DRAFT

BSR E1.50-1 – 202x

Entertainment Technology—Requirements for the Structural Support of Temporary LED, Video & Display Systems

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 related to rigging and stage machinery for theatrical events. ESTA is committed to developing consensus-based standards and recommended practices in an open setting. Future Rigging Working Group projects will include updating this publication as changes in technology and experience warrant, as well as developing new standards and recommended practices for the benefit of the entertainment industry.

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Acknowledgments

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Voting Members:

Observer Members:

Key to codes:

CP	Custom-market producer
DE	Designer
DR	Dealer
G	General interest
MP	Mass-market producer
U	User

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1 Introduction

1.1 Scope

The scope of this standard covers temporary installations of large format modular display systems, LED, video and other self-illuminating display structures not otherwise addressed by existing standards. The scope of this standard includes planning and site preparedness, assembly and erection, suspension and safety of components, special access requirements, use and dismantling of these systems. The scope of this standard includes LED, video and self-illuminating display systems that in any way rely on rigid structural support frames, overhead suspensions, ground-supported stands or wall-mounted techniques during any use or installation, and applies to any of these systems in areas where failure of any support or anchorage could cause personal injury, loss of life or property damage.

1.2 Intent

This standard intends to increase safety awareness and understanding of risks associated with the use of these systems. This standard does not intend to address aesthetics, image quality or visual intensity, content delivery or other factors not associated with risk or safety. It does not intend to provide a final, thorough or exhaustive list of potential hazards, nor does it intend to restrict development of new technology or techniques.

1.3 Annex Notes

This standard uses annex notes to supplement normative requirements with explanatory information. Additional Annex note information is indicated by the use of an asterisk (*) after the term or subject matter within the referring section, and refers to an Annex note having a corresponding section number preceded by the letter "A" - e.g. the annex note for a reference in section 4.5* will be labeled A4.5.

1.4 Reference Standards

The following reference standards contain information or supplemental requirements pertaining to this standard. The complete standard name is given here, but in the normative requirements the standards are referenced by an abbreviated title, e.g. ANSI E1.2. Unless a specific version is noted, all referenced standards refer to the most current published version.

ANSI E1.1, *Entertainment Technology - Construction and Use of Wire Rope Ladders*
ANSI E1.2, *Entertainment Technology - Design, Manufacture and Use of Aluminum Trusses and Towers*
ANSI E1.4, *Entertainment Technology - Manual Counterweight Rigging Systems*
ANSI E1.6-1, *Entertainment Technology - Powered Hoist Systems,*
ANSI E1.6-2, *Entertainment Technology - Design, Inspection and Maintenance of Electric Chain Hoists for the Entertainment Industry.*
ANSI E1.6-3 *Entertainment Technology - Selection and Use of Electric Chain Hoists in the Entertainment Industry.*
ANSI E1.8, *Entertainment Technology - Loudspeaker Enclosures Intended for Overhead Suspension -- Classification, Manufacture and Structural Testing*
ANSI E1.15, *Entertainment Technology - Recommended Practices and Guidelines for the Assembly and Use of Theatrical Boom & Base Assemblies.*
ANSI E1.21, *Entertainment Technology - Temporary Structures Used for Technical Production of Outdoor Entertainment Events*
ANSI E1.39, *Entertainment Technology – Selection and Use of Personal Fall Arrest Systems on Portable Structures Used in the Entertainment Industry*
NFPA 70 *- National Electric Code*
ANSI/ASSE Z359, *Fall Protection Code*
ASM1-10 *Aluminum Design Manual 2010*
D1.1/D1.1M:, *Structural Welding Code – Steel*
D1.2/D1.2M:, *Structural Welding Code - Aluminum*
AISC 360, *Manual of Steel Construction 14th Edition*

2 Definitions

2.1 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.

2.2 Display frame (cabinet): a load bearing component that supports one or more display modules; a component integral to the display module(s), intended specifically for its load bearing support.

2.3 Display module: any non-load-bearing display element intended to be used individually or as part of a larger display system.

2.4 Display support structure: the structural support to which one or more display frames are directly attached for primary structural strength and rigidity, but not otherwise classified as building structure.

2.5 Display system: the complete assembly of display modules, display frame(s)and display support structure together, as intended for its specific use or application, including personnel access and safety equipment where such are required for use of the display system.

2.6 Operations Management Plan (OMP): Documentation governing the installation throughout its entire use period, and equivalent to the intent of those requirements as described in ANSI E1.21.

2.7 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.

2.8 Risk assessment: a process that identifies all plausible risks associated with a system or task, and eliminates or reduces the risk to the extent that no injury or death occurs as a result of the identified risks.

2.9 Shall: denotes a mandatory requirement or restriction.

2.10 Should: denotes a non-mandatory recommendation.

3 General requirements

Structural support components and systems shall be designed and selected by a qualified person, regardless if the component or connection is a module, frame or structural support thereof. Structural connections shall be designed by a qualified person.

3.1 Reference standards compliance

Display systems shall comply with the following reference standards, as applicable:

- ***ANSI E1.1***, where wire rope ladders are used for access to the system
- ***ANSI E1.2***, where any portion of the system uses Aluminum trusses or towers for framing or support purposes.
- ***ANSI E1.4****,* where the system uses lifting system components such as loft blocks, pipe battens, etc.
- ***ANSI E1.6-1****,* where the display system uses powered hoisting devices other than those covered by the scope of *ANSI E1.6-2.*
- ***ANSI E1.6-2****,* and ***ANSI E1.6-3****,* where the display system uses serialized chain hoists.
- **ANSI E1.6-1, and ANSI E1.21** for requirements and intent of Risk Assessment/Risk Reduction criteria
- ***ANSI E1.8****,* where the display system uses suspended loudspeaker enclosures, or where display modules are required to support suspended loudspeaker enclosures or other display modules without additional support frame connections.
- ***ANSI E1.15,*** where the display system uses boom and base assemblies for support.
- ***ANSI E1.21****,* where the display system is configured such that it could be classified as standalone structure, regardless if the structure is used indoors or outdoors.
- ***ANSI E1.39***, where the display system requires direct personnel access for any reason.
- ***ANSI/ASSE Z359,*** *Fall Protection Code* where personal Fall Arrest Systems (PFAS) are required for access to any part of the display system.
- ***NFPA 70 – National Electric Code***
- **Society of Professional Rope Access Technicians (SPRAT),** *Safe Practices for Rope Access Work,* or **International Rope Access Trade Association (IRATA)**, *International Code of Practice*, where rope access is permitted to be used by trained and certified rope technicians as an alternative to PFAS. Use of

any other rope access standard or commonly recognized practice approved, accepted or recognized by a consensus of qualified persons performing such work, shall be permitted so long as such practice(s) represent what a reasonable person would do under same or similar circumstances.

3.1.1 Electrical safety. Electrical, signaling and communications equipment and its installation shall conform to NFPA 70 National Electric Code or other relevant prevailing codes.

3.2 Documentation
Indoor and outdoor system designs shall be documented in accordance with the following sections of ***ANSI E1.21****:*

- 3.4 *Engineering Documentation*
- 4.6 [Manufacturer] *Documentation*
- 5 *Use and Care*

3.2.1 General and site-specific documentation.*
System designs and documentation shall identify intended configurations, their associated design loads and site-specific OMP requirements. System designs and documentation shall consider erection or dismantling loads, dynamic loads from motion and shall distinguish them if more stringent than those considered under normal use and operation.

3.2.2 Identification
Display frames and display support structures shall be labeled in accordance with ANSI E1.2.

3.2.3 Engineering considerations

3.2.3.1 Mechanical and structural components. Display systems shall be constructed in accordance with recognized standards pertaining to the components, materials, connections and construction methods used. When used as a basis for design, existing standards shall be cited on the print and/or control documentation.

3.2.3.1.1 Component strength. Components shall have a permanent mark or indication of material strength, grade or rating.

3.2.3.1.2 Marking exceptions. Where permanent labeling or marking of individual components is impractical, such information shall be indicated in the design documentation.

3.2.3.2 Design documentation. When the entire system is fabricated by a single manufacturer, structural and mechanical strength aspects of display system designs shall be documented by the manufacturer. When display systems are assembled from new or existing display module and/or support structure components sourced from multiple manufacturers, a qualified person shall certify the entire display system design. Documentation shall include configuration details specific to maximum number of panels in height and width, presented for both vertical load and for effective wind surface area.

3.2.3.3 Lateral loads. The lateral design loads used for engineering analysis shall be included in the design documentation. Indoor systems shall be designed to resist a minimum lateral load of 2 pounds per square feet of the system’s largest vertically projected area, without loss of stability or failure of any system component. Display systems shall be stable under seismic conditions.

3.2.3.4 Components included or excluded. Documentation shall include materials, components, processes and methods used to construct the display system. Aesthetic aspects, electronic circuitry or electrically powered components are not required in the documentation unless such elements are integral to the strength or safety of the display system.

3.2.3.5 Working Load Limit (WLL). The designer of the display system shall publish a WLL for components and assemblies covered by this standard. The working load of a component or assembly shall be determined by the original equipment manufacturer and explained in the documentation. Connection hardware design factors shall not be less than 5, based on the ultimate strength of the component, unless otherwise approved by a qualified person.

3.2.4 Documentation Accessibility. Documentation shall be available to on-site personnel.

3.3 Component part security
Component parts shall not loosen or become dislodged during use.

3.3.1 Attachment and suspension components
Attachment and suspension hardware shall be constructed of materials that are appropriate for the intended use, as determined by a qualified person.

3.3.1.1 Design quality. Lifting media, attachment and suspension hardware shall be designed by a qualified person in accordance with acceptable engineering practice for specific display system conditions, or shall be tested in accordance with Section 3.3.2 Testing.

3.3.1.2 Design calculations or testing results. Design calculations or testing results shall validate the lifting media, attachment and suspension hardware strength, and shall show that the suspension hardware meets design factor requirements and shall show that it is fit for the intended purpose.

3.3.1.3 Repeatability. The testing results shall be repeatable for all material batches of individual components, where their respective material properties may vary for any reason due to component manufacturing processes.

3.3.1.4 Tolerances. The testing results shall be repeatable within an acceptable tolerance as determined by a qualified person.

3.3.1.5 Hardware connections. Each hardware component specifically used for suspension shall be affixed to a minimum of one (1) structural surface of the display system. There shall be no less than two suspension points provided for any overhead suspension application unless approved by a qualified person, or deemed acceptable by a written risk assessment process. The hardware shall be affixed to the display system with the aid of a reinforcement device so as to prevent all reasonable and foreseeable failure of the display system's structural material. The forces imposed on the entire display system shall not exceed its design capacity. All orientations allowed by the manufacturer shall be considered.

3.3.1.6 Corrosion resistance. Attachment and suspension hardware shall be corrosion resistant when the foreseeable intended use criteria includes exposure to moisture or other similarly corrosive environments.

3.3.1.7 Strength.* All suspension attachment hardware, methods and associated connections in the suspension load path shall be designed using a working load limit design factor of not less than 5 based on ultimate strength or design factor of 2 based on yield strength, unless otherwise approved by a qualified person.

3.3.2 Testing
Where designs cannot be analytically proven, structural load path elements shall be tested. Test methods shall be approved and supervised by a qualified person. Sample size shall not be less than 1% or 3 pieces, whichever is greater.

3.4 Installation conditions*
Aspects of the installation environment affecting Risk Assessment OMP or engineering requirements shall be considered, and shall be incorporated into the design process accordingly.

In addition to the general requirements of section 3, indoor and outdoor ground supported systems shall comply with ANSI E1.21 as applicable to the type of support structure used and the environment in which the system is installed.

3.5 Suspended systems
Suspension components shall be designed for overhead lifting.

3.5.1 Stabilizing and positioning
Where systems require the use of positioning, breasting or stabilizing points, the resulting connections and forces shall be accounted for in the design.

3.5.2 Connection points
All load-bearing connections, whether for lateral, vertical or combined forces, shall be designed by a qualified person.

3.6 Planning
Assembly, erection, use and disassembly procedures shall be planned and documented for each installation, with consideration given to the installation environment.

3.6.1 Risk assessment required
A risk assessment process shall be performed and documented for all installation sites, preferably by a group of 2 or more competent persons. When the risk assessment is completed by a single individual, that individual shall be a qualified person.

Assembly, erection, use and disassembly instructions shall be documented from the risk assessment results.

3.6.1.1 Residual risks. Risks that cannot be mitigated during planning, but which remain present at an acceptable level, shall be identified as residual risks.

3.6.1.2 Applicability of instructions. Instructions shall be construed as applicable and appropriate for all installations, unless site-specific criteria require modification to the OMP.

3.6.2 OMP requirements
Instructions and on-site risk mitigation procedures shall be included in the OMP documentation and available on site at time of installation.

3.6.2.1 Applicability of OMP. OMP documentation shall be specific to the installation environment.

3.6.2.2 OMP modifications required for indoor use. Modification of OMP documents for suitability to the installation environment shall be required for indoor installations. OMP documentation for indoor systems shall include the design load criteria used for lateral stability.

3.7 Component selection
Components shall be selected for strength and suitability for the application by a qualified person.

3.7.1* Qualified persons shall design display frames and display support structures to provide flexural stiffness, bracing and lateral stability necessary to meet the installation and use requirements of the system.

3.7.2 Components for structural strength, stability, mounting or suspension shall only be used in accordance with the component manufacturer's recommendations, unless otherwise approved by a registered design professional, or unless use of the system does not cause risk of any kind to persons, property or equipment.

3.8 Assembly, erection*, disassembly

3.8.1 Assembly, erection and disassembly shall comply with the system instructions and the OMP.

3.8.2 Assembly, erection and disassembly shall be performed by trained and competent persons.

3.9 Personnel access*
Personnel access onto display systems shall comply with applicable OSHA requirements for fall protection systems. Compliance with ANSI E1.39 shall be permitted. Rope access techniques shall be permitted when implemented by trained and certified rope technicians.

3.9.1 No part of a display system shall be used for personnel access unless it has been specifically designed for use as an access method.

3.9.2 Display systems designed for personnel access shall be used with an approved fall protection or rope access system.

3.9.3 No part of the video display system frame, module, header, or support shall be used as a fall protection anchorage, unless the manufacturer has designed the system to meet ANSI Z359.

3.10 Use
Systems shall be used in accordance with the system instructions and an OMP.

3.10.1 OMP requirements shall clearly indicate if they apply to indoor or to outdoor systems. Modifications to the OMP requirements based on indoor use shall be permitted.

3.10.2 For display systems that may be adversely affected by weather conditions, the OMP shall specify environmental monitoring procedures and define the actions to be taken for different parts of the structures during and in anticipation of specified weather conditions. A qualified person shall verify that such actions can be achieved as documented.

3.10.3 An OMP shall be prepared by the user and his engineer.

3.10.3.1 The OMP shall govern the operations of the assembly throughout its use period, including load-in and load-out of all supported and nearby elements.

3.10.3.2 The user’s designated person shall have authority to implement the actions required by the OMP to ensure the safety of people in relation to the structure.

3.10.3.3 The OMP shall include all manufacturers’ operational guidelines.

3.11 Training
Persons participating in assembly, erection, installation, operation, and dismantling shall be trained and competent, or shall be under the direct and continuous supervision of one or more trained and competent persons.

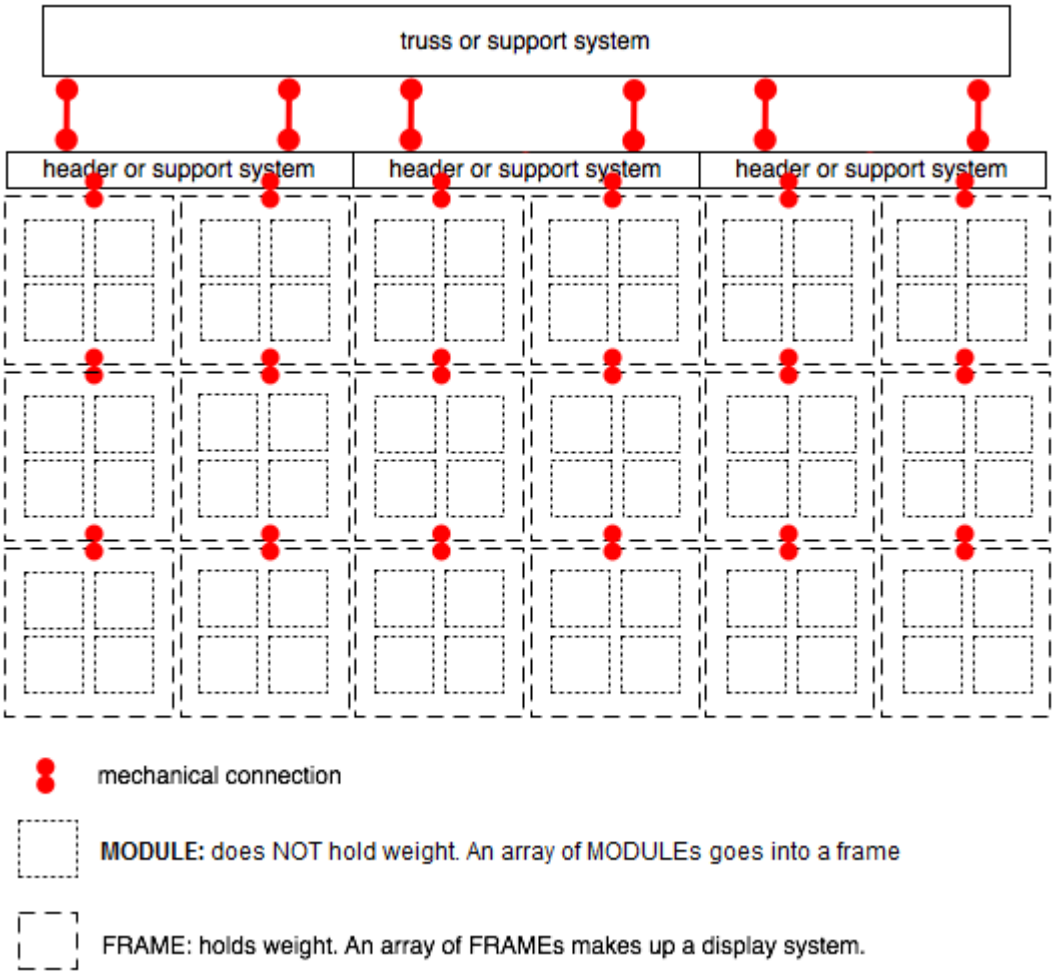
3.12 Inspections and maintenance
Systems shall be inspected prior to first use, and prior to every subsequent use.

3.12.1 Systems shall be inspected in accordance with manufacturer's inspection criteria, and as directed by operational documents required by section 3.1.

3.12.2* Systems shall be inspected after any environmental event that could adversely affect the system integrity.

4 Example diagram

The following diagram describes system elements and key terms used in this document.



5 Annex

A3.2.1 Design loads may differ based on site- or installation-specific criteria. For example, wind loading is not considered for indoor installations in the same manner as it is for outdoor installations, however indoor pressure differentials can have results similar to outdoor wind loads. General system configurations may also require certain modification to accommodate site-specific requirements. Where this information is known or anticipated in the design process, the system documentation should contain this information.

A.3.3.1.7 Strength. Suspension components in this section are used to directly suspend or support the entire video display system, and require a higher design factor than components that have redundancy or are not in the direct load path.

A.3.3.2 Testing. Examples of an existing test, which might be applicable to the testing of video display systems, are:

- ASTM E330 / E330M – 14 *Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference*
- International Building Code, latest edition, Section 1714
- The Aluminum Association “Specifications & Guidelines for Aluminum Structures” – Section 9 Testing
- *ASTM E73 “Standard Practice for Static Load Testing of Truss Assemblies”*

A.3.4 Installation conditions. Conditions of the installation environment may affect the Risk Assessment process, the OMP requirements and the overall design process. Temporary systems may be installed indoors or outdoors, so each type of environment represents different design and use criteria. Outdoor systems are subjected to wind loads, but it is not readily apparent that indoor systems may be subjected to air pressure differentials, too. Pressure differentials from HVAC and open doors can have momentary effects on displays. The display must remain structurally sound when subjected to self-weight plus lateral forces. Theoretically, the suspended display will swing, equalizing weight versus lateral load. However, the potentially flexible display may move less predictably. A qualified person should evaluate the structural integrity and inherent resilience to shaking that may occur under normal conditions in an event space. It is important for the designer to give appropriate consideration to these conditions. The intent of this standard should apply to any application, regardless of duration or location of installation.

A.3.7.1 As described in annex note A.3.4, the installation environment will dictate which design cases are appropriate. Suspended display systems may or may not use lateral bracing depending on the system type.

A.3.8 It is important for the installer to know the individual component weights for all components. These systems contain many small components that can aggregate to large combined weights and are often overlooked in the total system self-weight calculations.

A.3.9 Personnel access. If it is known that climbing on the structure is required for access to components, the design and use guidelines must appropriately account for personnel access.

Rope Access methods are becoming widely accepted as an alternative to Personal Fall Arrest Systems (PFAS), by worldwide organizations and by local Authorities Having Jurisdiction.

In addition to the cited organizational codes of practice, three North American governmental agencies formally recognize rope access techniques.

- The US Department of Interior Bureau of Reclamation's Safety and Health Office has published its Guidelines for Rope Access Work. According to the Bureau of Reclamation's website, *"These guidelines were developed in 2002–2004 for updating and standardizing the techniques, safety practices, and to some extent, the equipment used by Bureau of Reclamation personnel when performing tasks that require the use of rope to access the work site."* The complete report is accessible without a rope, at this web address: http://www.usbr.gov/ssle/safety/rope/Rope_Access.pdf
- New York OSHA has formed an alliance and cooperative agreement with Hi-Rope Corp of NY., to cooperate and promulgate the codes of practice for both SPRAT and IRATA. The compete agreement can be downloaded by clicking on the following link: https://www.osha.gov/dcsp/alliances/regional/reg2/hiropealliance_final.html

- WorkSafeBC, the OSHA enforcement agency in British Columbia, has recently introduced pending amendments to itsd fall protection regulations. These proposed amendments recognize and permit rope access techniques, without exception, as an alternative to traditional personal fall arrest systems.

Because of the extensive prior research and ongoing development of standardized practices, this standard fully supports and promulgates those referenced documents, codes of practice and regulations.

A3.12.2 Environmental events. Environmental events such as high wind, earthquake, icing, heavy snow or lightning strikes can cause damage to the system.