BSR E1.76 — 2022 DRAFT
Tension Wire Grids

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Interest category codes:

CP = custom-market producer
DE = designer
DR = dealer rental company
G = general interest
MP = mass-market producer
U = user

Table of Contents

Clauses that have an asterisk (*) have a corresponding informational entry in Appendix A. Appendix A contains no requirements and is informational only.

1 Scope (mandatory)

A Tension Wire Grid is a specialized walking/working surface used extensively in Entertainment venues.

This standard for Tension Wire Grids covers the design and application criteria including: the loading, self-weight considerations, transitions between levels, and suspension or support from structure. The standard provides deflection criteria for the woven mesh and structural frame as a system. The standard provides guidance on the size of openings, including rigging bays similar to loft wells.

The scope includes the railings and toeboards provided as fall protection accessories for the platforms, ramps and stair units within the scope of this standard.

The standard provides consideration for accessories such as stage lighting pipes.

This standard does not apply to the structure to which the Tension Wire Grid is attached.

Movable panels, used as part of the stage floor, trap covers, or pit fillers are outside the scope of this standard.*

2 Rationale for this standard (informative)

A Tension Wire Grid is a lightweight walking/working surface suspended above a production space. In some cases it forms an Interstitial Floor. The open weave floor allows the free transmission of light, sound, air and atmospheric effects. Both the floor surface and the rigging wells at the edges of frames allow for the passage of electrical cables and rigging suspension points.

The products covered by this standard are bespoke produced and structurally installed as part of the building to assist in the staging of entertainment events.

Tension Wire Grids have been in use since at least 1949 in an anechoic chamber. Construction designs for them have evolved over the decades without a guiding document for design, loading, rigging openings, and edge protection. Tension Wire Grids have evolved from black box theater lighting positions to massive access and work platforms for arena rigging.

The lack of product standards that clearly apply to Tension Wire Grids in the United States complicates the US market for them. At this time, there is no known standard for Tension Wire Grids. Theatre Consultants, Architects, and Engineers grapple with how to treat them in terms of building codes. A well written standard should be adopted in whole or in part by code writing bodies.

Stage technicians and venue managers who use these Tension Wire Grids are sometimes ill-informed as to the capacity and acceptable use of these grids. The labeling and user information requirements of this standard will rectify that situation. Our students and industry professionals are depending on Tension Wire Grids to be a safer way to access their work.

While there are no standards in North America for Tension Wire Grids, there is significant congruence for the minimum performance specifications among the various standards and codes that can be applied to them when used in various ways. This standard attempts to incorporate those performance requirements into a product standard.

3 US/SI conventions (mandatory)

This Standard uses both United States customary units and the International System of Units in parenthesis for stating its requirements. The requirement statements are not exactly equivalent between US customary units and SI, but the difference is insignificant for the purposes of this Standard. A requirement shall be considered to be met if a product meets the requirement whether expressed in US customary units or SI.

4 Definitions (mandatory)

Audience railing: A handrail or railing for fall protection in areas accessible to the general public.

Competent person: a person who is capable of identifying existing and predictable hazards in the workplace, and who is authorized to take prompt corrective measures to eliminate hazards.

Interior frame: Frame member that supports wire cables without being physically attached to the cables.

Long-wire grid: Tension wire grid in which the individual wire cables extend to the entire width and length of the grid.

May: Indicates a feature, accessory or methodology is permissible.

Modular grid: Tension wire grid with prefabricated frames in which the individual wire cables extend only the width and length of the frame.

Perimeter frame: Frame member to which the individual wire cables are anchored. Perimeter frames typically occur at the outside edges of a long-wire grid or the outside of a modular grid frame.

Qualified person: A person who by possession of a recognized degree, or certificate of professional standing, or who by extensive knowledge, training, and experience, has successfully demonstrated the ability to solve or resolve problems relating to the subject matter and work.

Registered Design Professional (RDP): An individual who is registered or licensed to practice their respective design profession as defined by the statutory requirements of the professional registration laws of the state or jurisdiction in which the project is to be constructed.

Shall: Indicates a mandatory requirement.

Should: Indicates a recommendation that is not a mandatory requirement.

Standard guardrail: A railing for fall protection in areas not accessible to the general public.

Toeboard: A protective lip at the perimeter of walking/working surfaces. Also known as kickrail.

Walking/working Surface: Any surface (including floors, roofs and platforms) walked upon by persons, used as a work area, or used to gain access to a work area.

5 Referenced standards

The following standards were referenced in the writing of this Standard. This Standard in general does not require compliance with these standards, except where specifically stated in a requirement of this Standard. However, the user of this standard is encouraged to consult these listed standards to gain an understanding of the context in which this Standard has been developed.

Note that compliance with these standards may be mandatory due to regulations or contractual obligations that might apply to users of this standard. That is, the lack of a compliance requirement in this Standard does not obviate the need to comply with a referenced standard if that compliance is required by a regulation.

- ANSI/ASSE A1264.1-2017 Safety Requirements for Workplace Walking/Working Surfaces and Their Access; Workplace Floor, Wall and Roof Openings; Stairs and Guardrail/Handrail Systems.
- 2010 ADA Standards for Accessible Design.
- ANSI/AISC 360 Specification for Structural Steel Buildings (most current edition)
- 2020 Aluminum Design Manual
- Structural Welding Code - Steel (ANSI/AWS D1.1).
- 2021 International Building Code® (referred to in this Standard as “the 2021 IBC”)
- NFPA 5000, Building Construction and Safety Code, 2021 edition (NFPA 5000-2021)
- Steel Construction Manual, 15th Edition
- ANSI/ASCE 19-16 Structural Applications of Steel Cables for Buildings
- ANSI/ASCE 7-16 Minimum Design Loads and Associated Criteria for Buildings and Other Structures
- 29 CFR 1910.25, Stairways
- 29 CFR 1910.29, Fall protection systems and falling object protection-criteria and practices.
- ANSI Z535.4 - 2011 (R2017), Product Safety Signs and Labels
- ANSI Z535.6 - 2011 (R2017), Product Safety Information in Product Manuals, Instructions, and Other Collateral Materials
- UL 94, the Standard for Safety of Flammability of Plastic Materials for Parts in Devices and Appliances

6 Construction Requirements (mandatory)

6.1 Fire behavior*

The materials to fabricate Tension Wire Grids are predominately metallic. Incidental plastics used in the construction or edge finishing shall meet UL94-V0.

6.2 Surface finish

To avoid injury to persons, accessible edges, corners, and protruding parts must be burr-free. As an alternative, the construction may allow for the use of accessories, such as ergonomically shaped edge guards or plastic end caps.

6.2.1 Corrosion

Corrosion-prone parts of metal must be protected by paint or other coatings.*

6.2.2 Ferrous metals

Ferrous metals must be primed and painted, plated or galvanized.

6.2.3 Non-ferrous metals

Non-ferrous metals may be painted or plated as required to prevent corrosion.

6.2.4 Metal prep

All metals shall have an appropriate surface preparation for the finishing process used (e.g. sand blast, vibratory, tumble, laser strip, acid wash).

6.3 Requirements for design

6.3.1 Minimum design loads

6.3.1.1 Uniformly distributed vertical load*

1) Walking/working surfaces of standard Tension Wire Grid panels shall be designed to support an evenly distributed vertical load of at least 20 pounds/square foot (0.96 kN/m^2). This is in addition to self-weight.

2) Walking/working surfaces of catwalk Tension Wire Grid panels shall be designed to support a uniformly distributed vertical live load of at least 40 pounds/square foot (1.92 kN/m^2).

3) These live loads shall not be reduced.

6.3.1.2 Concentrated load*

With the exception of stair units, Tension Wire Grid panels shall be designed to be able to support a minimum concentrated load of 300 pounds (14.36 kN/m^2) applied over a 12 inches by 12 inches (30.5 cm X 30.5 cm) area anywhere on the walking/working surface. The point load shall not be required to be supported at the same time as the uniformly distributed load.

6.3.1.3 Horizontal loads

The tension wire grid frame shall resist loads resulting from the cable tension and specified grid loads.

No horizontal loads shall be imposed upon the building except for seismic loads and sway loads caused by the movement of personnel on the grid.

Exception: If perimeter members have been provided within the building for the purpose of resisting horizontal loads applied from the tension wire grid.

6.3.2 Deflection

6.3.2.1 Vertical deflection of frames

The perimeter frame of Tension Wire Grid panels shall be designed per building code requirements.

6.3.2.1.1 Frames shall provide vertical support for the walking/working surface.

6.3.2.1.2 When uniformly distributed loads are applied, the difference in height between the perimeter surfaces of adjacent Tension Wire Grid panels shall not be more than 1/4” (6.3 mm) in an unloaded condition and not more than 1/2” (12.7 mm) with one panel fully loaded and no load on the adjacent one. The relative deflection may be limited by providing a means of attaching module frames together.

The difference in height between the perimeter surfaces of a Tension Wire Grid panel and a building structural element are not bound by this requirement.

6.3.2.1.3 This maximum vertical deflection under load shall be determined and reported in the documentation available to the specifier or user of the Tension Wire Grid.

6.3.2.2 Combined vertical deflection

The combined vertical deflection of both the wires and frame of the Tension Wire Grid walking/working surface under the allowable concentrated load shall not exceed 3” (76 mm).

6.3.2.3 Torsional forces

The frames of Tension Wire Grid panels shall be designed to resist the torsional forces from the wire tension.

6.3.3 Design

6.3.3.1 Engineered design

A Registered Design Professional (RDP) shall design the Tension Wire Grid to meet the specifications of this Standard, using established engineering practices.

The Registered Design Professional shall be licensed in the state or province where the Tension Wire Grid is to be installed.

6.3.3.2 Design calculations

Supply calculations demonstrating compliance with performance requirements and design criteria, including analysis data. At a minimum, the analysis data shall demonstrate:

1) Distribution of cable forces to the frame members shall be based on relative stiffness of perimeter frames and wire ropes using non-linear analysis methods.

2) Analysis of wire rope conforming to ASCE Structural Applications of Steel cables for Buildings.

3) Analysis of modular frames, corners and internal connections and suspension or support hangers per AISC 360 or other applicable standard.

6.3.3.3 Documentation of engineering practices

The design of the Tension Wire Grid shall be documented, including any assumptions, material specifications, calculations, testing procedures, and testing results, in sufficient detail that a second Qualified Person, working independently of the first Qualified Person, can judge the efficacy of the design work in meeting the specifications of this Standard.

The design documentation shall be preserved on file by the manufacturer for at least five years beyond the date of manufacture.

6.4 Functional requirements

6.4.1 Walking/working surface*

6.4.1.1 Woven walking/working surface

The wire rope walking/working surface shall be connected to the frame members in tension.

6.4.1.2 Weave

The weave shall consist of 1/8” minimum wire rope in a 2” (51mm) square pattern. The wires shall pass over and under each other at every crossing. Both the warp and the weft shall be tensioned. The frame must maintain the spacing of the wires at the perimeter.

Where wires pass through holes, the hole shall provide clearance of 115% to 125% the nominal diameter of the wire rope. Holes shall be finished to prevent sharp edges against the wire rope.

When the wire rope is not perpendicular to the frame, the wire rope must be terminated perpendicular to the axis of the wire rope or be bent over a radiused surface before being terminated perpendicular to the frame. The radius must be at least 2X the rope diameter, or a D/d of 4.*

6.4.1.3 Tensioned wires*

The wire rope shall be constructed of galvanized wires twisted to form strands and then twisted to form a rope. The minimum allowable diameter of the wire rope is 1/8” (3mm). The recommended wire rope for most applications is 1/8” (3mm) 7x19 galvanized per Federal Specification RR-W-410 H.*

The wire rope shall be protected from corrosion. When environmental conditions dictate, the use of stainless steel wire rope must be incorporated.* See A.6.2 Corrosion.

6.4.1.4 Wire rope terminations

In all cases, the wire rope end termination must be perpendicular to the frame, unless a self-aligning termination mechanism is used to prevent side loading on the connection.

Wire rope terminations shall allow the ends of the wire rope to deflect.

Wires shall be continuous from edge to edge of the frame and terminated with swaged terminations at each end. The swaged termination material shall be compatible with the wire rope and selected based on any special corrosion prevention requirements. Swaged terminations for galvanized wire rope in non-corrosive environments may be made of stainless steel or copper but not aluminum.

Wires shall be prestressed to meet the deflection requirements of 6.3.2.2.

6.4.2 Frames

Metal frames shall have welded or bolted corners and holes for bolted connection to suspension hardware. Internal bracing in one or both directions may be incorporated to achieve deflection criteria of wires and to prevent horizontal deflection (hourglass) of the frames.

6.4.2.1 Self-weight*

The self-weight of Tension Wire Grid panels including woven walking/working surface is a major consideration in the design. Self-weight must be considered with the roof load.

6.4.2.2 Adjacent frames

Frames shall maintain a 2” (51mm) maximum gap between adjacent frames. Provide bolted spacers between frames not greater than 32” (81 cm) on center.

6.4.2.3 Frame attachment

Frames shall not be welded into position. Frames shall be secured into position with threaded fasteners of a strength at least equivalent to SAE Grade 5 with self-locking nuts.

6.4.2.4 Abrasion prevention

Where internal bracing of a frame is used, and the weave rests on them in a non-loaded condition, a dampener shall prevent the wire weave from directly abrading against metallic internal bracing.

6.4.3 Suspension and support

6.4.3.1 Suspension from roof

Frames may be suspended from the building structure. Purpose designed supplementary steel may be needed.

6.4.3.2 Hangers

Hangers shall be free of sharp edges. Sleeves, when used shall not rotate.

6.4.3.3 Suspension or support from rigging beams

Frames supported by rigging beams may attach to the top or bottom flange of the beam.

6.4.3.4 Perimeter support

Modular grid panels may be supported by adjacent walls provided the walls can support the grid loads.

6.4.4 Surface transition

The walking/working surfaces of Tension Wire Grid panels, and the transition from panel to panel, shall be free from trip-hazards and sharp edges.

6.4.5 Rigging wells

Rigging wells of a maximum 6” width may be formed between the flange of the support beam and the edge of the Tension Wire Grid frame.

6.4.6 Trap door (hatch door)*

Trap doors whether single leaf or double leaf present specific hazards that must be mitigated.

6.4.6.1 Edges

The edges of trap door frames and trap door leaves shall be outlined with a 2” yellow painted edge or 2” yellow and black floor hazard tape.

6.4.6.2 Guard rails

Trap doors shall be equipped with guardrails per ANSI/ASSE A1264.1-2017, Section 3. Where permanent guardrail systems are not practical, temporary Guard rails must be erected.

6.4.6.2 Fall protection

A trap door presents an open hoist way. If field or operating conditions do not permit use of a guardrail system, a fall restraint or fall arrest system shall be developed and installed. This is beyond the scope of this document.

6.4.7 Stage lighting pipes

Stage lighting pipes are a common accessory for Tension Wire grids.*

Lighting Pipes shall be constructed of 1-1/2” sch 40 pipe (48.3 mm O.D.) or 2” (50.8 mm) O.D. round tube. The use of steel or aluminum is acceptable depending on the span between stanchions or hangers. Maintain a maximum deflection of L/180 with a 30 plf (44.6 kg/m) live load.

7 Additional conditions for access (mandatory)

7.1 Stair units

7.1.1 Securing

Stair units shall be fitted with devices to ensure that they do not shift away from any Tension Wire Grid platform to which they provide access during use.

7.1.2 Vertical point load for stairs*

Stair units shall be able to support a minimum point load of 1000 pounds anywhere on the walking/working surface on an area 4 inches by 4 inches (2.2 kN on an area 101 mm X 101 mm).

7.1.3 Step rise, run, and width*

The maximum riser height shall be 9.5 inches (24 cm). The minimum tread depth shall be 9.5 inches (24 cm). The minimum tread width shall be 22 inches (56 cm).

Multi-step units shall have a uniform tread depth and rise, varying less than 0.19 inches (5 mm) from step to step.

7.1.4 Rise toeboards

The rise must be fitted with a toeboard. The remaining opening cannot exceed 4” (10 cm) in height.

7.1.5 Construction

Stairs between levels of Tension Wire Grids may be constructed of traditional materials including diamond plate and grating when approved for such use.*

7.2 Ramps*

Ramps must be able to support the minimum design loads specified in 6.3.1 and should have the same load-bearing ability as the platform surfaces to which they are designed to lead. A slope of 1:8 (12.5%) must not be exceeded. A maximum inclination of 1:16.6 (6%) should not be exceeded for barrier-free access (e.g. for wheelchairs). The minimum width should be 36 inches (91 cm) for wheelchair access.*

7.3 Handrails

Stair units and ramps having a rise of 8 inches (20 cm) or more shall have a provision for mounting at least one handrail. Multi-step stair units and ramps wider than 47 inches (1.2 meters) shall have a provision for mounting two handrails.

Handrails will need to meet the requirements for a Standard Guardrail at a minimum, and may need to meet the requirements for Audience Railings when the stair units are in public areas and there is a fall hazard. The handrail mounting must be designed to support either type of railing.

8 Fall protection accessories (mandatory)

8.1 General

Fall protection is generally provided by Audience Railings or Standard Guardrails.

Other fall protection, such as personal fall arrest systems, or work positioning systems are frequently required around trap doors or removed frames when hoisting large objects through the Tension Wire Grid platform. These devices are outside the scope of this Standard.

For the purposes of this Standard, it should be assumed that any Tension Wire Grid, stair unit, or ramp that has a walking/working surface 4 feet (1.2M) or more above the lower floor shall be fitted with Audience Railings or Standard Guardrails.*

8.2 Audience railings

The vast majority of Tension Wire Grids are located in work areas not accessible to the public. As such this style of railing will infrequently be used.

8.2.1 Audience railing design load*

Audience Railings shall be designed to support a concentrated load of at least 200 pounds (0.9 kN) applied in any direction on the top rail. They shall be able to support a uniformly distributed load of 50 pounds per linear foot of railing length (0.73 kN/m).

Intermediate rails (all those except the top rail) shall be designed to withstand a horizontal load of 50 pounds (0.22 kN) applied to an area of one foot square (30.5 cm x 30.5 cm). The application of the load shall not cause the intermediate structure to bend or tear to create an opening larger than allowed in 8.2.2.

8.2.2 Audience railing height and bar spacing*

Audience Railings shall have a height of at least 42 inches (1.1 m).

The space between the top and bottom of the Audience Railing shall be filled with intermediate rails or a structure of bars, panels, or other elements spaced so that a 4-inch (100 mm) ball cannot be pushed through the structure.

8.3 Standard guardrails*

The vast majority of Tension Wire Grids are located in work areas not accessible to the public. As such this style of railing will most frequently be used.

8.3.1 Standard guardrail design load

Standard Guardrails shall be designed to support a concentrated load of at least 200 pounds (0.9 kN) applied in any direction on the top rail. They shall be able to support a uniformly distributed load of 50 pounds per linear foot of railing length (0.73 kN/m).

Intermediate rails, bars, or panels shall be designed to withstand without failure a force of at least 150 pounds (0.7 kN) applied in any downward or outward direction at any point along the intermediate member.

8.3.2 Standard guardrail height and bar spacing

Standard Guardrails shall have a height of at least 42 inches (1.1 m). The space between the top and bottom of the Standard Guardrail shall be filled with intermediate rails or a structure of bars, panels, or other elements so there is no space larger than 19 inches (48 cm).

8.4 Toeboards*

Catwalks and the perimeter edges of all Tension Wire Grids shall be equipped with Toeboards wherever the distance from the platform to the lower floor exceeds 4 feet (1.2 m). When the perimeter edge abuts a wall, toeboards are not required.

8.5 Floor marking of hazards

8.5.1 Elevation transition marking

Wherever the distance from the platform to the lower floor exceeds 1 foot (0.3 m) but is less than 4 feet (1.2 m), the edge of the upper platform shall be marked with continuous Yellow/Black Floor Hazard tape or

2” yellow painted edge. This is not required if guards, handrails or lighting pipes are located at this transitional edge.*

8.5.2 Rigging well marking

The edges of Tension Wire Grid frames that abut rigging wells shall have a 2” minimum yellow edge of paint or tape to visually alert the end of the grid and the beginning of the rigging well.

9 Labeling and user information (mandatory)

9.1 Grid panel labeling

Each Tension Wire Grid panel shall have a durable metal tag or label on it that specifies:

1) manufacturer with contact name;
2) manufacture year and month;

9.2 User information

The following information should be provided to the user of the Tension Wire Grid, in a hard-copy handbook, on a website, in a free app for portable devices, or via some other convenient medium.

9.2.1 Operating instructions and user information

The manufacturer and installer must provide a user manual with operating instructions and user information:

a) description of the installation and use situation (e.g., fitness for particular use);
b) the correct use of hatchways, trap doors, swing gates, stairs and ladders that provide or limit access;
c) recommendations for preventive measures to be taken by the user (e.g., footwear, bump cap);
d) instructions for the assembly, dismantling, and use of accessories, and the number of people required for manual handling indicated (e.g., lighting pipes, trap doors);
e) information on the static load capacity;
f) information on variable or mobile loads (e.g., wagons, carts, wheelchairs);*
g) notes on inspection and maintenance including repairs and testing;
h) information on spare parts procurement;
i) the maximum vertical or horizontal deflection under load.

9.2.2 Maintenance instructions

Maintenance instructions should include the following:

a) advice about the nature and frequency of visual and functional checks, inspections, and maintenance;
b) particular hazards during inspections and maintenance;
c) qualification of the persons responsible for the inspection and maintenance;
d) instructions for repairs and adjustments;
e) cleaning and care methods;
f) the scope of inspections and maintenance that may be carried out without the involvement of specialists;
g) contact details of the manufacturer of the Tension Wire Grid from which technical support is available.

9.2.3 Warnings and safety notices

Hazards shall be identified and reported to the user by appropriate labeling and safety notices per ANSI Z535.4 - 2011 (R2017), Product Safety Signs and Labels and ANSI Z535.6 - 2011 (R2017), Product Safety Information in Product Manuals, Instructions, and Other Collateral Materials.

9.3 Signage

Information and Caution signage shall be located at or near each entrance to the Tension Wire Grid. Signage shall meet the following requirements:

1) Signage shall be placed in clearly visible, accessible location(s).
2) Signage shall be in English with appropriate graphics. Additional similar signs shall be provided in languages commonly read by the personnel using the facility.
3) Signs shall be a minimum of 7” H x 10” W (17.8 cm H x 25.4 cm W).
4) The signage shall state load capacities and limitations of use.

10 Inspection and maintenance (mandatory)

10.1 Log

There shall be a log of all inspection and maintenance activities.

10.2 Inspections

Tension Wire Grids shall be inspected at the manufacturers recommended interval by a Qualified Person. At minimum, that interval shall be after first installation, after one year of service, and every five years thereafter.

A written report including photos of any problem or watch areas shall be filed with the maintenance log.

The inspector shall note any operational procedures witnessed that are contrary to the safe use of the Tension Wire Grid.

10.3 Inspection of areas with special concerns

High traffic areas, transitions between levels, and moving features such as trap doors may require more frequent inspections.

10.4 Inspection of modifications

Whenever a panel is removed, it shall be inspected after it is re-installed. The removal of a panel shall always be logged in the maintenance log.

In most installations the moving of lighting pipes does not constitute a modification.

10.5 Abnormal events

An inspection is required immediately after an abnormal event, such as running a hoisted load up into the mesh, or dropping a significant load from above onto the Grid.

10.6 Reports from personnel

Whenever personnel report an incident, such as tripping on a loose wire or a cut or abrasion from a sharp edge, the area in question should be inspected.

The hazard should be identified, and an attempt to remediate the hazard implemented (e.g. caution tape, foam edge protectors, repairing the panel).

10.7 Service

When a frame is found to require service (e.g. frayed or broken wire), the frame shall be curtained off and repaired immediately.

11 Recommended precautions for use (informative)

Every installation of Tension Wire Grid is custom to the architecture and serves many different functional requirements. As such, the following recommendations are to be considered when developing the operational procedures for a given facility.

11.1 Personnel

Only trained and authorized personnel may access and work on the Tension Wire Grid.

11.2 Precautions to limit falling objects

11.2.1 Personnel must remove all loose items from clothing pockets.

11.2.2 Loose objects must be secured, e.g. eyeglasses, cell phones and walkie talkies.

11.2.3 Hand tools small enough to fall through the weave or gaps at the edges of panels must be secured with lanyards.

11.3 Reducing hazards from falling objects

11.3.1 To reduce hazards from falling objects, access to the floor below must be limited. A combination of the following methods could be used:

11.3.1.1 Post signs at all entrances to the hazard zone that overhead work is in progress.

11.3.1.2 Lock doors where feasible that enter to the hazard zone space.

11.3.1.3 Erect exclusion zones using stanchions and caution tape.

11.3.1.4 Assign a spotter at the lower floor level. Spotter must remain out of the hazard zone.

11.3.1.5 All personnel at a lower floor level must wear hardhats.

11.4 Conduct

No running, jumping or bouncing on the tension wire grid. Observe the load capacities of the tension wire grid, including the unnecessary concentration of people.

11.5 Hazards

Report observed hazards to your supervisor or instructor. Hazards may be specific pieces of equipment or operational procedures.

11.6 Maintain the weave

It is possible to hand work the weave to create a larger hole to pass electrical cables or similar through the weave. Provide a non-conductive bushing to prevent the mesh from abrading the cable jacket and creating an electrical hazard.

Close all holes in the weave, including those that may occur from repetitive traffic.

Appendix A
Explanatory information
(informational, not mandatory)

A.1 Scope

Movable panels, used as part of the stage floor, trap covers, or pit fillers are outside the scope of this standard because their frames are supported in many fashions, frequently without pinning the corners. In addition, the required loading for Stage Floors is 150 pounds/square foot (7.2 kN/m^2).

A.6.1 Fire behavior

UL 94, the Standard for Safety of Flammability of Plastic Materials for Parts in Devices and Appliances testing is used to determine the material's tendency to either extinguish or spread the flame once the specimen has been ignited.

A.6.2.2 Corrosion

The site specific requirements may warrant advanced corrosion prevention measures in the following scenarios:

a) Venues located in coastal regions or near brackish waters.
b) Tension Wire Grids installed over or near fresh or saltwater aquatic pools, tanks, or aquariums.
c) Tension Wire Grids installed over or near zoological exhibits, especially aviary where droppings may fall onto the grid.
d) Tension Wire Grids installed inside greenhouses or biosphere with artificially controlled humidity.
e) Tension Wire Grids installed in aquatic centers or natatorium where caustic chemicals such as chlorine and bromine are used in swimming pool water treatment systems.

A.6.3.1.1 Uniformly distributed vertical load

The 20 pounds per square foot live load is similar to the ASCE 7-16 requirement for a minimum roof live load of 20 PSF to provide for loads caused by workers and materials during repair operations.

The 2021 International Building Code specifies a minimum UDL for "Catwalks" in Table 1607.1 of 40 pounds/square foot (1.92 kN/m^2). This higher load is used for narrow grids since the weight of a person is distributed over a smaller area resulting in a higher uniform load.

A.6.3.1.2 Concentrated load

This point load specification is taken from ICC 300.

A.6.4.1 Walking/working surface

Maintaining a walking/working surface with limited trip hazards is a paramount goal. Depending on the design, the variance from the top of wire weave to top of the frames range from as little as ¼" to 4" or more. A walking/working surface designed with a relatively smooth surface allows the use of rolling wagons, carts or other wheeled equipment.

A.6.4.1.2 Weave

For practical reasons, most frames are square or rectangular and the weave is perpendicular to the frame. Specialty frames that are triangular, trapezoidal, curved or irregular polygons present challenges. The weave may be adjusted from square to trapezoidal, but in no case may the opening exceed 4.5 sq/in (29 cm).

A.6.4.1.3 Tensioned wires

The use of black painted wire rope is discouraged in all locations, because the painting process requires some of the galvanizing to be removed. The paint eventually flecks off due to tread wear, and the rope develops surface corrosion.

A.6.4.1.5 Stage lighting pipes

Stage Lighting Pipes are frequently attached to the suspension hangers when same are designed for this dual purpose.

In most cases, attachments directly to the wire mesh are not acceptable.

A.6.4.2.1 Self-weight

The self-weight of standard Tension Wire Grid panels including woven walking/working surface may be as light as 5 pounds per square foot (24.4 kg/m2). The actual self-weight of each design must be considered with the roof load.

The self-weight of catwalk Tension Wire Grid panels including woven walking/working surface may be as light as 6 pounds per square foot (29.3 kg/m2). The actual self-weight of each design must be considered with the roof load.

A.6.4.6 Trap Door (hatch door)

Loads hoisted through a trap door are generally heavier and/or larger than that which can be hand lined up and lifted over the guardrails. As such, an overhead rigging beam should be part of the design to support the lifted load.

Center the beam over the door opening with sufficient headroom to clear the guardrails. Consider the magnitude of the load, and capacity of the platform where the load is to be landed.

A.7.1.2 Vertical point load for stairs

This is the load specification for permanent stairs required by OSHA's 29 CFR 1910.25(b)(6):
Each stair can support at least five times the normal anticipated live load, but never less than a concentrated load of 1,000 pounds (454 kg) applied at any point.

A.7.1.3 Step rise, run, and width

These rise, run, and width minimum specifications are taken from 29 CFR 1910.25(c)(2), 1910.25(c)(3), and 1910.25(c)(4). These OSHA regulations allow a higher rise and shorter tread depth than are allowed for assembly occupancy aisle stairs in NFPA 5000-2018.

The uniformity specification is based on ICC 300-2012, which defines non-uniformity as a variation of 0.188 inches (4.8 mm) or more. This Standard rounds the US customary unit specification to two significant digits and applies a similar rounding to the SI equivalent. A piece of 20-pound paper is about 0.00325 inches thick; taking the specification for step uniformity to a level of precision thinner than a piece of paper, as ICC 300 does, is unlikely to be helpful; two significant digits is precise enough.

A.7.1.4 Construction

Stairs could be made using Tension Wire Grid woven work-walk surfaces, but there is little impetus to do so. The vertical point load requirement would be very onerous.

A.7.2 Ramps

The slope specifications (12.5%) maximum is consistent with clause 16.2.5.6.5.1 (2) in NFPA 5000-2018. Per that clause, any assembly occupancy aisle steeper than 1:8 is required to be a stairway. The 1:16 slope for wheelchair access is lower than the 1:12 stated in clause 405.2 in the Department of Justice's *2010 ADA Standards for Accessible Design.* However, that document also says, “Where possible, designers and operators are encouraged to provide ramps with a slope less than the 1:12 maximum.” (Advisory 240.2.1).

Tension Wire Grids are most commonly located in technical spaces that are not for public access. As such it is not to be assumed that a traditional wheelchair has the tire footprint that will perform correctly. In fact the gaps between panels as well as the rigging loft wells present significant hazards for a wheelchair, particularly if approached in a near parallel rather than perpendicular crossing. With that understanding, both the grid and the wheelchair can be made accessible for many installations, especially academic. See also A.6.4.1.

A.8.1 General

Many codes and regulations require guardrail systems when then there is a potential for falling from a walking/working surface greater than 30” (76 cm) above a surface below.

A.8.2.1 Audience railing design load

These specifications are taken from ANSI/ASSE A1264.1-2017.

A.8.2.2 Audience railing height and bar spacing

These height and spacing requirements are broadly consistent across ANSI/ASSE A1264.1-2017., ICC 300-2012, and NFPA 102-2016. The purpose of requiring vertical bars (non-horizontal) is to make climbing on or over the railing difficult.

A.8.3 Standard guardrails

These requirements are essentially those found in ANSI/ASSE A1264.1-2017 and 29 CFR 1910.29(b) with the addition of a uniformly distributed load requirement.

A.8.4 Toeboards

Toeboard requirements vary depending on the type of grid panel since the grid itself provides no protection against falling objects. Grids with channel frames often use the height of the channel as the edge protection.

When the walk-work platform is greater than 4 feet (1.2 M) above the lower floor, the following is applicable:

Notice 1910.28(b)(3)(iv) includes toeboards with guardrail system: “Each employee is protected from falling into a ladderway floor opening or ladderway platform hole by a guardrail system and toeboards erected on all exposed sides, except at the entrance to the hole, where a self-closing gate or an offset must be used.” (source)

Further, OSHA standard 1910.29(k) includes standards for “protection from falling objects”. In particular, toeboards used for falling object protection are as follows:

- Toe Board Height Requirements: 29(k)(1)(ii): “have a vertical minimum height of 3.5 inches (9 cm) as measured from the top edge of the toeboard to the level of the walking/working surface”,

- Clearance : 29(k)(1)(iii): “do not have more than a 0.25 inch (0.5 cm) clearance or opening above the walking/working surface”, and
- Force: 29(k)(1)(vi): “should be capable of withstanding a force of at least 50 pounds (222 N) applied in any downward or outward direction at any point along the toeboard.”

A.8.5.1 Elevation transition marking

When the distance from the platform to the lower floor exceeds 4 feet (1.2 m), the hazard tape is not required because clause 8.2 or 8.3 prevail.

A.9.2.1 Operating instructions and user information

The wheels or tires of wagons, carts, and wheelchairs must be selected to perform on Tension Wire Grids.

Tension Wire Grids are most commonly located in technical spaces that are not for public access. As such it is not to be assumed that a traditional wheelchair has the tire footprint that will perform well. In fact the gaps between panels as well as the rigging loft wells present significant hazards for a wheelchair, particularly if approached in a near parallel rather than perpendicular crossing. With that understanding, both the grid and the wheelchair can be made accessible for many installations. See also A.6.4.1.