E1.71 – 202x
Powered Curtain Machines

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

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Foreword

The purpose of this standard is to establish the requirements for dedicated curtain machines.

At the time of this standard's publication, there are no North American standards that address curtain machines. The closest standard for vertical travel (lift) curtain machines is ANSI E1.6-1 (Entertainment Technology – Powered Hoist Systems). Many of the requirements of the Powered Hoist standard are onerous for a dedicated lift curtain machine. The closest standard for horizontal travel curtain machines is ANSI/CAN/UL 325 (Standard for Door, Drapery, Gate, Louver, and Window Operators and Systems). UL 325 is intended for rigid objects on powered actuators and does not address the unique conditions created by curtains.

Therefore, the hope is that this document will serve as the reference standard for machine designers, manufacturers, installers, and end users.

1 Administration

1.1 Scope

This standard establishes requirements for the design, manufacture, installation, inspection, and maintenance of machines intended for the movement of curtains. Curtains operated by these machines may be for scenery, performance, presentation, acoustical dampening, museum exhibits, retail displays, and theatrical production. Specifically included are control systems, mechanical construction, and powertrain components of said machines.

Excluded are the track, load carrying systems, and the curtain fabric construction.

Curtain effect machines such as Kabuki releases, and suck drops (curtain drums) are not included because they do not have the ability to automatically reset to a start position.

This standard does not apply to the structure to which the machine is attached, or machines covered by other existing standards such as utility hoists, fire safety curtains or performer flying.

1.2 Purpose

This standard defines the unique requirements for a definite purpose machine in contrast to a general-purpose machine such as those defined as powered hoists.

1.3 Alternative designs

The provisions of this standard are not intended to prohibit any design, materials, or methods of fabrication, provided that any such alternative is at least the equivalent of that described in this standard in quality, strength, and effectiveness.

2 Referenced publications

2.1 General

The following documents are referenced. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document, including any amendments, shall apply.

2.2 Publications

ANSI/AWS D1.1/D1.1M:2020 American Welding Society - *Structural Welding Code – Steel*
ANSI B11.TR3 2000 (R2015) Risk Assessment and Risk Reduction
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*

3 Definitions

3.1 Bottom pipe. A rigid or semi-rigid tube, rod, or equivalent placed in the bottom hem or behind a curtain or screen for the purpose of horizontal stabilization or additional weight. (also referred to as "bottom batten")

3.2 Characteristic load. The maximum force applied to a component of a curtain machine resulting from normal intended operating conditions while the system is at rest or in motion. This includes the apportioned fractions of the working load limit (WLL), self-weight including that due to load carrying devices and lifting media, and the forces due to inertia in normal use. (See Annex note.)

3.3 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.

3.4 Control station. A part of the control system that governs motion control of one or multiple curtain machines. The control station includes at least one motion control device (e.g., a "go" button, a "joystick", an "up / down" button pair, or any other device) that, when actuated, initiates motion of a machine.

3.5 Curtain. A flexible finished scenic, decorative, architectural, or utility element used to provide cover or separation between areas. A curtain may be transparent, translucent, or opaque. Curtains may be fabricated

from one or more materials combined into a singular finished flexible element. For the purposes of these definitions, retractable projection screens can be considered curtains. (See Annex note.)

3.6 Fabric. A material that characteristically flexes in all directions. Fabrics may be comprised of woven, knit, or bonded fibers which may be natural or synthetic. This definition may also include non-textile flexible materials including thin plastic sheeting, screening, and netting. Also included are flexible metal meshes.

3.7 Failure. Termination of the ability of an item to perform a required function. After a failure, the item has a "fault". A "failure" is an event, as distinguished from "fault," which is a state.

3.8 Fault. The state of an item characterized by inability to perform a required function.

3.9 Horizontal travel machine. A curtain machine used to move a curtain laterally.

3.10 Interlock device. A switch, sensor, or interconnected logic system that permits or prevents motion.

3.11 Limit, normal. A limit switch or sensor that prevents further movement in the direction of travel. (e.g., end of travel, initial)

3.12 Limit, positioning. A limit switch or sensor that stops a machine at a position between the end of travel limits.

3.13 Limit, secondary. A limit switch that senses over-travel in the event of failure of the normal position limit. (e.g., over-travel)

3.14 Limits of use. The parameters under which the system is designed to operate (e.g., working load limit, speed of movement, duty cycle, environmental conditions, user skill level, availability of maintenance).

3.15 Line weight. A device attached to the operating media to prevent slack lines or underweight operation. Line weights can be comprised of several different materials (e.g., steel shot, sand, solid stock, sash weights).

3.16 Load carrying device. The component(s) of a vertical travel curtain machine that connect the curtain to the lifting media (e.g., batten, truss).

3.17 Load securing device. A mechanical device that prevents unintentional movement of the curtain machine load.

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

3.19 Must. Indicates a mandatory requirement.

3.20 Operating media. The load carrying element that is driven by the machine to move the curtain or carrier (e.g., fiber rope, wire rope, webbing, roller chain).

3.21 Operational envelope. The area in which a curtain may move based upon the intended system design and operational limitations of the machine.

3.22 Operator intervention. Access point allowing a human operator to enable, stop, or otherwise control a machine's functions. A function of control stations.

3.23 Peak load. The maximum force applied to a component of a curtain machine, while the system is at rest or in motion, resulting from abnormal conditions or irregular operation (e.g., effects of uncontrolled stops, stalling of the prime mover, extreme environmental conditions). (See Annex note.)

3.24 Pile-on drum. Drum in which the individual lifting media winds in concentric layers and are constrained to rest on the prior layer.

3.25 Power transmission system. The components within the curtain machine that create, transfer, support, or dissipate mechanical force and motion (e.g., motors, gears, shafts, clutches, couplings, bearings).

3.26 Prime mover. A device that originates mechanical force and motion within a hoist power transmission system (e.g., electric motor). (See Annex note.)

3.27 Projection screen. A flexible media used as a substrate for projected lighting, images, and scenery.

3.28 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.

3.29 Reasonably foreseeable misuse. Use in a way that is predictable, but not intended (e.g., deliberate misuse of the machine to save time or materials, inadequate operator training).

3.30 Rigging hardware. Hardware used to attach lifting media or other rigging components to the load, anchorage, or each other. (e.g., shackles, eye bolts, eye nuts, turnbuckles)

3.31 Risk. Combination of the probability of occurrence of harm and the severity of that harm.

3.32 Risk assessment (RA). The process of identifying, evaluating, and quantifying the potentially hazardous conditions, severity, and probability of occurrence of harm.

3.33 Risk reduction (RR). Mitigation of risk created by hazardous conditions.

3.34 Screen. a) An open mesh fabric or fine netting (e.g., scrim or window screen); b) See projection screen.

3.35 Shall. Indicates a mandatory requirement.

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

3.37 Static load. The maximum force applied to a component of a curtain machine resulting from normal intended operating conditions while the system is at rest. This includes the apportioned fractions of the working load limit (WLL) and self-weight, including that due to load carrying devices and lifting media.

3.38 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.

3.39 System designer. The person or persons who specify the limits of use of the system and may also select and integrate the components of the system.

3.40 Top Pipe. A horizontal tube or equivalent used for suspending the top hem or other top finish of a curtain.

3.41 Ultimate load carrying capacity. The maximum load a component may support without fracture, buckling or crushing. This value may be calculated as the nominal strength using nationally recognized construction standards appropriate for the given material or by laboratory tests.

3.42 Vertical travel machine. A curtain machine used to move a curtain in the up and down directions.

3.43 Winding drum. A device used to connect the lifting media to the power transmission of a curtain machine; converts rotary motion of the gear shaft to linear motion of the operating media.

3.44 Working load limit (WLL). The maximum static load the user may apply.

4 Risk Assessment (See Annex note.)

Requirements for curtain machines shall be determined by risk assessment of the machine usage. Basic conditions for each risk assessment level are:

4.1 Level 1: Machines with very low risk for injury or damage.

4.1.1 Operational Envelope
Machines shall operate with no personnel in the operational envelope. (See Annex note.)

4.1.2 Curtains
Curtains may contain rigid components (e.g., projection screen masking edging)

4.1.3 Controls

4.1.3.1 Latching operation shall be permitted.

4.1.3.2 Machine may be initiated by a remote system (e.g., Show control, building automation)

4.2 Level 2: Machines with low risk for injury or damage. (See Annex note.)

4.2.1 Operational Envelope
The operational envelope may have personnel or objects that may be injured or damaged if contacted by the curtain. Personnel may not have knowledge of the operation or existence of the curtain machine.

4.2.2 Curtains

4.2.2.1 Curtains shall be entirely flexible with the exception of lightweight stiffeners (e.g., standard bottom pipe or leading-edge reinforcement that is not rigidly fixed to the track or carriers).

4.2.2.2 Fiberglass rods, lightweight stiffeners (e.g., cellular core PVC sheeting) are allowed. Framed panels and hard scenery shall not be permitted.

4.2.2.3 Bottom pipe used in vertical travel screens, roll drops, and lift curtains shall not exceed 0.5 pound per linear foot.

4.2.3 Travel Speed

4.2.3.1 Horizontal line speed should not exceed 100 fpm. (See Annex note.)

4.2.3.2 Vertical travel speed should not exceed 60 fpm.

4.2.4 Controls

4.2.4.1 Latching operation shall be permitted

4.2.4.2 Machine may be initiated by a remote system (e.g., Show control, building automation)

4.2.4.3 Stop control shall be in line of sight of the system.

4.2.4.4 Accessible local control should be provided. (See Annex note.)

4.3 Level 3: Machines with moderate risk for injury or damage.

4.3.1 Operational Envelope
The operational envelope may have personnel or objects that may be injured or damaged if contacted by the curtain. Personnel has knowledge of the operation and existence of the curtain machine.

4.3.2 Curtains

4.3.2.1 Curtains shall be entirely flexible with the exception of lightweight stiffeners (e.g., bottom pipe or leading edge reinforcement that is not rigidly fixed to the track or carriers).

4.3.2.2 Fiberglass rods, lightweight stiffeners (e.g., cellular core PVC sheeting) are allowed. Framed panels and hard scenery shall not be permitted.

4.3.2.3 Bottom pipe used in screens, roll drops, and lift curtains may exceed 0.5 pound per linear foot.

4.3.3 Travel Speed

4.3.3.1 Horizontal line speed should not exceed 200 fpm. (See Annex note.)

4.3.3.2 Vertical travel speed should not exceed 120 fpm.

4.3.4 Controls

4.3.4.1 Hold-to-run operation should be required with initiation and supervision by the operator.

4.3.4.2 Curtain machines triggered by a remote system shall allow operator intervention. (e.g., enable switch, E-stop).

4.4 Level 4: Machines with significant risk for injury or damage.

4.4.1 Operational Envelope
The operational envelope may have personnel or objects that may be injured or damaged if contacted by the curtain. Persons in the operational envelope may not have knowledge of the operation and existence of the curtain machine (e.g., audience members, patrons)

4.4.2 Curtains

4.4.2.1 Curtains shall be entirely flexible with the exception of any required stiffeners (e.g., bottom pipe or leading-edge reinforcement that is not rigidly fixed to the track or carriers).

4.4.2.2 Fiberglass rods, lightweight stiffeners (e.g., cellular core PVC sheeting) are allowed. Framed panels and hard scenery shall not be permitted.

4.4.2.3 Bottom pipe used in screens, roll drops, and lift curtains may exceed 0.5 pound per linear foot.

4.4.2.4 Curtains may contain rigid line weights or heavy bottom pipe used to achieve various curtain styles or functionality.

4.4.3 Travel Speed

4.4.3.1 Horizontal line speed may exceed 200 fpm. (See Annex note.)

4.4.3.2 Vertical travel speed may exceed 120 fpm.

4.4.4 Controls

4.4.4.1 Hold-to-run operation shall be required with initiation and supervision by the operator.

4.4.4.2 Curtain machines triggered by a remote system shall allow operator intervention. (e.g., enable switch, E-stop)

4.4.4.3 Curtain machines triggered by a remote system shall include safety interlocks or active monitoring. (See Annex note.)

4.4.4.4 Lift curtain machines shall incorporate redundancy in controls and mechanical components complying with the requirements of Chapters 6 and 7 of this document.

5 General Design Requirements

5.1 Curtain machines shall be designed by qualified persons.

5.2 Curtain machines shall incorporate all aspects of mechanical and control requirements herein (Section 6 – Mechanical design and Section 7 – Electrical equipment and control systems), unless otherwise determined by the risk assessment and risk reduction (RA/RR).

5.3 Curtain machines shall be designed for use in the anticipated environmental and operating conditions. The system designer shall define the limits of use.

5.4 Curtain machines shall be designed to allow for inspection, maintenance, and replacement. See also Chapter 10 – Installation.

5.5 Curtain machines shall be used in accordance with the manufacturer's recommendations.

5.6 Variations caused by the uneven application of load, deflections of lifted objects, deflection of supporting structure or Curtain system supports, and control synchronization errors, shall be assessed.

5.7 Calculation of the peak load shall assess the maximum torque output from the prime mover in a stalling condition and the effects of uncontrolled stops.

5.8 Curtain machines shall be designed for anticipated duty cycles and product life.

5.9 Curtain machines shall protect against uncontrolled speed and unintentional movements.

5.10 Curtain machine mounting shall resist unintentional sliding and detachment from the supporting structure in both the vertical and horizontal directions.

6 Mechanical Design

6.1 General requirements (See Annex note.)

6.1.1 The curtain machine shall be capable of moving the load from a static condition and returning it to the static state, maintaining control throughout the operation. (See Annex note.)

6.1.2 Characteristic loads and peak loads shall be considered in determining the loads applied to the building structure. (See Annex note.)

6.1.3 Category 0 stops shall not cause permanent deformation or failure of any component or portion of the system.

6.1.4 Fasteners shall be self-locking or secured by alternate means to prevent loosening. All components shall be designed to resist unintentional loosening.

6.1.5 Welds within the load path shall comply with current applicable American Welding Society standards.

6.1.6 All components in the tension load path of the machine or engaging the operating media shall be considered part of the curtain machine. (See Annex note.)

6.2 Power transmission components

6.2.1 Design factors (See Annex note.)

6.2.1.1 Machines with horizontal operation

For power transmission components that have a manufacturer’s recommended load rating, the characteristic load shall not exceed the mechanical load rating at a minimum Service Factor of 0.8. Power transmission components without manufacturer’s load ratings shall be designed so that stresses do not exceed the following:

6.2.1.1.1 Yield strength of the material shall be a minimum of 2X the shear stresses due to the characteristic load. (See Annex note.)

6.2.1.1.2 Yield strength of the material shall be a minimum of 1.58X the bearing (contact) stresses due to the characteristic load.

6.2.1.2 Machines with vertical or inclined operation

For power transmission components that have a manufacturer's recommended load rating, the characteristic load shall not exceed the mechanical load rating at a minimum Service Factor of 1.0. Power transmission components without manufacturer's load ratings shall be designed so that stresses do not exceed the following:

6.2.1.2.1 Yield strength of the material shall be a minimum of 3X the shear stresses due to the characteristic load. (See Annex note.)

6.2.1.2.2 Yield strength of the material shall be a minimum of 1.58X the bearing (contact) stresses due to the characteristic load.

6.2.1.2.3 For power transmission components for which the manufacturer has recommended load ratings, the load shall not be released upon application of the peak load. Power transmission components without a manufacturer's peak load rating shall be selected such that the peak load is less than the yield strength of the component.

6.2.1.3 Level 1 machines may have lower factors for safety when designed in accordance with section 5.2 of this standard.

6.2.1.4 The thermally limited load rating of power transmission components shall be suitable for the limits of use of the curtain machine. (See Annex note.)

6.2.2 Motors

6.2.2.1 Curtain Machine motors shall be sized appropriately for capacity, design criteria, and duty cycle.

6.2.2.2 Vertical and incline curtain machine motors shall have a minimum starting torque of 1.5X of the static load. Variable speed curtain machine motors shall have a minimum starting torque of 1.1X of the characteristic load.

6.2.2.3 Curtain machines shall be designed to prevent loss of directional control while reversing the motor. (See Annex note.)

6.2.3 Load securing devices

6.2.3.1 Horizontal travel curtain machines do not require a load securing device.

6.2.3.2 Vertical or incline travel machines shall include a load securing device.

6.2.3.3 The load securing device shall automatically engage when operational controls are released, or drive power is removed.

6.2.3.4 A low back-driving efficiency gear reducer, or a device that slows a load without stopping it may be used in place of a load securing device only when risk assessment and risk reduction mitigates hazards associated with descent of the load.

6.2.3.5 The load securing device shall not require external power to engage.

6.2.3.6 The load securing device shall be capable of stopping and holding 1.1X the static load unless otherwise permitted by section 6.2.3.4.

6.2.3.7 It shall be possible to test the effectiveness of a load securing device.

6.2.4 Chain and Belt Transmissions

This section applies to devices that transmit power to the transmission components.

6.2.4.1 Transmission media shall wrap the sprocket or pulley for sufficient distance to provide adequate strength and avoid disengagement.

6.2.4.2 A mechanism shall be included to prevent the chain from disengaging the sprocket teeth.

6.2.4.3 Sprockets shall be selected to mitigate the effects of chordal action.

6.2.4.4 Engineered material may be used to support chain sag.

6.2.4.5 Sprockets and pulleys shall be secured to maintain proper alignment.

6.2.4.6 Friction or toothed drive belts shall not be used in overhead lifting machines unless a load securing device is located on the load side of the system.

6.2.5 Winding drums

6.2.5.1 Winding drums shall take up the media in a defined and repeatable manner.

6.2.5.2 Winding drums shall be designed to take up the media in a way that does not cause damage or undue wear. Pitch diameter shall be appropriate to the service life.

6.2.5.3 Drum material and construction shall resist tread pressures imposed by the media.

6.2.5.4 Helically grooved drums (See Annex Note.)

6.2.5.4.1 The maximum allowable fleet angle from a grooved drum shall be two (2) degrees from perpendicular to the drum.

6.2.5.4.2 Grooves on rope drums shall be sized as recommended to support the media and to prevent crushing.

6.2.5.5 Pile-on drums shall have individual winding chambers, for each line, to ensure the media is layered in such a manner that its centerlines are aligned. (See Annex note.)

6.2.5.6 Roll tubes

6.2.5.6.1 Roll Tubes shall be of sufficient width to allow the media to offtrack in either direction without overhanging the edge of the drum.

6.2.5.6.2 Roll tube machines shall be designed with single point of failure analysis so the failure of one component will not allow the tube to fall.

6.2.5.7 Media terminations for lift curtain machines

6.2.5.7.1 The attachment of the media to a drum shall have a strength equal to or greater than 1.33X the peak load. This shall be accomplished by end termination alone, or by including the friction from the minimum turns of lifting media on the drum.

6.2.5.7.2 The attachment of the fabric to a roll tube is highly dependent on the curtain installed. The attachment method shall be developed and tested based on the individual application. The attachment shall have a strength equal to or greater than 2X the characteristic load including any bottom stiffener or reinforcement. This shall be accomplished by end termination alone, or by including the friction from the minimum turns of curtain on the tube.

6.3 Machine frames and static load bearing components.

6.3.1 Machine frames and static load bearing components shall be designed with a yield strength at least 2X the characteristic load. The ultimate load carrying capacity of the device shall be at least 3X the characteristic load.
6.3.2 Machine frames and static load bearing components shall be designed with an ultimate load carrying capacity at least 2X the peak load.

6.3.3 Deflection of load bearing components shall not be detrimental to machine operation.

6.4 Operating Media

6.4.1 General (See Annex note.)

6.4.1.1 Operating media shall be sized appropriately to the load being moved as determined by a qualified system designer.

6.4.1.2 Operating media shall not contact any part of the building structure, adjacent systems, or other equipment not intended for contact.

6.4.1.3 The grade and construction of operating media shall be appropriate for the intended use.

6.4.1.4 Anticipated duty cycle, detrimental conditions such as reverse bending, and environmental conditions shall be factored into the selection of operating media.

6.4.1.5 Operating media termination hardware shall have strength equal to or greater than 1.33X the peak load.

6.4.2 Lifting media used in RA Level 3 and 4 machines shall have the following additional requirements.

6.4.2.1 Minimum tensile strength of lifting media shall be no less than the following:

5X the characteristic load.
8X the static load.
1.33X the peak load.

6.4.2.2 For multiline lift machines and clews, the peak load for lifting media shall not exceed 6X the characteristic load. (See Annex note.)

6.4.2.3 The minimum tensile strength shall include termination efficiency and other applicable strength reduction factors. End termination of the lifting media shall have a minimum tensile strength not less than 8X the static load.

6.4.3 Wire rope requirements for vertical travel machines. (See Annex note.)

6.4.3.1 Wire rope clips shall be of forged steel or equivalent construction. Malleable wire rope clips shall not be permitted.

6.4.3.2 Swages shall be copper. Plated copper swages shall be used for stainless steel wire rope.

6.4.3.3 Thimbles shall be sized in accordance with the wire rope diameter.

6.4.4 Roller chain

Roller chain used as operating media shall comply with the following requirements in addition to the requirements of section 6.2.4.

6.4.4.1 Systems shall provide a method to prevent unintended disengagement from the sprockets.

6.4.4.2 When roller chains are used in combination with wire rope, provisions shall be made to prevent torsion induced by the wire rope twisting the roller chain beyond its functional limits.

6.4.4.3 Roller chain connections shall distribute the load evenly to the link plates on both sides of the chain. A connection that pivots freely about an axis perpendicular to that of the chain pins shall be permitted.

6.4.4.4 Chain tensioning devices shall be provided as required.

6.4.5 Fabric

6.4.5.1 Fabric shall comply with the requirements of 6.4.1 and 6.4.2 as appropriate. (See Annex note.)

6.4.5.2 In addition to tensile strength, resistance to shear must be considered and mitigated.

6.4.5.3 Vertical fabric edges shall be appropriately finished to prevent tearing or fraying. (See Annex note.)

6.4.5.4 Roll drum curtains are typically manufactured with horizontal seams. The strength of the bond (e.g., stitching, fusing) between panels shall be factored when determining the strength of the finished curtain.

6.4.5.5 Environmental conditions (e.g., UV, caustic atmospheres, flame resistance) shall be factored into the selection of fabric. (See Annex note.)

6.4.5.6 Fabric shall be flame resistant or treated with flame retardant.

6.4.5.7 Fabric shall be capable of supporting its self-weight plus any attached hardware (e.g., bottom batten or oleo roller).

6.4.6 Other operating media

This section covers operating media not specifically addressed by previous sections, such as webbing, sash cord, and wire center rope.

6.4.6.1 Terminations shall be made by a competent person.

6.4.6.2 Other lifting media shall be permitted provided the manufacturer approves it for this use. (See Annex note.)

6.5 Rigging Hardware

6.5.1 Shackles, eyebolts, eye nuts, and turnbuckles shall be of forged steel or equivalent construction.

6.5.2 Turnbuckles shall be secured after adjustment to prevent turnbuckle body rotation.

6.5.3 Screw pin shackles and turnbuckles with screw pin jaws shall be secured to prevent disconnection.

6.6 Blocks

6.6.1 Blocks shall be selected so that the characteristic load does not exceed its working load limit.

6.6.2 Blocks and other reeving components shall be mounted in a manner that permits inspection, maintenance, and replacement.

6.6.3 The maximum allowable fleet angle for operating media through a block shall not cause damage to the sheave or the operating media.

6.6.4 Operating media shall be prevented from unintentionally disengaging from sheaves.

6.6.5 Sheave diameter, sheave material, operating media, and anticipated duty cycle shall be factored into the selection of the block.

6.6.6 Manufacturer shall specifically designate blocks for motorized operation.

6.6.7 Blocks used in vertical travel curtain systems shall comply with the following additional requirements.

6.6.7.1 The working load limit for the block shall meet the following criteria:

6.6.7.1.1 For failure modes that result in yield of ductile materials, the yield strength of the material shall be at least 4X the characteristic load stresses.

6.6.7.1.2 For failure modes that result in collapse or fracture, the yield strength of the material shall be at least 6X the characteristic load stresses.

6.6.7.1.3 For bearing contact stress failure modes, application of the characteristic load shall not result in stresses greater than the yield strength of the material.

6.6.7.1.4 For rolling element bearings, application of the characteristic load shall result in a calculated L10 life of at least 2000 hours at maximum system design speed.

6.6.7.2 Blocks shall be selected so that the characteristic load does not exceed its working load limit.

6.6.7.3 Blocks shall be selected so that the block's ultimate load carrying capacity is at least 1.33X the peak load.

6.6.7.4 For single line blocks within multiline systems, the peak load for blocks shall not exceed 6X the characteristic load. (See Annex note.)

6.6.7.5 Shafts shall be installed so that no thread contacts the bearing or sheave housing. Shafts shall be locked against rotation within the block housing, unless specifically designed to rotate. Shafts shall not move axially.

6.7 Other Operational Track Components

6.7.1 Adequate end stops shall be provided on the track to contain the carriers.

6.7.2 Driven Carriers (See Annex note.)

6.7.2.1 Driven carriers shall be adequately attached to the operating media.

6.7.2.2 Systems may allow disengagement of driven carriers from the operating media (See Annex note.)

6.7.2.3 Driven carriers may have an engineered point of failure in their attachment to the operating media.

6.7.3 Self-propelled carriers are motorized carriers using traction or rack and pinion mechanics to engage the track. These carriers shall meet all applicable requirements of Sections 6.1, 6.2, and 6.3 of this standard. Additionally, the electrification system shall comply with the requirements of Chapter 7 of this standard.

6.8 Load carrying devices

6.8.1 Load carrying devices shall be selected so that the yield strength of the device is at least 2X times the characteristic load. Load carrying devices shall be selected so that the ultimate load carrying capacity of the device is at least 1.5X the characteristic load or the peak load resulting from uncontrolled stops. (See Annex note.)

6.8.2 Aluminum trussing shall meet the requirements of ANSI E1.2-2021, and deflection shall be calculated based on the characteristic load designated in the system designer's limits of use. Forces generated by the calculated deflection shall not exceed the maximum allowable component forces.

6.8.3 The bottom roller of an oleo drop and the bottom tray of an acoustic baffle shall be considered load carrying devices.

6.8.4 The bottom batten in an Austrian, Venetian, Brail, or Roman curtain may be considered load carrying devices.

6.9 Guarding

6.9.1 Exposed moving parts on or within 2.13 m (7 ft) above a walking/working surface, or that otherwise constitute a hazard, shall be guarded. Exposed moving parts within a 0.92 m (3 ft) horizontal reach of a walking/working surface shall be guarded.

6.9.2 Equipment located in technical spaces shall be guarded in accordance with this section, except that the lifting media, sheaves, drums used for lifting media, sprockets, and shaft assemblies turning at the same speed as the drums need not be guarded when the following requirements are met:

6.9.2.1 Access to the technical space is limited to authorized persons only.

6.9.2.2 A remote emergency stop, machine stop, or motor disconnect is located within reasonable proximity to the machine.

6.9.2.3 Clearances shall be provided around machines such that people need not contact unguarded components to access any part of the technical space. Contact with lifting media shall be permitted.

6.9.2.4 Shaft RPM and line speed are considered in the risk assessment.

6.9.3 When guards are located underfoot, or in such a manner that they are intended to serve as a step, they shall be capable of supporting, without permanent distortion, the weight of a 140 kg (310 lb) person.

6.9.4 Guards shall be secured.

6.9.5 Guards shall not create a hazard.

6.9.6 Guards shall be removable for service.

7 Electrical Equipment and Control Systems

7.1 Classification

There are many types of curtain machines, and as such the requirements for the control system are varied. These include the power of the machine, the supply voltage, the type of building and environmental conditions, and the risk category of the application.

7.1.1 Type of Installation

Curtain machines and their associated controllers that are labeled “Not for Commercial Use” or “For Residential Use Only” shall not be used for permanent installation. These may be applicable for temporary use on a set piece, if they meet all other relevant requirements.

7.1.2 Environmental conditions

Curtain machines and their associated controllers are to be installed in a dry, dust-free environment with an ambient temperature not to exceed 40°C (104°F). Machinery and controls exposed to heat, cold, rain or splashing water shall have their application specifically investigated and mitigated using the RR/RA process.

7.2 General Requirements

7.2.1 All systems must conform to the applicable requirements of NFPA 70 and any local codes.

7.2.2 Industrial Control Panels

The control system shall be in general conformance with NFPA 79, Industrial Control Panels as modified by the requirements set forth in this section.

7.2.2.1 Phase loss and rotation protection

Where a phase loss or an incorrect phase sequence of the supply voltage causes a hazardous condition or damage to the machine, protection shall be provided. Curtain machines in RA levels 1 and 2 are exempt. (See Annex note.)

7.2.2.2 A curtain machine with associated motor controls that is Listed and Labeled by an NRTL under an appropriate standard that address the electrical safety of the device is exempt for Level 1 & 2 machinery installations. (See Annex note.)

7.2.3 Thermal Overload

Motor controllers shall incorporate a thermal overload device.

7.2.4 Unintended start
The start and restart of a curtain machine shall require deliberate action by the operator.

7.2.5 Overcurrent Protection
Motor controllers shall incorporate an overcurrent device.

7.2.6 Reversing Contactors
Electrical and mechanical interlocks shall be provided to prevent simultaneous activation in both directions.

7.2.7 Ambient Conditions
All electrical equipment shall be designed and chosen to operate correctly in the expected environmental conditions.

7.2.8 Enclosures
Electrical enclosures shall be selected based on the environmental conditions.

7.2.9 Tubular Motors
A curtain machine incorporating a tubular motor with integral starter and thermal protection must meet the following requirements:

- The motor power shall not exceed ¾ hp or 562 Watts.
- Single phase AC motor voltage may be 120 or 240 VAC.
- DC motors shall not exceed 48 VDC.
- The motor shall be equipped with integral end of travel limit switches.
- The duty cycle for full round-trip operation of open and closed, or up and down, shall not exceed the thermal time limit of the motor.
- Any cable with attached power plug shall not be severed.
- The branch circuit protection to the outlet supplying the motor may not exceed 20 amps.

7.2.9.1 The motor start and reversal may be accomplished by connecting and reversing the current carrying conductors.

7.2.9.2 The motor start and reversal may be accomplished by a serial, low voltage, or wireless interface.

7.2.9.3 When the Category application or the RA/RR deems that overtravel limits are required, the control circuit must interrupt both power phases to the motor.

7.2.9.4 When the Category application or the RA/RR deems that a secondary brake is required, the control circuit for the secondary brake must interrupt both power phases (conductors) to the motor.

7.3 Interconnection wiring

7.3.1 Cables and wiring between control equipment shall be installed as required by applicable electrical codes.

7.3.2 Line voltage and control voltage shall be separated.

7.3.3 Connectivity to limit switches and sensors may be made with plug and play connectors. Cable and connectors used in these applications shall be appropriately rated for the environmental conditions in which they are installed.

7.4 Electrical Disconnect (See Annex note.)
A means shall be provided to disconnect the electrical machinery from the power source. The disconnect method shall not create a hazard.

7.4.1 The disconnecting means must be lockable.

7.4.2 The disconnecting means may be incorporated into the Motor Control Panel or adjacent to it.

7.4.3 When a motor disconnect is also required:

7.4.3.1 All line voltage motor leads and brake leads shall be disconnected.

7.4.3.2 A multi-pole cord and plug may be used. The receptacle shall be dedicated for the purpose of this machine. (See Annex note.)

7.5 Control stations (See Annex note.)

7.5.1 In the event of a control signal loss, the machine that lost the signal shall stop.

7.5.2 Access control shall be determined by RA/RR process.

7.5.3 Portable control stations shall be permitted.

7.5.4 Control operators, including pushbuttons, toggles, selectors, and joysticks shall be labeled with their function.

7.5.4.1 Operator control stations shall contain control means and status indication as required for the operation of the curtain machine.

7.5.4.2 Systems may be hold-to-run or latching based on RA/RR level. Generally, RA level 1 and 2 are exempt from hold-to-run requirements.

7.5.5 Control stations may be equipped with an Emergency Stop based on RA/RR level. Generally, RA level 1 and 2 are exempt.

7.6 Constraining travel

Design of the curtain system shall allow enough distance for deceleration from full speed, after activation of any limits, so that damage to the machine or additional hazards shall not be created. Limits are known by many names while serving common functions.

7.6.1 Loss of signal from end of travel limits shall stop the curtain machine.

7.6.2 The normal limit shall prevent further movement in the direction of travel. A position sensor may be used as a normal limit. When the normal limit is activated, movement in the opposite direction shall be allowed.

7.6.3 When secondary limits are required, their activation shall only allow the curtain machine to move in the opposite direction and away from the limit. (See Annex note.)

7.6.4 When positioning limits are required, activation of this limit shall bring the machine to a stop at a predetermined location.

7.6.5 Limit switches and sensors that require removal of covers for adjustments shall be touch safe or a Low Voltage, Low Energy (LVLE) circuit.

7.6.6 Sensors

7.6.6.1 Sensing devices requirements

The type of sensing device applied to the individual curtain system installation shall be chosen with respect to function, reliability, and operation as required by the control system and by risk assessment. All sensors shall be installed per the manufacturer's recommendations.

7.6.6.2 Mechanical switches

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

7.6.6.3 Additional sensors

Additional sensors may be required based upon the RA/RR process. Examples include pocket door open/close sensors, light curtains, Lidar, or other safety sensing devices.

7.7 Normal stop

Normal stop switches are required to interrupt latched run operation. Normal stop operators may be a flat form factor (flush), or graphic representations based on software applications.

7.8 Emergency Stop

The RA level shall determine the necessity of an Emergency Stop system or circuit. When required, the system shall meet the following requirements:

7.8.1 E-Stop operators

7.8.1.1 Contacts for E-stop functions shall be normally closed and shall have a positive break operation.

7.8.1.2 Operators for activating E-stop functions shall be raised oversized mushroom head switches.

7.8.1.3 E-stop operators shall latch in the depressed mode and require a special operation to release.

7.8.1.4 E-stop operators shall be colored red. The background immediately around E-stop operators shall be colored yellow. The button or the yellow background must read E-Stop or Emergency Stop.

7.8.1.5 E-stop operators shall not be of a flat form factor (flush) nor graphic representations based on software applications.

7.8.2 E-Stop function

7.8.2.1 E-Stop contactor

A motor control panel 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.

7.8.2.2 Safe Torque Off (STO)

A variable frequency drive (VFD) with a certified STO circuit meets the requirements of 7.8.2.1.

7.9 Activation of the machine

7.9.1 Pushbutton control is common for level 1 and 2 curtain machines.

7.9.2 Latching operation shall incorporate a normal stop button.

7.9.3 Remote activation (BAC, Show Control)

7.9.3.1 I/O Control over dry contacts is permitted based on RA/RR. (e.g., Crestron, Lutron, AMX, Dry Contact)

7.9.3.2 Serial Control is permitted based on RA/RR. (e.g., MODBUS, SMPTE, MIDI, DMX)

7.9.3.3 All remotely activated systems shall meet the following requirements:

- In the event of a control signal loss, the machine shall stop and require deliberate initiation by the control system to restart.
- Latching operation shall incorporate a normal stop button.
- Stop circuit shall utilize normally open contacts held closed by the host system.
- Physical Normal Stop and E-Stop stations may be required, in the vicinity of the operating envelope, according to RA/RR.
- Systems incorporating an E-Stop shall communicate its status to the initiating system.

8 Documentation

8.1 General

8.1.1 The supplier shall furnish a system manual or manuals, covering operations and maintenance of the system. (See Annex note.)

8.1.2 The system manual may be in hard copy or electronic format.

8.1.3 Necessary drawings of the curtain machine and installation shall be included.

8.1.4 The system manual shall state the limits of use.

8.2 Manual

The system shall be clearly described in this section and shall include, at minimum:

- Mounting and assembly
- Wiring
- Start-up
- Setting limit switches
- The maintenance section shall include recommendations for inspection, testing, and maintenance of the system.
- Troubleshooting Procedure for manual operation if equipped.

8.3 Additional Requirements

Level 3 and level 4 machines shall meet the following additional requirements as applicable:

8.3.1 A description of each safety function.

8.3.2 Descriptions of fault indications, including system responses and corrective procedures.

8.3.3 Comprehensive operator instructions.

8.3.4 A log for documenting inspections and work performed.

8.3.5 Curtain machines shall have a documented procedure for conversion to manual drive if this option is provided.

9 Labeling, Marking and Signage

9.1 Labeling and signage shall comply with the requirements of the following standards, where such requirements can be implemented with rigging components, assemblies, and systems:

ANSI Z535.1-2017, *Safety Color Code*
ANSI Z535.2-2011 (R2017), *Environmental and Facility Safety Sign*
ANSI Z535.3-2011 (R2017), *Criteria for Safety Symbols*
ANSI Z535.4-2011 (R2017), *Product Safety Signs and Labels*

9.2 The curtain machine shall have a label affixed indicating the manufacturer’s name, unique identification, date of manufacture, and rated capacity if applicable.

9.3 Lift curtain machines shall be labeled as a dedicated purpose machine at the load carrying device. (See Annex note.)

9.4 Lift curtain machines shall be marked with their working load limit (WLL).

9.5 The lifting media size and type shall be clearly indicated either by a label affixed to the machine or a sign or label directing the maintenance personnel to the system manual.

9.6 Electrical equipment and control systems shall be marked and labeled in compliance with the requirements of NEC and NFPA 79 or other applicable product safety standard.

9.7 Signage

9.7.1 Signage shall be required for all level 4 machines and as determined by the RA/RR process.

9.7.2 Signage shall be placed in clearly visible, accessible location(s).

9.7.3 Signage shall state that operation of the curtain machine shall be restricted to authorized persons.

9.7.4 Signage shall list the contact information for the supplier of the system.

10 Installation

10.1 Curtain machines shall be installed according to the designer's or manufacturer's recommended criteria and installed by a qualified person.

10.2 Machine installation shall comply with applicable building and electrical codes.

10.3 This standard applies to the curtain machine, but its operation is integral to the installed track and suspended rigging. Statically suspended rigging shall comply with ANSI E1.4-2 (Statically Suspended Rigging Systems).

10.4 Curtain machines attached to moving support systems (e.g., flown truss, battens) have unique situations including power and control feeder cable systems. The rigging systems these machines are attached to shall be in conformance with ANSI E1.4-1 (Manual Counterweight Systems) or ANSI E1.6-1 (Powered Hoist Systems) as applicable.

10.5 Soft goods installed on powered curtain machines shall comply with NFPA 701.

10.6 Curtain machines shall be installed in a way that allows access to the machine for maintenance, adjustment, and changes to limits or positioning. (e.g., access panels, catwalks, lift access)

10.7 Curtain machines defined by this standard shall not be used for flying performers. See ANSI E1.43 (Performer Flying Systems)

11 Inspection and testing

11.1 General requirements

11.1.1 The system designer or manufacturer shall establish recommended criteria for inspection and testing. These criteria shall be included in the systems operation manuals. In absence of established criteria, testing and inspection shall follow the procedures included herein.

11.1.2 Inspection and testing following installation shall verify that all system components and connections are present in the system, and that they comply with the design and operating criteria.

11.1.3 Systems shall be tested after installation, mishap, repair, or modification.

11.1.4 Inspection and testing for machines in levels 1 through 3:

11.1.4.1 Inspections and testing may be performed by a competent person.

11.1.4.2 Deficiencies discovered during inspection or testing shall be repaired under the supervision of a competent person.

11.1.4.3 Systems shall be inspected every 5 years, or on a more frequent schedule, as determined by a qualified person. Frequency may be determined by the manufacturer's recommended criteria.

11.1.5 Inspection and testing for machines in level 4 installations

11.1.5.1 Inspections and testing shall be performed by a qualified person.

11.1.5.2 Deficiencies discovered during inspection or testing shall be repaired under the supervision of a qualified person.

11.1.5.3 Systems shall be inspected annually, or on a more frequent schedule, as determined by a qualified person. (See Annex note.)

11.2 Minimum criteria for inspection (See Annex note.)

11.2.1 Components of the curtain machine shall be visually inspected for wear and damage.

11.2.2 The curtain machines shall be operated through its full range of travel and speeds. Unusual noises, motions, or other issues shall be reported for resolution.

11.2.3 Functionality of the control system shall be verified.

11.2.4 The presence of all mandatory signage and labeling as required in Section 9 shall be verified.

11.3 Inspection of fabric

11.3.1 All fabric shall be flame retardant or treated to be flame retardant in accordance with applicable codes.

11.3.2 All fabric shall be in serviceable condition and free of tears, fraying, or indications of dry rot.

11.3.2.1 Fabric is the lifting media for oleo drops and requires thorough inspection. Fabric shall be pliable when painted or printed, and structurally sound and stable. (See Annex note.)

11.3.2.2 Roll drops and banners shall be pliable when painted or printed, and structurally sound.

11.3.2.3 Projection screens shall be inspected according to the manufacturer's recommendations for serviceability.

11.3.2.4 Curtains with bottom battens supported by fabric shall be intact and structurally sound.

11.4 Testing procedures

11.4.1 Tests shall be non-destructive.

11.4.2 Operation of the control system including all limit switches, safety devices and interlock devices shall be confirmed.

11.4.3 Any additional tests required by the designer or manufacturer shall be conducted.

11.4.4 Test failure shall result in corrections and retesting until the system passes the test.

11.4.5 Lift curtain machines shall require the following additional testing.

11.4.5.1 Lift curtain machines shall undergo dynamic load tests at their minimum and maximum rated speed and acceleration.

11.4.5.2 The emergency stop function shall be tested at the maximum rated speed. This test shall be conducted in both the ascending and descending directions. Components shall be observed for indications of malfunction. (See Annex note.)

11.5 Documentation of inspection and testing

11.5.1 Inspection reports and test reports shall include the name of the person who performed the inspection or tests, the location of the equipment, and the date of the tests or inspection. Reports shall be signed by the person who performed the inspection or tests.

11.5.2 Test reports shall include documentation of the test procedures and the results of the tests.

11.5.3 Inspection reports and test reports shall be placed in a system log. (See Annex note.)

Annex A

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

Annex A contains explanatory material and recommendations, labeled to correspond with the applicable text paragraphs.

A.3.2
A.3.23
A.6.1.2
The dynamic forces in curtain machines vary between horizontal and vertical applications. For machinery of this type, calculations based on the static load alone have been found to result in unacceptable variation of the strength of components when compared to the actual applied forces.

Design calculations performed according to this standard are based on three basic loading conditions: static, characteristic, and peak. The static load is that which occurs in a component while the system is in normal use but at rest. The characteristic load includes the static load but also any other forces that might occur during use such as inertial forces due to acceleration and those due to a moving or variable load on the batten. Finally, the peak load is the maximum load that can be reasonably anticipated to occur as a result of normal or abnormal conditions or irregular operation. All these loads are apportioned to each component based on the curtain machine system geometry and the maximum loads defined in the limits of use.

It is not possible to foresee every type of peak load or situation in which a piece of equipment might be misused. It is incumbent on the designer to anticipate those situations which are either likely to occur or could be of such a great consequence that the user must be protected. One common source of peak loads is an uncontrolled stop such as that experienced in the event of a power failure and the resulting sudden application of the brakes. Another common peak load would occur when the full strength of a stalled motor comes to bear on a load in excess to the machine capacity such as a condition where the load is caught on adjacent obstructions or is pulled into a block (two block) or during an attempt to move a load that is just too heavy.

Design factors applied to the static and characteristic loads are intended to be large enough to result in equipment that performs well throughout the product life just as long as it is operated within the limits of use. Design factors applied to the peak load are smaller by comparison and reflect the philosophy that although the machine is not intended to move those larger, atypical loads on a routine basis, it is intended that such an overload does not result in failure.

For further information, refer to the annex notes in ANSI E1.6-1.

A.3.5 Curtains can be comprised of many materials and may include columns of chain, beads, rope or other flexible medium (e.g., bead or chain mesh curtains). Curtains may have a rigid leading edge but are not entirely framed or rigid.
Framed panels and hard scenery are not allowed under this standard. Just because it is covered in fabric does not make it a curtain.

A.4 Note that there is no requirement that only one entity is responsible for the entire RA/RR. Any entity performing the RA/RR should take into consideration how the RA/RR of others may impact the analysis. RA/RR is an ongoing and iterative process. There are key points within the design, fabrication, installation, and production (show or normal usage) when the RA/RR must be performed in relation to the specific phase.

For example, the initial specifier will perform a RA/RR to define the limits of use of the curtain machine and its capabilities. The machine designer will perform a RA/RR for elements within the framework of the specification. An installer will perform a RA/RR to commission the system on site. The technical director will perform an RA/RR in the context of the performance or production.

A.4.1.1 Some systems are installed in acoustical chambers or overhead areas with controlled access. Screen masking systems are frequently installed against walls or in other areas that personnel or objects are unlikely to enter.

The operational envelope for overhead systems extends to the full area below the system if there is potential for injury or damage. Therefore, some systems that appear to be a level 1 are actually a level 2 or 3.

A.4.2 This category covers many typical installations and is intended to include most travelers, and lightweight lift curtains.

A.4.2.3.1 Line speed is the most consistent means of determining the speed of a machine or system. A one-way draw system moves at 1x the line speed. A bi-parting system has a functional speed of 2x the line speed. As each panel moves at line speed, the size of the opening increases or decreases at double the speed of each individual panel.

A.4.2.4.4 Local controls and the ability to stop the machine are recommended for all installations regardless of normal initiation or activation method. These controls should be in a location that can be accessed by reasonable means with no use of ladders.

A.4.3.3.1 Line speed is the most consistent means of determining the speed of a machine or system. A one-way draw system moves at 1x the line speed. A bi-parting system has a functional speed of 2x the line speed. As each panel moves at line speed, the size of the opening increases or decreases at double the speed of each individual panel.

A.4.4.3.1 Line speed is the most consistent means of determining the speed of a machine or system. A one-way draw system moves at 1x the line speed. A bi-parting system has a functional speed of 2x the line speed. As each panel moves at line speed, the size of the opening increases or decreases at double the speed of each individual panel.

A.4.4.4.3 Show or ride control systems frequently use LIDAR, light curtains, or other zone monitoring devices, sensors, and systems to prevent machine movement if the operational envelope is breached.

A.6.1 Design factors used in this standard are based on strength. Deflection, fatigue and other serviceability concerns also need to be considered when selecting curtain machine components. The thermal limits of power transmission components need to be evaluated per intended limits of use.

A.6.1.1 Various curtain effects require manual intervention to reset or restore normal operation of the machine (e.g., kabuki curtain release mechanisms and curtain sniffers/suck drops). These types of curtain effect machines are not covered under this standard.

A.6.1.2 (See A.3.2)

A.6.1.6 Components like master carriers, live and dead end pulleys horizontal track systems are part of the tension load path. Whereas individual curtain carriers are not. Note that backpack carriers are considered part of the system when moving in the open direction of travel.

A.6.2.1 Uniform load and eight hours per day of use are equivalent to a Service Factor of 1.0. The service factor may need to be increased to account for duty cycle and environmental conditions.

A distinction is made between components that are rated based on endurance and specified using service factors, e.g., gear reducers and couplings, and those for which strength is the basis of design such as keys and shafts. Peak loads are limited to the manufacturer’s peak load rating or the yield strength of the component to prevent excessive deformation or failure.

A.6.2.1.1.1 The 2X shear stress factor is approximately equal to a 4:1 design factor on the static load assuming an additional 40% for dynamic loading. Peak loads are limited to the manufacturer’s peak load rating or the yield strength of the component to prevent excessive deformation or failure.

Failure mode of power transmission components does not factor into horizontal travel machines. Should failure occur, the load will not be released.

A.6.2.1.2.1 The 3X shear stress factor is approximately equal to the current ASME B30 series requirements for a 5:1 design factor on the static load assuming an additional 75% for dynamic loading. Peak loads are limited to the

manufacturer's peak load rating or the yield strength of the component to prevent excessive deformation or failure.

A.6.2.1.4 A distinction is made between mechanical strength and thermal capacity of power transmission components. When thermally limited components are selected it is important to verify that the mechanical design factors within this standard are maintained.

A.6.2.2.3 Machines powered by most single-phase motors require the motor to come to a complete stop prior to reversing the direction. This stop allows the centrifugal direction starting switch to come to rest and the motor to be electrically reversed. An example of the potential hazard occurs when a lift curtain machine is running in the up direction. If the down pushbutton is simultaneously pressed and then the up pushbutton is released, the machine will not change direction of travel. The machine will bypass the normal limit switches and only be stopped by the secondary limits. Preventive remedies include mechanically interlocking switches, and interposing timer relays.

Curtain machines powered by three phase motors may exhibit a loss of direction control when a phase has been lost in the power circuit. Initially the lift curtain machine may run down in a "single phasing mode", where gravity has started the rotation. Attempts to reverse the direction of operation from down to up will not be successful and motion will only continue in the down direction. The inclusion of phase loss monitors in the control system are a common preventive remedy.

A.6.2.5.4 For additional information on selection of wire rope and grooved drum design, see ANSI E1.6-1.

A.6.2.5.5 Pile-on drums should be used with caution. As the lifting media winds on to the drum the pitch diameter is increased with each layer, resulting in increased media speed and reduced load capability. The pitch diameter is affected by factors such as the clearance between the lifting media and the drum side plates, and by the crushing, stretching, or distortion of the lifting media. Synchronizing multiple lift lines may be especially difficult.

A.6.4.1 Lifting media should be selected, consistent with the application, for cut and abrasion resistance; heat weakening and flammability resistance; strength reduction from bending ratios and fatigue, and in consideration of environmental factors (cold, heat, atmospheric) for strength, flexibility, and durability.

A.6.4.2.2
A.6.6.7.4
In multiple line lift curtain machines, the actual peak load on a single line may be equal to the stalling strength of the machine. Current practice assumes that this may result in isolated failure of lifting media or rigging components. Limiting the peak load to 6X the characteristic load provides reasonable design strength.

A.6.4.3 There are no specific requirements for wire rope used in horizontal applications.

A.6.4.5.1 Design factors for the fabric in oleo drops should consider the effect of scenic treatments to the fabric. Regular inspection of the working fabric is of particular importance.

A.6.4.5.3 Woven and knit textiles are typically serged if made from natural fibers. Synthetic fibers can be fused. Bonded materials (e.g., vinyl) may not require edge preparation.

A.6.4.5.5 These environments are common conditions for cruise ships, theme parks, and enclosed swimming pools.

A.6.4.6.2 The approval is required from either the curtain machine manufacturer, the lifting media manufacturer or both, depending on the lifting media. In the cases where the lifting media has no specific manufacturer or is not specifically manufactured for use as a lifting media, it is the responsibility of the curtain machine manufacturer to incorporate it in the design and approve it for use in the machine as a lifting media.

A.6.6.7.4 (See A.6.4.2.2)

A.6.7.2 Track carriers may be active or passive. Active carriers engage the operating media and are attached to the powertrain of the curtain machine (e.g., master carriers).

A.6.7.2.2 Passive carriers in systems are designed to engage the operating media in only one travel direction (e.g., backpack carriers) or in specific sections of their travel. Some systems operate using this concept and individual passive carriers can become active carriers at specific points along the travel of the system.

A.6.8.1 Battens should be designed for a maximum deflection that is not visible in the finished curtain deployment. A deflection of 1/240 is generally used in this application.

A.7.2.2.1 This is a requirement of NFPA 79 Chapter 7.7. Some practical scenarios are:

Phase loss is common after electrical storms. If the electrical supply loses a phase, the machine when commanded to operate cannot generate torque, and in many cases the brake will not be released. If the commanded direction of travel is down, it is possible the machine will run down. If the commanded direction of travel is up, the machine may travel down due to gravity.

Phase reversal is common when physical plant transformers are replaced or electrical maintenance or upgrades within the panelboard occur. If the electrical supply has a phase reversal, the machine when commanded to go up will go down and vice versa. The normal limits will have no effect and the only constraints to travel will be the secondary limits when so equipped.

A.7.2.2.2 Screens are commonly listed to ANSI/UL122 (Photographic Equipment). Some curtain machines are listed to ANSI/CSA/UL 325 (Door, Drapery, Gate, Louver, and Window Operators and Systems)

A.7.4 The hazard is two-fold. In one scenario, an electrocution hazard exists. In another, the load can be released.

A typical motor disconnect interrupts the power to the motor. In the case of a constant speed machine, using a motor-powered brake, this is an acceptable solution. Thermostat leads and/or control leads to the brake rectifier do not require interruption.
In the case of a variable speed machine, with the disconnect off, the possibility exists for electrocution while servicing the brake. The power leads to the brake are energized separately from the motor power. This requires a disconnect with sufficient poles for motor power and brake power to be interrupted.

Alternately, an operator could command the machine to travel while the disconnect is off and the brake would release the load.
In the case where the machine has secondary electric brakes, the power leads to those devices must also be disconnected.

A.7.4.3.2 A plug may be locked out using a cord lock box.

A receptacle or motor power inlet may be locked out using a lockable cover.

A.7.5 Many systems do not have access control. The owner’s specific requirements and risk assessment and risk reduction process may determine that access is unlimited.

Historically, most curtain machines have been designed with latching (Open-Close-Stop or Raise-Lower-Stop) controls. In many applications, this is acceptable. Machines that carry greater degrees of risk may require hold-to-run controls to mitigate these risks.

Many machines have no E-Stop requirement. RA/RR should determine whether E-Stop conditions should apply to individual machines or to a machine network/control system.

Variable speed machines may incorporate a Fast Stop feature that is not considered a true E-Stop, but halts movement nearly instantaneously.

A.7.6.3 Secondary limits are not required in all systems and/or in both directions of travel. Level 3 and 4 systems generally require overtravel limits as determined by the RA/RR process.

In some systems the secondary limit is a redundant normal limit switch (wired in series).

A.8.1.1 Manuals should comply with the requirements of ANSI Z535.6-2011 (R2017), Product Safety Information in Product Manuals, Instructions, and other Collateral Materials.

A.9.3 Lift curtain machines may not be used for utility purposes and are not designed to function as hoists for scenery, lighting, or any other equipment. Utility hoists are covered by ANSI E1.6-1.

A.11.1.5.3 Systems installed in contact with unaware persons or the unassuming public should be inspected daily upon opening of the venue to verify proper operation. (e.g., interactive exhibits or installations)

A.11.2 This text is a comprehensive guideline for many machines. The procedures must be customized to match features and equipment of the machines to be inspected.

SAMPLE MOTORIZED CURTAIN MACHINE INSPECTION PROCEDURES

- Verify that operations manuals are available and accessible to system users.
- Verify that operational and warning signage is in place.
- Inspect components for damaged, loose, or missing hardware.
- Inspect operating media termination hardware for the correct type and installation.
- Verify that shackles, turnbuckles, and other rigging hardware are of the appropriate material, grade, and are secured to resist loosening.
- Inspect the operating media for excessive wear and damage.
- Verify that sheave material does not show signs of excessive wear, cracks, or chips.
- Verify that all equipment operates smoothly throughout the available range of travel and without unusual friction, noise, or motions.
- Verify that fleet angles are suitable and operating media does not contact any obstructions.
- Verify that guards, where required, are existing and in good condition.
- Covers and guards, designed to be removed, should be removed to inspect components within.
- Verify that the direction of movement is correctly labeled on the controls.
- Test the emergency stop(s). Verify that the emergency stop(s) disconnect power to the motor and not solely to the control circuit.
- Verify that all indicator lamps are functional.
- Verify that all fuses and disconnects are the correct size and type for the applications and for the machines.
- Verify that indicators show the correct position of the load.
- Visually inspect the condition of controller cables, strain reliefs and junction boxes related to the machine.
- Verify that the brake (when so equipped) stops the machinery when the machine is commanded to stop.
- Verify that the normal travel limit sensors are functional and set to avoid collision with surrounding objects.
- Verify that moving elements are lubricated to comply with the manufacturers limits of use or as determined by a qualified person.
- Verify that a maintenance log is in use and up to date.

A.11.3.2.1 An oleo roller tube is supported by the fabric and not by its operating line. These components must be inspected individually.

A.11.4.5.2 In addition, the building structure, though outside the scope of this document, should be observed for indications of malfunction.

A.11.5.3 The log should be made available to inspectors and technicians.

Annex B

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

Curtain styles and operation descriptions

Austrian Curtain – A type of lift curtain that has both horizontal and vertical fullness. Lifting is achieved with regularly spaced lift lines. The curtain gathers from the bottom to the top as it is raised up.

Bi-Part Operation – A horizontal operation traveler track system with two panels moving opposite of each other when opening and closing.

Brail Curtain – A lift curtain that has no horizontal or vertical fullness. Brail curtains do not stack evenly when lifted and the aesthetic may be irregular, similar to a furled sail. Lifting is achieved with regularly spaced lift lines. The curtain gathers from the bottom to the top as it is raised up.

Brail Operation – Any style of lift curtain system operated by lift (brail) lines rigged through hardware incorporated into the sewn panel(s).

Contour Curtain (Contour Venetian) – A lift curtain in which the lift lines move at different speeds or distances to achieve a shaped opening in the bottom of the curtain. Lifting is achieved with regularly spaced lift lines. The curtain gathers from the bottom to the top as it is raised up. Venetian style curtains are recommended for contour operation.

Guillotine Curtain – (See Straight Lift Operation)

Lift Curtain – A curtain that travels in the vertical direction.

One Way Draw Operation – A single horizontal travel curtain that moves from one end of the track to the other. Sometimes called a wipe.

Piped Traveler Curtain – A traveler curtain that has a bottom pipe used to keep the curtain flat or stable as it moves. This is typically used for masking, legs, or painted scenic panels.

Roman Curtain – A lift curtain that has no horizontal fullness and minimal vertical fullness. Horizontal battens run across the width of the curtain and are placed between each guide ring to allow even folding/stacking between each ring. Lifting is achieved with regularly spaced lift lines. The curtain gathers from the bottom to the top as it is raised up.

Straight Lift Operation – A lift curtain that does not stack or gather as it is raised up. The curtain can be any style or fullness and is raised up from the top of the curtain. Also known as a Guillotine Curtain.

Tableau (Tab) Operation – A curtain panel that opens from the bottom of one side toward the top of the opposite side. This action is achieved using a single lift line running nominally diagonally across the back of the curtain. Tableau curtains are typically used in overlapping pairs similar to a bi-part. Pulling the lift lines creates an opening between the panels.

Traveler Curtain – A curtain that moves horizontally on a track.

Trip Curtain – A type of lift curtain containing a horizontal batten on the back of the panel, placed approximately 1/3 of the way up from the bottom. The lift lines are attached to this middle batten and are used to raise the curtain so that it stacks flat but in 1/3 the height of the finished panel. Trip curtains are typically used as cycloramas or drops for stages with little or no fly space.

Venetian Curtain – A type of lift curtain that has horizontal fullness and has the same appearance as a pleated curtain panel when completely lowered. Lifting is achieved with regularly spaced lift lines. The curtain gathers from the bottom to the top as it is raised up. Venetian curtains can be rigged as a contour curtain.