BSR E1.4, Entertainment Technology — Manual Counterweight Rigging Systems

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Secretariat for ASC E1, Safety and Compatibility of Entertainment Technical Equipment and Practices

Entertainment Services and Technology Association

Contact:
Karl G. Ruling - Technical Standards Manager
E.S.T.A.
875 Sixth Avenue, Suite 1005
New York, NY 10001
212-244-1505
Fax 212-244-1502

Foreword

(This foreword is not a normative part of the standard.)

No American National Standards have previously existed covering the design and manufacture of products for lifting and holding scenic, lighting and masking elements, or which concern actors and technicians involved in the theatrical and entertainment industry. In order to improve the level of safety and to establish a minimum standard for the manufacture of rigging equipment for use in the entertainment industry, United States Institute for Theatre Technology, Inc. (USITT) established its Rigging and Stage Machinery Standards Committee, with the mission of creating a comprehensive set of standards for this purpose. To further this goal, sub-committees were established to write standards in several areas that combine to achieve a set of standards to fully describe the mechanical equipment used in theatres. This document is the work of the sub-committees for Manual Counterweight Flying Systems and Rope and Sandbag Flying Systems. The results of the work of these two committees were combined and formed the basis of this document.

It is intended that this document be accepted as a standard of USITT and that it ultimately become an American National Standard. In order for the latter to happen, the USITT draft document was turned over to Accredited Standards Committee E1, Safety and Compatibility of Entertainment Technical Equipment and Practices, which is also known as ESTA's Technical Standards Program. It has been further developed by the Rigging Working Group within that program. Members of the Rigging Working Group include appropriately qualified people who represent the broader industry of people who specify, manufacture, sell, and use of this equipment, so that all interests are recognized and the standards represent a great depth of knowledge and experience in regards to the equipment.

This document establishes minimum standards for equipment. However, the proper installation and operation of this equipment are equally important. Equipment shall be installed, operated and maintained under the supervision of a competent person. Further, the selection of the proper equipment for any application shall be entrusted only to experienced personnel with the proper knowledge and training to recognize and understand all of the hazards and functional requirements involved in the particular installation.

This standard represents equipment manufactured under the constraints of current technology. It is not intended to restrict further developments or enhancements. Revisions of this standard will be considered by the committee in the light of further advances in technology, changes in entertainment requirements, and operating practices. Future revisions will not imply that previous editions of the standard were inadequate. Nor is it the intention of this standard to suggest that equipment manufactured before the creation of this standard is inherently inadequate.

Referenced Standards Organizations

AISI	-	American Iron and Steel Institute, Inc.
ANSI	-	American National Standards Institute
ASME	-	American Society of Mechanical Engineers
ASTM	-	American Society for Testing and Materials
AWS	-	American Welding Society
ESTA	-	Entertainment Services and Technology Association
IFI	-	Industrial Fasteners Institute
ISO	-	International Organization for Standardization
NACM	-	National Association of Chain Manufacturers
OSHA	-	Occupational Safety and Health Administration, Department of Labor
SAE	-	Society of Automotive Engineers
USITT	-	United States Institute for Theatre Technology, Inc.

1 Scope

1.1 General

(a) This standard applies to arrangements of rigging hardware for the raising, lowering, and suspension of scenery, properties, lighting, and similar loads. The single purchase, double purchase, and rope and sandbag systems illustrated in the Figures section describe three common arrangements used over performance areas.

(b) The use of rope, as well as rope and sandbags, is a variation of manual counterweight rigging. Where equipment for rope or rope and sandbag rigging differs from equipment used in regular counterweight rigging, differences will be noted.

(c) This standard applies to rigging hardware only, and not to the structure from which it is supported. While not part of this standard, the ability of the building structure to support the intended loads shall be considered in the design and application of rigging systems.

1.2 Exclusion: This standard does not apply to raising or lowering people, or to any powered equipment.*

1.3 Annex note references: This document uses annex notes to provide additional reference information about certain specific section requirements, concepts, or intent. Subject matter with a corresponding annex note reference is identified by the asterisk (*) symbol, and the associated reference text is found in the Annex A section, identified with the referring text section number, e.g. an Annex Note to section 3.2 will be identified in the annex section as A.3.2.

2 Definitions

Arbor Guide: See Guide Shoe.

Arbor pit: A pit that extends below the stage floor to allow extended travel of counterweight arbors.

Batten: A pipe, tube, or other singular structural shape that is secured to the lift lines. Battens are used for flying scenery, curtains, lighting and audio equipment, adjustable architectural/acoustical decor, or combination thereof. Battens are typically installed parallel to the proscenium, horizontal to the floor, and typically extend beyond the width of the proscenium opening.

Batten Clamp: A piece of rigging hardware, typically consisting of two pieces of metal bolted around a batten and having a hole for the attachment of a hanging chain, turnbuckle assembly, or rope.

Belaying pin: A pin, usually wood or metal, that is inserted in a pin rail hole, and is used for securing rope lift lines or spot lines.

Block: An assembly of one or more sheaves in a housing designed to support one or more running lines during a change of direction.

Breaking Strength: The load at which failure will occur in a component.

Bridle: A variation of attaching lift lines to battens, in which two separate (secondary) cables are attached to the batten from a single (primary) lift line termination, and typically used where primary lift line spacing is too large to maintain the batten deflection criteria of this standard. Any suspension configuration in which two or more lines run from a load to a single suspension point.

Cable clip: See **Wire Rope Clip**

Clew: A device with multiple holes used to connect several lift lines into a common line.

Compensating system: A component of the counterweight system that automatically varies to counterbalance the weight of the lift lines as it shifts between load and counterweight.

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.

Counterweight: A weight used to balance the load on a line that is being raised, lowered, or held in position.

Counterweight arbor: A moveable rigid metal carriage assembly and inclusive guides that holds counterweights, and is used to counterbalance a load.

Counterweight arbor guide: A component of a counterweight arbor assembly that engages the guide rails in order to maintain vertical alignment over the length of the arbor travel. Guides may contain special materials or roller elements in order to reduce operational friction during arbor movement. See **Guide Shoe**, **Roller Guide**, and **Wire Guide** for additional definitions.

Counterweight carriage: See counterweight arbor.

Design factor: (a) Any operational or strength criteria considered in the design of an item. (b) Conditions that affect the ability of a product to carry a load, such as size, temperature, vibration, elasticity, etc. (c) A ratio of the working load limit to the ultimate breaking strength of a material or component.

Design Load: The maximum anticipated load that will be imposed upon a system or device under normal conditions.

Double purchase: A system using compound reeving of the lift lines and operating line, designed to allow the batten to travel twice as far as the arbor, but requires the arbor to be loaded at twice the weight of the batten.

Fleet angle: The included angle between a line representing the travel of a rope, from the groove in a sheave, and a line drawn perpendicular to the axis of the sheave.

Guide shoe: A device that connects a counterweight arbor or tension block to the guide rails in order to control the path of its travel.

Guide rails: A means of guiding the counterweight arbor throughout its travel in the vertical plane, but which also prevents horizontal or twisting motions of the arbor.

Head block: The stationary sheave or block assembly directly above the counterweight arbor or pin rail. The head block permits lift lines to change direction. In manual systems, the head block is also grooved to allow the purchase line to change direction by 180 degrees.

Head block beam: Structural framing designed specifically to support the head blocks and all associated resultant loads.

Hemp system: See **Rope and Sandbag System**

Idler block: a block designed to support only the self-weight of one or more lift lines, and guide those lines to a load bearing block without changing direction of the line. Idler blocks are used for the same purpose as sag bars

Installer: The person or organization that is responsible for the installation of the rigging equipment.

J-bar or J-bar track: A variation of guide rails using J-shaped members.

Lattice track: A type of guide rail system in which the arbor guides are attached to opposing sides of the arbor assembly, rather than on one side only.

Lift line: Any rope or cable, tied-off at a counterweight arbor or pin rail at their offstage ends, reeved through head blocks and loft blocks, and attached to a load. Lift lines may operate singly, as spot lines, or in "sets" of several lift lines working together to support a load or a batten.

Line set: A system of multiple lift lines, operated together to raise, lower, or suspend a load; All of the mechanical, component subsystems required for supporting, positioning, and operating those lift lines as a system.

Loading bridge: An elevated area, located to permit counterweight loading and unloading at the arbor, while the battens are at low trim.

Locking collar: A locking device, located on a counterweight arbor rod, designed to impede the unintended movement of counterweights from the arbor.

Locking rail: A structural railing that supports the rope locks.

Loft block: The overhead block through which one or more lift lines pass before being attached to the load being lifted or supported.

Mule block: A supplementary block located between the head and loft blocks, designed for the specific purpose of changing the direction of line travel.

Out-of-balance condition: A condition where the loads attached to a batten differ from the weight of its associated counterweight equipment by more than 23Kg (50 Lbs).

Outrigger batten: A batten mounted in a fixed position parallel to the locking rail, and intended to protect counterweight equipment from contact by ground supported scenic elements. Outrigger battens may also support locking rail work lights.

Pin rail: A rigidly mounted railing, with holes designed to accept belaying pins, used in tying off rope and sandbag rigging lines, and that transfers the unbalanced system loads to the building structure.

Pitch diameter: The diameter of a sheave measured to the centerline of a rope or cable for which it is designed.

Purchase line: The operating line attached to the top and bottom of a counterweight arbor, permitting an operator to raise and lower a batten.

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.

Reeve: To pass a rope over the sheaves in a pulley or system of pulleys.

Retainer: See **"Spacer."**

Reverse Bend: A condition where a line is reeved in opposing directions.

Rigging: General term for the hardware and systems used to raise and lower, hold, or move scenery, lights, or curtains on or over a stage.

Roller guide: A device that employs rollers instead of sliding materials and is attached to a counterweight arbor in order to engage a guide rail and control the path of its travel.

Rope and Sandbag System: A common term for a type of counterweight system that uses natural or synthetic rope, instead of wire rope, for the lift lines, and uses sandbags as the counterweight method.

Rope lock: A positioning device, located on the locking rail, that grips or releases the purchase line of a counterweight set.

Safe working load: See "**Working load limit."**

Safety factor: See **"Design Factor."**

Sag bar: A bar or other non-sheaved mechanism used to support the self-weight of one or more lift lines, as those lines extend to a load-bearing block. A Sag bar is used for the same purpose as an idler block.

Sandbag: Fabric bag filled with sand, and used with rope rigging to counterbalance a load.

Shall: A term used in this standard to indicate that an action is mandatory.

Should: A term used in this standard to indicate that an action is recommended under most conditions, but is not mandatory

Shock load: Loads or forces generated by the sudden application of a force or motion to an object, or by the collision of moving bodies. These loads are in addition to the static or dynamic loads implied under normal operating conditions.

Single purchase: A system of rigging employing weights, blocks and lines to hold or move a load of similar weight.

Spacer: Any structural member inserted between the side plates of a block to provide the proper spacing between plates, add rigidity, and to contain the ropes or cables in the sheave groove(s).

Spot block: A block designed to function as either a head block or loft block in temporary applications, and is also designed to be easily repositioned.

Spot line: A single line, used in conjunction with a spot block to support a load.

Spreader plate: Plate that is installed between counterweight arbor rods to keep the rods from spreading during rapid travel or impact in order to prevent counterweights from falling out of the arbor.

T-bar or T-bar track: A variation of guide rails employing T-shaped members.

Tandem block: A block that encompasses a series of single groove sheaves, each mounted on a separate shaft.

Tension block: A block designed to remove slack from a purchase line, prevent the purchase line from twisting in its travel, and from rubbing against wire ropes, structural framing, and adjoining equipment.

Thimble: A grooved fitting around which a rope or cable is bent to form an eye. It supports and protects the rope or cable to prevent kinking and wear.

Trim chain: A system employing a length of chain and fittings used to connect a lift line to a batten (or other load) and adjust its level.

Trim clamp: A device with spring-loaded cams that allow several ropes to be operated together as a single unit.

Tread diameter: The diameter of a sheave measured to the bottom of its groove.

Truss batten: Pipes, tubes, or other structural shapes, assembled together with cross bracing as a truss, and used in place of a pipe batten.

Wire guide: Equally tensioned wire ropes installed plumb, in equally spaced pairs, on the centerlines of the arbor guides and used to guide the path of counterweight arbors or clews.

Wire Rope Clip: A device used for forming eye terminations on wire rope.

Working load: See "**Working load limit.**"

Working load limit: The maximum load that shall be safely applied to a device.

3 Components*

Component assemblies shall be manufactured to withstand all design loads without deformation or damage to components and shall meet the requirements of section **6 Design Factors**

Housings and mounting components shall use materials having ductile properties that will deform plastically without fracturing.

Unless specifically noted otherwise, fasteners shall have a minimum SAE J429 Grade 5 or ISO R898 Class 8.8 rating. Mated bolts and nuts shall have the same rating. Nuts shall be self-locking, or shall use lock washers. Installers shall adhere to torque values, where such values are specified or required for the specific mounting application. Attachments made through slotted or elongated holes shall use flat washers. Attachments requiring a specified torque value, or other applications as determined by a qualified person, shall use hardened flat washers.

The maximum allowable fleet angle for lift lines and purchase line shall be in accordance with section **6 Design Factors**, unless the grooves in the block and the bearings are designed to accept a greater side thrust and not harm the wire rope or rope.

All welding shall be performed in accordance with current AWS standards.

3.1 Head blocks

3.1.1 Construction

(a) Block assemblies shall consist of a housing that encompasses one or more sheaves with bearings, and one or more shafts. Lines shall be prevented from unintentionally leaving their grooves.* Provisions shall be made for accurately mounting the block assembly to the structural framing in a secure and safe manner.

(b) Shafts shall be fabricated from cold finished steel with a minimum Yield Strength of 310,230 KPa (45,000 psi). Shafts shall be installed so that no thread contacts the bearing or sheave housing. Unless specifically designed to rotate, shafts shall be locked against rotation within the block housing. Shaft nuts shall have a minimum rating of SAE J429 Grade 2. Shafts shall not move axially.

(c) All grooves on a sheave shall have equal pitch diameters.

(d) See section **4 Labeling and marking** for labeling requirements.

3.1.2 Upright: Upright head blocks shall mount to the top side of the structural framing, with the purchase and lift lines passing around the sheave and down through the mounting base.

3.1.3 Underhung: Underhung head blocks shall mount to the bottom side of the structural framing with the purchase and lift lines passing around the sheave below the mounting base. The block shall be designed to facilitate the passage of lift lines from the loft block to the lifting and support mechanism.

3.1.4 Tandem: The housing shall encompass a series of single or multiple groove sheaves, mounted with bearings on separate shafts, locked against rotation in the housing, with spacers as needed to keep each rope in its groove and to strengthen the assembly. Provision shall be made for secure attachment to the support structure.

3.1.5 Horizontal Mounting: Horizontal mounted blocks shall incorporate methods to retain the rope or cables within their respective grooves.

3.1.6 Accessories

Modifications shall be permitted, including, but not limited to paragraphs (a) and (b) below. All shall be built to the same standards as the main block assembly. Accessories shall not interfere with the wire ropes and shall be mounted to the assembly in a manner that permits the sheave, bearings, etc. to be easily removed for maintenance and repair.

(a) A double purchase head block shall have a bracket properly located for attaching the dead ends of the lift line wire rope and rope terminations.

(b) Tie off brackets for arbor guide wires or clews shall be located so the guide wires are parallel to each other, and in line with the clew or arbor assembly.

3.1.7 Mounting

(a) Provisions shall be made for accurately mounting the block assembly to the supporting structure in a secure and safe manner. The mounting shall be designed to prevent block movement and prohibit loosening of block or mounting hardware over time by either load or vibration.

(b) Welding shall be permitted with the approval of a licensed professional engineer. This attachment method shall only be performed in a manner that permits removal of the block via weld grinding, when maintenance or replacement becomes necessary.

(c) Drilling of structural framing, for attachment of a block with bolts, shall be permitted with the approval of a licensed professional engineer.

(d) When attaching blocks, the anchors shall be selected and installed according to both the manufacturer's recommendations and local code requirements, for the loads and the materials into which they are inserted.*

(e) Mounting clips shall be constructed and sized for the block load and mounting condition. They shall be installed so that the block cannot shift on the support structure. When clips are used to grip a beam flange, the clip shall deflect not more than 3mm (7/64 inch) when fully clamped at the block manufacturer’s recommended torque values*.

(f) If the block is designed to swivel (360 degrees) about a pin, or pivot (180 degrees) about a shaft, the mounting shall be designed to accommodate the additional forces in a manner that shall not restrict the free movement of the block.

3.2 Loft blocks

3.2.1 Construction

Loft blocks shall meet the requirements of section **3.1 Head Blocks**. Loft blocks shall be permitted to incorporate additional grooves in the sheave to support additional lift line wire ropes.

3.2.2 Upright: Upright blocks shall mount to the top side of the structural framing. The block shall be designed to facilitate the passage of wire ropes from the load to the head block.

3.2.3 Underhung: Underhung blocks shall mount to the bottom side of the structural framing with the lift line passing over the sheave below the mounting base. The block shall be designed to facilitate the passage of lift line wire ropes between the load and the head block.

3.2.4 Mounting: Mounting shall be done in accordance with section **3.1.6 Mounting.**

3.3 Spot blocks

Except as noted in section **3.3.1 Mounting** below, spot blocks shall comply with the requirements of section **3.2 Loft Blocks**.

3.3.1 Mounting: The block mounting shall be designed to provide secure attachment under a variety of mounting conditions. Round Bend, Hook Bolts, and J-bolts (as defined by the Industrial Fasteners Institute) shall be permitted if the mounting prevents movement of the block under the designed loads.

3.4 Mule blocks

3.4.1 Construction

(a) Mule blocks shall meet the requirements of section **3.1 Head Blocks.** If field conditions require, the assembly shall be adjustable to maintain proper fleet angle alignment of the lift lines. The block shall lock in position after final adjustment, so it is not supported by wire rope tension.

(b) Brackets for attachment of guide cables or other accessories shall be mounted on the assembly in a manner that permits the mule sheave, bearings, etc. to easily be removed for maintenance or repair. Any additional loads imposed by these assemblies shall be accounted for in the design of both the housing and mounting assembly.

3.4.2 Mounting: Mountings shall meet the requirements of section **3.1.6 Mounting.**

3.5 Sag bars

3.5.1 Construction: Sag bars shall be designed using materials and configurations that minimize friction and noise during operation, and shall contain no sharp edges to catch or wear the wire ropes. Stationary surfaces that are in direct contact with wire rope shall be replaceable when worn.

3.5.2 Mounting: Where sag bars are provided, they shall be supported from the rigging structural support steel or from the building structural framing.

3.6 Idler blocks

Idler blocks shall consist of one or more sheaves contained within an assembly. If the assembly is not an integral part of a load-bearing block, it shall be securely fixed to the structural framing. Idler blocks shall provide only vertical support to the lift lines.

3.7 Tension blocks

3.7.1 Construction

Tension blocks shall meet the requirements of section **3.1 Head Blocks.**

3.7.2 Mounting: Tension blocks shall be mounted in a manner that prevents interference between the purchase line and any other system or structural element. Tension block mountings shall meet the requirements of section **3.1.6 Mounting**, or shall use guide shoes when mounting to guide rails. If guide shoes are used, they shall be fabricated to permit block travel along the guide mechanism without the use of tools. Lubrication shall not be required for either the guide shoes or the guide mechanism. The guide shoes shall prevent the tension block from releasing when the counterweight set is operated, but shall also allow readjustment of tension when so intended.

3.8 Battens

3.8.1 Typical batten:

(a) The typical batten shall be fabricated using materials that support the design loads in accordance with the requirements of this standard.*

(b) Battens exceeding one standard pipe length shall be joined using internal splicing sleeves. Threaded couplers shall not be permitted. Spliced battens shall have at least the same overall capacity, deflection, and strength as the component pipe. Battens shall be coated with a rust resistant finish. A minimum of

100 mm (4 inches) at each end of the batten shall be permanently marked with an approved OSHA color, except in architecturally sensitive areas.

(c) The batten shall be capable of supporting at minimum 45 Kg/m (30 lbs/ft) of uniformly distributed load. Battens shall be capable of sustaining a point load of 45 Kg (100 pounds) at mid-span between any two lift lines with a maximum span deflection of 1/180 of the span.

(d) See section **4.6 Battens** for labeling requirements.

3.8.2 Alternate batten constructions: Alternative batten and splicing designs that meet the intent of this standard shall be deemed acceptable. Deviations from the typical construction shall require alternative batten sizing and design.

Engineering specifications for all truss-batten systems shall be developed to meet the performance criteria of the specific application.

Aluminum truss systems shall comply with ***ANSI E1.2-2000, Entertainment Technology – Design, Manufacture, and Use of Aluminum Truss and Towers.***

3.8.3 Batten connection hardware: All hardware types and applications shall be based upon load parameters, stress factors, and system design. All hardware shall be installed and used in accordance with the manufacturer's recommendations.

See Section **3.17.3 Wire rope terminations**.

3.8.3.1 Single-batten clamps

Batten clamps shall be made from steel or other ductile materials. Clamps shall fully wrap the circumference (or perimeter, for non-circular cross sections) of the batten, and shall provide a positive resistance to rotational loads. The clamp shall permit attachment to the lift line using hardware specifically designed for the connection type, and in a manner that meets the criteria of section **6 Design Factors**. Batten clamps shall not have sharp edges or corners.

3.8.3.2 Multiple-batten clamps

The same criteria shall apply if more than one batten, or combination of battens and electrical raceways, are connected by batten clamps. Each batten in the assembly shall conform to the requirements in section **3.8 Battens**. Labeling as required by section **4.6 Battens** shall be based on the total assembly, including all battens, connections, and other factors. Unless specifically designed to carry loads, electrical raceways shall not be considered a structural component when determining load ratings.

3.8.3.3 Bridles

Bridle components, attachments, fittings, terminations, and connections shall comply with all related and relevant requirements of this standard. Bridles shall not be spliced to lift lines.

Resultant load angles created by bridle assemblies shall not exceed 60-degrees (30-degrees from vertical), or shall be as approved by a qualified person, based upon the specific loading conditions of the application.

Bridle connections at the batten shall be fixed in place in a manner that prevents slipping along the batten.

3.9 Counterweight arbors

3.9.1 Construction

(a) Counterweight arbors shall be designed to hold weights for balancing loads in a manner that permits safe handling and easy access while retaining the counterweights within the arbor, even in the case of unexpected impact. Arbor frames and fittings shall be of materials having ductile properties that deform plastically without fracturing. The use of double nuts shall be permitted on arbor rods, to satisfy fastener, locking requirements

(b) All counterweight arbor tops shall be equipped with attachment points for the lift lines and purchase lines, and the attachment points shall be sized so that terminations do not rest on, pinch, or otherwise bind adjacent terminations.

(c) Counterweight arbors shall be designed to hold counterweights as described in section **3.9.2 Counterweights**, and shall be designed to hold such counterweights without dislodging in the event of unexpected impact loads.

(d) Where arbor designs contain two steel rods as part of the primary support structure, they shall meet the following criteria:

> 1) The rod center distance shall be 25 cm (10 inches), unless otherwise required. Arbor rods shall be made of minimum 19 mm (¾ inch) diameter ASTM A36 steel bar.
>
> 2) Spreader plates that slide freely up and down on the arbor rods shall be permanently installed between the arbor top and bottom plates, and shall be designed to prevent arbor rods from spreading apart under impact.
>
> 3) One spreader plate shall be provided for each .6 meters (two feet) of arbor height, or fraction thereof.
>
> 4) The counterweight arbor shall be equipped with one locking collar per arbor rod, each located above the top spreader plate. No tools shall be required to tighten or loosen the locking collar fastening hardware.

(e) The inside of the counterweight arbor bottom frame shall be configured so that there is a flat, stable surface on which the counterweights rest without rocking. Counterweights shall not be permitted to rest on any bolt, nut, fastener, or other mounting hardware.

(f) The arbor frame shall contain either bushings for wire guides, or guide assemblies for engaging guide rail systems. For wire guide applications, bushings shall be located in the top and bottom arbor plates and shall be constructed of friction reducing material. In guide rail applications, guide assemblies shall run freely, and engage the rail assembly in a manner that prevents arbors from disengaging under normal usage. The guide assemblies shall be designed to minimize noise and friction.

(g) Double purchase arbors shall be equipped with sheave assemblies at the top and bottom of the counterweight arbor. The sheave assemblies shall be designed and fabricated in accordance with section **3.1.1 Construction,** paragraphs **(b), (c), and (d)**.

(h) Other arbor configurations shall be permitted for special applications where increased capacity or space restrictions dictate and where the need to interchange standard weight is not a requirement.

(i) See section **4.7 Counterweight arbors** for labeling requirements.

3.9.2 Counterweights

(a) Counterweights shall be made of steel or other materials having ductile properties that will deform plastically without fracturing.* The weights shall be free from sharp edges. The counterweight shall be shaped in a manner to prevent the weights from accidentally disengaging from the arbor. Counterweights shall be of dimensions and shapes that can be safely handled by an average worker, and shall vary in size by no more than 3 mm (1/8 inch). Individual counterweights shall not weigh more than 13.6Kg (30 lbs).

(b) Counterweights that are not subject to relocation during normal use shall be exempt from the size and weight limitations.

(c) The use of cast iron or other materials shall be acceptable only when meeting the requirements of paragraph (a).

3.10 Compensating system

Compensating systems shall be used when the maximum allowable load imbalance requirements of section **6 Design Factors, Table 1** cannot be met.*

3.11 Wire guides

(a) Guide attachment points/brackets shall be incorporated into the locking rail at the lower end, and incorporated into the head block assembly at the upper end. Alternate locations are permitted. All attachment points shall be designed to accept the loads imposed by both tension in the guide wires and sway of the arbors.

(b) There shall be a minimum of one wire guide for each end of each arbor, and the guide wires shall be installed plumb. Guide wire terminations and connections shall be designed to withstand anticipated loads. A load rated tension adjustment device shall be incorporated into the assembly, and shall be fixed in position after final adjustments are made. Arbor stops, if used, shall not impart additional load to the wire guides or their respective terminations, and shall slip under load.*

(c) The minimum spacing between the arbors shall be such that adjacent counterweights or obstructions cannot come into contact with each other under normal operating conditions.

(d) Head blocks shall be positioned over the guide wires so that the counterweight arbor imparts the least amount of horizontal force on the guide system.

3.12 Guide rails

3.12.1 Construction
(a) The minimum spacing between the guide rails shall be such that adjacent counterweights or obstructions cannot come into contact with each other under normal operating conditions. Guide rail systems shall consist of minimum 38 mm x 38 mm x 4.7 mm (1-1/2 inch x 1-1/2 inch x 3/16 inch) steel or aluminum T-bar or J-bar, rigidly fastened to a horizontal supporting structure at not more than five-foot intervals. Other sizes, profiles and metals shall be permitted for guide systems as long as they meet the operational criteria of this standard.

(b) Guide rails shall be attached to steel support members located perpendicular to the guide rails. All splices shall be finished in a manner that provides smooth transition between the abutted edges, without offset, warping or twisting of the rails. Guide rail horizontals shall be rigidly attached to the building structure so that the guide rails cannot move in any direction. Guide rail horizontals shall also be equipped with bracing where required to maintain rigidity of the guide system. The bottom support shall be bolted or anchored to the floor using anchorages specifically designed for the loads, mounting surface and conditions.

(c) Stop battens or bars shall be attached where they will provide a secure stop for the arbors at their designated upper and lower limits of travel, and shall be structurally attached in locations that prevent interference by the arbor or stop, with any other component of the system. The bottom stop shall be located above the level of the tension blocks and shall be capable of supporting the weight of a fully loaded arbor, plus an additional 22.6 Kg (50 lbs) of allowable load imbalance. The top stop shall be capable of supporting the weight of a batten when loaded to the capacity of its arbor, plus an additional 22.6 Kg (50 lbs) of allowable load imbalance. Hardwood bumpers shall be bolted to the impact face of both stop assemblies, or shall be permitted to attach to the top and bottom of the arbor assembly.*

(d) Head blocks shall be positioned over the guide rails so that the support lines are plumb and the counterweight arbor does not impose a horizontal force on the guide system.

3.12.2 Lattice tracks: Guide assemblies shall be mounted on the sides of the arbor so that the arbor is held between two tracks. Tracks shall be installed straight and plumb. Brackets shall be designed to insure that the tracks remain parallel and prevent binding or release of the arbor over the length of its travel. Tracks shall be secured to the adjoining structure at not more than 1.2-meter (4 foot) intervals. Arbor stops designed to support a minimum of 1.25 times the static design load of the arbor shall be installed at each end of the track. The stops shall be designed so they do not bind or abrade the purchase line.

3.13 Locking rails

The locking rail shall be constructed from structural steel shapes and shall consist of a top railing and its supports. The rail top shall be drilled to receive the rope locks on the required centers. The rail shall be designed to accept either the anticipated loads imposed by the counterweight sets, or 23 Kg (50 pounds) per rope lock plus concentrated loads of 227 Kg (500 pounds) at the midpoint between each locking rail upright, whichever is greater. It shall also be designed to absorb a horizontal load as dictated by system design and applicable codes. See section **4.3 Locking rails** for labeling requirements.

The rail shall be attached to the building structure using bolts or anchors specifically sized and designed for the loads, mounting surfaces, and conditions, or shall be welded. All anchorages and weldments shall fully resist anticipated loads, without loosening.

3.14 Outrigger batten

The outrigger batten, when used, shall be mounted so it does not interfere with the movement of purchase lines, or other building equipment. The batten shall be rigidly mounted to the guide wall, or directly to the building structure. The batten shall run the full length of the locking rail.

3.15 Rope locks

(a) Rope locks shall remain locked until released, once the rope lock handle is placed in the locked position. A rope lock shall sustain an out of balance condition of 23 Kg (50 pounds).

(b) Housings shall be made of a material having ductile properties that will deform plastically without fracturing.

(c) An adjustment mechanism on the rope lock shall permit adjustment of the clamping members for worn ropes or ropes of differing diameters.

(d) Rope locks shall have a ring or latch designed to prevent accidental release.

(e) Attachment of the lock to the rail shall be such that loads imposed on the lock are safely transferred to the rail structure.

(f) Rope locks shall be positioned to impose minimal wear on the operating line as it passes through the system. Rope locks shall not be welded to the locking rail.

(g) See section **4 Labeling and marking** for labeling requirements.

3.16 Purchase lines

3.16.1 Material: Purchase lines shall be of polyester synthetic or premium grade manila, and shall conform to section **6 Design Factors, Table 1.**

3.16.2 Minimum rope diameter: The minimum nominal diameter of purchase lines shall be no less than 19 mm (3/4 inch).

3.16.3 Reeving: The purchase line shall be installed so that it freely runs through the tension block, head block, and arbor blocks (if used). With the exception of the rope lock, the purchase line shall not contact adjacent line sets or other equipment. If contact with the building structure is unavoidable, a method as determined by a competent person, shall be used to prevent such contact.

3.16.4 Purchase line termination

(a) The purchase line for single purchase systems shall attach to eyes or brackets mounted to the top and bottom of the arbor and designed for that purpose.

(b) The purchase line termination for double purchase systems shall be attached to eyes or brackets mounted at the head block, and at a point below the arbor.

(c) The line shall be terminated with a knot or splice that maintains a minimum 60% of the rope's tensile strength. The termination shall not interfere with adjacent equipment, and shall be finished in a manner that prevents fraying or unraveling of the rope ends, loosening of the termination, and shall be done in accordance with the rope manufacturer's recommendations.

(d) Natural fiber purchase lines shall be protected from abrasion and excessive bending stress at the termination by an oval or round thimble of the same size as the rope.

3.17 Lifting lines

Wire rope shall not be permitted to contact any part of the building structure, adjacent line sets or other equipment not otherwise intended for contact. If such contact is unavoidable, a method as determined by a competent person, shall be used to prevent such contact.

3.17.1 Splicing: Lift lines shall be fabricated of continuous un-spliced lengths of material.

3.17.2 Reverse bends: In applications where reverse bends are incorporated, the wire rope service life shall be decreased.

3.17.3 Wire rope terminations: All wire rope eye terminations shall use metal thimbles that shall be sized in accordance with the wire rope diameter.

All additional termination hardware shall be load rated and sized for the working load of the line. Shackles and turnbuckles shall be of forged steel construction only. Turnbuckles shall be provided with a means of being fixed in position after adjustment. Screw pin shackles and turnbuckles with screw pin jaws shall be provided with a redundant fixing means, after pin insertion. The fixing method shall be performed in accordance with the manufacturer's recommendations.

All hardware shall be installed and used in accordance with the manufacturer's recommendations.

The following termination methods shall be acceptable:

(a) Swage type wire rope fittings shall be selected and applied in accordance with the fitting manufacturer's recommendations. Copper, aluminum, and coated fittings shall be selected as appropriate for the wire rope materials and construction being fastened and as modified by environmental considerations.

(b) Forged wire rope clips shall be installed in accordance with manufacturer's recommendations, and in accordance with any applicable jurisdictional regulation, where the requirements of such regulation are more stringent. Malleable clips shall not be used.

(c) Trim chains shall be made of NACM Grade 30 or better proof coil chain, 6 mm (1/4 inch) or larger. The wire rope eye termination shall pass through the end link of the chain. The chain shall be long enough to wrap one and one-half times around the batten and return to connect at the eye termination using a load-rated connection. The installed trim chain assembly shall have a breaking strength greater than the breaking strength of the wire rope.

Any chain used in a single load path assembly shall be certified in writing by the chain manufacturer as suitable for the intended application.*

3.17.4 Manila and synthetic rope terminations

(a) The rope shall be attached to the batten and pin rail in such a manner that maintains the design factors for rope lifting lines as shown in **Table 1**, after all derating factors are applied.*

(b) When attaching a lifting line directly to the load, non-slipping knots shall be used. Consideration shall be given to the possibility of excessive stress on the rope fibers, caused by passing the lifting line around a small diameter attachment, and only attachments that minimize this stress shall be used.

3.18 Pin rail

3.18.1 Location

Pin rails (where necessary to the function of a rigging system) shall be located such that they permit the fleet angles as required by section **6 Design Factors**, and located to provide horizontal clearances for any sandbags that may be attached to the lift lines, to pass on the onstage side of the rail. Pin rail location(s) shall not interfere with any other operational system element.

3.18.2 Construction

(a) Pin rail assemblies shall be permitted to consist of single or multiple pin rails, to allow battens at high and low trims to be tied off to separate rails.*

(b) The pin rail shall be a horizontal beam of round or substantially round cross-section. Rectangular or square shapes shall be permitted if all edges are radiused to a dimension equal to, or greater, than the rope diameter. Pin rails shall be of steel, or solid wood construction. Pin rails shall be designed to accept either a) the anticipated loads imposed by the sets, or b) 749 Kg per linear meter (500 pounds per linear foot), or c) a point load of 455 Kg (1000 pounds) in either an upward or a downward direction, at the midpoint between each pin rail support, whichever is greater. In specialized applications, other minimum design load criteria shall be acceptable, provided that such information is clearly detailed in the systems manuals (refer to section **4.9 – Manuals**).

(c) The pin rail shall be drilled through vertically at regular intervals to accommodate either steel or hardwood belaying pins to which the lifting lines are tied. Belaying pins shall be sized to safely secure all anticipated load. Fixed (permanently attached to the pin rail) or loose (removable from the pin rail) belaying pins shall be permitted.

(d) See section **4.4 Pin rail** for labeling requirements.

3.19 Accessory equipment

3.19.1 Sandbag

(a) Sandbags shall be attached to the lift lines between the head block and the pin rail where required to counterbalance the load.

(b) Sandbags of any size shall be permitted, but shall have a capacity not greater than 136 Kg (300 Lbs).

(c) Sandbags shall be fabricated using heavy-weight canvas or synthetic fabric, double seamed for strength, reinforced and supported by synthetic straps or manila rope sized to carry the weight of the loaded sandbag including all design factors.

(d) The rope or strap used to suspend the loaded sandbag shall be equipped with a rated hook and safety catch.

3.19.2 Trim clamp: Trim clamps shall be used only on fiber rope rigging systems and shall be attached to the lifting lines between the head block and the pin rail. They shall be rated to support the maximum anticipated load of sandbags, taking into account the same design factors as described for lifting lines in section **6 Design Factors.**

4 Labeling and marking

All labeling and signage shall comply with the requirements of the following recognized national standards, where such requirements can be implemented with rigging components, assemblies, and systems:

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

4.1 Language: All signs or labels shall be in English. If operating personnel are not familiar with English, additional signs or labels in the appropriate language shall be permitted.

4.2 Capacities and sizes: The working load, manufacturer's name, or grade reference mark shall be permanently displayed on each piece of equipment and hardware. Chain, rope and wire rope shall be exempt from this requirement. If the hardware or equipment is size-specific (e.g. wire rope clips), then the size shall be displayed on the product. Where permanent labeling or marking of individual components is impractical, then the load, manufacturer, or grade reference information shall be indicated in the system reference documents as required in section **4.9 Manuals**.

4.3 Locking rails

(a) All locking rails shall have an individual, permanent number or name displayed at each rope lock. Provisions shall be made for the temporary display of secondary descriptions.

(b) A sign shall be displayed at each locking rail stating the capacity of the line sets, electrics, bridges, or other equipment controlled from that position.

(c) Locking rails used with wire-guided arbors shall have a sign displayed that warns against excessive tension in the wire guides.

4.4 Pin rail: A sign shall be displayed at each pin rail stating the capacity of line sets and for individual spot lines controlled from the pin rail.

4.5 Operating/loading galleries: Operating galleries and loading platforms shall have a sign outlining counterweight storage parameters and limits in pounds per square foot (Kilograms per square meter). Building structural engineer shall provide this information to installation contractor. A warning not to stack counterweight above the toe board shall also be included. The weight of each counterweight type and size provided in the system shall also be included.

4.6 Battens: Each batten shall be marked and labeled with its set number, stage centerline, and lift line locations. Each batten end shall also be marked.

4.7 Counterweight arbors: Each T-bar arbor shall have a sign affixed to the back plate at .6 meter (2-foot) intervals stating **"CAUTION: Locate spreader plate here."** Systems employing wire guide type arbors shall have readily visible signs stating that spreader plates shall be located at .6 meter (2-foot) nominal intervals.

4.8 Lubrication: Any equipment requiring lubrication shall be identified in the maintenance manual stating quantity, type of lubricant, and frequency of lubrication. Lubrication points shall be clearly indicated. Lubrication points shall be accessible without major disassembly of the component.

4.9 Manuals: All rigging installations shall include an operations and maintenance manual (“Systems Manual”) for the system. All unique elements of the particular system shall be clearly detailed. The systems manual shall include final print drawings, applicable maintenance requirements, and servicing guidelines plus a listing of component working loads and design factors.*

A supplemental maintenance log shall be maintained, describing all inspections, modifications and repairs to the system, and identifying the person(s) performing such actions.

4.10 General Signage: A sign shall be posted in an accessible location providing the name, address and phone number of the primary system contractor, manufacturer, and supplier (if not already listed) of the system equipment.

5 Proof Testing

5.1 General requirements: All systems shall be proof tested after installation, and prior to user operation. Controlled proof test loads shall be applied at no less than 150% of the design loads. Tests shall be applied to individual line sets and based upon the total number of line sets in the installation. The specific testing criteria shall be randomly applied to a base percentage of the total number of line sets in an installation or renovation, in accordance with the following testing criteria.

Line sets shall be selected for batch testing in a manner that is completely random, unless testing of the complete system is required.

All installations shall be visually inspected, and shall be tested for operation in a non-destructive manner, prior to operation by the user. Qualified persons other than the installer shall oversee the inspection and testing process, and shall certify that all proof testing requirements have been met.

Proof testing procedures and results shall be fully documented. The testing supervisor, the installer and the system owner shall retain complete copies of the test documentation.

5.2 5% Testing criteria: 5% of the total number of line sets (rounded to the next higher unit number) shall be tested in installations meeting all of the following criteria:

a. Rigging system components are manufactured under controlled process environments, and to engineered designs.
b. Rigging system components are installed under conditions where qualified professionals evaluate system design.
c. Rigging system component manufacturers provide detailed recommendations for the application and installation of their respective products
d. The system installation consists of standardized components and equipment layouts
e. The entire system installation is subject to visual inspection, and non-destructive operational testing by qualified individuals other than the installer.

5.3 10% Testing Criteria: Systems not meeting the requirements of section 5.2, either (a), (b), <u>or</u> (c) above shall be subject to random batch testing of 10% of the total number of line sets. The requirements of section 5.2 (d) and (e) shall be met under the 10% testing criteria, regardless.

5.4 100% Testing Criteria: Systems not meeting the requirements of section 5.2 (a), (c), <u>and</u> (d) above shall be subject to proof testing of 100% of the system.

Systems meeting the criteria of Section 5.2 or 5.3, but that fail any proof test performed shall be subject to 100% proof testing.

5.5 Exemptions: For systems meeting all requirements of section 5.2 except (d), the manufacturer shall be permitted to designate portions of the system, as either “standard” or “non-standard”. This provision shall apply for the sole purpose of determining applicable proof testing criteria, and shall permit an exemption for any equipment designated as “non-standard”. Portions designated as “standard” shall be tested according to the criteria fulfilled by each distinct portion, but in no case shall any portion of the system be exempted from proof testing on the sole basis of section 5.2 (d).

6 Design factors

6.1 Recognized codes: All equipment shall be manufactured to comply with the standards listed herein, and any applicable recognized codes (or any applicable jurisdictional regulation, where the requirements of such regulation are more stringent).

6.2 Design factors: Unless modified by other sections of this document, other codes listed, or governing bodies with jurisdiction over a particular facility, the factors listed in ***Table 1*** shall be used as minimums for design purposes, but shall not serve as a substitution for evaluation and determination by a qualified engineering professional. Design factor ratios shown are versus tensile (ultimate) strength.

TABLE 1

#	ITEM	MINIMUM DESIGN FACTOR / SIZE
1	Wire rope strength	8:1
2	Sheave diameter	Minimum diameter recommended by rope or wire rope manufacturer*
3	Maximum fleet angle	1½ degrees, or per manufacturer's specific recommendation(s)
4	Bearings	L10 rating equal to two times block design load at a speed of 1.5 meters/second (300 feet/minute) for 2000 hours
5	Block assemblies	8:1
6	Steel	8:1
7	Terminating hardware	8:1
8	Purchase lines	Minimum tensile strength of 21,600N (4,860 pounds), when new
9	Trim chain assembly	8:1
10	Batten clamps	8:1
11	Rope lifting lines	10:1 [16 mm (5/8 inch) minimum diameter]
12	Max. allowable load imbalance	23 Kg (50 lbs)

6.3 Lift Lines: The design factor of lift lines shall be determined by the following calculation:

$$\frac{\text{(Breaking Strength)} \times \text{(Strength Reduction Factors)}}{\text{(Design Load Limit)}}$$

Where:

(1) Breaking Strength = the minimum load at which tensile failure occurs, as certified by the manufacturer.

(2) Strength Reduction Factors = the factors that reduce the static load breaking strength. Strength reduction factors take into account bending as the lift line passes over sheaves, and the types of knots or fittings used. Refer to the current edition of the Wire Rope User's Guide, or to manufacturer's specific recommendations for appropriate strength reduction values.

(3) Design Load Limit = the maximum anticipated static load that the lift line will support in use.

TABLE 2

Suggested Allowable Radial Bearing Pressure of Ropes on Various Sheave Materials Values shown in kilopascals (kPa) and [pounds per square inch (psi)]									
Material	**Regular Lay Rope**				**Lang Lay Rope**			**Flattened Strand, Lang Lay**	**Remarks**
	6 x 7	**6 x 19**	**6 x 37**	**8 x 19**	**6 x 7**	**6 x 19**	**6 x 37**		
Cast Iron	2,068 [300]	3,309 [480]	4,033 [585]	4,688 [680]	2,413 [350]	3,792 [550]	4,551 [660]	5,516 [800]	Based on min. Brinell hardness of 125
Carbon Steel Casting	3,792 [550]	6,205 [900]	7,412 [1,075]	8,687 [1,260]	4,137 [600]	6,895 [1,000]	8,136 [1,180]	9,997 [1,450]	30-40 Carbon. Based on min. Brinell hardness of 160
Chilled Cast Iron	4,482 [650]	7,584 [1,100]	9,136 [1,325]	10,687 [1,550]	4,930 [715]	8,343 [1,210]	9,997 [1,450]	12,273 [1,780]	Not advised unless surface is uniform in hardness
Cast Polyamides*	13,790 [2,000]	13,790 [2,000]	13,790 [2,000]	13,790 [2,000]	13,790 [2,000]	13,790 [2,000]	13,790 [2,000]	13,790 [2,000]	Refer to specific material manufacturer for additional details

Radial bearing pressure is determined using the following formula:

$$P = \frac{2T}{Dd}$$

where: P = Radial bearing pressure, in kPa (psi)
T = Wire rope tension, in Newtons (pounds)
D = Sheave tread diameter, in centimeters (inches)
d = Wire rope nominal diameter, in centimeters (inches)

Table 2 note: for 7 x 19 Galvanized Aircraft Cable or 7 x 19 Specialty Cord, use table values for Regular Lay Rope 6 x 19

Table data taken from the Wire Rope User Manual and other sources.

FIGURE 1

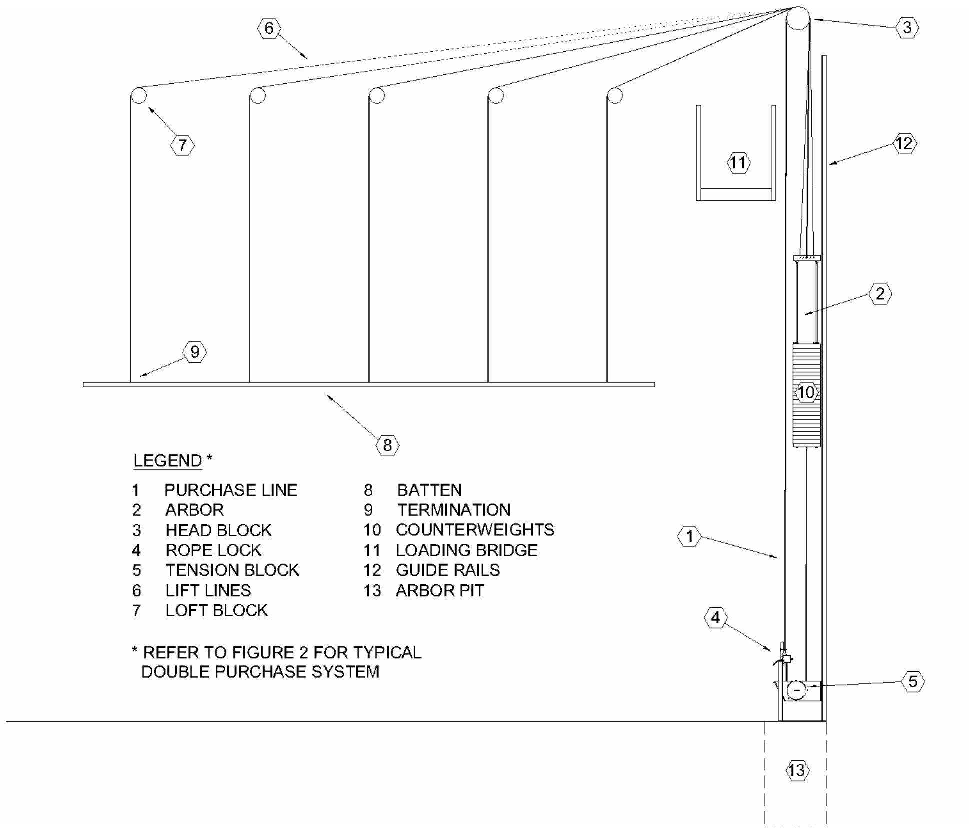

Figure 1: Typical Single Purchase Lineset: In a single purchase system, the rope purchase line (1) attaches to the top of the arbor (2), reeves up around the head block (3), down through the rope lock (4) and the tension block (5), and then terminates to a tie-off point on the arbor bottom. The wire rope lift lines (6) are also attached to the top of the arbor, and reeve over the head block and loft block (7), and are attached to the batten (8) at the batten terminations (9). Counterweights (10) serve to counterbalance the attached batten loads (at a 1:1 ratio), and are loaded (unloaded) to the arbor from the loading bridge (11). Arbors may be guided using rigid T- or J-shaped guide rails (12), or may be wire-guided (not shown) in locations where the arbors must be located in open floor space, away from an adjacent support wall. An arbor pit* (13) may be used to increase the overall arbor travel distance. Component details are described in section **3 Components**.

FIGURE 2

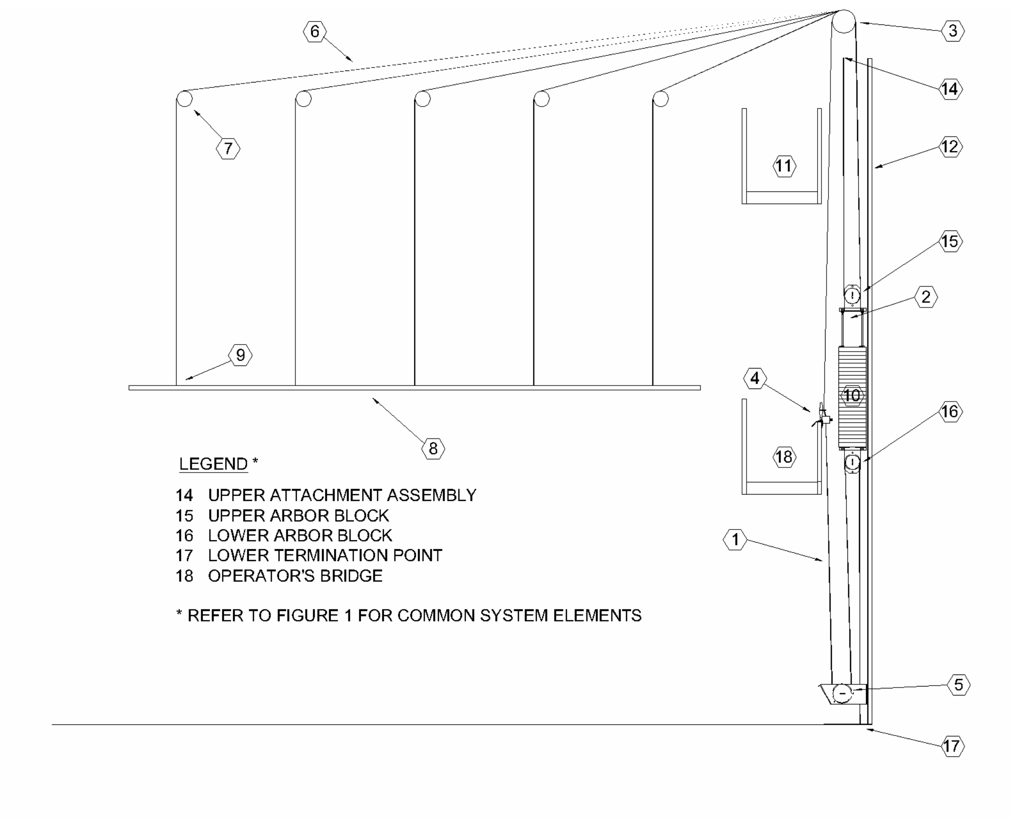

Figure 2: Typical Double Purchase Lineset: The double purchase system configuration differs slightly from the Single Purchase lineset system (refer to Figure 1), in that the purchase line and the lift lines are reeved through additional block assemblies at the top and bottom of the arbor. The purchase line is attached to an upper attachment assembly (14) located below the head block. This assembly is either integral to the head block assembly, or directly attached to the head block structural support steel. The purchase line then reeves down and around an upper arbor block (15), then back up around the head block, down through the rope lock, around the tension block, then reeves up and around a lower arbor block (16), then down to a lower termination point (17), located below the tension block. The wire rope lift lines also attach to the upper attachment assembly, and reeve down and around the upper arbor block, back up and over the head and loft block, then down to the batten termination points. This configuration requires a 2:1 ratio of counterweight to batten load. However, the arbor travel distance is ½ of the batten travel distance. Component details are described in section **3 Components**.

FIGURE 3

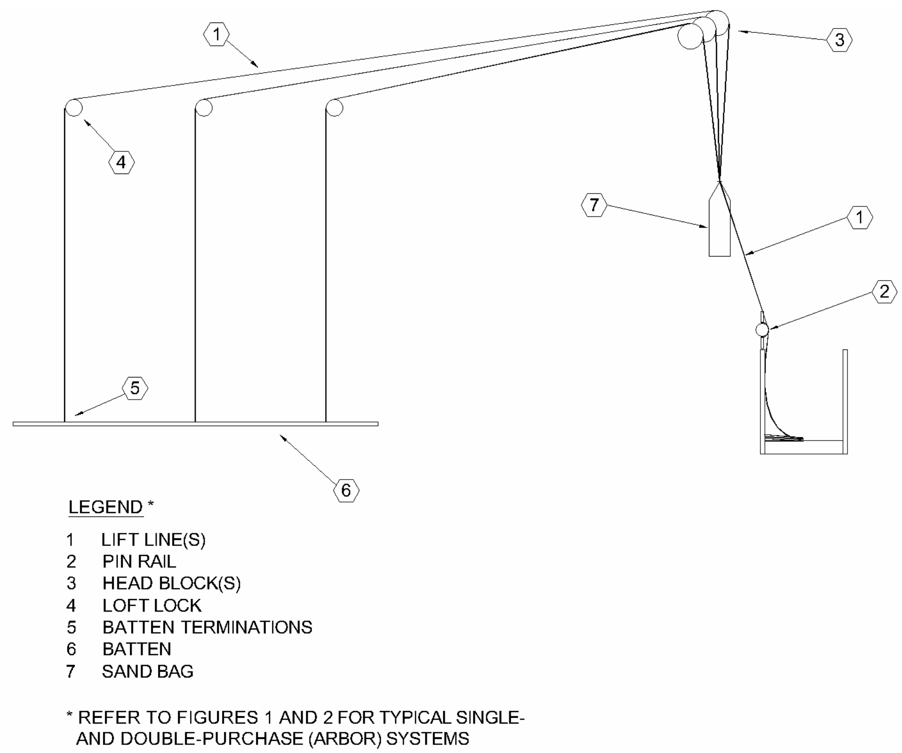

Figure 3: Typical Rope and Sand Bag Lineset: The Rope and Sand Bag system uses manila or synthetic fiber rope lift lines instead of wire rope. The lift lines (1) are tied off at the pin rail (2), are reeved up over the head block (3), and the loft blocks (4), then down to termination points (5) along the batten (6). The attached batten loads are counterweighted using sand bags (7), instead of arbors. Component details are described in section **3 Components**.

Annex A

This annex contains informative notes that are not part of the normative requirements of the standard.

A.1.2 Exclusions: Refer to ANSI/BSR E1.6 – Powered Rigging Systems for information pertaining to winch-powered rigging systems. As of the date of this publication, this document is a DRAFT standard, and has not yet been published. Currently, no standards exist for the use of manually powered winch systems in the entertainment industry, or for lifting humans.

A.3 Components: Since the general definition of ductile refers more to a material's ability to be drawn out into a wire, the standard elaborates by also specifying a plastic deformation. Another way to relate this concept is by comparison of the material's yield point to its ultimate tensile strength. Materials having ductile properties, and that deform plastically without fracturing, either a) have a yield point very close to its ultimate tensile strength, or b) have no yield point value, because the yield point is, essentially, equal to its ultimate tensile strength. This helps to clarify that acceptable materials will give a clear indication of failure, by first deforming (within its plastic range) before ultimate failure actually occurs.

Torque values for threaded connections vary based upon the materials, type of connection, and the predominate forces to which the connection is subjected (e.g. tensile, shear, etc.). Often, a connection will not require a specified torque value, while in some cases a minimum torque value is critical in order to achieve and maintain the full connection strength. Each type of connection and application should be evaluated by a licensed professional engineer in order to determine a) if a minimum torque value is applicable, b) if applicable the actual torque value or range, and c) the correct method for obtaining the specified torque, where required.

The use of flat washers is also relevant to minimum torque values. Where no minimum torque values are specified, the use of flat washers is probably not important. Conversely, any time minimum torque values must be achieved, or in applications where slotted or elongated holes are part of the connection, consideration should be given to the use of hardened flat washers as part of the appropriate connection method.

A.3.1.1 (a) Head Block Construction: Typically spacers are used to satisfy both requirements for stiffening and retaining rope cable in grooves.

A.3.1.6 Mounting, paragraph (d): Throughout the document, references are made to following the manufacturer's recommendations when selecting, using, applying or installing certain components or assemblies. Manufacturer's recommendations may include printed instructions, recommended procedures, guidelines, or may even include specific requirements. It is always preferable to obtain and follow printed instructions from the manufacturer, where possible, as this allows for more complete documentation of procedures for any given application.

A3.1.7 (e) Mounting Clips: Beam clips are typically bent with a short right angle (referred to as the "toe"), or can have welded to them a piece of round or flat stock. These shimming methods serve to minimize bending of the clip when the mounting bolts are tightened. Ideally, the tightened bolts will be perpendicular to the clamped materials, but in practice this is frequently not the case. Thus, the toe (or shim) also serves to maintain the perpendicularity between the bolt and the clamped material by limiting the amount of deflection that can occur. In doing so, this also helps maintain the contact surfaces between the bolt head, the nut, and the clamped materials. Refer to annex note A.3, paragraph 2 for additional information.

A.3.8.1.9 (a): Typical battens are constructed of 1-1/2" (nominal I.D.) Schedule 40 pipes. While other sizes may meet the structural requirements of this section, it is important to recognize that many commonly available pipe and fixture clamps used to make load attachments to the batten are specifically made to accommodate a range of pipe sizes up to, but not exceeding, this size of pipe.

A.3.9.2 (a): Lead is classified as a hazardous material in some jurisdictions, and is therefore not recommended for use as a counterweight material.

A.3.10 Compensating Systems: Excessive load imbalances are particularly inherent to systems having extremely long arbor travel distances, in which the self-weight of the wire rope, associated fittings, and other components creates a load shift such that the normal out-of-balance condition exceeds the maximum allowable. Compensating systems help to reduce the overall net imbalance by transferring a variable load on to, or off of, the arbor as it moves through its normal range of travel.

As the arbor is raised, the system load imbalance shifts from the arbor to the batten. At the same time, the compensating load shifts onto the arbor, minimizing the out-of-balance condition. Conversely, as the arbor is lowered, the load shift on both the lineset and the compensating system is reversed.

The typical compensating load is determined by the net system load imbalance (per lineset), divided by the overall travel distance. For example, if a lineset has a 60-foot travel, and a 60-pound net load imbalance at the arbor travel extents, the compensating load required would be 60 pounds/60 feet = 1 pound per foot of travel.

A.3.11 (b) Wire Guide Stops: Arbor stops on wire-guided systems are intended as a visual indication of arbor location only. Imparting additional loads to the wire guides and terminations is not recommended. Therefore any style of stop that attaches to wire guides should slip under load.

A.3.12.1 (c) Stop battens: Stop battens are intended to prevent metal-to-metal contact of surfaces, to minimize operational noise due to such contact, and to minimize impact loads occurring as an ancillary result of normal operating conditions. Stop battens are not intended to prevent structural damage in the event of unanticipated shock loads, nor are they intended to stop uncontrolled movement (such as a runaway arbor), because such conditions are not normal to proper operation of the system.

A.3.17.3 Wire Rope Terminations: The installer or user of components and assemblies, such as terminations, fittings, fasteners, and components, has a responsibility to determine if these components are used as intended by the specific manufacturer of the component. Generally, such components will be easily identifiable, often by means of unique manufacturer markings that indicate the variety, type, style, or material composition of the component. Where such markings are not present, or where the manufacturer's recommended usage criteria is unclear, the manufacturer of the component should be consulted to verify that the intended use is acceptable.

A.3.17.3 (c): The typical trim chain assembly described provides a multiple load path between the batten attachment and the lift line. The intent of the section is to require either a) manufacturer's certification that the chain is rated for overhead lifting, in accordance with NACM definitions, or b) manufacturer's certification that the chain is suitable for the intended application if its material properties and strength characteristics do not meet or exceed that of Grade 30 Proof Coil chain. As of the publication date of this standard, only Grade 80 alloy chain is acceptable by the NACM for overhead lifting.

A3.17.4 (a): At a pin rail, the lifting lines are typically lashed to the belaying pins by looping the rope twice around the belaying pin above and below the pin rail in a figure-8 pattern, with the free rope end tucked under the final loop at the top of the pin rail. For normal operation, this accomplishes a secure termination that can be easily undone.

A.3.18.2 (a) Pin rails: Multiple pin rail arrangements maximize available pins on which to hang excess rope, thus minimizing tripping hazards and damage to rope fibers.

A.4.9 System Manuals: Users of the system should read and thoroughly understand the information contained in the systems manual. Knowledge of the system-specific load capacities, operating instructions, and maintenance schedules are important to establishing safe operating practices.

A.Table 1, Item #2 – minimum sheave diameter: The commonly accepted value used to determine minimum sheave diameter is a D:d ratio of 28:1, where 'D' is the root diameter of the sheave, relative to 'd' (the nominal diameter) of the wire rope. However, manufacturers may specify other minimum acceptable values. In all cases, a larger D:d ratio will both increase wire rope life (by minimizing wear due to bending factors) and will also reduce operational noise.

A. Table 2 – Cast Polyamides: Cast polyamide is a generic term used as a reference for any one of several materials, all in the nylon polyamide family of thermoplastics. These materials are available from a wide range of manufacturers, usually specializing in special purpose, or high-strength sheaves. Although these materials are in the same family, they can differ in material properties, so the specific manufacturer of the material should be consulted for accurate material property values for the purpose of radial bearing pressure calculations. The values shown in Table 2 are for general use only, and based upon minimum loads above which the pressure of the cable acting upon the sheave over a period of time will temporarily deform the sheave.

A. Figure 1, item 13 – Arbor pits are often used to allow a longer arbor travel than normal, particularly in circumstances where the overall arbor travel may be adversely limited by extremely tall arbor sizes. Where pits are used, they should be designed to facilitate inspection and maintenance operations. For arbor pits that adjoin habitable space below the stage area, and that have a depth greater than 1.5m (5 ft.) below the stage elevation, separate access doors should be provided that permit access to the pit area at the pit floor elevation. Pit access doors should be lockable from the adjoining area side(s), but should also be fully operable from the pit area side.

As a precautionary measure, pit access doors should have signage attached to the exterior that clearly states: “**DANGER**! Moving Equipment Inside! Authorized Personnel Only!”