DRAFT

BSR E1.2

Entertainment Technology — Design, Manufacture and Use of Aluminum Trusses and Towers

Approved by the ANSI Board of Standards Review on_____

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The Rigging Working Group, which authored this standard, consists of a cross section of entertainment industry professionals representing a diversity of interests. ESTA is committed to developing consensus-based standards and recommended practices in an open setting. Investors in Innovation

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Voting members:

Observer (non-voting) members:

Interest category codes:

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

CONTENTS

An asterisk (*) next to a clause number indicates that there is a matching explanatory clause in the informative Appendix A.

FOREWORD

Prior to the original 2000 version of this standard, there were no specific American National Standards covering the design, manufacture and use of aluminum trusses in the entertainment industry. In an attempt to improve safety and standards in the industry, the Entertainment Services and Technology Association (ESTA) convened a series of meetings to prepare a draft standard. Columbus McKinnon Corporation kindly hosted these meetings at their facilities in Buffalo, New York, and Abingdon, Virginia,

The preparation of the standard was entrusted to the Truss Team working as part of the Rigging Work Group for the Technical Standards Council (TSC) of ESTA. The Truss Team is generally comprised of manufacturers and their structural engineering advisors. As this document has been revised Working Group members have come from manufacturers, engineers, designers, and users of truss and ground support systems.

It has been assumed in the drafting of this standard that the execution of its design provisions are entrusted to appropriately qualified and experienced people, and that the fabrication and use is carried out by qualified and suitably experienced people and organizations.

This standard presents a coordinated set of rules that may serve as a guide to government and other regulatory bodies and municipal authorities responsible for the guarding and inspection of the equipment falling within its scope. The suggestions leading to accident prevention are given both as mandatory and advisory provisions; compliance with both types may be required by employers of their employees.

This standard represents equipment manufactured under the constraints of current technology. It is not intended to restrict further developments or enhancements. Future revisions will not imply that previous editions of the standard were inadequate, nor is it the intention of this standard to suggest that equipment manufactured before the creation of this standard is inherently inadequate. However, the developers of this standard recognize that advancements in technology, combined with evolving awareness of safety and risk management throughout the entertainment industry, might also cause changes in traditionally acceptable or recommended industry practices.

Safety codes and standards are intended to enhance public safety. Revisions result from committee consideration of factors such as technology advances, new data, and changing environmental and industry needs. Revisions do not imply that previous editions were inadequate.

Compliance with this Standard does not of itself confer immunity from legal obligations.
BSR E1.2 DRAFT Aluminum Trusses and Towers

1* Scope

This document describes the design, manufacture and use of aluminum trusses, towers and associated aluminum structural components such as head blocks, sleeve blocks, bases, and corner blocks in the entertainment industry. It does not cover individual, separate rigging hardware such as half couplers and shackles.

The standards described herein are for a variety of uses that are confined to the entertainment industry and apply to a range of structures subjected to normal atmospheric conditions.

The requirements described herein do not cover the detail design of castings, hard-clad curved shell structures or structures subjected to severe thermal or chemical conditions. These requirements do not cover the design of containment vessels, airborne structures or vessels or for any application where other specific standards exist.

If "truss" is referred to in a particular clause in this standard, then it shall equally apply to ‘tower’ and vice versa. It shall also apply to associated aluminum hardware.

2 Definitions

2.1 abrasion: loss of material due to wear.

2.2 allowable load: maximum static equivalent load that can be safely imposed on truss / tower in addition to the self-weight.

2.3 ancillary: supplementary

2.4 authorized person: a person assigned by a competent or qualified person to perform a specific type of duty or duties at the job site.

2.5 AWS: American Welding Society.

2.6 bent member, truss or tower: component or assembly that has permanent deviation from the intended center line.

2.7* bolted connection: a connection of two modules using bolts.

2.8* camber: intended vertical deviation of a truss, usually radiused.

2.9 chord: the element of a module that will carry the axial forces associated with flexural, axial, or combined flexural and axial loading.

2.10* 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 them.

2.11 components: parts of a whole.

2.12 connecting plates: plates welded to the end frames of a module that are used to connect adjacent modules together.

2.13 consumables: items that require regular replacement with use.

2.14 CPL (center point load): a concentrated load that is applied at the midspan of a truss or tower.

2.15* crack: a crevice type discontinuity in the material.

2.16* damage: condition that may adversely affect the intended use of a module (usually load carrying capacity).

2.17 dent: localized permanent deformation in the surface of member or element.

2.18 design factor: the ratio of maximum load to component capacity. Also called factor of safety.

2.19 design strength: the capacity of a structural element or module determined using a recognized design manual.

2.20 diagonal: an element of a module that is not at a 90 degree angle to the main chords.

2.21 dye penetrant testing: a standard non-destructive testing method (NDT) using dye to highlight cracks in welds.

2.22 dynamic loading: forces caused by the acceleration or deceleration of an object.

2.23 factor of safety: see design factor (2.18)

2.24 flare test / drift test: a test on drawn, seamless aluminum round tubes to check structural integrity of the tube wall. Refer to ASTM B210-04.

2.25 incident: occurrence where damage to one or more modules has or may have been sustained.

2.26 manufacturer: person or company that fabricates modules or systems.

2.27 module: singular trussed structure that is stable under load and can be used alone or assembled interchangeably into larger assemblies as defined in this standard.

2.28* NDT (non-destructive test): a method for testing one or more aspects of structural integrity while leaving the tested material or piece intact.

2.29* pinned connector: chord end connector that uses a removable pin to affect a connection between modules.

2.30* 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 problems relating to the subject matter and work.

2.31 rack: Being forced out of shape or out of plumb.

2.32 reaction: A force acting at a support that acts in opposition to an external force or load.

2.33 repetitive use: Describing a module regularly assembled in various configurations, with loads applied differently, supported at different points, or transported to different locations.

2.34 single use: the assembly and installation of modules or assemblies specifically intended to either be permanently left in place or scrapped after being dismantled.

2.35 shall: indicates that the rule is mandatory and must be followed.

2.36 should: indicates that the rule is a recommendation, the advisability of which depends on the facts and conditions in each situation.

2.37 skin: a material cover to a truss structure (usually on a roof system).

2.38 span: the distance between support points.

2.39 static equivalent load: a static load whose magnitude equals the peak force reached by a dynamically applied load.

2.40 sweep: intended lateral deviation of a truss, usually radiused.

2.41* temporary: not permanent. Reference shall be made to local building codes for relevant definitions.

2.42 tower: one or more modules assembled vertically to carry primarily axial load; usually square or triangular in cross section.

2.43 twist: rotational deformation about the longitudinal axis of the module.

2.44 truss: one or more modules assembled to carry load over a distance, generally horizontal, and primarily acting in flexure.

2.45 user: person or company who assembles or uses modules or systems, or who assembles and uses modules or systems.

2.46* UDL (uniformly distributed load): a constant load that is distributed over the entire length of a truss or tower.

2.47 WPS (Welding Procedure Specification): a formal, written document that provides detailed instructions on how to weld a specific joint to ensure repeatable and high-quality results that meet code requirements. It serves as a set of welding parameters, including information on base metals, joint design, welding position, process variables like voltage and amperage, and filler materials, acting as a recipe for welders to follow.

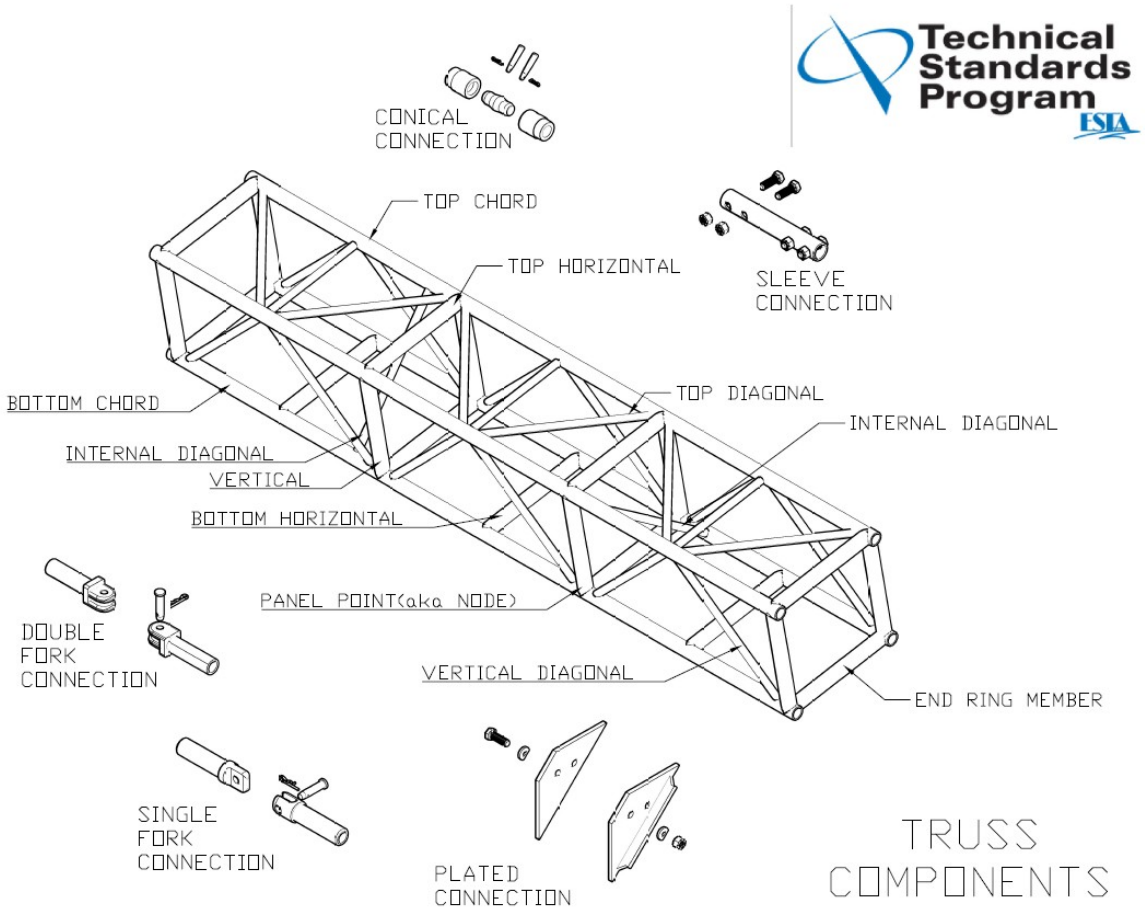
CONICAL
CONNECTION
TOP CHORD
TOP HORIZONTAL
SLEEVE
CONNECTION
BOTTOM CHORD
TOP DIAGONAL
INTERNAL DIAGONAL
INTERNAL DIAGONAL
VERTICAL
BOTTOM HORIZONTAL
PANEL POINT(aka NODE)
DOUBLE
FORK
CONNECTION
VERTICAL DIAGONAL
END RING MEMBER
SINGLE
FORK
CONNECTION
PLATED
CONNECTION
TRUSS
COMPONENTS

Figure 1

3 ENGINEERING

3.1 Intent

The intent of this section is to provide the engineer with the minimum basis on which aluminum trusses and towers shall be designed.

3.2 Design

3.2.1 Design shall be performed in accordance with established engineering practice.

3.2.2 Truss structure design, at a minimum, shall meet the requirements of 3.2.2.1 through 3.2.2.7 as applicable.

3.2.2.1 Aluminum Association:
ADM-2020 Aluminum Design Manual 2020: Part I-A Specification for Aluminum Structures, Allowable Stress Design; Part I-B Specification for Aluminum Structures, Load and Resistance Factor Design

3.2.2.2 American Welding Society (AWS):
D1.1/D1.1M:2015, Structural Welding Code – Steel
D1.2/D1.2M:2014, Structural Welding Code – Aluminum
B2.1/B2.1M:2014-AMD1, Specification for Welding Procedure and Performance Qualification
D16.4M/D16.4:2015, Specification for the Qualification of Robotic Arc Welding Personnel

3.2.2.3 American Society of Civil Engineers:
ASCE 7-22 Minimum Design Loads for Buildings and Other Structures

3.2.2.4 ASTM International:
ASTM B210/B210M-19A Standard Specification for Aluminum and Aluminum-Alloy Drawn Seamless Tubes

3.2.2.5 American Institute of Steel Construction:
“Manual of Steel Construction 15th Edition”

3.2.2.6 ESTA:
ANSI E1.21 - 2024, Entertainment Technology – Temporary Structures Used for Technical Production of Outdoor Entertainment Events

ANSI ES1.19-2018, Safety Requirements for Special Event Structures

ANSI E1.39-2021, Entertainment Technology – Selection and Use of Personal Fall Arrest Systems on Portable Structures Used in the Entertainment Industry

3.2.2.7 IBC
IBC 2024

3.2.3 All conditions of use considered in design shall be outlined in the engineering documentation. Design strength may be established using either Load Factor Resistance Design or Allowable Stress Design methods. Additionally, design strength may be developed by physical testing as outlined in ADM-2020.

3.2.4 Two engineering design categories of trusses and towers are defined as follows:

a. Design of truss or tower structures for single use: Such structures shall be designed in accordance with the provisions of the standards cited herein.

b*. Design of truss or tower modules for repetitive use: The design strength determined in accordance with the standards cited herein shall be multiplied by a factor of 0.85 when the components will be subjected to repetitive use. This reduced design strength shall be greater than or equal to the maximum demand on the module from the intended loading conditions.

3.3 Engineering Analysis

3.3.1 Engineering analysis of the truss or tower structures for the intended loading conditions shall be performed by calculation, modeling, or physical testing or by a combination of two or more of these methods.

3.3.2 Engineering analysis shall consider the worst combination, application, and configuration of loads and effects possible within the use guidelines.

3.3.3 The design shall be structurally stable for the intended applications.

3.3.4 The structure shall be designed for the effects of eccentricities in element and module connections.

3.3.5 Truss and tower deflections shall be calculated for load conditions provided in the User Information.

3.3.6 The design shall address any coating or surface finishing techniques used in manufacturing that affect the structural properties and load-bearing capabilities of the truss or tower structures.

3.4 Engineering Documentation

3.4.1 Engineering drawings of the truss or tower designs shall be developed and maintained. Engineering drawings shall include dimensions, components, subassemblies, material types, fastener types and specifications, weld sizes and types, and welding consumables.

3.4.2 All weld types and sizes shall be indicated in accordance with the AWS Standards D1.1/D1.1M-04 and D1.2/D1.2M-03. All welding procedures that are not prequalified under AWS shall be documented in accordance with AWS procedures.

3.4.3 Engineering calculations, design notes and test results as applicable that demonstrate compliance with this standard for the intended load conditions and uses shall be developed and maintained.

3.4.4* If the User Information includes a statement about the design factor, commonly called the safety factor or factor of safety, then the manufacturer shall clearly state to what condition the design factor refers and shall provide engineering documentation that supports the claims.

4 MANUFACTURING

4.1 Intent

The intent of this section is to ensure that all manufacturers maintain a satisfactory level of quality throughout the manufacturing process and that each and every module is traceable back to the manufacturer in the event of defect.

4.2 Material

4.2.1 The aluminum used shall comply with ADM-2020. Component dimensions shall be within the set limits and tolerances given therein.

4.2.2 Drawn or extruded aluminum round tubes shall be flare tested as per ASTM B210/B210M-19A.

4.3 Welding

4.3.1 All welders involved in producing modules through manual welding processes and all robotic welding operators shall be certified in accordance with the requirements in AWS Standards listed in 3.2.2.2.

4.3.2 All welding processes shall be carried out in accordance with the AWS Standards listed in 3.2.2.2.

4.4 Inspection

4.4.1 After the welding process has been fully completed, all welds shall be visually inspected.

4.4.2 Any welds that do not appear sound shall be tested further by using a NDT method and repaired as required.

4.4.3 Inspection during and after fabrication shall verify the product has been built in accordance with design drawings.

4.4.4 New truss modules shall be inspected by the manufacturer before any surface coatings are applied in advance of delivery to the customer.

4.4.5 Modules shall be inspected for compliance with manufacturer's acceptable tolerances before being released to customers. Criteria shall include tolerances for camber, sweep, racking and twist.

4.5 Coatings and Surface Finishes

4.5.1 Coatings and surface finishes shall be applied only in accordance with 3.3.6.

4.5.2 The application of powder coating shall use processes during which modules are heated only in accordance with the requirements set forth in ADM-2020.

4.5.3 All preparations for painting or coating using a chemical process shall include a procedure to completely flush out or neutralize all corrosive materials that have entered the tubes.

4.5.4* Chemical removal of coatings and surface finishes shall be carried out only after consulting with the chemical manufacturer to ensure that the chemical will not affect the mechanical properties of the aluminum. Abrasion-blasting shall not be used on aluminum less than or equal to 1/8 inch (3mm) thick.

4.6 Identification

4.6.1 The manufacturer shall mark each module with an identification mark unique to that manufacturer and to that module. The mark shall be easily recognizable. The mark shall be durable and difficult to remove. The identification mark shall include the manufacturer's name and the date of manufacture.

4.6.2 The manufacturer shall affix to each section of truss an engraved or embossed marking which will provide permanent traceability of each module. This will be in addition to the requirements of 4.6.1.

4.6.3 The manufacturer shall be responsible for keeping records relating to module identification marks.

4.6.4 At a minimum, the manufacturer's labeling shall include the maximum allowed span with the UDL and expected deflection of that span for that truss format.

4.6.5 The user shall be responsible to create and apply a unique identification mark to the truss module if the manufacturer's marking is removed or destroyed and is no longer legible.

4.7 User Information

4.7.1* For each type of truss and tower, Manufacturers shall produce User Information Sheets or documentation which shall include the following minimum information:

a) a statement that towers, and assemblies made with combinations of trusses and towers, require review by a qualified person;
b) the maximum horizontal span into which modules may be assembled and used according to the manufacturer's guidance;
c) the maximum allowable load, UDL and CPL, for a range of truss spans, which must also list the design standards used, and whether the indicated loads are for single use or repetitive use;
d) theoretical maximum truss deflection expected at each given load and span combination; and what deflection limit was used to determine;
e) Whether truss loading has been determined through review and calculation, physical / destructive testing, or a combination of both shall be notated;

f) to what extent, if any, dynamic loading has been considered in the design;

g) the required connection hardware, and its required installation methods;

h) requirements for regular and annual inspections, manufacturer-specific inspection criteria, and routines for each size and type of truss and tower in accordance with Section 6;

i) that full engineering documentation exists, and how it may be obtained;

j) If manufacturer allows mixing of brands, guidelines for doing so must be provided;

k) Type of load table – single use versus repetitive use, and deflection limits and deflection factor;

l) If truss has been powder coated by the factory, documentation defining the finishing time and temperature shall be provided to the purchaser.

4.7.2 Manufacturer shall provide users with inspection criteria. Criteria shall provide maximum allowed amounts for deviation in camber, sweep, racking and twist. Information shall be in a form to allow users to inspect all lengths of truss using that criterion.

4.7.3 It is stressed that the above list of information, instructions and cautions is the minimum information that a Manufacturer shall provide for each type and size of truss and tower. For configurations outside of those specified by the Manufacturer, the user shall engage a qualified person.

5 USE AND CARE

5.1 Intent

The intent of this section is to provide the end-user with information to ensure that modules are handled correctly during storage, transportation, erection, and dismantling, and that the assembled truss and tower systems are used on site within the limitations of the User Information provided by the Manufacturer.

5.2 User Information

User shall obtain, read and keep on file User Information Sheets from the manufacturer for each type and size of truss and tower as specified in Section 4.7.1.

5.3 Coatings and Surface Finishes

5.3.1 Coatings and surface finishes shall only be applied after consultation with the coating or finish manufacturer or other party qualified to evaluate the possible effects of the coating or surface finish on the structural properties and load-bearing capabilities of the module.

5.3.2 The application of powder coating shall use only a low cure process. The heating of truss and tower modules shall only be done in accordance with Table A.4.2 in ADM-2020 (see 3.2.2.1 above for full reference.)

5.3.3 Before any coating is applied to truss already in user's inventory, a Regular Inspection shall be conducted to confirm that the truss is free of issues which may be difficult to observe after a coating is applied. Records of this inspection shall be added to the records for the module.

5.3.4 Records shall be kept detailing the application of any coating or surface finish with particular attention to processes requiring the application of heat. Records will include documentation of the accumulated heating time truss has been exposed to during its lifetime.

5.3.5* Chemical removal of coatings and surface finishes shall be carried out only after consulting with the chemical manufacturer to ensure that the chemical will not affect the mechanical properties of the aluminum. Abrasion-blasting shall not be used on aluminum less than or equal to 1/8 inch (3mm) thick.

5.4 Applied Loads and Forces

5.4.1 When assessing loads and forces on the fully assembled system, the weight of all loads and the effect of all forces shall be considered including, but not limited to, equipment and any other loads supported by that equipment. Other examples of loads imposed onto the assembled system could include any hoists, light and

sound equipment, multicore cables, follow-spot chairs, temporary personnel occupancy, and reactions from fall protection systems shall be considered.

5.4.1.1 If the loads or forces applied to the system exceed the capacity of the truss then loads or forces shall be reduced to an amount that the truss can support, or a truss with adequate capacity shall be substituted.

5.4.1.2 The effects of loads and forces acting on all axes shall be considered.

5.4.2 At a minimum, consideration shall be given to the following:

a) disposition of the loads on the trusses, and whether the loads are evenly balanced beneath the centerline of the truss or are mainly concentrated on one side or the other;

b) the weight of the cables towards the point of entry of those cables onto the trussing. A concentrated load resulting from cables extending vertically downward from the truss;

c) the possible dynamic effects on the trusses from the raising and lowering of the suspended equipment, or from the raising and lowering of the completed truss system;

d) the effect of external dynamic forces imposed upon installed trusses;

e) the wind forces that could load the truss system during erection and after completion in both the unloaded and fully loaded state;

f) any additional surface area that allows the imposition of additional wind load on the system from items such as banners, roof skins, sound and lighting equipment, projection screens, scenery, etc;

g) environmental actions that affect the performance of the truss including freeze/thaw cycles, dissimilar metal corrosion, or other environmental factors;

h) the weight of snow that may lie on the system or any covering;

I) seismic forces that might act on the system;

j) impact damage to any element of the system.

5.4.3 The requirements of the local building codes and regulations shall be adhered to in all cases.

5.4.4 Consideration for all loads related to truss and tower systems used outdoors shall be in accordance with Section 3.5 of ANSI E1.21.

5.4.5 Consideration for all loads related to fall protection installed on truss shall be in accordance with ANSI E1.39

5.5 Handling

5.5.1 Individual modules and assembled trusses and towers, together with any ancillary components that form part of a complete system, shall not be subjected to impact damage and abrasion during handling.

5.5.2 The modules, trusses, and towers shall not be dragged across the ground, but shall be carried or moved on dollies or trolleys; the modules and assemblies shall not be dropped, but shall be set down without damage or abrasion.

5.5.3 The modules, trusses, and towers shall be adequately secured and supported during transportation and shall be stacked with sufficient spacers or protection between successive heights and adjacent stacks to prevent abrasion.

5.5.4 End connections shall be protected from damage.

5.6*Erection & Installation

5.6.1* Layout drawings with anticipated design loads shall be prepared for each use of the system and shall include the following:

a) accurate overall dimensions;
b) the locations of applied loads;
c) the locations of support points;
d) the reactions at each support point with supporting calculations.

5.6.2 Modules shall be inspected before assembly in accordance with Section 6 (User Inspection). Modules shall be assembled, joined together, and erected by authorized persons in accordance with the layout drawings and calculations with oversight provided by a competent or qualified person.

5.6.3* If the trusses are to be supported on towers which form part of the complete system, then a qualified person shall make a full assessment of the load bearing capabilities of the ground on which the towers are to be erected. If the assessment finds inadequate ground capacity, then modifications or improvements shall be made to attain the required bearing capacity. Improvements shall be reviewed and approved by the qualified person.

5.6.4 The completed system shall be inspected by a competent person prior to each use in accordance with Section 6 User Inspection

5.6.5 Hardware and accessories attached to truss shall be applied in a manner that does not cause damage.

5.6.6 Modules shall be joined together using the hardware specified by the manufacturer and following their guidelines for installation of connection hardware.

6 USER INSPECTION*

The intent of this section is to establish minimum required inspection routines and guidelines for the module user. While every effort is made to provide a thorough listing of situations and inspection criteria, complete listings are beyond the scope of this standard. Specific advice shall be sought by the user for specific inspection routines from the manufacturer or a qualified person.

Inspection criteria listed in this document shall be used in conjunction with any manufacturer specified inspection items and the inspection criteria required by section 4.7.2. Some use cases may overlap with multiple usage classifications. The most conservative inspection criteria shall govern the interval and category of inspection.

6.1 Usage classifications

Frequency and type of inspection of truss shall be decided based upon the following truss usage categories.

6.1.1 Rental - Truss that is used on an irregular schedule as determined by rental use.

6.1.2 Touring - Truss is used for an extended period of time as part of a traveling equipment package and is not returned to owner's control between events.

6.1.3 Permanently Installed, Statically Hung - Truss is part of a fixed system located in a venue and is not raised or lowered as part of its regular operation. The installed equipment on the truss is fixed and does not induce dynamic loads on the structure.

6.1.4 Permanently Installed, Truss is movable - Truss is part of an installed system which is raised and lowered as part of its regular operation.

6.1.5 Permanently Installed, Truss supports dynamic loads – Truss is part of an installed system and the installed equipment on the truss or the activities performed on the truss induce dynamic loads on the structure.

6.2 Inspection records

6.2.1 Initial inspections and annual inspections shall be documented.

6.2.2 Documentation of regular inspections is not required but is recommended.

6.2.3 Inspection records for each truss module shall be kept on file by the owner. Records shall be kept either electronically or by physical documentation. Records shall include notation of any issues, date of inspection, and name of inspector. Inspection records must positively identify the truss module, referencing the manufacturer's identification method or the owner's inventory control method.

6.2.4 Inspection records shall be dated and signed by the person conducting the inspection.

6.2.5 Repairs, and removal from service, shall be documented in the inspection records.

6.3 Initial Inspection

When purchased new from the manufacturer, all modules shall be inspected in accordance with Section 6.4. If truss is acquired used then all modules shall be inspected in accordance with Section 6.5.

6.4 Regular Inspection

Regular inspections shall be conducted by a competent person following the items in Table 6.4 and listed below.

Table 6.4 - Frequency of Regular Inspections					
Usage Classification					
Rental	Touring	Permanent Static	Permanent truss moves	Permanent with dynamic loads	**Item to Inspect - Regular Inspection**
Before truss is sent out for a project, or upon its return to owner from client.	Performed by touring personnel at start of work day before installation.	Annually. If installed equpiment is changed then truss shall be inspected at the same time. Environmental effects may require more frequent inspections.	At a minimum, every three months. Any time system is brought in from trim.	Inspect monthly.	Module geometry. Truss modules shall be inspected for the presence of bending (camber and sweep),racking, and twisting of any truss module component.
					Missing elements. Truss module inspections shall verify that all module elements are present, according to the manufacturer's module layout drawings.
					Damaged elements. All truss elements shall be inspected for the presence of deformities, bending, dents, and abrasion.
					Connection elements. As applicable to the truss module, connection elements shall be inspected for deformation and wear in plates, forks or spigots, tolerance and roundness of connection hole, and that all fasteners are in accordance with the manufacturer's criteria.
					Weldments. Welds shall be visually inspected for breaks, cracks, and deformities.
					Labels. Labels shall be visually inspected for presence and legibility.
* Usage Classification determines frequency of inspections.					

6.4.1 The following items shall be visually inspected as part of a regular inspection.

6.4.1.1 Module geometry. Truss module geometry shall be inspected for the presence of bending (camber and sweep), racking, and twisting, of any truss module component.

6.4.1.2 Missing elements. Truss module inspections shall verify that all module elements are present, according to the manufacturer's module layout drawings.

6.4.1.3 Damaged elements. All truss elements shall be inspected for the presence of deformities, bending, dents, and abrasion.

6.4.1.4 Connection elements. As applicable to the truss module, connection elements shall be inspected for deformation and wear in accordance with the manufacturer's criteria.

6.4.1.5 Weldments. Welds shall be visually inspected for breaks, cracks, and deformities.

6.4.1.6 Labels. Labels shall be visually inspected for presence and legibility.

6.4.2 If records of Regular Inspections are maintained for each piece of truss, then the time between Detailed Inspections may be extended to no more than once every 24 months. Records shall include date, person performing the inspection, and any found issues that require review by a qualified person.

6.5* Detailed Inspection
Detailed inspections shall be conducted by a qualified person following the items and frequency listed in Table 6.5 and listed below. If records of Regular Inspections are maintained for each piece of truss, then the time between Detailed Inspections may be extended to no more than once every 24 months. The module shall be removed from service during the inspection.

Table 6.5 - Frequency of Detailed Inspections					
Usage Classification					
Rental	Touring	Permanent Static	Permanent moving	Permanent with dynamic loads	**Item to Inspect - Detailed Inspection**
At a minimum, at least once every 12 months.	At a minimum, once every 12 months. If inspection date will occur while equipment is on tour, then inspection will be completed before tour.	Performed when an issue is found during regular inspection. Performed in place.	At a minimum, at least once every 12 months.	Every three months where movement of all or part of the system is an integral part of its use.	**All Items included in Regular Inspections**
					Module Geometry. Truss modules shall be measured for camber, sweep, racking and twist within tolerances as established by the manufacturer.
					Connection methods. Connection elements shall be measured to verify that any wear is within the tolerances set forth by the manufacturer.
					Weldments. All welds shall be visually inspected for presence of breaks, cracks, abrasions, and deformities. Non-destructive testing methods (NDT) shall be used to verify the condition of any suspected cracks. Testing shall be performed by a qualified person. Test results shall be documented in the inspection records.
* Usage Classification determines frequency of inspections.					

6.5.1 Detailed inspections shall include the same criteria as regular inspections.

6.5.2 The following additional items shall be inspected as part of the detailed inspection.

6.5.2.1 Geometry. Truss modules shall be measured for camber, sweep, racking and twist within tolerances as established by the manufacturer.

6.5.2.2 Connection methods. Connection elements shall be measured to verify that any wear is within the tolerances set forth by the manufacturer.

6.5.2.3 Weldments. All welds shall be visually inspected for presence of breaks, cracks, abrasions, and deformities. Non-destructive testing methods (NDT) may be used to verify the condition of any suspected cracks. Testing shall be performed by a qualified person. Test results shall be documented in the inspection records.

6.6* Inspection of truss with surface coatings
When inspecting truss which has a powder coated or wet paint coating applied, additional care shall be taken during inspection. Issue with chipped or lifting finishes may be indicative of stretching, cracking, or other issue present in the underlying truss material. Small cracks in welds may be more difficult to detect when surface coatings have been applied.

6.7 Removal from Service

6.7.1 Truss modules failing inspection, showing visible damage, or that are suspected of containing a damaged element, whether visible or not, shall be removed from service.

6.7.2 Inspection shall be performed in accordance with section 6.5 before returning the module to service.

6.7.3 Damaged modules shall be marked in a manner that clearly and visibly indicates their condition.

6.7.4 Unrepairable truss modules shall be permanently removed from service and destroyed.

6.8 Repairs

6.8.1 Repairs to damaged truss modules shall be permitted only when the original structural design capacity can be restored.

6.8.2 A qualified person shall perform and document an assessment of the module, to determine if it can be repaired and subsequently returned to service. Repairs shall adhere to the original WPS as provided by the manufacturer.

6.8.2.1 Old weld filler shall be removed completely and ground flush to base material prior to repair completion.

6.8.2.2 Repairs shall use the same welding process and filler material as used during original manufacture.

6.8.3 Repairs shall be made by a qualified person.

6.8.4 Repaired truss modules shall be inspected according to the requirements of section 6.5 before being returned to service.

Appendix A, Commentary

This commentary is not part of the Standard and contains no mandatory requirements. It offers some explanatory information about the clauses in the standard. The relevant clauses have the same clause number, but without the "A" prefix. The clause numbering here is not continuous because no comments are offered on some of the clauses in the Standard.

Since no mandatory requirements are stated in this commentary, if there is any disagreement between the text of this appendix and the requirements stated in the body of the standard, the requirements in the body of the standard shall prevail.

A1 Scope The minimum requirements described within this document are for a variety of uses of aluminum truss, towers and their related aluminum components confined to the entertainment and event industry. Furthermore, this standard also applies to the use of these components to create various structures or be incorporated into other structures.

A2.7 A typical bolted connection is one that utilizes a bolt through connection plates. This is not an axial or pinned connection and is typically less efficient structurally. It is also the most common connection seen in USA.

A2.8 Camber is typically used to minimize the visible deflection of a truss span. The use of cambered truss requires extra attention to ensure the proper orientation.

A2.16 It is important to note that a component may exhibit damage but said damage may NOT adversely affect the performance or use of the component. It may be completely superficial. Refer to the manufacturer for guidance.

A2.21 For more information on NDT methods, see section A2.28

A2.28 NDT is regularly recommended to verify the integrity of various components. The most common of these, dye-penetrant testing is used to identify cracks in welds. However, it is important to note that this testing only identifies those cracks at the surface level. It cannot verify the depth of the weld or proper fusion of the materials.

Ultrasonic testing is an available option, however, with the varying thicknesses of material, different intersecting angles of components within a module, and variances in weld sizes, this testing can lead to inconsistent results. Furthermore, there is much that can be left open to interpretation leading to different inspectors coming to different conclusions from the same data.

Lastly, with aluminum as a non-ferrous metal, magnetic particle testing, which can more readily identify surface and subsurface variances, is not an available option for the types of modules addressed in this standard.

A2.29 There are a variety of “pinned connectors” in use within the entertainment industry. Some of these can be described as fork and blade, spigot, or conical. The important similarity between these connection types is that they engage the main chords of the truss component in a manner that the connection is directly in line with the central axis of the chord. All of these connection types could equally be referred to as “axial connections”.

A2.41 The definition of “temporary” can vary by jurisdiction. Some relevant references within entertainment standards can be found in E1.21 for outdoor structures. Also, IBC-2024 incudes reference to temporary structures.

A2.46 Uniform distributed loaded is typically conveyed as a measurement of allowable load per unit of length or as a total allowable load evenly applied over a span. It is imperative that the user refer to manufacturer data to identify the relevant per unit increment (i.e. foot, meter, etc.).

A3.2.4 b. The intent of this 0.15 reduction is to account for the inevitable wear and tear that occurs with aluminum truss in a rental or repetitive-use environment. Individual scrapes, abrasions and dents on an aluminum module might be within a manufacturer’s guidelines but cumulatively could weaken the module. This reduction factor provides a modest safeguard against this occurrence.

Additionally, manufacturers may not include this reduction in their published load tables on the basis that they do not know where the product will ultimately be used. Therefore, if it is not stated on published load data, it is incumbent on the User to verify with the manufacturer and apply the load data accordingly.

A 3.4.4 Structures and structural elements can fail due to many mechanisms. “Failure modes” can include tension, compression, bending, shear, buckling, lateral-torsional bucking, deflection, and other mechanisms. Failure can be caused by over-stress conditions, material yielding, material rupture (fracture) and buckling of shapes or structures. Some failure modes and associated design factors may be intuitively obvious to a user, for example: Common 1/4” diameter 7x19 steel wire rope is often noted to have a breaking strength of 8,000 pounds in tension, allowable loading for the same wire rope is often noted to be 1,000 pounds. This would indicate an 8:1 design factor for that wire rope in tension, this is clear and easy for a user to visualize. Other failure modes may not be as intuitively clear; clarity regarding failure modes can be useful to the end-users’ understanding of truss loading limitations. As regards truss, for example: truss, when used as a beam, typically is performance-limited (failure limited) by one of two mechanisms: either bending failure (excessive bending stress, typically for long-span conditions) or, by shear failure (excessive shearing stress, typically for short, heavily loaded spans). It is often not clear for tabular data which failure mode controls in which situation. While a reader can make an informed guess as to the limiting failure mode and associated design factor for any allowable load, a clear indication of the limiting failure mode aids in understanding of truss behavior and, provides insight for the user into proper truss usage. Truss allowable loads, when published with associated design factors, should indicate the failure mode that limits the allowable loads. This provides clear information and enhances user understanding of truss behavior in daily use.

A4.5.4 Abrasion blasting can remove unquantifiable amounts of material, thereby reducing the thickness of the material below that which was considered in the design. Additionally, due to the nature of aluminum, abrasive blasting can cause work hardening of the material, increasing brittleness and the likelihood of cracks developing in the modules.

A4.7.1 c The truss manufacturer must state if the repetitive use factor has been applied to their respective loading tables. However, regardless if a repetitive use reduction is applied to the manufacturer's table, the user is responsible for determining if the repetitive use reduction applies in their actual use condition.

A5.3.5 Abrasion blasting can remove unquantifiable amounts of material, thereby reducing the thickness of the material below that which was considered in the design. Additionally, due to the nature of aluminum, abrasive blasting can cause work hardening of the material, increasing brittleness and the likelihood of cracks developing in the modules.

A5.6 If the trusses are to be suspended from the roof beams or other structure within an existing building or from a framework that is not part of the complete trussing system, then a full assessment should be made by a qualified person of the roof beams or other structure from which the trusses are to be suspended. If necessary, the position of the suspension points should be moved to other acceptable locations and/or suitable strengthening measures shall be made to the existing structure.

A5.6.1 There is not currently an industry wide consensus on the format of layout drawings or rigging plots. The important aspect of these drawings is that they can be shared and used to demonstrate the layout has been properly planned and included all of the necessary factors.

A5.6.3 When the bearing capacity of the supporting surface is insufficient, a typical remediation is to increase the size of the base to further spread the load over a larger area. Consideration must be given to the type of material used to spread this load to ensure that it is stiff enough to properly transfer force across the surface. Additionally, bearing capacity must be considered by calculating the area of the base that is in contact with the floor. For example, a 2 foot square base may not equate to 4 sq. ft of contact area if the bottom of the base is a frame and not fully in contact with the ground over the entire 4 sq. ft area.

If stipulated by the qualified person after their assessment, the ground shall be improved to provide a suitable bearing surface or load bearing spreader plates of sufficient capacity and size shall be provided beneath the tower bases to adequately distribute the tower loads.

A6 Environmental conditions must be considered during inspection. Trusses that are installed outdoors, exposed to caustic environments, etc will potentially have damage that is unique to that installation environment.

A6.5 If a system is permanently installed and cannot be removed for inspection then the system shall be considered to be removed from service until the inspection is completed and the truss is deemed acceptable to return to service. The principle of “lock-out / tag-out” as used in electrical equipment, can be used for inspection of truss components that cannot be removed from physical service but can be secured (locked out) during inspection in place.

A6.6 Inspecting truss that has been finished with powder coat or painted finishes may present additional challenges in detecting cracks in welds and material. When inspecting truss with coatings the evaluation for issues such as bend, twist, and racking are of greater importance as they may give indication of issues concealed by the finish. If a user is applying finishes to a used truss, or touching up existing finishes, then careful inspection for existing cracks or damage must be done before finish is applied.