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BSR E1.42 – 202x
Entertainment Technology—
Safety Standard for Entertainment Lifts

Approved by the ANSI Board of Standards Review on _____

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The Stage Machinery Working Group, which authored this standard, consists of a cross section of entertainment industry professionals representing manufacturers, consultants, dealers, and end-users. ESTA is committed to developing consensus-based standards and recommended practices in an open setting. Future Stage Lift Working Group projects will include (a) increasing the scope of this standard to include other forms of orchestra pit and stage lift (b) updating this publication as changes in technology and experience warrant.

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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

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NOTICE: An asterisk (*) indicates that explanatory material on the text can be found in Annex A.

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Foreword

This standard is a revision of ANSI E1.42-2018 *Entertainment Technology – Design, Installation, and Use of Orchestra Pit Lifts*. Stage and orchestra lifts are specifically excluded from ASME A17.1 *Safety Code for Elevators and Escalators*. The previous version provided a reference standard for the design, manufacture, installation, and inspection of orchestra pit lifts. This revision expands its scope to include stage lifts and other similar lifts.

These lifts have widely varying requirements and operating conditions. Procedures for risk assessment and risk reduction have been added to accommodate these conditions. As a result, many sections have been reorganized and renumbered. To reflect the increased scope and more closely follow ASME A17.1, the title has also been changed to *Safety Standard for Entertainment Lifts*.

1 Administration

1.1 Scope*

1.1.1 Scope. This standard covers the design, construction, operation, inspection, testing, maintenance, alteration and repair of stage and orchestra lifts and similar lifts, their associated parts, rooms, spaces, enclosures and hoistways, where located in a theatre or a similar place of public entertainment.
Examples of lifts covered by this standard include:

- Orchestra lifts.
- Lifts that raise and/or lower a portion of the stage floor
- Scenic lifts
- Stage wagon compensation or transition lifts
- Piano and organ console lifts
- Choral and orchestra riser lifts
- Sound console or media lifts
- Auditorium seat wagon lifts
- Auditorium seating re-configuration lifts

1.1.2 This standard does not apply to passenger and freight elevators covered by ANSI/ASME A17.1 *Safety Code for Elevators and Escalators*, nor to platform lifts covered by ANSI/ASME A18.1 *Safety Code for Platform Lifts and Stairway Chairlifts*.

1.1.3 Existing equipment* Existing lifts that do not comply with the provisions of this standard shall be permitted to be continued in service, provided that the lack of conformity with these documents does not present a serious hazard as determined by the Authority Having Jurisdiction.

1.2 Purpose

1.2.1 Purpose. The purpose of this standard is to establish the minimum requirements to safeguard health, safety, and general welfare.

1.2.2 Alternative designs. The provisions of this standard are not intended to restrict or prevent the use of alternative designs not specifically described herein, provided that such designs meet or exceed the intent of this standard's requirements.

1.3 Units

This standard uses U.S. customary units. Metric (SI) equivalents are shown in parentheses immediately after.

1.4 Hydraulic mechanisms

This standard shall not preclude the use of hydraulic mechanisms.

2 Referenced publications*

2.1 General

The documents or portions thereof listed here are referenced within this standard and shall be considered part of the requirements of this document. Where the requirements of a referenced standard differ from the requirements of this standard, the more stringent requirement shall govern.

2.2 Publications

ANSI/AWS D1.1/D1.1M:2020 American Welding Society - *Structural Welding Code - Steel*
ANSI/AWS D1.3/D1.3M:2018 American Welding Society - *Structural Welding Code - Sheet Steel*
ANSI/NFPA 70:2020 National Fire Protection Association - *National Electric Code*
ANSI/NFPA 79:2021 National Fire Protection Agency - *Electrical Standard for Industrial Machinery*
ANSI/NEMA Z535.1-6:2017 Safety color code – Complete set
Merriam-Webster's *Collegiate Dictionary, Eleventh Edition*
UL 508A – 2018 Underwriters Laboratories - *Industrial Control Panels*
UL 60947 – 2020 Underwriters Laboratories – *Low Voltage Switchgear and Controlgear*

3 Definitions

The definitions contained herein shall apply to the terms used in this standard. Where terms are not defined herein, they shall be defined using their ordinarily accepted meanings within the context in which they are used. Merriam-Webster's *Collegiate Dictionary, Eleventh Edition*, shall be the source for the ordinarily accepted meaning.

3.1 actuator: A mechanism or device that provides the primary motive force to move and position the Lift platform, either singularly or in coordination with other actuators.

3.2 authority having jurisdiction*: The organization, office or individual responsible for enforcement of this standard. Where compliance with this standard has been mandated by legislation or regulation, the "authority having jurisdiction" is the regulatory authority.

3.3 authorized person: A person approved or assigned by the employer to perform specific type of duties and who is qualified to perform the assigned duties.

3.4 competent person: A person who has received training on the operation and hazards involved, is capable of identifying existing and predictable hazards in the workplace, and who is authorized to take prompt corrective measures to eliminate them.

3.5 control station*: A device for operating a lift and displaying information to the lift operator.

3.6 contactor: As used in this standard, the term contactor includes both electro-mechanical and solid state devices used to make or break the current in one or more devices.

3.7 dead load: The weight of the lift platform structure, flooring, skirts and permanently installed equipment. The dead load includes the weight of any parts of the lift machinery supported by the actuators.

3.8 encoder: That sensor which provides position information to the control system derived from linear or rotation motion of the lift drive train or actuators.

3.9 E-stop (Emergency stop)*: A function of the control system wherein the lift is brought to a complete stop in as rapid a manner as possible and brought to an inherently safe state at the conclusion of the stop where all sources of power or energy are removed and isolated from the actuators.

3.10 E-Stop station: An E-Stop Station is a station that contains only an E-stop button.

3.11 enable station: A station that contains a control that a person must hold-to-operate to permit motion initiated from a control station.

3.12 fault*: An action or condition characterized by inability to perform a required function.

3.13 guarded access portal: An access way with monitored barriers to restrict personnel from access into lift enclosure. Physical barriers may consist of doors, hatches, panels, or demountable barriers.

3.14 initial limit (sensor)*: That sensor whose function is to stop the lift in the event of over-travel beyond the highest or lowest target. In the event of a contactor-based control system, this may be the same sensor as the upper and lower positioning sensor.

3.15 jogging (inching): The quickly repeated closure of the circuit to start a motor from rest for small movements of the lift.

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

3.17 lift A motorized platform or section of flooring intended to be moved in a substantially vertical direction.

3.18 lift enclosure*: The lift hoistway plus all the areas bounded by physical barriers.

3.19 lift hoistway*: The vertical space containing the lift, extending from the machinery pit floor to the highest point of lift platform travel.

3.20 lift platform: The horizontal structure of the lift intended for supporting user applied loads.

3.21 lifting load*: The maximum live load intended for the user to add to the lift platform to be moved at the rated speed.

3.22 listed: Equipment, materials or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

3.23 live loads: Loads produced by the use and occupancy but do not include construction or environmental loads such as wind load, snow load, rain load, earthquake load, flood load or dead load.

3.24 normal access: Usage of doors, gates, handles and latches by other than competent persons.

3.25 owner: Any person, agent, firm or corporation having a legal or equitable interest in the property.

3.26 override: A momentary switch or other means for temporarily bypassing a safety function.

3.27 positioning or target limit (sensor): That sensor whose function is to stop the platform at a predetermined target.

3.28 power screw A mechanical drive component comprised of a shaft and nut used to convert rotary motion of the shaft into linear movement of the nut.

3.29 pressure sensitive safety edge: A safety device consisting of a continuous linear pressure sensitive sensor.

3.30 programmable electronic system (PES): A system for control, protection, or monitoring based on one or more programmable electronic devices, including all elements such as power supplies, sensors and other input devices, data highways, other communication paths, actuators, and other output devices.

3.31 qualified person*: One who, by possession of a recognized degree, certificate, or 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 the work.

3.32 rated speed: The maximum speed at which the lift platform is designed and built to move.

3.33 ready indication: An indicator on a control station that shows the control station is active.

3.34 reset: A control function that restores normal operation of the system after all fault conditions have been corrected.

3.35 risk: combination of the probability of occurrence of harm and the severity of that harm.

3.36 risk assessment (RA)*: the process of identifying, evaluating, and quantifying the potentially hazardous conditions, severity, and probability of occurrence of harm.

3.37 safety device: Any device that monitors operating conditions and initiates actions to prevent abnormal, inadvertent, or hazardous operating conditions.

3.38 shall: Indicates a mandatory requirement.

3.39 should: Indicates a recommendation, not a mandatory requirement.

3.40 skirt: A vertical guard attached to the edge of the lift platform or floor edge, designed to restrict access to the space below the lift platform or floor.

3.41 static load*: The live load that the lift is designed and installed to support while the lift platform is not in motion.

3.42 Stop Categories.

Category 0 Stop. An uncontrolled stop caused by the immediate removal of power to the machine actuators.

Category 1 Stop. A controlled stop with power to the machine actuators available to achieve the stop, then remove power when the stop is achieved.

Category 2 Stop. A controlled stop with power left available to the machine actuators.

3.43 ultimate limit (sensor)*: That sensor whose function is to prevent damage to the lift or building.

4 Risk Assessment and risk reduction

4.1. Risk assessment and risk reduction (RA/RR) for a lift or lift system shall be performed throughout design, fabrication, installation, and testing. Risk assessment and risk reduction shall be performed when lifts or lift systems are modified.

4.2. It is preferable that risk assessment and risk reduction be performed by a group of two or more competent persons. When the risk assessment and risk reduction is completed by a single individual, that individual shall be a qualified person.

4.3. The group or person performing the risk assessment and risk reduction shall determine the acceptable level of residual risk.

4.4. The group or person conducting a risk assessment and risk reduction shall:

4.4.1. Identify and document the limits of use.

4.4.2. Identify and document the tasks anticipated throughout the life of the system.

4.4.3. Identify and document the hazards associated with each task. For each identified hazard:

- Estimate the severity of harm associated with exposure to the hazard.
- Estimate the probability of occurrence of harm from the hazard.
- Identify the risk by considering the severity and probability of harm.
- Evaluate the risk associated with each hazard to determine if the risk is acceptable.
- Take measures to reduce unacceptable risks.
- Determine whether new or additional hazards have been introduced, or if the level of existing risks have been changed.
- Repeat this process until an acceptable level of residual risk is achieved.

4.5. Documentation of the risk assessment and risk reduction shall include the mitigating actions taken for each

hazard and the resulting reduction in risk.

5 Design and manufacturing requirements

5.1 Design criteria

5.1.1 Structural design.* Lift structures shall resist the maximum design loads and load combinations specified by the applicable building code.

5.1.2 Static load. Static load capacity shall not be less than the highest code-required live load of any adjacent floor surface. The static load shall include a 3000 lb (13.3 kN) concentrated load applied over a 2.5-foot by 2.5-foot area.

5.1.3 Lifting load. Lifting load capacity shall not be less than 50 psf (2.4 kN/m²) uniformly distributed load over the lift surface area. The lifting load shall be in addition to any other integrated or user-defined payloads.

5.2 Lift Pit

5.2.1 Floor. Lift pit floor shall be approximately level and designed and constructed to support all loads imposed by the lift machinery without permanent deformation.

5.2.2 Ground water. Pits shall be designed to prevent the entry of ground water into the pit.

5.2.3 Sump pits. Sumps and sump pumps in pits where provided shall be covered. The cover shall be secured and level with the pit floor.

5.2.4 Accessibility. The lift machinery and controls shall be accessible with the lift in any position.

5.2.5 Lighting. Areas requiring access shall have a means of illumination. Illumination levels shall not be less than 10 foot candles [108 lux].

5.2.6 Conflicting equipment. Equipment or building systems that would impede the normal function of the lift shall not be installed or stored in the space under the lift platform.

5.3 Lift Machinery

5.3.1 Mechanical drive components. Mechanical drive components shall be capable of supporting without failure the dead load plus the greater of 300% of the lifting load or 150% of the static load.

5.3.2 Drift. The lift shall be capable of supporting the static load in a static condition with no more than 1/16 inch (2 mm) vertical movement over a period of 7 days.

5.3.3 Duty cycles. The operational duty cycle of the lift shall be determined during the design process. Mechanical drive components shall be designed to meet or exceed the duty cycle requirements.

5.3.4 Brakes

5.3.4.1 There shall be two separate means of stopping and preventing unintended movement of the lift platform.

5.3.4.1.1 One means shall be a brake that automatically engages to prevent motion whenever power is removed from the actuators.

5.3.4.1.2 An inherently self-locking gear reducer or actuator that resists motion by a restraining force 150% or greater than the applied force shall be permitted for use as a secondary means against uncontrolled or unintended movement.

5.3.4.1.3 For hydraulic systems, check valves and flow control valves shall function as brakes.

5.3.4.2 Brakes shall be applied whenever there is a fault or an E-stop.

5.3.4.3 A brake shall be required for each actuator.

5.3.4.4 Brakes shall engage when power to the brake is removed.

5.3.5 Power screws*

5.3.5.1 Power screws shall be provided with a mechanism designed to support the load in the event of the failure of the nut. Redundant nuts should serve as part of a mechanism for measurement of the state of wear of the power screw nut threads.

5.3.5.2 Power Screws shall be accessible for inspection and maintenance. Guards and cover shall be removeable.

5.4 Lift platform

5.4.1 Structural members. Structural members shall be designed in accordance with recognized design standards.

5.4.2 Deflection.* The maximum deflection of structural members under uniformly distributed live load shall not exceed 1/600 of the member's span length, and adjacent edge distances shall comply with the requirements of Section 5.5.2 below.

5.5 Functionality and clearances

5.5.1 Loads. The lift shall be capable of moving the combined lifting load and dead load from a static condition and return it to the static condition, maintaining control throughout the movement. The lifting load and the static load shall be posted on or near the lift.

5.5.2 Vertical elevation differences. When stopped, the difference in elevation between the edge of the lift platform floor and the edge of any adjacent fixed floor, where intended for the passage of goods and persons, shall not exceed 1/8 inch (3 mm) anywhere along the edge of the lift platform at any uniformly distributed load up to the lifting load or a concentrated load of 1000 pounds (4.45 kN) applied at any point. These loads are not required to be applied concurrently.

5.5.3 Horizontal clearances.

5.5.3.1 The horizontal gaps between the edges of the lift platform floor and fixed floors shall be greater than zero (to avoid direct contact) and not greater than 3/8 inch (10 mm).

5.5.3.2 Where intended for passage of persons or goods the horizontal gaps between the edges of the lift platform surface shall not be greater than 1/4 inch (6 mm).

5.5.4 Over-travel.* After striking an ultimate limit sensor, the lift's limits of travel shall accommodate deceleration and stopping distance.

5.6 Guides

5.6.1 Lateral movement. The lift shall be guided.

5.6.1.1 Guides shall limit the lateral movement to prevent external contact with adjacent structures.

5.6.1.2 Guides shall limit the lateral movement to prevent exceeding the manufacturer's tolerances on the actuators.

5.6.2* Guides shall not bind or otherwise malfunction due to expansion and contraction of the lift and surrounding building structure.

5.6.3* Horizontal forces. Guides shall resist horizontal forces applied to the lift platform not less than the greatest of 10% of the lifting load or 5% of the static load.

5.6.4* Lift guides shall resist seismic forces required by applicable codes. These forces may be greater than the horizontal forces and may impact the design.

5.7 Welding*

5.7.1 Qualification of welders. Welding personnel (welders, welding operators, and tack welders) shall be qualified in accordance with ANSI/AWS D1.1. For materials and processes not covered by ANSI/AWS D1.1, welding personnel shall be qualified in accordance with applicable AWS requirements.

5.7.2 Welding steel. Welding design and procedure requirements of the applicable section of ANSI/AWS D1.1 or ANSI/AWS D1.3 shall apply.

5.7.3 Welding metals other than steel. Welding of metals other than steel shall be done in accordance with the latest AWS requirements.

5.8 Multiple Lifts*

5.8.1 Risks resulting from multiple lifts shall be determined by a risk assessment and mitigated. The residual risks shall not be more hazardous than those from a single lift.

5.8.2 Simultaneous movement of lifts shall be constrained as determined by risk assessment. When the risk assessment requires synchronized lift platform operation, allowable discrepancies between rate of travel and platform elevations shall be defined.

6 Control systems

6.1 General

6.1.1 Listed.* All industrial control panel equipment shall meet the listing and labeling requirements of the Authority Having Jurisdiction.

6.1.2 Interconnection wiring. Cables and wiring between control equipment shall be installed in accordance with the applicable electrical code.

6.1.3 Drive machinery disconnect. A lockable disconnect switch serving the driving machinery shall be provided outside the access point to the driving machinery.

6.1.4 Limited access. Lift control equipment shall be guarded against unauthorized access.

6.1.5 Fault indication. Control systems shall indicate fault conditions.

6.2 Motor control centers

6.2.1 E-stop Contactor.* A motor control center shall include a separate contactor or other safety rated means of removing motor power in an E-stop condition. The E-stop contactor or other means shall be in series with or integral to the directional contactors or the motor drive to ensure stopping has redundancy in the event of failure of a directional contactor or motor drive.

6.2.2 Motor Controller

6.2.2.1 Thermal overload. Motor starters shall incorporate a thermal overload device.

6.2.2.2 Overcurrent protection Motor starters shall incorporate an overcurrent device.

6.2.2.3 Jogging.* Motor contactors or drives shall be rated for any cycle or combination of start, stop, and reverse permitted by the control system.

6.2.2.4 Stopping. The control system shall allow for the momentum, stopping characteristics, and natural frequency of the mechanical system being controlled.

6.2.2.4 Reversing starters. Where the control system includes the ability to reverse the rotation of an electric motor, a method of electrical and mechanical interlocks shall be provided to prevent accidental simultaneous activation in both directions.

6.2.3 Variable-speed Controllers Electronic motor control drives shall be designed for and compatible with the motor type and load characteristics of the lift and shall contain control and parameter functions, including overload, as required by the application.

6.3 Control stations

6.3.1 Location

6.3.1.1 Control devices shall be protected against unintentional and unauthorized actuation.

6.3.1.2 Control stations shall be located where movement of the lift platform can be visually monitored via direct line-of-sight for all lift platform movements at all times, except as permitted in 6.3.1.3.

6.3.1.3 When line-of-sight operation is not possible from a control station, a means of visual monitoring shall be provided to ensure safe operation during lift movement. The method of monitoring shall be determined by the risk assessment.

6.3.2 E-stop. Control stations shall incorporate an E-stop button.

6.3.3 Multiple controls interlock. Where a system has multiple control stations, hardware or software interlocks shall prevent simultaneous control operations, other than E-stop, of the lift by more than one control station.

6.3.4 Wireless control. Wireless control stations shall be permitted, but shall meet the same design and safety requirements as wired systems.

6.4 Enable stations
Where remote visual monitoring is not practical or sufficient, an enable station containing a momentary contact button shall be provided unless determined unnecessary by the risk assessment. The lift platform shall only move while every applicable enable station is activated.

6.5 E-stop stations
Location and quantity of E-stop stations shall be determined by a risk assessment.

6.6 Control system parameters*

6.6.1 Control station. Lift operator control stations shall contain control means, feedback, and/or status indication as required for the safe and reliable operation of the lift system.

6.6.2 All control stations shall be equipped with a common emergency stop system. Activation of any of the emergency stops shall stop all lifts in the system.

6.6.3 Systems monitoring. The control system shall not permit any operation that exceeds the design parameters of the lift.

6.6.4 Data retention. In the case of programmable electronic systems (PES)s with telemetry, controls shall retain in non-volatile memory, position data and all data necessary for the performance of the lift.

6.6.5 Restoration of position data. When actual and stored position data differ, setting or restoring position data for the lift shall only be done by qualified persons**.**

6.6.6 Control lock. Lift movement shall only be possible after unlocking the control system. The locking method shall be determined by a risk assessment and operational requirements.

6.6.7 Ready indication. When the system is unlocked, enabled, and reset, the one active control station shall indicate that the system is in a ready state.

6.6.8 Resetting. Resetting the control system shall only be possible after all faults are cleared or temporary overrides engaged.

6.6.9 Hold-to-operate. Motion of the lift platform shall only be possible while the operator maintains pressure on a control. Release of pressure by the operator shall stop motion.

6.6.10 Brake release. Brakes shall only be released when all the actuators connected to the lift are energized. Brakes shall be engaged at all other times.

6.6.11 Faults. Faults shall not lead to hazardous operating conditions and shall not prevent stopping.

6.6.11.1* A method of temporarily overriding fault conditions shall be provided for the purpose of clearing a fault. The temporary override shall permit lift movement in a limited manner as determined by a risk assessment.

6.6.11.2* Activation of the temporary override shall require additional operator(s) as determined by the risk assessment.

6.6.12 Programmable electronic system (PES). Functions integrated into a programmable electronic control system (PES) may also serve as safety functions. The implementation in the PES shall meet the same design, safety, and reliability requirements as a respective electronic or electromechanical solution. Failure of a PES shall not disable safety functions. When safety functions implemented in a PES fail, the lift system shall automatically stop.

6.6.13 Unintended start. The start and restart of lift platform motion shall require deliberate action by the lift operator.

6.6.14 Loss of feedback. Loss of signal from position sensors shall stop the lift.

6.7 Constraining lift travel

All lift control systems shall include sensors that constrain the travel distance of the lift platform in order to protect the lift system and building structure. The installation must contain, at minimum, devices to stop the platform at the upper and at the lower extremes of travel.

6.7.1 Sensor definitions. Position or Travel sensors are known by many names while serving common functions. Refer to Figure 1, while referencing the definitions for *ultimate limit*, *initial limit*, and *positioning, or target, limit*.

6.7.1.1 Override. The circumstances requiring the override must be investigated by a qualified individual before an override is engaged and may only be performed by an authorized person in communication with the lift operator. Override devices must be located in a position so as to provide the authorized person a clear line of sight to the condition requiring the override. Indicators at all lift operator position(s) shall change state to inform the lift operator that the override has been engaged. The override device must not initiate motion without the direct action of the lift operator and may limit speed and direction of travel while engaged.

6.7.1.2 Reset. In some control systems, some faults disable the control system, and further activity is not possible until the fault is cleared and a reset button pressed.

6.7.2 Sensor actions

6.7.2.1 Ultimate limit.*

6.7.2.1.1* Ultimate limits are required in both directions of travel in all systems where a travel hazard exists.

6.7.2.1.2 The ultimate (overtravel) limit shall be a snap-acting or positive break mechanical limit switch.

6.7.2.1.3 Initiation of the ultimate limit switch shall immediately initiate a category 0 stop utilizing a means separate from the motor controller (reversing contactor or drive).

Using a separate contactor between the line and the motor controller complies with this requirement. Using Safe Torque Off" (STO) input or certified "Safe Off" input complies with this requirement.

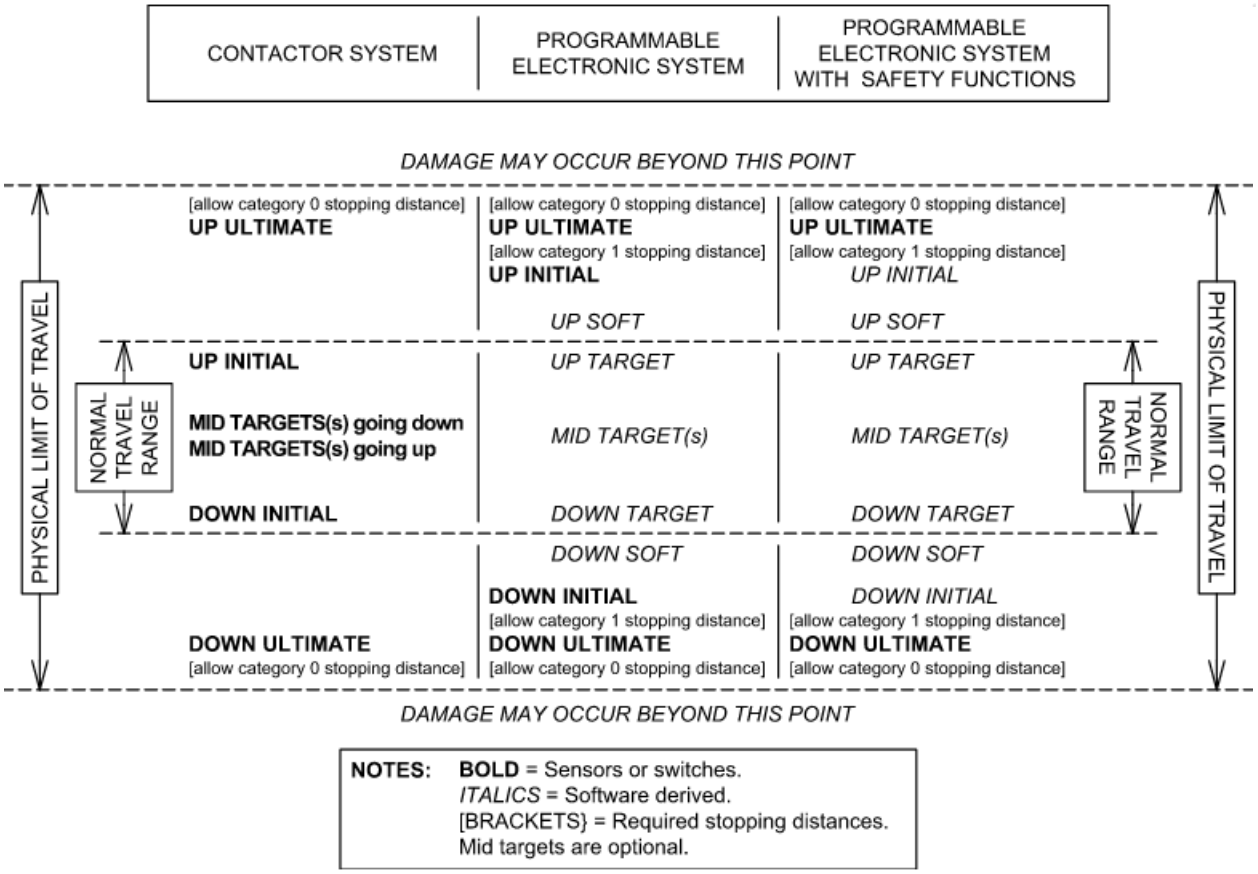

Figure 1. Reference for definitions of travel limits

6.7.2.1.4 Further operation of the lift in either direction shall be restricted. Restarting the lift after activation of this sensor shall require operation of a safety override device. While the safety override device is activated, the lift shall only be allowed to move in the opposite direction and away from the sensor.

6.7.2.2 Initial limit-

6.7.2.2.1 Initial limits are required in both directions of travel in all systems where a travel hazard exists.

6.7.2.2.2 Activation of an initial limit shall bring the lift to a stop before it activates the ultimate limit. When the initial limit is activated, movement in the opposite direction shall be allowed.

6.7.2.2.3 Activation of an initial limit sensor shall be indicated at the control station.

6.7.2.2.4 Means should be provided for temporarily overriding the initial limit sensors to test the ultimate limit switches.

6.7.2.3 Positioning or target sensor. When operated at any speed and any load, activation of this sensor shall bring the lift platform to a safe stop at the predetermined position. Further operation of the shall not be restricted in either direction. Restarting the lift after activation of this sensor shall not require the lift operator to perform any special task.

6.7.2.4 Encoder. Encoding systems may be employed to provide position sensing for all positions within the operating range of the lift platform. Encoding systems may also be employed to provide the function of the Initial Limit as long as the control system and the encoder are certified to meet the requirements of the safety standard applied. Encoding systems shall never be employed to act as ultimate limit sensors.

6.7.3 Sensing devices – types. The type of sensing device applied to the individual lift installation shall be chosen with respects to function, reliability and safe operation as required by the control system and by risk assessment. All sensors shall be installed per the manufacturer's recommendations.

6.7.3.1 Mechanical sensors. All mechanical switches shall be snap-acting or positive break type.

6.7.3.2 Optical/Photo actuated sensor. Optical sensors must be capable of being sensed in all potential artificial atmospheres used within the venue.

6.7.3.3 Electronic sensors. All electronic sensors shall be installed per the manufacturer's recommendations.

6.7.4 Positioning tolerance. All sensors shall be selected, positioned, and installed so as to provide positive, repeatable and accurate signaling to stop the lift at the intended stopping position.

6.7.5 Annunciation. All sensors and bypass devices for sensors shall have their actions (state changes) visually indicated to the operator at all control station(s).

6.7.6 Over-travel compensation. All sensors shall be positioned so as to allow for enough over-travel distance to compensate for drift, freewheel stopping or deceleration distance (the deceleration period) before the application of the braking system.

6.7.7 Mechanically-struck switches. Mechanically struck limit switches or position sensors shall be installed so that the sensor is not damaged by overtravel or released back to its deactivated state during the deceleration period.

6.8 Multiple motor/actuator systems

6.8.1 Shared loading. Lifts employing multiple actuators that are not mechanically coupled shall cause a fault when the load is not divided between the actuators per the design intent.

6.8.2 Fault interlocks. The faulting of one motor shall prevent the operation of associated coupled motors unless the system is designed to compensate for a motor failure.

6.8.3 Individual overloads. Each motor in a multiple motor system shall have an individual overload device.

7 Safety and E-Stop Systems

7.1 Safety devices*

7.1.1 Activation. Safety device activation shall initiate a stop. The type of stop and allowable successive action shall be appropriate for the safety device or function activated, as determined by a risk assessment. Stops initiated by edge protection devices shall meet the requirements of 7.2.4.

7.1.1.1 Activation response. A motor control center(s) shall include a separate safety contactor or other safety rated means of removing motor power in an E-stop condition. The switched terminals of the E-stop contactor or other means shall be in series with or integral to the directional contactors or the motor drive to ensure stopping has redundancy in the event of failure of a directional contactor or motor drive. The E-Stop system shall open the safety contactor or other means, upon activation of an E-Stop actuator.

7.1.2 Device testing. All safety devices shall be capable of being individually tested for effectiveness and functionality. It shall be possible to perform these tests safely and non-destructively.

7.2 E-Stop System*. An E-Stop system shall be included in the design of entertainment lift control systems. The E-Stop system shall provide the User with the ability to safely bring to a full stop all machinery in motion by

activating an E-Stop Actuator. The E-Stop system shall be so designed that a decision to use it during an emergency event does not require the user to hesitate engaging it due to consideration of the possible resultant effects. The type of stop shall be determined by a risk assessment.

7.2.2 Switch operators (buttons) and switch contacts

7.2.2.1 Buttons for activating E-stop functions shall be normally closed and shall have a positive break operation.

7.2.2.2* The types of buttons permitted for E-stop functions shall include, but are not limited to, the following:
(1) Push-button operators
(2) Pull-cord operators

7.2.2.3 E-stop operators shall not be flat form factor or graphic representations based on software applications.

7.2.2.4 E-stop operators shall be colored red. The background immediately around E-stop operators shall be colored yellow.

7.2.3 E-Stop Fault. Activation of any E-stop device shall create a fault condition.

7.2.4 Restart. Motion following an E-stop shall be permitted only after the fault condition has been corrected. Removing or resetting of the E-stop fault condition shall not restart the lift system, but shall only permit restarting.

7.3 Shear and crushing protection

7.3.1 Use

7.3.1.1 Any projection or edge within 9 inches (22.8 cm) of the edge of the lift platform at any point of its travel, including projections or edges of the lift platform itself, shall be protected against shear and crushing hazards in any direction of lift platform travel.

7.3.1.2* Edge protection devices shall be any combination of pressure sensitive safety edges, optical beam detectors, or other suitable active guarding mechanism, except as noted in 7.3.1.3 below.

7.3.1.3 Gaps in safety edges shall not exceed 1 inch nor avoid detection of a 3 inch diameter test rod placed at any location.

7.3.1.4* Exception. A continuous bevel shall be a permitted option where horizontal projections are less than 1 inch (25 mm). The bevel shall be not less than 60 degrees from horizontal.

7.3.2 Fail-safe. Edge protection devices shall be fail-safe. Disconnection of or damage to any component of an edge guard shall cause a fault condition.

7.3.3 Test force. Edge protection devices shall not exert a force greater than 34 lbs (150 N) on a 3 inch (76 mm) diameter test rod before activation nor a force greater than 90 lbs (400 N) before the Lift platform comes to a complete stop.

7.3.4 Activation of edge protection device. Activation of an edge protection device shall stop the lift and the system shall indicate that the device has been activated.

7.3.4.1 Activation of an edge protection device shall not cause the lift to automatically reverse direction.

7.3.4.2 While edge protection devices are activated, motion shall only be possible in the direction opposite the edge protection device strike.

7.4 Guarding lift enclosure and machinery

7.4.1 Physical barriers. Physical barriers shall be employed to control access into the lift enclosure and any lift machine room to prevent personnel from being exposed to a fall hazard or hazard presented by coming in contact with machinery or moving parts.

7.4.2 Unintended access to lift pit

7.4.2.1 Where a lift platform can be raised above the audience level, access under the lift platform from the audience side shall be prevented.

7.4.2.2 Where a lift platform can be raised above stage level, access under the lift platform from the stage side shall be prevented.

7.4.3 Barrier monitoring. All permanent physical barriers which are part of the lift system shall be monitored by the lift control system. An open barrier condition shall cause a fault and require a system reset.

7.4.4 Controlled access. Any physical barrier (such as a door or gate) that is used for passage into the lift enclosure for normal access shall be locked by the lift control system when opening the barrier would expose a fall hazard or hazard presented by coming in contact with machinery or moving parts.

7.4.4.1 Bypass controlled access. Physical barriers shall have a bypass system to allow competent persons to access the lift enclosure for service, maintenance and repair.

7.4.4.2 Emergency egress. Physical barriers that provide egress from the lift enclosure at any level shall be provided with a mechanism for local emergency unlocking or unlatching and egress.

7.4.4.3 Release systems. Physical barriers shall comply with local codes and be compatible with the latch mechanisms and door hardware.

7.4.5 System or power failure. During system or power failure, the state of locks shall remain unchanged and the mechanism for local emergency unlocking shall remain operable for a period not less than as required by applicable code requirements.

7.4.6 Emergency unlocking signage. Instructions for the local activation of emergency unlocking or unlatching release systems shall be posted on a sign near or on the egress point.

7.4.7 Hazard signage. All openings that access any part of the mechanical equipment or the lift enclosure shall have a sign installed on or adjacent to the opening that identifies the hazard beyond the opening.

7.4.8 Encroachment. Physical barriers shall not encroach into the lift hoistway when open or partially open.

8 Installation and commissioning

8.1 Installation

8.1.1 Drawings*. Prior to installation, coordination drawings and documents shall be provided to the owner which shall include the following:

- the maximum loading imposed at each mounting point for the lift mechanisms,
- the dimensional layout of mountings and clearances required for the lift,
- the environmental conditions for which the lift machinery has been designed,
- the electrical-power requirements for the lift machinery and controls,
- inspection criteria.

8.1.2 Site condition.* lift installation requires special conditions that shall be determined in advance by an evaluation for the installation.

8.1.3 Supervision. The installation shall be supervised by a qualified person.

8.1.4 Registered design professional. Drawings shall be sealed by a registered design professional.

8.2 Compliance testing

8.2.1 Compliance testing shall be completed after the installation is substantially complete. Compliance testing shall verify conformance with the manufacturer's engineered drawings, engineering data, and operational criteria. Successful compliance testing shall be completed prior to system turnover and training.

8.2.2* Compliance testing shall be observed by an Owner's representative who shall be a qualified person having knowledge and understanding of the testing requirements of this standard.

8.2.3 Compliance testing shall be scheduled to permit safe access by the Owner's representative to all installed equipment.

8.2.4 The lift system shall not be deemed complete and ready for use until the Owner's representative has recommended acceptance.

8.2.5* Following successful compliance testing, up to date systems documentation including, but not limited to, the as-installed conditions, shall be delivered to the Owner.

8.3 Mechanical inspection*

8.3.1 The interface with the building

Inspect the following:

- Compliance with approved drawings and manufacturer's recommendations.
- Guides plumb, all bolts and fasteners for presence and correct type, cleanliness, smoothness, and guide running surface splices for correct alignment.
- All associated hatches, traps, pockets, receivers, railings, barriers, and other devices in floors adjacent to the lift for fit, finish, smooth opening and closing, functioning locking mechanisms, and trip hazards.
- Inspect the lift pit for any signs of damage or water.

8.3.2 Lift structure

Inspect the following:

- Welds for completeness and conformity to the approved drawings.
- Lift platform framing for damage.
- Protective coatings for completion.
- All bolts and fasteners for presence, correct type, and correct torque.

8.3.3 Lift machinery

8.3.3.1 Inspect the gear reducers, bearings, and couplings for lubrication in accordance with the manufacturer's recommendations.

8.3.3.2 Motors and drive shafts

Inspect the following, with protective covers and shrouds removed:

- The security of motor mounts, alignment of and completeness of couplings between the motors and the lift mechanism, and conformance to manufacturer tolerances.
- That all moving parts in the area are free of conflicts, including the motor, mounts, couplings, joints, shafts, and other drive components.
- That all electrical work serving motors and drive components is operable and accessible as required for maintenance.
- Inspect exposed lift actuator assemblies for cleanliness, lubrication of the lift actuator, and for being free of dirt and debris.
- Inspect other mechanisms for vibration, fit and finish.
- Inspect and note any deviations from the documents described in sections 8.1.1 and 8.2.

8.3.4 Lift platform

Inspect the following:

- The finished floor for damage, edge finishing, levelness with adjacent surrounding surfaces, permissible gaps, and gap tolerances.
- All hatches, traps, pockets, receivers, and other devices in the lift platform floor for fit, finish, smooth opening and closing, functioning locking mechanisms and trip hazards.

- The lift platform edges, bevels, and skirts for smoothness and neatness with no protruding edges that can catch or snag adjacent structure.
- The pressure sensitive safety edges for secure mounting.

8.4 Electrical inspection*

Electrical inspection shall include, but not necessarily be limited to verification that the following devices, wiring, and containment are secure, clean, protected from lift operational hazards and fit for purpose:

- motor control center, particularly for the listing and labeling requirements in section 6.1.1.
- Lift operator control and enable stations.
- junction and pull boxes.
- wiring in junction boxes.
- flexible cable and flex conduit.
- devices including limit switches, encoders, and proximity detectors.
- the pressure sensitive safety edge wiring for completeness and protection from damage by lift platform movement.
- all associated electrical work is installed so it is operable; accessible for routine operation, service, and for complete inspection; and in compliance with all electrical codes.

8.5 Operation and controls tests

Perform operation and controls testing to verify compliance with the manufacturer's operating and design criteria. Testing shall include:

- All functions of control and enable stations.
- Up and down commands.
- Any variable speed commands.
- Positioning and targeting inputs and commands.
- All functions of programmable electronic systems (PES).
- All other operating interfaces.

8.6 Positioning accuracy tests

Positioning accuracy shall be measured during each cycle of the dynamic load tests and with each stop in the operation and control tests. Measurements shall be made for all preset stops and verified for conformance with the required tolerances.

8.7 E-stop tests

E-stop test shall be conducted by using a load equal to the lifting load uniformly distributed across the lift platform, and manually engaging an E-stop button while the lift is in motion at the maximum rated speed.

8.7.1 Testing shall be performed at least once in each direction of travel.

8.7.2 Testing all other E-stop buttons at any load and speed.

8.7.3 Verify in every E-stop test that:

- Power has been removed from all the actuators.
- Lift motion cannot be initiated while the E-stop is engaged.
- Motion is not re-initiated when the E-stop is released.

8.8 Shear and crushing protection tests*

8.8.1 Confirm the edge protection complies with the requirements of section 7.3.

8.8.2 Repeat test for all safety edges. Each section or run of safety edge shall be tested at least once.

8.8.3 On sections or runs greater than 4 feet (1.2 m), the test shall be performed at intervals of 4 feet (1.2 m) to ensure the safety edge works properly along its entire length.

8.8.4 Verify that lift motion cannot be initiated in the shearing direction while any safety edge is engaged.

8.9 Dynamic load tests

8.9.1 Test. The lift shall be dynamically tested using the lifting load uniformly distributed on the lift platform by moving the lift platform through the minimum number of cycles listed below.

8.9.2 Range. Each cycle shall include movement over the full travel range between the highest and lowest limits and returning to the starting position.

8.9.3 Speed. Each test cycle shall be successfully performed at the required speeds.

8.9.4 Duty cycle of the lift. Duty cycle of the lift shall determine the time gap between each cycle test.

8.9.5 Fixed speed lifts. Fixed speed lifts shall be tested at their rated speed for five cycles.

8.9.6 Variable speed lifts. Variable speed lifts shall be moved for 5 cycles at each of the following 3 speeds: 100% rated speed, 50% rated speed, and 10% rated speed.

8.9.7 Inspect the following:
- signs of damage.
- incomplete assembly or installation.
- misalignment.
- unexpected noise during operation.
- any other anomalies.

8.10 Guarded access portal tests
System tests shall verify the following guarded access portal functions:
- Opening a guarded access portal causes the lift to stop and indicates a fault condition.
- The lift platform cannot move while any guarded access portal is open.
- The lift platform cannot move until the fault is cleared and the control system is reset.
- The barriers intended for normal access control cannot be opened by normal means unless the conditions of section 7.5 are satisfied.
- Egress is possible through any portal when the lift is not at a preset level.
- Enabling entry by authorized persons through secured guarded access portals when such passage is deemed necessary for emergency or testing purposes, including power loss.

8.11 Subsequent inspections*
After installation, lifts shall be inspected as recommended by the manufacturer or as required by applicable state and local codes.

9 Operation, maintenance, and repair

9.1 Lift operator training

9.1.1 Lift operator training.* Lift operators shall be trained and shall read and understand the pertinent sections of the manufacturer supplied documentation.

9.1.2 Records. A written record of all lift operator training including the names of the trainee, the name and affiliation of the trainer, and the date of training shall be maintained and shall be made available for inspection on request.

9.2 Operation

9.2.1 General. The lift operator shall follow all instructions for operation, including the warning and safety signs, and shall be familiar with all controls, safety devices, warnings, and their locations.

9.2.2 Pre-operation tasks. The lift operator shall before each use without entering hazard areas verify that:
- all physical barriers are closed and locked,
- no objects obstruct the lift hoistway with particular attention to shear hazards,
- all fall hazard protection, removable guards, and safety barriers required are in place,
- no load is on the lift platform in excess of the lifting load.

9.2.3 In-movement tasks. The lift operator shall monitor the lift throughout its entire movement, and shall not initiate movement if any of the following conditions exist:

- any person is on the lift platform, except as permitted by section 9.3.
- any safety device is disabled or inoperable.
- any objects are protruding into the lift hoistway.
- load exceeds the lifting load.
- any warning signs or placards are missing or unreadable.

If any of these conditions develop during operation, the lift operator shall stop movement until the condition is resolved and, where applicable, perform the duties listed under malfunction.

9.2.4 Malfunction. If a fault, malfunction, damage, unusual sound, or other unusual performance of the lift occurs, then the lift operator shall stop the lift and evaluate the lift status. If corrective action cannot be taken within the authority of the lift operator, then the lift shall be taken out of service and referred to a qualified person. Any such event and resulting actions shall be recorded.

9.3 Passengers on lift*

9.3.1 Stage and orchestra lifts should not be used to carry passengers.

9.3.2 Performers or technicians may ride on a lift when the following conditions are fulfilled:

- Performers riding on the lift shall be an intrinsic part of performance.
- Technicians riding on the lift shall be required for material handling or other duties when riding the lift is the least hazardous means of performing that duty.
- Hazards associated with persons riding on the lift shall be mitigated by risk assessment.

9.3.3 All lifts used to carry personnel shall have a written operation plan. At a minimum, this plan shall address the following requirements:

- Persons riding on the lift shall be supervised by a competent person.
- Persons riding on the lift shall be instructed in the recognized hazards, procedures, and safety precautions.
- Rescue procedures in case of equipment malfunction, power failure, or other emergency situations.

9.4 Maintenance

9.4.1 Applicability. This standard shall be referenced during maintenance and modifications.

9.4.2 Trained personnel. Maintenance shall be performed by a qualified person.

9.4.3 Manufacturer's instructions. Maintenance shall be performed in accordance with the manufacturer's instructions with any updates subsequently issued by that manufacturer**.**

9.4.4 Record keeping requirements. All tests and maintenance activities shall be recorded in writing, maintained in a secure location on premise, for review by authorized persons. Records shall include:

- description of all maintenance tasks performed and dates.
- dates and descriptions of examinations, tests, adjustments, and repairs.
- dates and description of any malfunction, damage, unusual sound, or unusual performance reported by lift operators.

9.5 Repairs and alterations

9.5.1 Qualifications

9.5.1.1 Alterations to lifts manufactured to this standard shall be designed or approved by a registered design professional.

9.5.1.2 Alterations and repairs to lifts manufactured to this standard shall be performed by persons trained and authorized by the manufacturer. In the absence of the manufacturer's authorized personnel, such alterations and repairs shall be made by qualified persons.

9.5.2 Failures. In the event of any mechanical, electrical or controls failure, repairs shall be made prior to any subsequent use of the lift.

9.5.3 Documentation. Alterations and repairs shall be fully documented and recorded in the owner's operations and maintenance manuals.

9.5.4 Repair parts. Repairs shall be made with parts of at least equivalent strength, design, and material of the original manufacturer's specifications.

9.5.5 Welding. Welding shall be done in accordance with this standard.

9.5.6 Testing after repair or alteration.

9.5.6.1 Lifts shall not be returned to service until all alterations or repairs have been completed. After completion the lift shall be inspected and operationally tested in accordance with this standard by a qualified person.

9.5.6.2 If alterations or repairs are made to any structural or load bearing elements of the lift, it shall also be dynamic load tested.

Annex

This annex is not a part of the requirements of this document but is included for informational purposes only. It contains explanatory material and recommendations, labeled to correspond with the applicable text paragraphs.

A.1.1 Scope. The term 'lift' is used to differentiate lifts from passenger and freight elevators as defined in North America under ASME A17.1-2019/CSA B4-10, which specifically excludes stage and orchestra lifts under paragraph 1.1.2.

A.1.1.3 Existing equipment. Existing lift installations should, at a minimum, be brought into conformance with the safety provisions of this standard.

A.2 Referenced publications. The documents or portions thereof listed here are referenced within this non-mandatory annex and should be considered part of the recommendations of this annex.

ANSI/AISC 360-2016 *Specification for Structural Steel Buildings.*

ANSI/ASCE 7-16 *Minimum Design Loads and Associated Criteria for Buildings and Other Structures.*

ASME A17.1-2019 / CSA B44-10 *Safety Code for Elevators and Escalators.*

ASME A17.7-2007(R2012) / CSA B44.7-07 *Performance-based Safety Code for Elevators and Escalators.*

EN 1760-2 2001+A1 2009 (E) *Safety of Machinery – Pressure sensitive protective devices – Part 2: General principles for the design and testing of pressure sensitive edges and pressure sensitive bars.*

NEMA ICS2-2000 (r2005) *Industrial Control and Systems - Controllers, Contactors and Overload Relays Rated 600 Volts,* Tables 2-4-3 for three-phase controllers and 2-4-4 for single phase controllers.

NFPA 79 *Electrical Standard for Industrial Machinery,* 2021 Edition.

A.3.2 Authority having jurisdiction. This is also referred to using the acronym AHJ. This definition is consistent with that used by other national standards organizations, including NFPA and ASME.

A.3.5 Control station. There may be one or more control stations in a system.

A.3.9 E-stop. Unlike a normal stop, which may decelerate the lift to a stop gradually, an E-stop is designed and configured to:

(a) completely stop motion as quickly as mechanically possible,

(b) be operable in a manner that is quick and simple so that even a panicking user can operate it,

(c) be obvious even to an untrained lift operator or a bystander.

A.3.12 Fault. A fault is often the result of a failure of the item itself, but may exist without prior failure.

A.3.14 Initial limit (sensor). This sensor is sometimes referred to as the Normal Travel Limit, End-of-travel Limit or Normal Limit.

A.3.18 Lift enclosure. Lifts differ from elevators in many ways, one of which is that orchestra lifts do not have enclosures or cabs which travel in a hoistway. A lift is a moving platform which operates in an area open to the theatre and open to adjacent stages, audience areas and orchestra pits. A lift passes by floor slabs and platforms, with or without adjacent walls, and is accessed at various levels by audience, technicians, musicians, and performers.

A.3.19 Lift hoistway. This definition is not exactly the same usage of "hoistway" in the elevator codes in that it describes the area occupied by the moving platform and attachments only, which are located within a much larger

volume of free air consisting of the auditorium and understage areas served by the lift. Doors and walls forming a rated enclosure may be some distance from the lift hoistway.

A.3.21 Lifting load. The lifting live load can include integrated payloads, scenery, portable platforms, or music equipment intended to be moved by the lift.

A.3.31 Qualified person.

(a) This is the standard ESTA definition of a qualified person.

(b) Whether an employee is considered to be a "qualified person" will depend upon various circumstances in the workplace. For example, it is possible and, in fact, likely for an individual to be considered "qualified" with regard to certain equipment in the workplace, but "unqualified" as to other equipment.

(c) An employee who is undergoing on-the-job training and who, in the course of such training, has demonstrated an ability to perform duties safely at his or her level of training and who is under the direct supervision of a qualified person is considered to be a qualified person for the performance of those duties.

A.3.36 Risk assessment. This is a process of identifying risks and establishing acceptable risk exposure. A resource for how to perform a risk assessment is ISO 12100:2010 Safety of machinery - General principles for design - Risk assessment and risk reduction, which describes general methods that can be applied to a variety of machinery applications including Stage Lifts.

A.3.42 Static load. The static load can include but is not limited to personnel, orchestra members, audience members, integrated payloads, scenery, portable platforms, and stage equipment.

A 3.43 Ultimate limit (sensor). This sensor is sometimes referred to as the Ultimate, Over-travel Limit, Ultimate end-of-travel limit, or Emergency limit. lift operators must be notified by the control system that this sensor has been struck and that further inspections are needed before restart. User manuals should detail inspection points of equipment and/or structures that are to be inspected before operation can resume.

A.5.1.1 Structural design. In the absence of a local building code, the maximum loads and load combinations should be those stipulated by ANSI/ASCE 7-16, by IBC chapter 16 or by EN-1990 in Europe.

The registered design professional for a new building should review the loading information provided for the lift. For retrofits or renovation the owner should engage the services of a registered design professional to assess the building's structural framing in respect to the lift. Lift frames should be designed in accordance with ANSI/AISC 360.

A5.3.5 Power screws The use of power screws to support lift platforms presents a risk of failure at the interface of the nut and the screw. In the case of screws made with machine threads the screw is typically steel and the nut is a somewhat softer material such as bronze that is selected to provided suitable friction and wear characteristics. It is anticipated that the softer material will be worn away from the internal threads of the nut during normal use and that the nut will have a finite service life before enough material is worn from the threads that the strength design factors are compromised. In the case of ball screws the races may both be hardened however loss of the balls from the race could result in disengagement of the nut from the screws and a sudden release of the lift platform. The intention of the redundant nut requirement is to control the risk of releasing the platform. In the case of machine threaded screws, the distance between the main nut and redundant nuts can also provide a convenient means to assess the state of wear of the threads allowing the main nut to be removed from service before the mechanism fails. Both of these types of mechanism rely on lubrication to control the rate of wear at the interface of the nut and the screw and for this reason the mechanism must be accessible for inspection and relubrication.

A.5.4.2 Deflection. Deflection criteria is important because meeting strength criteria only might result in unacceptably high deflections at the lift edges where they meet existing stages.

A.5.5.4 Over-travel. If a lift platform over-travels and activates an ultimate limit, there should be appropriate stopping distance so that the platform and its load do not cause damage or create a safety hazard, and so that the lift system can be safely inspected and repaired after such an event. Failure to accommodate this condition could

cause damage to the lift guides, actuators, frame, building structure or lift or other components that would create an unsafe condition for occupants and/or service personnel.

A5.6.2 A variety of guides designed specifically for application to lifts and elevators are commercially available. Many more rigid guides are available for applications such as automation and machine tools. The rigidity and the degrees of fixity of the guide mechanisms must be carefully selected to avoid conditions that could leave the machine vulnerable to construction tolerances and expansion/contraction of the surrounding building structure. The scale of typical orchestra lifts is such that normal movement of the concrete structure over time may exceed the capacity of rigid guides in an over-constrained arrangement.

A.5.6.3 Horizontal forces. For most lifts, there should be no lateral loads imposed on the building's structural framing under normal conditions. The movement of objects on the lift platform, the effect of off-center loading, or seismic activity may impose lateral loads to the guides. The values listed in this section historically been adequate. For extreme conditions, evaluation by a registered design professional is recommended.

A.5.6.4 Seismic design forces vary widely and should be determined in accordance with ASCE 7 or other applicable standard.

A.5.7 Welding. The requirements are similar to those in section 8.8 of A17.1.

A.5.8 Multiple lifts
Multiple lifts, especially when the lifts are adjacent to each other create additional hazards which must be mitigated by the risk analysis.
Example risks include:

- Multiple shear edges
- Fewer locations for guides and increased difficulty controlling clearances between lifts
- The relative speeds between lifts may be increased, such as if lifts move in opposite directions.
- Increased power requirements
- Increased opportunity for access under lift platforms.

Adjacent lifts pose additional hazards if they are moving in opposite directions. These include higher relative speed between lifts. Traditional shear edge detection is only sensitive in one direction of motion and is unable to detect which lift is creating the shear hazard. Common mitigation methods include:

- Limiting motion to one lift at a time
- Limiting lift motion to only one direction and speed at a time
- Allowing multiple lifts to move simultaneously, but only in the same direction.
- More extensive control system and edge protection that can track the relative positions of adjacent lifts.

A.6.1.1 Listed. The scope of UL508A can be found at
https://standardscatalog.ul.com/standards/en/standard_508a_3

A.6.2.1 E-stop contactor. For hydraulic driven systems, the E-stop should cause electric power to be removed from the electrically operated valves and pump motor. (Similar to that defined by ASME A17.1)

A.6.2.2.3 Jogging. Motor contactors should be sized for the worst-case jogging current draw and heat buildup. Plug stop, plug-reverse and jogging duty should be per IEC 60158.1 type AC4 or NEMA ICS2-2000 tables 2-4-3 or 2-4-4. The control system should allow for the momentum, stopping characteristics, and natural frequency of the mechanical system being controlled. The control system may limit how rapidly the actuator(s) can be restarted or reversed.

A.6.6 Control system parameters. Annunciation of Movement may be provided and if so, the following are suggested:

(a) Activation of the lift should cause an audible and visual warning at each level serviced by the lift platform and at the machinery pit level.

(b) The warning period should be for three seconds, after which the lift platform may begin movement.

(c) Means should be provided for a competent person to temporarily override the warning and 3 second delay in movement.

(d) Warning devices should be arranged to be audible and visible within 6 feet (1.8 m) of the lift enclosure area at stage level and within the perimeter of physical barriers at all lower levels.

(e) The visual warning devices should be strobes or rotating beacons.

(f) Signage located at each stage level door and landing doors immediately adjacent to the lift hoistway should flash when a fall hazard may exist at that level.

(g) Backlit signage should read "Warning Lift Fall Hazard"

A.6.6.11.1 It is advisable to have visual and audible annunciation when the temporary override mode is engaged, so that personnel are aware that the override is active.

A.6.6.11.2 It is advisable that devices used for temporary override have restricted access via a locking method; require a positive pressure from a lift operator to be placed and held in the active state; and when the pressure holding them active is removed they return to a deactivated state.

It is advisable to have at least two (2) qualified persons required to operate the lift controls during an override situation. Additional personnel should be on hand to evaluate and clear any obstruction, so that the lift operator(s) may remain at the control station(s).

A.6.7.2.1 Ultimate limit. Ultimate limit switches (sensors) stop the lift in the event of over-travel beyond the normal limit stop point, so that additional faults or damage to the lift or surrounding elements does not occur. If an ultimate limit is engaged, that engagement is likely caused by a condition that must be dealt with first hand by a qualified person. It is not possible for a lift operator to operate the lift after it has engaged an ultimate switch.

A.6.7.2.1.1 For hydraulic lifts only, the ultimate stop in the down direction may be a buffer or bumper of sufficient strength to withstand without failure the impact of the lift platform with lifting load at the rated speed.

A.7.1 Safety devices. If required by risk assessment, the lift should incorporate additional sensors and interlock devices.

A.7.2 E-Stops. System integration when there are multiple systems that incorporate E-Stop functions within the same stage or auditorium with the lift, such as overhead rigging, stage wagons, or other lifts, the lift control system should be capable of allowing the E-stop functions to be integrated with the other stage systems, so that pressing any E-stop button should activate all E-stop systems in the same stage and auditorium.

A.7.2.2.2 In the context of this clause, the word "operator" is the mechanical device that activates the contacts of the switch contacts, most commonly referred to as a 'button'. The word 'switch' refers to the assembly of contact(s) that make or break the electrical circuit.

A.7.3.1.2 Areas typically protected with pressure-sensitive edge-switches are the underside of landings, underside of floor slabs, edges of hoistway finishes, edges of skirts and the underside edge of lift platforms. Selection of pressure sensitive edge-switches:

(a) Pressure-sensitive edge-switches should be sufficiently sensitive to prevent injury to unprotected limbs and sufficiently robust to withstand everyday use.

(b) Pressure-sensitive edge-switches should be selected based on the maximum lift speed to provide a stop signal with maximum 5/8 in (16mm) of travel or within safe reaction zone of the pressure-sensitive edge-switch.

A.7.2.1.4 Beveled millwork on the lift or on the fixed edges may be used to:

- Cap or end the lift table flooring,
- Cap or end the fixed edge buildout for railing sockets et cetera, and
- Hold an operational tolerance between bevels at all landings.

- Allow for a greater gap at and below the bevel nosing to the facias during travel so anything caught in there can fall away.
- Beveled surfaces should be sufficiently smooth with a low coefficient of friction to push objects back away from the hazard instead of gripping them.

A.8.1.1 Drawings Temporarily installed lifts may have modified documentation requirements as acceptable to the owner.

A.8.1.2 Site condition. Special conditions for the installation may include, but are not necessarily limited to:

(a) During the installation process, only equipment related to the installation, the lift, or safety should be allowed in the lift hoistway.

(b) A project schedule should be provided to assist the general contractor and/or lift installer with the installation procedure.

(c) Lift set up instructions should include details of the following:
- Warnings: The installation procedure should include warnings of hazards and recommend a sequence of operations to ensure safe efficient installation. Corrosion avoidance should also be addressed.
- Handling: The instructions should include the handling procedure for installation, giving the mass of each separate part of the lift with details of lifting points, if critical.

A.8.2.2. The owner should designate as a representative the registered design professional responsible for reviewing the design of the lift or the theatre consultant responsible for the specification of the lift.

A.8.2.5. Owner's documentation should include the following:

(a) summary of engineering calculations for all lift elements, except proprietary elements.

(b) shop drawings (mechanical) of all lift structures and mechanical systems.

(c) shop drawings (electrical) of the control system including at a minimum all motor control centers, lift operator control stations, enable stations and E-stop system

(d) manufacturers data sheets (also known as cut sheets) for all purchased and replaceable components.

(e) spare parts list of recommended spares to be held on site and supplied by the manufacturer.

(f) lift operation manual.

(g) lift maintenance manual including preventative maintenance checklists, intervals, and procedures and also written testing procedures and reporting forms.

(h) calibration certificates for any instrumentation used.

(i) fall protection Statement of what fall protection has been provided by the manufacturer.

A.8.3 Mechanical inspection. Typical static mechanical problems include damage, incomplete assembly, incomplete installation, and visible anomalies. Typical dynamic mechanical problems include undue vibration, chattering, or unusual movement patterns of the drive shafts and mechanisms.

A.8.4 Electrical inspection. Typical electrical problems include damage, incomplete assembly and/or installation, visible anomalies, wires not terminated into terminal blocks or industrial type wire devices, and wiring not permanently and legibly labeled.

A.8.8 Shear and crushing protection tests. The following is a supplemental test based on the product requirements and annexes of EN1760-2.

(a) While the lift is stationary, confirm that a pressure of 34 lbs (150 N) causes actuation of the safety system.

(b) Lay a 3” (76 mm) diameter test cylinder across a shear edge location and move the lift platform until the test implement engages the pressure-sensitive edge-switch and the lift stops. Confirm that the force applied is below 90 lbs (400 N) and below the manufacturer’s stated maximum.
(c) Confirm the compression distance is within the manufacturer’s specified safe crush zone of the shear edge protection.

(d) Repeat test for all pressure-sensitive edge-switches. Each section or run of pressure-sensitive edge-switch should be tested at least once.

(e) On sections or runs greater than 4 feet (1.2 m), the test should be performed at intervals of 4 feet (1.2 m) to ensure the pressure-sensitive edge-switch works properly along its entire length.

(f) Verify that lift motion cannot be initiated in the shear direction while any pressure-sensitive edge-switch is engaged with a test implement.

(g) Test implement is a smooth-sided rigid cylinder 3” (76 mm) in diameter that is instrumented to measure a compression of 200 lbs (890 N) with no more than a 1/16” (1.6 mm) deflection.

A.8.11 Subsequent inspections.
(a) Annual and Five-year inspections are recommended when no equivalent inspections are called out by the manufacturer in the Operations and Maintenance information provided by them to the Owner unless the manufacturer’s proposed inspections are more stringent. Inspections should conform to the following requirements:

(b) If the lift has not been operated for any inspection interval, that inspection should be performed before the lift is put back into service.

(1) Records. Dated inspection reports and records should be maintained. Records should be kept by the Owner and made available for viewing.

(2) Personnel. Inspection should be by a competent person.

(3) Notice. The location of inspection records and the date last inspected and by whom should be posted at the main control equipment enclosure.

(4) Recorded information should include:
- Date of inspection.
- Name of inspector, inspection company and contact information for person(s) performing inspection.
- Condition of equipment including notation of presence or absence of evidence of damage or wear.
- Operational status of the lift and associated equipment.

(5) Control stations. Accessible electrical parts of Control stations and electrical cords to and from them should be inspected for damage, wear, and proper operation.

(6) Cleanliness. Mechanical parts and the machinery area should be visually inspected for damage, wear, fluid leakage, metal or plastic shavings, uncommon odors, and any loose or missing fasteners.

(7) Safety devices. Confirm the operation of all safety devices.

(8) Test cycle. Operational inspection during test cycle should consist of:

(a) Running the lift through its complete cycle of operation from lowest to highest points without stopping.

(b) Moving the lift into each pre-programmed intermediate level position while traveling in each direction.
(c) Observing and recording that the lift makes all stops within appropriate tolerances.

(d) Confirming the operation of all safety devices.

(9) Defects. Any defect directly affecting the safety of the lift should cause it to be taken out of service until the defective part has been adjusted, repaired, or replaced.

(10) Control updates. Where an entertainment lift utilizes a PES for the main operation and controls, the competent person performing the inspection should contact the manufacturer to inquire about software updates, patches, or bug fixes. The result of such an inquiry should be recorded in the inspection records along with any revision, part, or serial numbers of the installed software.

(d) Five-year inspection. At every interval of five years or 5,000 movements, whichever comes first, an inspection should be performed by a Qualified person. The inspection should be a re-commissioning per section 8.3 through 8.11.

A.9.1.1 Lift operator training. A lift operator training video should be recorded as both a record of formal training for commissioning requirements and as a way for trained lift operators to review in the future.

A.9.3 Passengers on lift In some cases, stage and orchestra lifts may be required to carry passengers. Often these passengers may be performers for which the lift motion is integral to the performance. Other times technicians may be required to load or unload scenery or other equipment such as wagons or carts. The lift may also provide the sole means of access to some areas such as seat wagon storage level.

Passengers on the lift create additional hazards that must be mitigated. Some of these hazards including shear and crushing hazards are already covered by this standard. Other hazards, including fall hazards are not addressed and need to mitigation.

Depending on the arrangement of the lift hoistway and any adjacent lifts, a fall hazard may exist as the lift moves between floor levels. The use of passive fall protection such as removable railings or active fall restraint may be impractical given the lift operation. Since the fall hazard exists only for a short time, potential mitigation means may include

a. Performer blocking that is carefully planned and rehearsed so the performer never come close to a lift edge. ANSI ESTA E1.46 *Standard for the Prevention of Falls from Theatrical Stages and Raised Performance Platforms* can provide guidance.

b. Requiring passengers to keep at least six feet away from any fall edge. Alternatively, they may be required to be stationary while the lift is in motion.

c. Passengers should be instructed to keep all parts of their body inside the lift while the lift is in motion.