of the supporting material is not exceeded. Where portable grandstands rest directly on a base of such character as to be incapable of supporting the load without appreciable settlement, mud sills of suitable material, having sufficient area to prevent undue or dangerous settlement, shall be installed under base plates, runners, or sleepers. All bearing surfaces shall be in contact.

4-7.4 A-frames or other supports and seat stringers for portable grandstands shall be secured to prevent accidental displacement during occupancy.

4-7.5 Field connections to wood members shall be by means of rivets, bolts, approved connectors, friction or other devices, or lag screws. The use of nails, lag screws, and wood screws is permissible for holding wood parts together, except that these shall not be used for demountable joinings, nor shall these be used where their loosening or splitting of surrounding wood would jeopardize the structure or its occupants. Members in tension shall be connected at each end by means of not less than two bolts, rivets, or lag screws or by approved connectors or other approved devices. All ferrous fastenings and fastening devices shall be stainless steel or hot-dipped galvanized. [*See ASTM A153, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.*] Adequate provision shall be made to prevent the splitting or shearing of wood at such connections.

4-7.6 Portable grandstands shall not be used for public occupancy unless all parts have been erected, or reerected, in accordance with the approved design and specifications. Members constituting the seating, walkways, railings, bracing, and supporting members shall be structurally sound.

4-8 Spaces Underneath Grandstands. Spaces underneath a grandstand or bleacher shall be kept free of flammable or combustible materials.

Exception No. 1: Accessory uses such as ticket booths, toilet facilities, or concession booths shall be permitted in such spaces where of noncombustible or fire-resistive construction.

Exception No. 2: Small food serving or processing stands, such as a concession booth, that are protected by an automatic fire suppression system or are of 1-hour fire resistance-rated construction shall be permitted.

Exception No. 3: Assembly occupancies that are protected throughout by an approved, automatic sprinkler system and that are of 1-hour fire resistance-rated construction shall be permitted.

4-9 Maintenance. The owner shall provide for not less than annual inspection and required maintenance of each grandstand to ensure safe conditions. At least biennially the inspection shall be performed by a professional engineer or registered architect. Where required by the authority having jurisdiction, the owner shall provide certification that such inspection has been performed.

Chapter 5 Folding and Telescopic Seating

5-1 Application. Folding and telescopic seating shall be permitted only if the supporting structure is of adequate strength and there are adequate exit facilities to accommodate the occupants of the seating as well as all other occupants.

5-2 Design.

5-2.1 The design of folding and telescopic seating shall be in accordance with accepted structural engineering practice.

5-2.2 Load tests in accordance with accepted engineering practice shall be permitted in lieu of the design analysis for a seating unit or part thereof.

5-2.3 Where required by the authority having jurisdiction, the manufacturer shall submit either calculations verifying the design analysis prepared by a professional engineer or registered architect or a report of load tests conducted by an approved independent testing laboratory and certified by a professional engineer. Where required by the authority having jurisdiction, the manufacturer shall certify that the equipment supplied is in accordance with the design or is essentially identical to the structure tested.

5-2.4 Design Loads.

5-2.4.1 Folding and telescopic seating shall be designed to support, in addition to its own weight and the weight of added accessories, a uniformly distributed live load of not less than 100 lb/ft^2 (488 kg/m^2) of gross horizontal projection.

5-2.4.2 Seat boards and footrests shall be designed for a live load of not less than 120 lb/linear ft (179 kg/linear m).

5-2.4.3 A sway force applied to seats shall be 24 lb/linear ft (36 kg/linear m) parallel to the seats and 10 lb/linear ft (15 kg/linear m) perpendicular to the seats. Sway forces shall not be required to be applied simultaneously.

5-2.4.4 Handrails shall be designed and constructed for:

(a) A concentrated load of 200 lb (91 kg) applied at any point and in any direction, and

(b) A uniform load of 50 lb/ft (74 kg/m) applied in any direction.

The concentrated and uniform loading conditions shall not be required to be applied simultaneously.

5-2.4.5 Guards shall be designed and constructed for:

(a) A concentrated load of 200 lb (91 kg) applied at any point and in any direction along the top railing member, and

(b) A uniform load of 50 lb/ft (74 kg/m) applied horizontally at the required guardrail height and a simultaneous uniform load of 100 lb/ft (149 kg/m) applied vertically downward at the top of the guardrail.

The concentrated and uniform loading conditions shall not be required to be applied simultaneously.

5-2.4.6 Each of the horizontal forces in 5-2.4.3, 5-2.4.4, and 5-2.4.5 shall not be required to be applied simultaneously with other lateral forces such as wind or seismic loads.

5-2.4.7 Stresses permitted in the design standards of the various materials shall be permitted to be increased 33⅓ percent due to sway or wind loads or by a combination of sway or wind loads and vertical loads, provided that no such increases shall be allowed for stresses due to vertical loads acting alone.

5-2.5 Structural design shall consider the stresses in all members due to all of the loadings indicated in 5-2.4, with particular attention to the following:

(a) Vertical dead load and live load,

(b) Wind loads,

(c) Sway load parallel with the seats,

(d) Sway load to the front and sway load to the rear,

(e) Wall attachments,

(f) Partial loading conditions,

(g) For movable, reverse-fold, and forward-fold folding and telescopic seating, stability against overturning forward or backward during normal operation, or in any condition of intended use, when operated in accordance with the manufacturer's operating instructions.

5-2.6 All design criteria shall be met when the seating is in each configuration intended for occupancy.

5-3 Review and Approval.

5-3.1 Design and installation drawings shall be approved prior to installation, and seating shall be installed in conformance therewith. These data shall include the following:

(a) Conformance with approved designs; this shall be permitted to be by reference to approved standard drawings with any variables applicable to the job noted;

(b) Location of the folding or telescopic seating units and details of attachments, if any;

(c) Location of guards and details thereof.

5-3.2 The owner, or his duly authorized representative, shall file with the authority having jurisdiction evidence of the following:

(a) The adequacy of means of egress to accommodate the occupants of the seating as well as all other occupants, based on NFPA *101, Life Safety Code*;

(b) Structural ability of the site to support the folding and telescopic seating dead loads when closed and also to support the dead loads and live loads when open.

5-4 Seating.

5-4.1 The horizontal distance back-to-back of seats shall be not less than 22 in. (55.9 cm) for seats without backs. There shall be a space of not less than 12 in. (30.5 cm) between the back of each seat and the front of each seat immediately behind it. If seats are of the chair type, the 12-in. (30.5-cm) dimension shall be measured to the front edge of the rear seat in its normal unoccupied position. All measurements shall be taken between plumb lines.

5-4.2 The depth of footboards (footrests) and seat boards in folding and telescopic seating shall be not less than 9 in. (22.9 cm). Where the same level is not used for both seat foundations and footrests, footrests independent of seats shall be provided.

5-4.3 Individual chair-type seats shall be permitted in folding and telescopic seating only if firmly secured in groups of not less than three.

5-4.4 Any opening between the seat board and footboard that is located more than 30 in. (76 cm) above grade shall be provided with intermediate construction such that a 4-in. (10.2-cm) diameter sphere cannot pass.

5-5 Guards and Rails.

5-5.1 Railings or guards not less than 42 in. (107 cm) high above the aisle surface or footrest or 36 in. (91 cm) vertically above the center of the seat or seat board surface, whichever is adjacent, shall be provided along those portions of the backs and ends of all folding and telescopic seating where the seats are more than 4 ft (1.2 m) above the floor.

Exception: Where all openings between the folding or telescopic seating and an adjacent wall, of at least the required guard height, prevent the passage of a 4-in. (100-mm) sphere, a guard shall not be required.

5-5.2 Where the front footrest of any folding or telescopic seating is more than 2 ft (0.6 m) above the floor, railings or guards not less than 33 in. (84 cm) high above such footrests shall be provided.

Exception: Where the front row of seats includes backrests, the rails shall be not less than 26 in. (66 cm) high.

5-5.3 Rails 42 in. (107 cm) high shall be located at the foot of each aisle that extends to the front of such folding or telescopic seating and along the front of any cross aisle located at the front of the seating where the foot of the aisle or the cross aisle is more than 30 in. (76 cm) above grade.

5-5.4 Cross aisles located within the seating area shall be provided with rails not less than 26 in. (66 cm) high along the front edge of the aisle.

Exception: Where the backs of the seats in front of the cross aisle project 24 in. (61 cm) or more above the surface of the cross aisle, this rail shall not be required.

5-5.5 Vertical openings between guardrails and footboards or seat boards shall prevent the passage of a 4-in. (10.2-cm) diameter sphere.

5-6 Maintenance and Operation.

5-6.1 Instructions in both maintenance and operation shall be transmitted to the owner by the manufacturer of the seating or his or her representative.

5-6.2 Maintenance and operation of folding and telescopic seating shall be the responsibility of the owner or his or her duly authorized representative and shall include the following:

(a) During operation of the folding and telescopic seats, the opening and closing shall be supervised by responsible personnel who will ensure that the operation is in accordance with the manufacturer's instructions.

(b) Only attachments specifically approved by the manufacturer for the specific installation shall be attached to the seating.

(c) An annual inspection and required maintenance of each grandstand shall be performed to ensure safe conditions. At least biennially the inspection shall be performed by a professional engineer or qualified service personnel.

Chapter 6 Permanent Membrane Structures

6-1 General.

6-1.1 Membrane structures designed to meet the applicable requirements of NFPA *101, Life Safety Code*, this chapter, and the building codes shall be considered as permanent buildings or parts thereof.

6-1.2 Membrane structures shall be permitted for any occupancy in accordance with the applicable building code.

6-1.3 Heights and areas shall be limited by the requirements of applicable building codes based on the type of construction and occupancy classification.

6-1.4 Testing of membrane materials for compliance with this section's use of the categories of noncombustible and limited-combustible materials shall be performed on weathered membrane material as defined in Section 2-2.

6-1.5 Membrane materials shall not be used where fire resistance ratings are required for walls or roofs.

Exception No. 1: Where every part of the roof, including the roof membrane, is not less than 20 ft (6.1 m) above any floor, balcony, or gallery, a noncombustible or limited-combustible membrane shall be permitted to be used as the roof in any type of construction.

Exception No. 2: With approval of the authority having jurisdiction, membrane materials shall be permitted to be used where every part of the roof membrane is sufficiently above every significant fire potential that the imposed temperature will not exceed the capability of the membrane, including seams, to maintain its structural integrity.*

6-1.6 Flame spread of all membrane materials exposed within the structure shall be Class A as defined in Section 6-5 of NFPA *101, Life Safety Code*.

6-1.7 Roof membranes shall have a roof covering classification as required by the applicable building codes, when tested in accordance with NFPA 256, *Standard Methods of Fire Tests of Roof Coverings*.

6-1.8 Flame Resistance. All membrane structure fabric shall meet the requirements of both the small-scale and large-scale tests contained in NFPA 701, *Standard Methods of Fire Tests for Flame-Resistant Textiles and Films*.

6-1.8.1 The authority having jurisdiction shall require a certificate or other evidence of acceptance by an organization acceptable to the authority having jurisdiction or the report of tests made by other inspection authorities or organizations acceptable to the authority having jurisdiction as evidence that the fabric materials have the required flame resistance.

6-1.8.2 Where required by the authority having jurisdiction, confirmatory field tests shall be conducted using test specimens from the original material, which shall have been affixed at the time of manufacture to the exterior of the structure.

6-2 Tensioned-Membrane Structures.

6-2.1 Design. The design, materials, and construction of the building shall be based on plans and specifications prepared by a licensed architect or engineer knowledgeable in this type of construction.

6-2.2 Material loading and strength shall be based on physical properties of the materials verified and certified by an approved testing laboratory.

6-2.3 The membrane roof for structures in climates subject to freezing temperatures and ice buildup shall be composed of two layers with an air space between them through which heated air can be moved to guard against ice accumulation. In lieu of the above, any other approved methods that protect against ice accumulation shall be permitted.

6-2.4 Roof drains shall be equipped with electrical elements to protect against ice buildup, which would prevent the drains from functioning. Such heating elements shall be served by on-site standby electrical power in addition to the normal public service. In lieu of the above, any other approved methods that protect against ice accumulation shall be permitted.

6-3 Air-Supported, Air-Inflated Structures.

6-3.1 General. In addition to the foregoing, the requirements of this section shall apply to air-supported structures.

6-3.2 Structural Requirements.

6-3.2.1 Envelope Design. The design, materials, and construction for the structural envelope shall conform to the requirements of this section. Membrane structures shall be designed by a licensed architect or engineer knowledgeable in this type of construction.

6-3.2.2 Material Strength. Calculation of fabric stresses shall include consideration of inflation pressure; the radius of the structure; and wind, ice, snow, and earthquake loads. The minimum design criteria for material strength shall comply with the requirements of ASI 77, *Air Structures Design and Standards Manual*. Minimum design criteria shall be for 80 mph (129 km/hr) wind conditions. More severe design loads, as specified in local building codes, shall be required as a result of local climatic conditions. All material characteristics shall be verified by an approved test method. Material strengths shall be certified by the manufacturer and verified by test data from an organization acceptable to the authority having jurisdiction.

6-3.2.3 Joint Strength. All seams shall develop the full strength of the envelope material as specified in ASI 77, *Air Structures Design and Standards Manual*.

6-3.3 Load Distribution.

6-3.3.1 The envelope shall be patterned and constructed to minimize stress concentrations in crown areas, around openings, and where rigid components such as door frames, vent pipes, and structural members are attached to the envelope.

6-3.3.2 There shall be sufficient clearance between the envelope and rigid components to permit free movement under load.

6-3.3.3 Reinforced areas, such as around openings, shall provide a flexible but airtight seal.

6-3.4 Pressurization (Inflation) System.

6-3.4.1 The operating inflation pressure for the structure shall be adequate to withstand a wind velocity of 80 mph (129 km/hr). Pressurization for higher wind conditions shall be provided where required by local climatic conditions, as determined by local authorities.

6-3.4.2 The pressurization system shall consist of one or more operating blower units. The system shall include automatic control of auxiliary blower units to reliably maintain the required operating pressure. This equipment shall meet the following requirements:

(a) Blowers shall be powered by continuous-rated motors at the maximum power required.

(b) Blowers shall have adequate personnel protection, such as inlet screens and belt guards.

(c) Blower systems shall be weather protected.

(d) Blower systems shall be equipped with back-draft check dampers.

(e) There shall be not fewer than two blower units, each of which has adequate capacity to maintain full inflation pressure with normal leakage.

(f) The blowers shall be designed to be incapable of overpressurization.

(g) The auxiliary blower unit(s) shall operate automatically if there is any loss of internal pressure or if an operating blower unit becomes inoperative.

(h) The design inflation pressure and the capacity of each blower system shall be certified by a professional engineer.

6-3.5 Standby Power System.

6-3.5.1 Design.

6-3.5.1.1 A fully automatic standby power system shall be provided. The system shall be either an auxiliary engine generator set capable of running the blower system or a supplementary blower unit that is sized for 1 times the normal operating capacity and is powered by an internal combustion engine.

6-3.5.1.2 The standby power system shall be fully automatic to ensure continuous inflation in the event of any failure of the primary power. This system shall be capable of operating continuously for a minimum of 4 hours.

6-3.5.2 Certification. The sizing and capacity of the standby power system shall be certified by a professional engineer.

6-3.6 Anchorage Design.

6-3.6.1 Basic Requirements. A positive anchorage system shall be provided to securely anchor the envelope to the ground or to the structure.

6-3.6.2* Specific Requirements. Anchor loading shall be determined and verified by analytical data prepared by a professional engineer. The minimum requirements for anchorage designs shall be in accordance with the requirements of ASI 77, *Air Structures Design and Standards Manual.*

6-3.7 Accessory Equipment. The design and use of accessory equipment for heating, air conditioning, lighting, and similar functions shall conform to the requirements of Chapter 10 and to approved recognized standards.

6-4 Maintenance and Operation.

6-4.1 Instructions in both operation and maintenance shall be transmitted to the owner by the manufacturer of the tensioned-membrane, air-supported, or air-inflated structure.

6-4.2 An annual inspection and required maintenance of each structure shall be performed to ensure safety conditions. At least biennially the inspection shall be performed by a professional engineer or qualified service representative.

Chapter 7 Temporary Membrane Structures

7-1 General.

7-1.1 Membrane structures designed to meet all the requirements of this chapter shall be permitted to be used as temporary buildings subject to the approval of the authority having jurisdiction.

7-1.2 Temporary membrane structures shall comply with all the requirements for:

(a) Chapter 6, except 6-1.1, 6-1.4, 6-1.5, and 6-1.6; and

(b) Chapter 9.

7-1.3 Temporary tensioned-membrane structures shall be permitted to comply with Chapter 8 instead of this chapter.

7-2 Safety.

7-2.1 Operating Pressure. Operating pressure shall be maintained at the design pressure.

7-2.2 Clearance. There shall be a minimum clearance of 3 ft (0.9 m) between the membrane and the contents or equipment within the building and between the membrane and any exterior object.

Chapter 8 Tents

8-1 General. Tents shall be permitted only on a temporary basis.

8-2 Size Limitations. Tents shall be erected to cover not more than 75 percent of the premises, unless otherwise approved by the authority having jurisdiction.

8-3 Structural Requirements.

8-3.1 All supporting members shall be of sufficient size and strength to support the structure.

8-3.2 The poles and their supporting guys, stays, stakes, and fastenings shall be of sufficient strength and attachment to resist a minimum wind pressure of 20 lbf/ft^2 (0.96 kPa) of projected area of the tent.

8-3.3 Tents shall be adequately guyed, supported, and braced to withstand a minimum pressure or suction of 10 lbf/ft^2 (0.48 kPa).

8-3.4 Pull-down ropes (jump ropes) shall be provided on all poles.

8-4 Flame Resistance.

8-4.1 All tent fabric shall meet the requirements of the large-scale test contained in NFPA 701, *Standard Methods of Fire Tests for Flame-Resistant Textiles and Films.*

8-4.2 The authority having jurisdiction shall require a certificate or other evidence of approval by a laboratory of recognized standing or the report of tests made by other inspection authorities as evidence that the tent fabric materials have the required flame resistance.

8-4.3* Where required by the authority having jurisdiction, confirmatory field tests shall be conducted using test specimens from the original material affixed at the time of manufacture to the exterior of the tent.

8-5 Location and Spacing.

8-5.1 There shall be a minimum of 10 ft (3 m) between stake lines.

8-5.2 Adjacent tents shall be sufficiently distant from each other to provide an area to be used as a means of emergency egress. Where 10 ft (3 m) between stake lines is not sufficient for means of egress, the distance necessary for means of egress shall govern.

Exception No. 1: Tents not occupied by the public and not used for the storage of combustible material shall be permitted to be erected less than 10 ft (3 m) from other structures only if the authority having jurisdiction deems such close spacing safe from hazard to the public.

Exception No. 2: Tents, each not exceeding 1200 ft² (111.5 m²) in ground area, located in fairgrounds or similar open spaces shall not be required to be separated from each other, provided safety precautions meet the approval of the authority having jurisdiction.

8-5.3 The placement of tents relative to other structures shall be at the discretion of the authority having jurisdiction with consideration being given to occupancy, use, opening, exposure, and other similar factors.

Chapter 9 Protection

9-1 Flammable Liquids and Gases.

9-1.1 Storage and handling of flammable liquids or gases shall be in accordance with the applicable standards below:

(a) NFPA 30, *Flammable and Combustible Liquids Code;*

(b) NFPA 54, *National Fuel Gas Code;*

(c) NFPA 58, *Standard for the Storage and Handling of Liquefied Petroleum Gases.*

9-1.2 No storage or handling of flammable liquids or gases shall be permitted at any location where it would jeopardize egress from the structure.

9-1.3 Refueling of equipment with liquids having flash points below 100°F (38°C) shall not be permitted within the structure.

9-2 Fire Hazards.

9-2.1 The applicable provisions of NFPA *101, Life Safety Code*, that pertain to fire hazards shall govern in tents and membrane structures.

9-2.2 The ground enclosed by any tent or temporary membrane structure and for a reasonable distance, but not less than 10 ft (3 m) outside of such structure(s), shall be cleared of all flammable or combustible material or vegetation. This work shall be accomplished to the satisfaction of the authority having jurisdiction prior to the erection of such structure(s). The premises shall be kept free from such flammable or combustible materials during the period for which the premises are used by the public.

Exception: Necessary support equipment.

9-2.3 No hay, straw, shavings, or similar combustible materials that have not been treated to make them flame retardant to a degree acceptable to the authority having jurisdiction shall be permitted within any structure used as an assembly occupancy.

Exception: Animal bedding and fodders in quantities approved by the authority having jurisdiction.

9-2.4 Where prohibited by the authority having jurisdiction, smoking shall not be allowed in any tent or temporary membrane structure.

9-2.5 Fireworks or unauthorized open flames shall be prohibited in any tent or temporary membrane structure.

9-3* Fire Extinguishing Equipment.

9-3.1 Enclosed stadia, arenas, and similar structures shall be protected throughout by an approved, supervised automatic sprinkler system in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems.*

Exception No. 1: Where the ceiling or roof, whichever is lower, of the playing (activity) area is more than 55 ft (17 m) above the floor, the authority having jurisdiction shall be permitted to allow the omission of sprinklers above the playing (activity) area.

Exception No. 2: Sprinklers shall not be required above seating areas that view the playing (activity) area.

9-3.2 In other than enclosed stadia, arenas, and similar structures, enclosed areas shall be protected by an approved sprinkler system in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems.*

Exception No. 1: Press boxes less than 1,000 ft² (93 m²) in area.

Exception No. 2: Storage facilities less than 1,000 ft² (93 m²) in area if enclosed with minimum 1-hour fire resistance-rated construction.

Exception No. 3: Enclosed areas underneath grandstands or bleachers that comply with the exceptions to Section 4-8.

9-3.3 Portable fire extinguishing equipment of approved types shall be furnished and maintained in tents and temporary membrane structures by the person operating any assembly occupancy in such amount and in such locations as directed by the authority having jurisdiction.

Exception: Where a functioning garden hose that can reach all portions of the private party tent is provided.

9-3.4 Fire extinguishing equipment shall be maintained in accordance with NFPA 10, *Standard for Portable Fire Extinguishers.*

9-3.5 Employees shall be trained to operate fire extinguishing equipment and shall be required to exhibit their skill when requested by the authority having jurisdiction.

9-4 Emergency Communications. One or more methods of fire alarm and emergency communications shall be provided to the satisfaction of the authority having jurisdiction.

9-5* Fire Detail. Fire details, if deemed necessary in any assembly occupancy, shall be determined by the authority having jurisdiction.

Chapter 10 Services

10-1 Electrical Installations.

10-1.1 Electrical installations shall conform to the requirements of NFPA 70, *National Electrical Code®.*

Exception: As otherwise provided by law, ordinance, or regulation.

10-1.2 The electrical system shall be installed, maintained, and operated in a safe and professional manner. If portable, it shall be inspected daily when in use by a qualified person representing the owner, and any defects found shall be corrected before the public is admitted.

10-1.3 The electrical system and equipment shall be isolated from the public by proper elevation or guarding, and all electrical fuses and switches shall be enclosed in approved enclosures. Cables on the ground in areas traversed by the public shall be placed in trenches or protected by approved covers.

10-2 Heating Devices.

10-2.1 Fired Heaters.

10-2.1.1 Only labeled heating devices shall be used.

10-2.1.2 Fuel-fired heaters and their installation shall be approved by the authority having jurisdiction.

10-2.1.3 Ducts used to convey heated air shall comply with NFPA 90A, *Standard for the Installation of Air Conditioning and Ventilating Systems.*

10-2.1.4 Containers for liquefied petroleum gases shall be installed not less than 5 ft (1.5 m) from any tent or temporary membrane structure and shall be in accordance with the provisions of NFPA 58, *Standard for the Storage and Handling of Liquefied Petroleum Gases.*

10-2.1.5 Tanks shall be secured in the upright position and protected from vehicular traffic.

10-2.1.6 Heating devices shall comply with the requirements of the following standards:

(a) NFPA 31, *Standard for the Installation of Oil-Burning Equipment;*

(b) NFPA 54, *National Fuel Gas Code;*

(c) NFPA 211, *Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances.*

10-2.2 Electric Heaters.

10-2.2.1 Only labeled heaters shall be permitted.

10-2.2.2 Heaters used inside a tent or temporary membrane structure shall be approved.

10-2.2.3 Heaters shall be connected to electricity by electric cable suitable for outside use and of sufficient size to handle electrical load.

Chapter 11 Referenced Publications

11-1 The following documents or portions thereof are referenced within this standard and shall be considered part of the requirements of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

11-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 10, *Standard for Portable Fire Extinguishers*, 1994 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 1994 edition.

NFPA 30, *Flammable and Combustible Liquids Code*, 1993 edition.

NFPA 31, *Standard for the Installation of Oil-Burning Equipment*, 1992 edition.

NFPA 54, *National Fuel Gas Code*, 1992 edition.

NFPA 58, *Standard for the Storage and Handling of Liquefied Petroleum Gases*, 1995 edition.

NFPA 70, *National Electrical Code*, 1993 edition.

NFPA 90A, *Standard for the Installation of Air Conditioning and Ventilating Systems*, 1993 edition.

NFPA *101*, *Life Safety Code*, 1994 edition.

NFPA 211, *Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances*, 1992 edition.

NFPA 220, *Standard on Types of Building Construction*, 1992 edition.

NFPA 251, *Standard Methods of Fire Tests of Building Construction and Materials*, 1990 edition.

NFPA 256, *Standard Methods of Fire Tests of Roof Coverings*, 1993 edition.

NFPA 259, *Standard Test Method for Potential Heat of Building Materials*, 1993 edition.

NFPA 701, *Standard Methods of Fire Tests for Flame-Resistant Textiles and Films*, 1989 edition.

11-1.2 ASTM Publications. American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM D2898, *Test Method for Accelerated Weathering of Fire-Retardant-Treated Wood for Fire Testing*, 1981.

ASTM E136, *Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*, 1993.

ASTM G26, *Practice for Operating Light/Exposure Apparatus (Zenon-Arc Type) With and Without Water for Exposure of Non-Metallic Materials*, 1993.

11-1.3 ASI Publication. Industrial Fabrics Association International, 345 Cedar Street, St. Paul, MN 55101.

ASI 77, *Air Structures Design and Standards Manual*, 1977.

11-1.4 ASCE Publication. American Society of Civil Engineers, 345 East 47th Street, New York, NY 10017.

ASCE 7, *Minimum Design Loads in Buildings and Other Structures*, 1993.

Appendix A Explanatory Material

This Appendix is not a part of the requirements of this NFPA document but is included for informational purposes only.

A-1-1 The provisions of this standard are intended to be applicable to facilities and structures where a number of persons might stand or sit for the viewing of a contest, exhibition, performance, or for entertainment, and other facilities and structures used for other occupancies as permitted by the applicable building code.

The management of crowds outside of bleachers, grandstands, tents, or membrane structures while approaching or departing from events is beyond the scope of this standard, but the following principles should be considered in the overall planning.

Routes of departure should lead to a street or public way of sufficient capacity to allow continued movement of persons leaving the facility. Parking areas can absorb much of this crowd, but structures and garages should not be considered refuge areas unless designed for this purpose. At least one street should be kept clear at all times to permit access of emergency equipment. In addition, adjacent automobile parking lots, open fields, public parks, etc., can also be used as places of refuge. Where such space is needed for this purpose, the continued use of the facility should be contingent on free access to the space during the periods when crowds assemble.

A-2-2 Air-Supported Structure. A cable-restrained air-supported structure is one in which the uplift is resisted by cables or webbing that are anchored by various methods to the membrane or that might be an integral part of the membrane. This is not a tensioned-membrane structure.

A-2-2 Exit. In structures where all parts of the means of egress are essentially open to the exterior and, therefore, are not likely to be significantly affected by combustion products from a fire in the structure, an exit in functional terms is that portion of the egress system where flows from the largest number of egress routes are combined. Such an exit would include such items as an opening in the ticket control barrier, a major means of vertical circulation to the level of exit discharge, or similar feature where the maximum number of egress flows converge.

A-2-2 Tensioned-Membrane Structure. The publications *Architectural Fabric Structures: The Use of Tensioned-Fabric Structures by Federal Agencies* and *AFSI Recommended Code Provisions for Architectural Fabric Structures* provide details such as materials in general use, coating materials, characteristics of composite materials, and fire safety for membrane structures.

A-4-6.2 Fire-Retardant-Treated Lumber. The increases permitted in the sizes of wood grandstands, if of fire-retardant-treated lumber, are predicated on the use of lumber impregnated by pressure processes with fire retardant preservatives in accordance with NFPA 703, *Standard for Fire Retardant Impregnated Wood and Fire Retardant Coatings for Building Materials*, or AWPA C20, *Structural Lumber Fire Retardant Treatment by Pressure Processes*, and AWPA C27, *Plywood-Fire Retardant Treatment by Pressure Processes*.

A-6-1.5 Exception No. 2. A method of appraising fire impact factors on ceilings of large dimension spaces such as covered stadia follows:

Determine the maximum burning rates of potential fires.

The method presented in this appendix depends on the ability to predict reasonably the maximum rate of energy release from fire. The fires of concern include those that might occur within the open space or intrude upon it from adjacent rooms or spaces.

Where the necessary burning rate data exist, they can be used in the appraisal. Where they do not exist, they should be obtained by test prior to use of this method. The appraisal should cover each critical fire potential. A critical fire potential is one that releases greater energy into the open room than any other source located nearer to the roof (or ceiling) membrane than it.

In a typical covered stadium, critical fire potentials are selected starting with the top reaches of the stands. The fire potential at this level might consist of either the seats or a concession stand. Descending toward the playing fields it is necessary to determine any greater fire potentials. Typically, the fuel load on the playing field level would be a critical potential if the space is used for exhibitions. If the playing field will not be used for exhibitions or other special fuel concentrations, it is likely that the maximum potential exposure will occur from a fire in a storeroom or similar space abutting the public space.

Table A-6.1.5(a) Unit Heat Release Rates for Fuels Burning in the Open

Commodity	Heat Release Rate (Btu/sec)†
Flammable Liquid Pool	290/ft^2 of surface
Flammable Liquid Spray	2000/gpm of flow
Wood Pallets (Single Stack)	1500/ft of height
Wood or PMMA* (vertical)	
-2 ft height burning	30/ft of width
-4 ft height burning	70/ft of width
-8 ft height burning	180/ft of width
-12 ft height burning	300/ft of width
Wood or PMMA	
-Top of horizontal surface	65/ft^2 of surface
Solid Polystyrene (vertical)	
-2 ft height burning	65/ft of width
-4 ft height burning	
-8 ft height burning	400/ft of width
-12 ft height burning	680/ft of width
Solid Polystyrene (horizontal)	120/ft^2 of surface
Solid Polypropylene (vertical)	
-2 ft height burning	45/ft of width
-4 ft height burning	100/ft of width
-8 ft height burning	280/ft of width
-12 ft height burning	470/ft of width
Solid Polypropylene (horizontal)	70/ft^2 of surface

† To convert from (Btu/sec) to [W], multiply by 1.055.1
* PMMA-Polymethylmethacrylate (plexiglas, lucite, acrylic)

Table A-6-1.5, from the work of Alpert and Heskestad[1], lists examples of rates of energy release from a number of fuel arrangements. The data for this table were developed by Factory Mutual Research Corporation. Additional burning rate data have been reported by NBS[2]. In some instances the existing data will suffice. Often, however, special tests will be required. Such tests should be large scale

[1] Alpert, R. L. and Ward, E. J., *Evaluating Unsprinklered Fire Hazards*, SFPE Technology Report 83-2, Society of Fire Protection Engineers, Boston, MA, 1983.

[2] Lawson, J. R., Walton, W. D., and Twilley, W. H., *Fire Performance of Furnishings as Measured in the NBS Furniture Calorimeter*. Part 1, NBSIR 84-2787, National Bureau of Standards, Washington, DC, 1983.

Table A-6.1.5(b) Unit Heat Release Rates for Commodities (Compiled by G. Heskastad)

Heat-release rate per unit floor area of fully involved combustibles, based on negligible radiative feedback from the surroundings and 100 percent combustion efficiency.

	Commodity	Btu/sec-ft^2 (of Floor Area)
1.	Wood pallets, stacked 1½ ft high (6-12% moisture)	125
2.	Wood pallets, stacked 5 ft high (6-12% moisture)	460
3.	Wood pallets, stacked 10 ft high (6-12% moisture)	940
4.	Wood pallets, stacked 16 ft high (6-12% moisture)	1500
5.	Mail bags, filled, stored 5 ft high	35
6.	Cartons, compartmented, stacked 15 ft high	150
7.	PE letter trays, filled, stacked 5 ft high on cart	750
8.	PE trash barrels in cartons, stacked 15 ft high	175
9.	PE-fiberglass shower stalls in cartons, stacked 15 ft high	125
10.	PE bottles packed in Item 6	550
11.	PE botles in cartons, stacked 15 ft high	175
12.	PU insulation board, rigid foam, stacked 15 ft high	170
13.	PS jars packed in Item 6	1250
14.	PS tubs nested in cartons, stacked 14 ft high	475
15.	PS toy parts in cartons, stacked 15 ft high	180
16.	PS insulation board, rigid foam, stacked 14 ft high	290
17.	PVC bottles packed in Item 6	300
18.	PP tubs packed in Item 6	390
19.	PP & PE film in rolls, stacked 14 ft high	550
20.	Methyl alcohol	65
21.	Gasoline	290
22.	Kerosene	290
23.	Diesel oil	175

Note: PE—Polyethylene
PS—Polystyrene
PVC—Polyvinylchloride
PP—Polypropylene
PU—Polyurethane

For SI units: 1 Btu/sec-ft^2 = 11.35 kW/m^2.

and produce rates of heat release. The specific techniques for testing can be any method that reliably produces the rate of heat release of the assemblies involved.

As an alternate, the rate of energy release can be conservatively determined using the semi-universal rate of heat release curve developed by Cooper[3]. Figure A-6-1.5.1 presents that curve. The semi-universal fire curve gives a maximum rate of heat release likely to be produced by a collection of solid fuels in a readily consumable form. To use the curve, determine the weight of the fuel. In determining the fuel weight consider plastic materials (other than PVC or other highly halogenated plastics) as twice their actual weight. Enter the curve from the fuel consumed entries on the left. Use the weight of fuel as the fuel consumed. Read the time of burning from the bottom scale. Transfer to the rate of heat release curve. Read the rate of heat release from the right scale. For simple formulas, as presented in this appendix, use that value.

Determining Flame Height.

Use Figure A-6-1.5.2 to determine the maximum flame height. Figure A-6-1.5.2 was developed by Alpert[1]. Enter Figure A-6-1.5.2 from the base. Use the rate of energy release developed from the preceding determination of burning rate. Use the curve indicated for the location of the fire (i.e., in corner, adjacent to a wall, or away from walls). Read the flame height from the left scale. The temperature of the flame at the indicated flame height is approximately 600°F (315°C).

Use Figure A-6-1.5.3 in the same manner as Figure A-6-1.5.2 to determine the height of the solid (continuous) portion of the flame. The temperature of the flame at the flame height indicated by Figure A-6-1.5.3 is approximately 1850°F (1010°C). Figure A-6-1.5.3 is derived from a formula developed by Hasemi and Tokunaga[4].

For points in the flame between the continuous flaming zone and the maximum height the temperature decreases from the 1850°F (1010°C) level to 600°F (315°C) at approximately a uniform rate.

Determining Ceiling Plume Jet Temperatures.

For points located over a potential fire but above the maximum flame height, the temperature of the plume is as shown in Figure A-6-1.5.4. This figure is derived from a formula developed by Alpert[1].

A-6-3.6.2 Anchor loading varies with the size, height, and anchor spacing for the structure. These loadings are the same as envelope fabric loadings, but must be converted from lb/in.^{2} (kg/cm^2) to the equivalent load for the anchor spacing used [generally in terms of lb/ft^2 (kg/m^2)]. Anchor loadings are based upon 80 mph (129 km/hr) wind, and a design safety factor of 2 should be used to ensure secure anchorage under steady load conditions.

A-8-4.3 For an appropriate confirmatory field test, see NFPA 705, *Recommended Practice for a Field Flame Test for Textiles and Films.*

A-9-3 Fire Extinguishing Equipment. Recommendations on the distribution, use, and maintenance of portable fire extinguishing equipment are given in NFPA 10, *Standard for Portable Fire Extinguishers.*

The general information in NFPA 10, *Standard for Portable Fire Extinguishers*, defines Class A, B, C, and D fires and contains specific recommendations for the minimum area of distribution for each extinguisher for "light," "ordinary," and "extra hazard" occupancies. An appendix to the standard gives the appropriate ratings of each type and size of extinguisher based upon a standard method of test.

The requirements cited in the standard are, in general, minimum requirements and do not preclude the installation of additional fire extinguishing equipment where desired.

[3] Cooper, L. Y. and Stroup, D. W., *Calculating Available Safe Egress Time (ASET) — A Computer Program and User's Guide*, NBSIR 82-2478, National Bureau of Standards, Washington, DC, 1982.

[4] Hasemi, T. and Tokunaga, T., *Modeling of Turbulent Diffusion Flames and Fire Plumes for the Analysis of Fire Growth*, Fire Dynamics and Heat Transfer, The American Society of Mechanical Engineers, 21st National Heat Transfer Conference, HTD-Vol. 25, 1983.

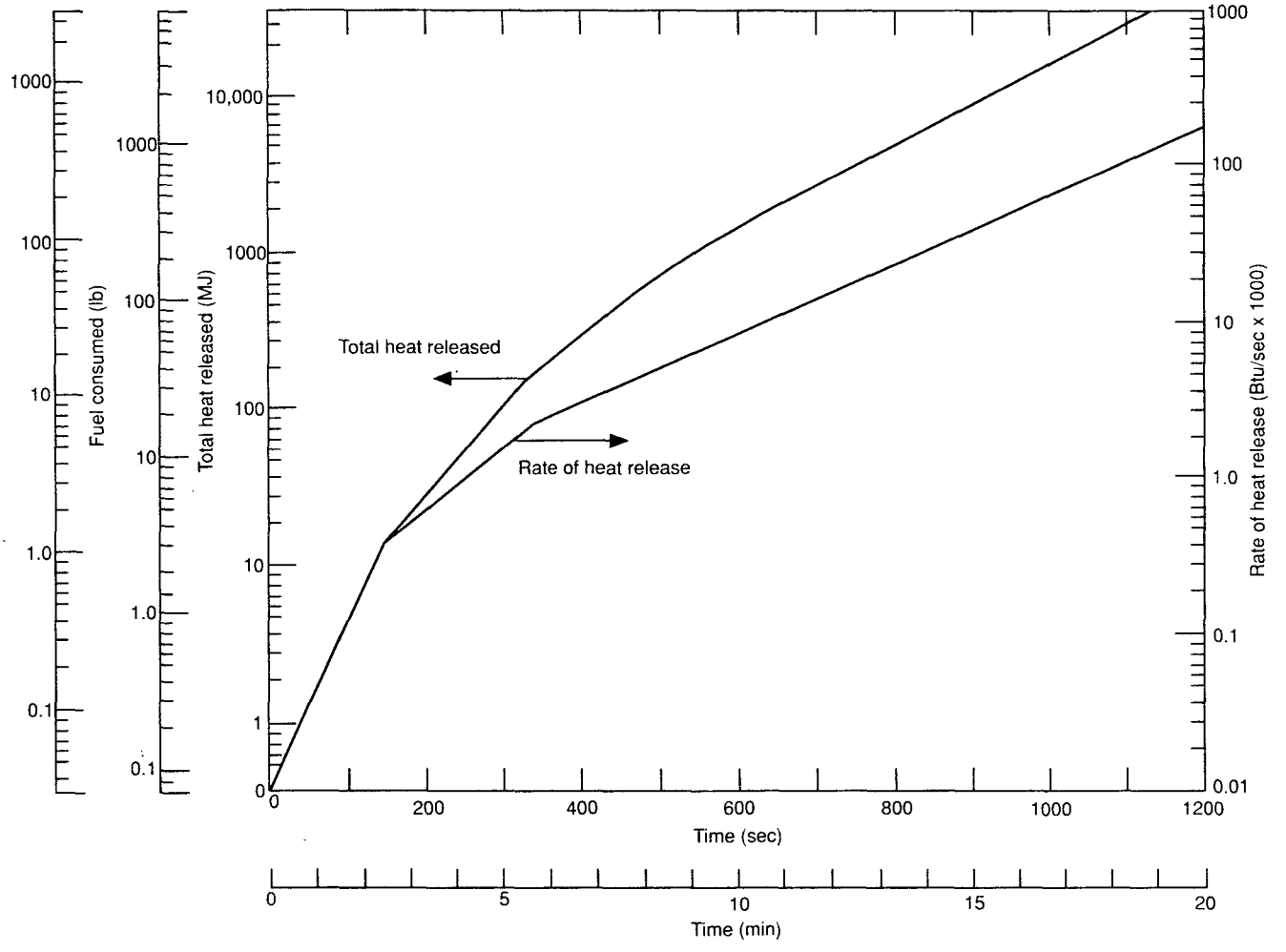

Figure A-6-1.5.1 Semi-universal fire curve.

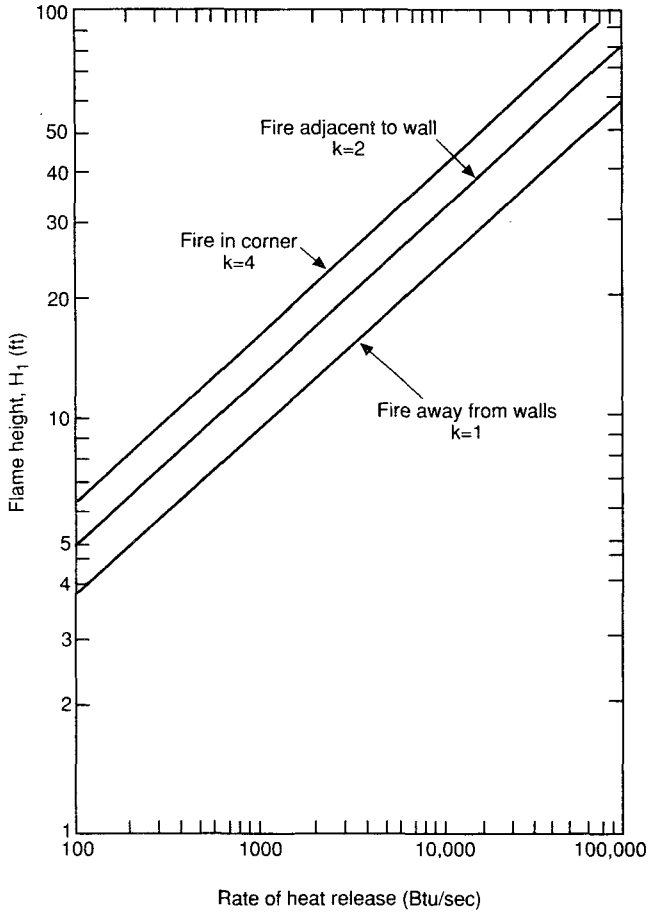

Figure A-6-1.5.2 Maximum flame height.

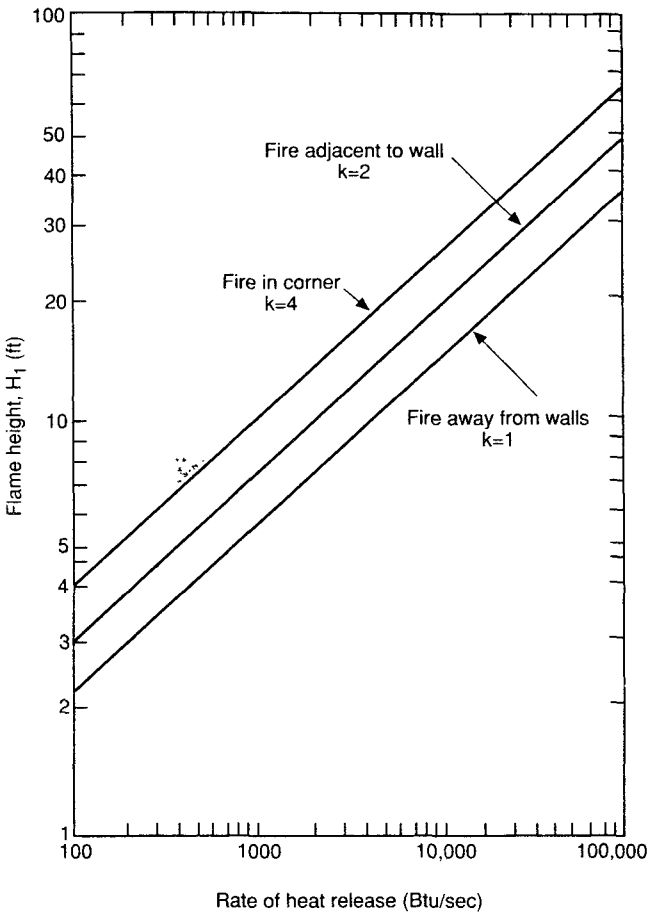

Figure A-6-1.5.3 Continuous flame height.

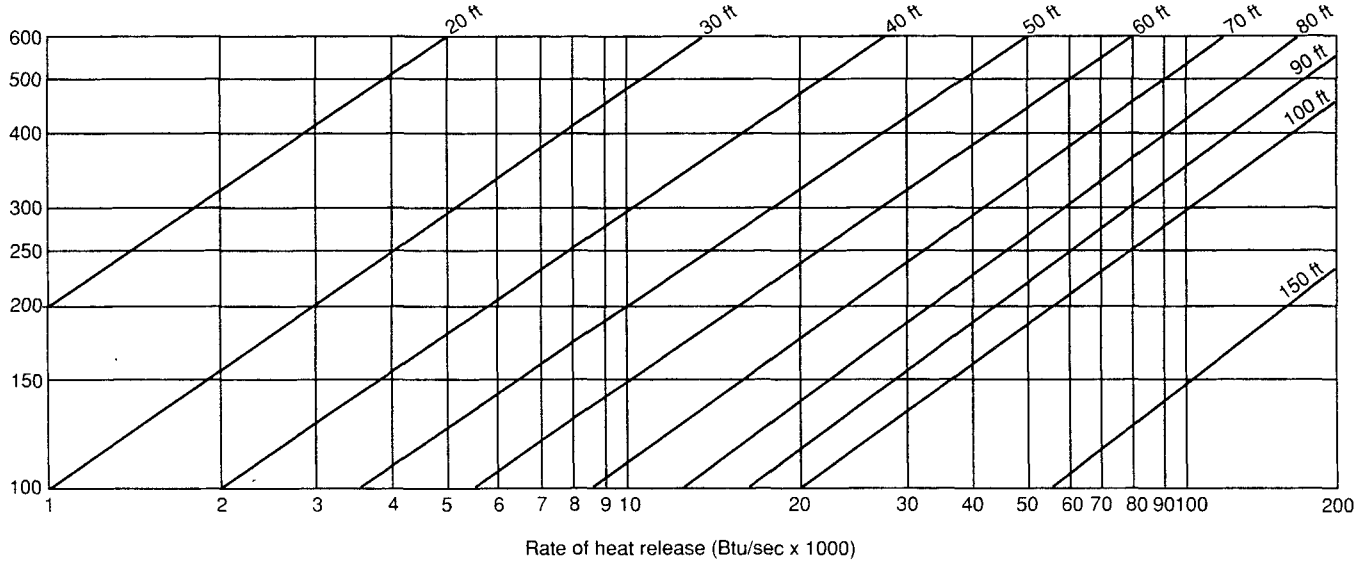

Figure A-6-1.5.4 Ceiling plume jet temperatures (at point of impact).

A-9-5 Patrols or Fire Details. Because of the variety of types of places of assembly covered in this standard, no general requirement for patrols or fire watchers has been included. The committee fully recognizes the importance of this feature of fire protection, however, and believes that a system of well-trained patrols or fire watchers should be maintained in every place of assembly where fire hazards might develop. Such locations would include, among others, the spaces underneath grandstands and the areas inside and outside tents and air-supported structures. The fire watchers serve to detect incipient fires and to prevent an accumulation of materials that will carry fire. The number of such watchers required will, of course, vary for the different types of assembly occupancies, depending upon the combustibility of the construction and the number of persons accommodated. Provided with an adequate supply of portable fire extinguishing equipment located at readily accessible points, such a fire watch or detail should be able to prevent small fires from reaching serious proportions.

Appendix B Referenced Publications

B-1 The following documents or portions thereof are referenced within this standard for informational purposes only and thus are not considered part of the requirements of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

B-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 10, *Standard for Portable Fire Extinguishers*, 1994 edition.

NFPA 703, *Standard for Fire Retardant Impregnated Wood and Fire Retardant Coatings for Building Materials*, 1992 edition.

NFPA 705, *Recommended Practice for a Field Flame Test for Textiles and Films*, 1993 edition.

B-1.2 ASTM Publication. American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM A153, *Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware*, 1982.

B-1.3 AWPA Publications. American Wood Preservers Association, 1625 I Street, NW, Washington, DC 20006.

AWPA C20, *Structural Lumber Fire Retardant Treatment by Pressure Processes*, 1991.

AWPA C27, *Plywood-Fire Retardant Treatment by Pressure Processes*, 1991.

B-1.4 Other Publications.

AFSI Recommended Code Provisions for Architectural Fabric Structures, Second Edition 1987, Industrial Fabrics Association International, 345 Cedar Street, St. Paul, MN 55101

Architectural Fabric Structures: The Use of Tensioned-Fabric Structures by Federal Agencies, National Research Council, 1985, National Academy Press, Washington, DC.

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