

Section 19

Hoisting Equipment, Piledrivers, and Conveyors

This section discusses hoisting equipment, piledrivers, and conveyors. It specifically addresses the following:

- General requirements
- Inspections and testing
- Recordkeeping
- Qualifications of hoisting equipment operator
- Operating requirements
- Critical lifts
- Wire rope
- Overhead, gantry, monorail, and underslung cranes
- Portal, tower, and pillar cranes
- Derricks
- Floating cranes and derricks
- Material hoists
- Overhead hoists
- Elevators and personnel hoists
- Conveyors and related equipment
- Cable highlines
- Base-mounted drum hoists
- Specialized hoisting systems
- Piledrivers

19.1 General Requirements for Hoisting Equipment

Maintain and operate equipment covered by this section in a safe manner. Use the more stringent of the Occupational Safety and Health Administration (OSHA), American Society of Mechanical Engineers/American National Standards Institute (ASME/ANSI), or Bureau of Reclamation standards, or use the manufacturer's guidance to install, set up, operate, and maintain all covered equipment.

19.1.1 Equipment Design. Design and install cranes and other hoisting equipment covered by this standard in accordance with the applicable standards listed in table 19-1.

Table 19-1.—Crane and hoisting equipment design and construction standards

ASME/ANSI B30.2	Overhead and gantry cranes (top running bridge, single or multiple girder, top running trolley hoist)
ASME/ANSI B30.3	Construction tower cranes
ASME/ANSI B30.4	Portal, tower, and pillar cranes
ASME/ANSI B30.5	Mobile and locomotive cranes
ASME/ANSI B30.6	Derricks
ASME/ANSI B30.7	Base mounted drum hoists
ASME/ANSI B30.8	Floating cranes and floating derricks
ASME/ANSI B30.11	Monorails and underhung cranes
ASME/ANSI B30.12	Handling loads suspended from rotorcraft
ASME/ANSI B30.14	Side boom tractors
ASME/ANSI B30.16	Overhead hoists (underhung)
ASME/ANSI B30.22	Articulating boom cranes

19.1.2 Modification and Reconfiguration. Do not make modifications, additions, or repairs that affect the structural competence, capacity, or safe operation of the equipment or system without the manufacturer's written approval or the approval of a professional engineer (PE).

19.1.3 Documentation. The following documents must be immediately available to the operator at all times:

- a. The manufacturer's operating manual or equivalent for the specific make and model of crane.
- b. Operating manuals for any attachments or accessories with which the crane is equipped.
- c. The load rating chart for construction cranes; portal, tower, and pillar cranes; mobile and locomotive cranes; floating cranes; floating derricks; and articulating boom cranes. This chart must be completely legible. It must also include the crane make and model and contain a complete range of the manufacturer's approved crane load ratings for all configurations for which the crane is designed.

19.2 Requirements for Cranes and Hoisting Devices, Inspections, and Testing

Inspect cranes and hoisting devices used in Reclamation activities. The equipment is subject to operational and load-performance tests as required by this section, other applicable standards, and manufacturer's recommendations.

19.2.1 Inspections. A designated person must conduct all inspections and must cover, at a minimum, the items identified in attachment 19-1. For the purposes of this section, a designated person is a person selected or assigned by the employer as competent to perform specific duties. For inspection of non-Reclamation owned equipment, notify a Reclamation representative at least 24 hours before the inspection to observe the inspection.

a. Types of Inspections. Inspect cranes in accordance with table 19-2 and this section.

Table 19-2.—Crane and hoist equipment inspection criteria

When to inspect	Type of inspection	Notes
Before initial use - new cranes	Initial inspection	Performed by manufacturer.
Before initial use - altered cranes	Initial inspection	"Altered " is defined as any change to the original manufacturer's design configuration, that is, replacement of weight handling equipment, parts, or components with other parts or components. A qualified person must conduct this inspection.
Before initial use on a Reclamation project	Periodic inspection	"Initial use" refers to the first time Reclamation takes possession of and assembles a crane or whenever a non-Reclamation-owned crane is brought onto a jobsite and set up for use.
Before every operation (shift)	Start-up inspection	
Annually or as required by manufacturer (if more frequent) for equipment in regular use	Periodic inspection	If the hoisting equipment has not been in service, inspect prior to operation. However, do not use the equipment if you have not inspected it in more than 12 months.
Before using a crane which is not in use on a regular basis and which has been idle for more than 1 month but less than 6 months	Frequent inspection	Also inspect running ropes. Annual (periodic) inspection also applies.
Before using a crane that is not used on a regular basis and that has been idle for more than 6 months	Periodic and frequent inspection	Also inspect running ropes.
Standby cranes, at least semi-annually	Frequent inspection	Standby cranes are those not used regularly but are available, on a standby basis, for emergencies (e.g., emergency operation and maintenance work); requirements for frequent inspections of standby cranes are in addition to the requirement for a annual (periodic) inspections.

- b. A copy of the completed inspection report must be readily available at the operating site.

19.2.2 Performance Tests. Performance tests include operational tests or load tests. Conduct performance tests in accordance with the manufacturer's recommendations; at the minimum, performance testing must meet the requirements listed in attachment 19-2. Conduct performance tests as required by these standards and the ANSI B30 standard appropriate for the equipment being tested.

a. Operational Tests. A designated person must conduct operational tests without load, as follows:

- Before initial use of cranes in which a load bearing (excluding the rope) or load controlling part or component, brake, travel component, or clutch has been altered, replaced, or repaired. In this case, a selective operational performance test—testing only those components that have been or may have been affected by the alteration, replacement, repair, or reassembly—may be performed.
- Each time it is reconfigured or reassembled after disassembly.
- Annually, unless the hoisting equipment has not been in service, in which case you may defer the test until before its operation. However, do not use equipment if the last operational test was conducted more than 12 months ago.

19.2.3 Load Tests. Conduct load tests, under the direction of a qualified person, as follows:

- Before initial use of cranes in which a load bearing or load controlling part or component, brake, travel component, or clutch has been altered, replaced, or repaired.
- Each time it is reconfigured or reassembled after disassembly.
- Before any lift where the load is expected to be at least 75 percent of the rated capacity of the crane or hoisting equipment. Load test results will remain valid for 5 years, and load tests for subsequent lifts are not required during this period.

Test loads must be at least 100 percent, but not more than 110 percent, of the manufacturer's load rating capacity chart at the configuration of the test, except for manufacturer testing of new cranes and as excepted in the subsection for maximum lifts.

For the purposes of this section, a qualified person is a person who, by possession of a recognized degree or certificate of professional standing, or who, by extensive knowledge, training, and experience, has demonstrated the ability to solve or resolve problems relating to the subject matter and work.

- a. Boom Stop Testing.** Test hoisting equipment with boom stops during the operating test process.

19.3 Availability and Retention of Records

Keep written records of inspections and performance tests, identifying the type and nature of the inspection and testing, readily accessible to operating personnel and make them available upon request to employees or compliance officials.

19.4 Qualifications for Operating Hoisting Equipment

19.4.1 Operators. Only qualified and designated personnel may operate hoisting equipment. Only operators qualified to operate a particular type of crane or hoisting device may operate that equipment.

19.4.2 Proficiency. Operators of cranes and hoisting equipment must be qualified through formal training, testing, and demonstrated proficiency in operating the equipment to a designated person. After initial qualification, operators must complete a total of 24 hours of periodic refresher training over any 3-year period, covering safe operation of the types of cranes and hoisting devices they operate. Operators of non-Reclamation-owned equipment must provide evidence of operator qualification before beginning work on Reclamation activities.

19.4.3 Physical Qualifications. Operators must be physically qualified to operate hoisting equipment.

a. Physician's Certification. Operators must have a physician's certification that the operator meets physical qualifications to operate hoisting equipment involving mobile cranes, cableways, cab operated bridge cranes, derricks, mobile excavators, loaders, and similar heavy equipment when used for hoisting materials. Consider the following physical qualifications:

- Vision of at least 20/30 Snellen in one eye and 20/50 in the other, with or without corrective lenses
- Normal depth perception and field of vision
- Ability to distinguish colors, regardless of position
- Adequate hearing, with or without hearing aid, for the specific operation
- Sufficient strength, endurance, agility, coordination, manual dexterity, and speed of reaction to meet the demands of equipment operation
- No tendencies to dizziness or similar undesirable characteristics

b. Examination Validity. The physician's certificate of examination must be no more than 12 months old at the time of any hoisting operation.

c. Disqualification Factors. Evidence of physical defects; emotional instability that could render a hazard to the operator, others, or safe operation of the crane; or evidence that the operator is subject to seizures or loss of physical control constitutes sufficient reason for disqualification. In cases where the operator may be disqualified, specialized medical tests may be required to determine these conditions and their effects.

19.5 Operating Requirements for Hoisting Equipment

19.5.1 Duty Periods. Operators must not work or be at the jobsite more than 12 hours in any 24-hour period.

19.5.2 Authority. Operators must be responsible for those operations under their direct control. Whenever there is any doubt as to safety, the operator must have the authority to stop or to refuse to handle loads until safety has been ensured. Other onsite personnel must alert the operator if they believe unsafe operating conditions exist.

19.5.3 Other Duties. When hoisting equipment is in operation, operators must not perform any other work or leave the operator's position while a load is suspended.

19.5.4 Environmental Conditions

a. Crane and hoisting operations must be shut down when wind speeds exceed 25 miles per hour, or in accordance with specific manufacturer's instruction, whichever is less.

b. If dust, darkness, fog, snow, rain, or other environmental conditions impair the operator's visibility, shut down the crane operation until steps are taken to compensate for the lack of visibility.

c. Shut down crane and hoisting operations when lightning is present and equipment is vulnerable to lightning strikes. See the section on "Work Planning," for specific practices.

19.5.5 Maximum Lifts

a. Do not lift loads greater than the rated load of the crane, except for performance load testing purposes or as otherwise permitted in this subsection.

b. Overhead and gantry cranes, operating in accordance with ASME/ANSI B30.2, may exceed their rated capacities for performance load testing purposes (up to 125 percent), or planned engineered lifts.

19.5.6 Riding Loads. No person may ride loads, blocks, buckets, hooks, scaffolding, boatswain's chairs, cages, or other devices attached to hoist lines, booms, or attachments of any crane, derrick, or materials hoist. Designated maintenance personnel may ride the carriage service platform of a cableway to perform inspection testing or maintenance. Under limited circumstances where employees cannot perform work through other means, you may use crane-supported personnel platforms (manships) after obtaining written authorization, supported by written risk assessment, from the office head.

19.5.7 Barricades. Barricade the rear-swing radius area of rotating superstructures of cranes to physically prevent people or equipment from entering the danger zone.

19.5.8 Radio Communications. During critical lifts or lifts involving use of crane-supported work platforms, maintain and use direct radio communications among the operator, personnel on the work platform (when applicable), and an individual observing the load.

19.5.9 Crane and Hoist Signals

a. Signal Systems. Use a uniform standard signal system in operating cranes, derricks, and hoists. Hand signals, as illustrated in "Hand Signals for Cranes and Hoisting Equipment," must be used. Where hand signals are insufficient, or when the distance between the operator and the signal person is over 200 feet, the operator and signal person must use voice or other direct means of communication. The operator and signal person must maintain communication.

b. Posting. Post signals at the operator's position and, as practical, at signal control points and at other locations as necessary to inform those using the signals.

c. Signal Visibility. Protect signal systems from unauthorized use, damage, or interference. Predesignate a signal person and identify that person by special color of hard hat, armband, or other distinguishing marking. The predesignated person will give crane and hoist signals.

19.5.10 High-Voltage Lines. See the section on "Electrical Safety" for specific requirements pertaining to operation of cranes and other equipment near high-voltage lines.

19.5.11 Taglines. Use taglines to control loads when their use is practical and will not create additional hazards to personnel, equipment, and structures.

19.5.12 Crane-Supported Personnel Platforms. Conduct activities involving crane-supported personnel platforms using the requirements of subsection on crane-supported personnel platforms, located in the "Walking and Working Surfaces" section. These activities are critical lifts. Conduct them as required in the following subsection on critical lifts.

19.6 Requirements for Critical Lifts

A critical lift is a non-routine lift requiring detailed planning and additional or unusual safety precautions. Critical lifts include: (1) lifts made when the load weight is 75 percent or more of the rated capacity of the crane or hoisting device; (2) lifts made with more than one crane; (3) hoisting personnel with a crane; or (4) any lift that the crane or hoist operator believes critical.

19.6.1 Lift Supervisor. Designate a person, other than the crane operator, to supervise the planning and execution of all critical lifts.

19.6.2 Critical Lift Plans. Prepare a written critical lift plan before making any critical lift. The lift supervisor must prepare the plan in coordination with the crane/hoisting equipment operator and rigger. All personnel involved in the lift should review and sign the critical lift plan. The plan must include the following information:

- Exact size and weight of the load, including all crane and rigging components that add to the weight. Include the manufacturer's maximum load limits for the complete range of the lift.
- Exact information about the sequence of events and procedures, including equipment positioning, height of the lift, load radius, and boom length and angles, where applicable.
- Rigging plans with lift points, procedures, and hardware requirements.
- Conditions and procedures under which the lifting operation is to be stopped.
- Coordination and communications procedures.
- Names of lift supervisor, hoisting equipment operator, rigger, and other personnel with key roles in the operation.
- For tandem lifts, general information on the hoisting equipment, including make, model, operating speeds, and other information to ensure the equipment is compatible.
- Ground conditions and other information needed to ensure that a level, stable foundation with sufficient bearing capacity for the lift supports the hoisting equipment. This includes outrigger, crawler track, and support mat design calculations.

19.7 Requirements for Working with Wire Rope

19.7.1 Safe Working Load. See the "Wire Rope" appendix for the approximate safe working load for various specified sizes and classifications of improved steel wire rope. Do not exceed these values unless manufacturers' data are available and the data permit greater loads.

19.7.2 End Fasteners. Use only commercial wire rope fittings. Install wire rope clips as specified in the "Wire Rope" appendix. Make job-fabricated eye

splices in accordance with the manufacturer's instructions and test them before use. Give eye splices three or more full tucks. When using a wedge socket fastener, secure it with either an extended wedge through which a wire rope clip is secured, a short piece of wire rope secured to the dead end with a wire rope clip, or a dual-saddle (piggyback) clip that fastens tightly to the dead end but slides freely on the live side. Never use a single clip to secure the live side and the dead end.

19.7.3 Hoisting Rope. Except for end fasteners, wire rope used to hoist or lower loads must be continuous, without knots or splices.

19.7.4 Spooling of Rope. Overwind or underwind wire rope correctly from right to left or left to right, in accordance with the lay, to avoid twisting, spreading, or overlapping on winch drums in accordance with the wire rope manufacturer's instructions.

19.7.5 Sheave Diameter. The ratio between the rope diameter and the drum or sheave diameter must not be less than specified by the rope manufacturer. When not specified, the ratio must be in accordance with the appropriate ANSI standard. Drums, sheaves, and pulleys must be smooth and free of defects that could damage the rope.

19.7.6 Sheave Groove Tolerance. Use the sheave groove tolerances as recommended by the sheave manufacturer.

19.7.7 Lubrication. Lubricate wire rope with manufacturer-approved lubricants and follow the manufacturer's approved methods at the intervals required by the type of service.

19.7.8 Removal and Replacement. Remove wire rope with one or more of the following defects from hoisting or load-carrying service immediately:

- a. **Corrosion.** Corrosion of the rope or end attachments.
- b. **Broken Wire.**
 1. One or more valley breaks. (A valley break is a wire break in the valley between two adjacent strands.)
 2. Six randomly spaced broken wires in one lay or three broken wires in one strand in one lay.
- c. **Abrasion.** Abrasion, scrubbing, flattening, or other damage resulting in the loss of more than one-third of the original diameter of the outside wires.
- d. **Kinking.** Kinking, crushing, bird caging, or other damage resulting in distortion of the rope structure.
- e. **Heat Damage.** Evidence of heat damage.

f. Reduction in Diameter. Reductions from nominal diameter of more than 3/64 inch for rope diameters up to and including 3/4 inch, of more than 1/16 inch for diameters 7/8 to 1-1/8 inches, or of more than 3/32 inch for rope diameters of 1-1/4 to 1-1/2 inches.

19.7.9 Socket Breaks. Resocket or remove from service the wire rope when any broken or corroded wires are next to a socket or end fitting. Resocket the wire rope or remove it from service.

19.7.10 Hazardous Location. Guard running lines of stationary hoisting equipment located within 8 feet of the ground or working level or enclose or barricade the hazardous area.

19.8 Requirements for Mobile and Locomotive Cranes

In addition to the requirements set forth in these standards, mobile and locomotive cranes must conform to the standards in the current edition of ANSI/ASME B30.5, Mobile and Locomotive Cranes; side boom wheel or crawler tractors must conform to the ANSI/ASME B30.14, Side Boom Tractors.

19.8.1 Performance Inspection and Testing. Conduct and record performance inspections and testing in accordance with the requirements of this section and attachment 19-2.

19.8.2 Boom Angle Indicator. Equip mobile cranes with a boom angle or radius indicator located within the operator's view.

19.8.3 Boom Stops. Provide cranes or other hoisting devices with cable-supported booms with stops to resist the boom falling over backwards. Design boom stops to provide increasing resistance from the initial point of contact to a stopping point no more than 87 degrees above horizontal.

19.8.4 Boom Hoist Disengagement Device. Provide mobile crane booms with a functional boom hoist disengagement device that will automatically stop the boom hoist mechanism when the boom reaches its highest rated angle.

19.8.5 Anti-Two-Blocking Device. Equip all mobile cranes with a two-block damage prevention feature or an anti-two-blocking device. Two-block damage prevention features must prevent damage to the crane or hoist line in case of a two-block condition. Anti-two-blocking devices must have automatic capabilities to disengage all crane functions whose movement can cause two-blocking. For lattice-boom cranes manufactured before 1992, two-block warning features may be used to alert the operator to an impending two-blocking condition. However, do not use cranes so-equipped in critical lifts or personnel hoisting operations.

19.8.6 Level Indicator. Provide a means for the operator to visually determine the levelness of the crane.

19.8.7 Jib Stops. In addition to boom stops, jibs must have a positive stop to prevent overtopping.

19.8.8 Cab Windows. Windows in crane cabs must be safety glass or equivalent. Cab windows must not introduce any distortion that interferes with the crane's safe operation.

19.8.9 Audible Warning Device. Mobile cranes must have an audible warning signal device distinguishable and audible above the usual construction noise.

19.8.10 Securing Booms. When they are not in use, lower crane booms to the ground or otherwise secure them to prevent displacement by wind or other outside forces.

19.8.11 Fire Extinguisher. Provide the cab with a 2-A:40-B:C fire extinguisher.

19.9 Requirements for Overhead, Gantry, Monorail, and Underslung Cranes

In addition to requirements set forth in these standards, overhead and gantry cranes must conform to requirements contained in the current edition of ANSI B30.2. Monorails and underslung cranes must conform to the requirements contained in the current edition of ANSI B30.11.

19.9.1 Design. The manufacturer or a PE must design crane installations and equipment.

19.9.2 Performance Inspections and Tests. Conduct and record performance inspections and testing in accordance with requirements of the "Cranes and Hoisting Devices, Inspections, and Testing" section, and attachment 19-2.

19.9.3 Crane Access. Provide safe access to the cab or bridge walkway with a fixed ladder, stairs, or platform, with no step or gaps exceeding 12 inches. Fixed ladders and stairways must comply with the requirements set forth in the section on "Walking and Working Surfaces."

19.9.4 Platforms and Walkways. Install maintenance platforms and walkways protected by standard guardrails and toeboards, and means of safe access onto the trolley and bridge. Where it is impractical to install platforms and walkways, install safety lines with runners to attach safety belt lanyards to afford safe inspection and maintenance. Refer to the section on "Walking and Working Surfaces."

19.9.5 Markings. Mark the rated load of the crane on both sides of the crane. Mark the rated load of each hoist on the crane on the hoist, trolley unit, or load block. All markings must be readable from the ground or floor.

19.9.6 Hoist Identification Markings. For cranes with multiple hoists, distinctively mark each hoist so that it is visible from the ground or floor. Clearly mark operator controls to correspond to the hoist markings to indicate the controls that operate each hoist.

19.9.7 Warnings. Cranes must have appropriate warning labels, as required by ANSI B30.2.

19.9.8 Fire Extinguisher. Mount a fire extinguisher of 2-A:40-B:C rating in the cab or near the operator's position.

19.9.9 Outdoor Equipment. Secure outdoor cranes from unauthorized access when not in use.

19.10 Requirements for Portal, Tower, and Pillar Cranes

In addition to the requirements set forth in this section, portal, tower, and pillar cranes must conform to the applicable standards in the current edition of ANSI B30.4, "Portal, Tower and Pillar Cranes," and ANSI B30.3, "Construction Tower Cranes."

19.10.1 Design. The manufacturer or a PE must design the crane equipment and oversee its installation.

19.10.2 Performance Inspections and Tests. Conduct and record performance inspections and testing in accordance with requirements of this section and attachment 19-2.

19.10.3 Fire Extinguisher. Mount a fire extinguisher of 2-A:40-B:C rating in the cab or near the operator's position.

19.10.4 Crane Erection and Dismantling. Erect and dismantle cranes in accordance with the manufacturer's recommendations and applicable ANSI/ASME standards. Following are the minimum requirements:

- a. Erect cranes under the supervision of a qualified person.
- b. Make the manufacturer's or a qualified person's written instructions and the weights of each component to be erected at the site.
- c. Develop and implement a job hazard analysis (JHA) during the planning and erection process. The JHA must include consideration of temporary guying and bracing requirements during the erection.

19.10.5 Environmental Conditions. Place the crane into its most favorable protected position to protect personnel and property when environmental conditions require lifting operations to cease.

19.10.6 Unattended Tower Cranes. Place unattended tower cranes in a weathervane configuration.

19.10.7 Limiting Devices. Where applicable, install the following limiting devices:

- a. Trolley limit switches to prevent further trolley motion beyond predetermined points on tower crane booms.
- b. Anti-two-block switches that cause the hoist drum to automatically stop, preventing contact between the load hook and the head block.
- c. Load-limiting switches to avoid exceeding crane capacities.
- d. Limit switches and stops or buffers at each end of the tracks of track-mounted cranes.

19.10.8 Boom Angle Indicator. Install boom angle indicators on machines having booms capable of moving in the vertical plane.

19.11 Requirements for Derricks

Derricks, in addition to the requirements set forth in this subsection, must conform to the requirements contained in the current edition of ANSI B30.6, "Safety Standards for Derricks."

19.11.1 Design. A PE must design derrick installations and equipment.

19.11.2 Inspections and Performance Tests. Conduct and record inspections and performance tests in accordance with requirements of this section and attachment 19-2.

19.11.3 Foundation. Set derricks on foundations designed and constructed to support the weight of the crane plus the maximum rated load.

19.11.4 Boom Angle Indicator. Provide a boom angle or radius indicator and place it within the operator's view.

19.11.5 Fire Extinguisher. Mount a fire extinguisher of 2-A:40-B:C rating at the operator's station.

19.12 Requirements for Floating Cranes and Derricks

In addition to the requirements set forth in these standards, floating cranes and derricks must conform to the requirements contained in the current edition of ANSI B30.8, "Safety Code for Floating Cranes and Floating Derricks."

19.12.1 Design. The manufacturer or a qualified person must design and certify all floating cranes and derricks.

19.12.2 Inspections and Performance Tests. Conduct and record inspections and performance testing using this section and attachment 19-2.

19.12.3 Fire Extinguisher. Mount a fire extinguisher of 2-A:40-B:C at the operator's station.

19.12.4 Personal Flotation Devices. All personnel must wear U.S. Coast Guard-approved personal flotation devices while onboard, except while in enclosed cabins. Additionally, provide and make readily accessible at least two U.S. Coast Guard-approved Type IV life rings (30 inch diameter) with at least 90 feet of line. For night operations, equip at least one ring with a water-activated flashing light.

19.12.5 Rescue Skiff. Make available a rescue skiff meeting the requirements in the section on "Personal Protective Equipment."

19.12.6 Load Rating Chart. When reducing load ratings to compensate for "barge list," provide a new rating chart. The manufacturer must rate barge-mounted cranes designed and constructed as a unit. All other barge-mounted cranes must be large enough to limit the "list" under maximum load to 5 degrees.

19.12.7 Wave Action. Suspend crane operation when significant wave action affects the stability of the barge.

19.12.8 Mobile Cranes. Block and secure mobile cranes mounted on barges or pontoons to prevent shifting.

19.13 Requirements for Material Hoists

Construct, install, test, operate, and maintain material hoists as set forth in the latest edition of ANSI A10.5, "Safety Requirements for Material Hoists," and the requirements of this section. The manufacturer or a PE must design material hoist installations.

19.13.1 Assembly. A qualified individual must directly supervise erecting and dismantling of hoist towers and material hoists.

19.13.2 Inspection. A qualified person must inspect the hoist, including all its components, after initial installation and before it is placed into service. A designated individual must inspect it monthly thereafter in accordance with ANSI A10.5.

19.13.3 Car-Arresting Devices. Test car-arresting devices before initial use and every 4 months thereafter. Conduct tests in accordance with ANSI A10.5.

19.13.4 Posting. Post operating rules, including signals, line speeds, and loading, at the operator's station and on the cage frame or crosshead. A copy of the hoist operating manual must be available at all times of operation.

19.13.5 Riding. Do not permit anyone to ride a material hoist except for inspection and maintenance. Conspicuously post with "NO RIDERS ALLOWED."

19.13.6 Hoistway Entrances. Protect entrances to the hoistway with substantial gates or bars installed the full width of the landing entrance. Paint entrance bars and gates with diagonal contrasting colors, such as black and yellow stripes. Bars must not be less than 2- by 4-inch wood, or equivalent, and not less than 36 inches or more than 42 inches above the floor. Bars must be at least 2 feet from the hoist and equipped with a latching device. Where gates are used, they must be at least 66 inches high, with a maximum underclearance of 2 inches, and must be no more than 4 inches from the hoist sill. Gate grilles or lattice must have openings no larger than 2 inches.

19.13.7 Overhead Protection. Protect the top of the cage or platform with 2-inch planking, 0.75-inch plywood, or material of equivalent strength.

19.13.8 Tower Enclosures. You may or may not enclose hoist towers on all sides. However, the following requirements must apply:

a. Enclosed. An enclosed hoistway or tower must be enclosed on all sides for its entire height, with 0.5-inch wire mesh screen, No. 18 U.S. gauge or equivalent, except at access points.

b. Open Sides. For an unenclosed hoist tower, totally enclose the hoist cage or platform on all sides between the floor and the protective top with 0.5-inch wire mesh screen, No. 14 U.S. gauge or equivalent. The hoist cage or platform enclosure must include the required gates for loading and unloading. Install an enclosure at least 6 feet high on the unused sides of the hoist tower at ground level.

19.13.9 Operator's Station. Protect the operator's station with overhead planking not less than 2 inches thick or with material of equivalent strength.

19.13.10 Towers and Shaftways. A PE must design towers and shaftways with a safety device capable of stopping and holding the platform with maximum load in the event of a cable failure.

19.13.11 Tower Support. Towers must rest on solid foundations. Ensure the towers are plumb and well guyed or otherwise anchored in four directions at the top and at least every 30 feet in height.

19.13.12 Hinged Roof. The car or platform roof may be hinged to accommodate long material.

19.13.13 Electric Hoists. Electric hoists must be provided with an automatic motor brake to automatically stop and hold the load in case of a power failure.

19.13.14 Operating Restrictions. One hoisting machine, or one operator, must operate only one cage, bucket, or hoist platform at a time.

19.13.15 Hoisting Machines. Design and install hoisting machines to raise and lower the maximum rated load plus the weight of equipment and ropes. Hoisting machines must incorporate the following features:

a. Brakes. The brakes must be capable of stopping and holding 125 percent of the rated hoisting capacity under all operating conditions.

b. Mechanical Brakes. Install mechanical brakes to stop movement of the hoist drum and equip the mechanical brakes with a positive acting device that will hold the brake in the engaged position.

c. Ratchet and Pawl. Equip friction-clutch-driven winding drum hoisting machines with an effective pawl and ratchet capable of holding the rated load capacity when suspended.

d. Controls. All controls must, when released, automatically return to neutral and set the brake. Plainly mark each control to indicate its function; it must be within easy reach of the operator.

19.13.16 Position Indicator. Use a positive system to indicate when the hoist car or platform has reached specific locations, including the top and bottom landings.

19.13.17 Signal System

a. Hand Signals. You may use hand signals on a single drum hoist when the hoist tower is no more than 50 feet high and the signals are clearly visible to the operator at all times.

b. Electrical Communication. Use a closed-circuit electrical communication system on all other material hoist installations. The system must be two-way, with a speaker located at the hoist operator's station and at each landing. The hoist operator must be able to communicate by voice to and from each station.

19.13.18 Fire Extinguisher. Mount a fire extinguisher of 2-A:40-B:C rating at the operator's station.

19.13.19 Inspections and Performance Testing. Performance test material hoists under the direction of the design engineer or his or her designee. Conduct the test in accordance with ANSI A10.5 requirements and this section. Include the car-arresting device in the test.

19.14 Requirements for Overhead Hoists

Install, operate, and maintain overhead hoists in compliance with the more stringent provision of this section and ANSI B30.16, "Overhead Hoists (Underhung)."

19.14.1 Design. The manufacturer or a PE must design hoists and hoist suspensions and anchorages.

19.14.2 Inspections and Performance Tests. Conduct and record inspections and performance tests in accordance with requirements in the section on "Cranes, Hoisting Devices, Inspections, and Testing," and attachment 19-2 of these standards.

19.14.3 Safe Working Load. Indicate the safe working load, as determined by the manufacturer, on the hoist. Do not exceed the safe working load.

19.14.4 Support. Design the supporting structure to withstand the loads and forces imposed by the weight of the hoist and its rated load. The support must provide unobstructed movement of the hoist and load. It must also permit the operator to stand clear of the load in all hoisting positions.

19.14.5 Limit Switch. Equip power-operated overhead hoists with a limit switch to prevent the load hook from exceeding the upper travel limit.

19.14.6 Hoist Controls. Controls on powered hoists must return to a neutral position when released, and load hook movement must stop.

19.14.7 Brakes. Except for hand-powered hoists, all overhead hoists must have brakes that apply automatically when the controls are in neutral.

19.14.8 Air-Operated Hoists. Connect air hoists to an air supply of sufficient capacity and working pressure to safely operate the hoist with maximum load.

19.14.9 Hand-Powered Hoists. Hand-powered hoists must be worm-gear-driven or equipped with a pawl or ratchet system that provides continuous effective control and braking reliability.

19.15 Requirements for Elevators and Personnel Hoists

Design, construct, test, inspect, and maintain permanent elevators in accordance with the current editions of ANSI A17.1, "Elevators and Escalators," and ANSI A17.2, "Inspectors' Manual for Elevators and Escalators." You must design, install, and test elevators under the direction of the manufacturer or a PE. Following installation, inspect, test, and certify elevators in accordance with referenced standards.

19.16 Requirements for Personnel Hoists

Construct, install, test, operate, and maintain personnel hoists as set forth in the current edition of ANSI A10.4, "Safety Requirements for Personnel Hoists," and the requirements of this subsection.

19.16.1 Design and Installation. Observe manufacturer's drawings, specifications, and limitations when installing and operating personnel hoists. A qualified person must design all personnel hoists, and a PE must certify them.

19.16.2 Inspections and Performance Tests. A qualified person must performance test and inspect personnel hoists at initial installation, and a designated person must inspect them annually thereafter. Conduct the tests in accordance with ANSI A10.4, "Safety Requirements for Personnel Hoists." Maintain a comprehensive report detailing test and inspection procedures and results.

19.16.3 Posting. Post rated load capacities, recommended operating speeds, and special hazard warnings on cages, platforms, and at the operator's station.

19.16.4 Hoistway Enclosure. Hoist towers that are installed outside buildings or structures must be enclosed for the full height of the side or sides used to enter or exit to the building or structure. Enclose the other sides to a height of at least 10 feet above the lowest landing. Enclose the sides of the tower adjacent to floors or scaffold platforms to a height of 10 feet above the level of such floors or scaffolds. Enclose towers inside buildings or structures on all four sides throughout the full height.

19.16.5 Tower Anchorage. Anchor towers to the structure at no less than 25-foot intervals. In addition to tie-ins, install a series of guys. Where tie-ins are not practical, anchor the tower by wire rope guys, at least 0.5 inch in diameter, securely fastened to anchorages to ensure stability.

19.16.6 Cage Enclosure. Fully enclose cages on all sides and the top, except sides used for entrance, which must have car gates or doors.

19.16.7 Entrance Doors. Provide a door or gate that covers the full height and width of the cage entrance opening, at each entrance to the cage.

19.16.8 Door Interlocks. Provide doors or gates with interlocks that prevent movement of the cage unless the door or gate is fully closed.

19.16.9 Overhead Protection. Overhead protection of 2-inch planking, 0.75-inch plywood, or other material of equivalent strength must cover the top of the cage.

19.16.10 Overspeed Safety Device. Equip the cage with an overspeed safety device that must stop and hold the cage, plus the maximum rated load, when the cage exceeds governor tripping speed or the hoist rope fails.

19.16.11 Brakes. Equip the hoist with two independent braking systems. One must be a system that automatically applies when the controls are in neutral or when there is a power failure. In addition, attach a manually operated braking system to the hoist drum that is capable of stopping and holding 125 percent of the rated load in any position.

19.16.12 Power-Up and Power-Down. Design the hoist power unit to provide power-up and power-down at all times. Refer to requirements in the subsection on "Overhead Hoists."

19.16.13 Controls. On manually controlled hoists, the controls must return to the stop position when pressure is removed from the control lever.

19.16.14 Maximum Speed. The speed of the cage must not exceed 200 feet per minute.

19.16.15 Travel Limit Stops. Equip hoists with upper and lower travel limit switches.

19.16.16 Hoist Ropes. Hoist wire ropes must meet the following minimum requirements:

- a. Minimum Number.** Drum hoists must have at least two hoisting ropes, and traction hoists must have at least three hoisting ropes.
- b. Safety Factor.** Hoisting ropes must have a minimum safety factor as identified in table 19-3, but in no event may the ropes be less than 0.5 inch in diameter.

Table 19-3.—Safety factors for hoisting ropes used in personnel hoists

Rope speed ft/min	Minimum safety factor
0-100	8.00
101-125	8.10
126-150	8.25
151-175	8.40
176-200	8.60
201-225	8.75
226-250	8.90
251-300	9.20
301-350	9.50
351-400	9.75
401-500	10.25
501-600	10.70

19.16.17 Emergency Stop Switch. Install an emergency stop switch in the cage and mark it "STOP."

19.16.18 Maintenance Access. Provide safe accessways for inspection and maintenance of hoist towers and equipment.

19.16.19 Bridge Tower Construction. A PE must design personnel hoists used in bridge tower construction, and a PE must supervise their erection. Inspect these hoists at least weekly and whenever exposed to winds exceeding 35 miles per hour.

19.16.20 Wire Rope. Inspect hoisting rope daily and remove it from service when any of the conditions described in the subsection, "Requirements for Working with Wire Rope," exist.

19.16.21 Signals. Where a hoist operator controls personnel hoists, users must signal the operator either through direct radio communications with that operator or through a visual and audible electrically operated signal system between the operator and each cage access point.

19.17 Requirements for Conveyors and Related Equipment

Design, install, operate, and maintain conveyors and related equipment according to the standards in the current edition of ANSI B20.1, "Safety Standards for Conveyors and Related Equipment," and the requirements of this subsection.

19.17.1 Safe Access. Provide accessways to enable employees to safely lubricate, repair, and maintain the conveyors. Provide stairways, ladders, catwalks, or work platforms to all areas requiring lubrication and maintenance. Such areas must include elevated head pulleys, tail pulleys, and drive stations on belt conveyors. Unless rollers on a belt conveyor are self-lubricating or remotely lubricated, erect a walkway protected by a standard guardrail and by toeboards for access to all elevated sections of the conveyor system.

19.17.2 Startup Signal. Equip conveyor systems with a time-delay audible warning system, which must automatically sound an alarm before startup.

19.17.3 Anti-Runaway Device. On conveyors where reversing or runaway is possible, install anti-runaway or "backup" stops.

19.17.4 Start and Stop Switches. Provide start and stop switches, capable of starting and stopping drive motors, at the operator's station. Install stop switches at each motor or engine location.

19.17.5 Emergency Stopping. If you install conveyors within 8 feet of the ground or you allow access along the conveyor or adjacent to unguarded moving parts of a conveyor, presenting a hazard to employees, you must

install an emergency stop system. The system must consist of a line running along the entire length of the exposed section of conveyor and its moving parts. Attach a power disconnect switch that, when pulled, will stop the conveyor. Design the system to prevent the conveyor from restarting until you have manually reset the switch or disconnect.

19.17.6 Spillage. Design and install conveyors with sideboards or some other provision to eliminate spilling or dislodging materials.

19.17.7 Elevated Crossings. Where conveyors pass next to or over work areas, accessways, roadways, railways, etc., install suitable and effective protection. The overhead protection must be capable of catching and retaining any material that may fall from the conveyor. Each day, remove all spilled material on retaining platforms or decking to prevent overtopping of sideboards.

19.17.8 Crossovers and Underpasses. Adequately protect crossovers or underpasses for passage over or under conveyors.

19.17.9 Hazardous Locations. Whenever conveyors are in tunnels, shafts, pits, or similar confined areas, provide ample room to permit safe access. Where this is not possible, completely enclose the conveyor. Unless enclosed, install emergency stop systems. Provide adequate lighting for such areas.

19.17.10 Stockpiled Materials. Keep conveyor tunnels under stockpiled bulk materials, such as sand and gravel, open at both ends.

19.17.11 Hoppers, Chutes, and Bins. Guard or protect openings to hoppers, bins, chutes, or other hazard areas to prevent employees from stepping or falling into them.

19.17.12 Riding Prohibited. Prohibit riding material conveyors; post "DANGER-NO RIDING" signs along the conveyor.

19.17.13 Equipment Lockout. Lock out conveyors, feed screens, and other moving parts in accordance with the section on "Control of Hazardous Energy (Lockout/Tagout)" and hazardous energy control procedures, FIST Volume 1-1, during repair or maintenance work, except for lubrication normally provided with conveyor operating. Lubrication points must be easily accessible and safe for lubrication. Ensure that personnel performing these tasks are able to safely complete the work.

19.18 Requirements for Cableways and Highlines

In addition to the requirements of this subsection, cableways and highlines must comply with the installation, testing, operation, and maintenance requirements in this section and the standards in the current edition of ANSI/ASME B30.19, "Cableways."

19.18.1 Design and Installation. A PE must design cableways and highlines. You must install and operate cableways and highlines according to the PE's design drawings, specifications, and operating, maintenance, and inspection instructions.

19.18.2 Inspection and Performance Tests. Conduct inspections and performance tests in accordance with the requirements of this subsection and ANSI B30.19.

19.18.3 Inspection and Maintenance. Inspect all cableway components daily and provide daily routine maintenance and lubrication.

19.18.4 Cableway Log. Maintain a log for each cableway or highline on which you record inspections, lubrication, maintenance, and repair activities. The log must also include operating time and downtime, and the employee responsible for performing the maintenance or repair work must sign it. Make the log available for review.

19.18.5 Signal System. Continuously maintain at least two systems of communication between the operator and the signalperson. One or both of the systems must provide voice communication by telephone or radio. You may substitute lights or bells for one of the systems. When the dual system is not functioning properly, the operator may deliver the load suspended from the cableway, but the operator may rig no further load until both communication systems are functioning.

19.18.6 Control Consoles. During operation of the cableway, permit only the operator(s) in the control console room. The console room windows must be safety glass that introduces no distortion that interferes with the safe operation of the cableway.

19.18.7 Operating Controls. All controls must automatically return to neutral and set the brakes when released. Plainly mark each control to indicate its function and ensure that it is within easy reach of the operator.

19.18.8 Cableway Platforms and Carriages. Provide cableway inspection platforms, moving and stationary, with standard guardrails and toeboards. Enclose open areas on carriages and moving platforms with wire mesh to reduce the hazard from falling objects.

19.18.9 Concrete Buckets. Design concrete buckets with a safety device to prevent accidental opening of the bucket while in transit to the discharge site. Construct buckets to prevent aggregate from lodging on any part of the bucket. Refer to the section on "Concrete, Masonry, Construction, and Formwork."

19.18.10 Riding Cableways. Prohibit riding the cableway, except designated maintenance personnel may ride the carriage service platform of a cableway to perform inspections or maintenance. Prepare and review a JHA before performing inspections or maintenance.

19.18.11 Track-Mounted Towers. Equip track-mounted cableway towers or structures with both limit switches and rail stops or buffers at each end of the tracks. Equip the wheel with track or rail sweeps extending below the top of the rail and effective in all directions of travel. When two or more towers operate on the same track, install an automatic control system to prevent the towers from colliding.

19.19 Requirements for Base-Mounted Drum Hoists

Base-mounted drum hoists must conform to the requirements of ANSI B30.7, "Base-Mounted Drum Hoists." Air-powered hoists must conform to the requirements of ANSI/ASME HST-6M, "Performance Standard for Air Wire Rope Hoists," or more stringent requirements of this section. Hoisting machines used in personnel related systems must also meet the requirements in the subsection on "Overhead Hoist."

19.19.1 Design. The hoist manufacturer or a PE must design hoisting systems covered by this subsection.

19.19.2 Restrictions. Base-mounted drum hoist systems involving personnel use or exposure (e.g., movable work platforms, raising or lowering drilling machines, and personnel hoists) must conform to the provisions of this section.

19.19.3 Inspections and Performance Tests. Conduct and record inspections and performance tests using the requirements of this section and the appendix.

19.20 Requirements for Specialized Hoisting Systems

19.20.1 Manlifts. Manlift design, installation, testing, and operations must conform to requirements of ANSI A90.1, "Safety Standards for Manlifts."

19.20.2 Draglines. Do not use draglines as hoisting devices without the manufacturer's approval.

19.20.3 A-Frame Trucks. The design and operation of A-frame trucks must conform to this section and "Mobile and Stationary Mechanized Equipment." Do not use them to hoist personnel.

19.20.4 Mobile Hydraulic Excavators and Hoes, Crawlers, Wheel Loaders, and Similar Machines.

a. Requirement. Do not use mobile hydraulic excavators and hoes, crawlers, wheel loaders, and similar machines to hoist personnel. Use them to hoist materials only when they conform to the requirements of this paragraph and appropriate SAE-recommended practices.

b. Restrictions. Use only machines certified for hoisting by the manufacturer and equipped with manufacturer-installed closed lifting eyes or lugs for hoisting. The maximum load in any machine position must not exceed the rated capacity in the least stable position.

c. Testing. Load-test the machine at 110 percent of the maximum load. Hoist test loads clear of the ground at the maximum load radius and move them through the maximum angle of articulation or arc radius in both directions from the longitudinal centerline of the machine.

19.20.5 Facility Maintenance Hoisting Systems. Design, construct, install, and use hoisting systems to inspect and maintain facilities, such as penstocks, spillways, airshafts, and for external building maintenance such as window washing, in accordance with ANSI A10.22, "Safety Requirements for Rope-guided and Nonguided Workmen's Hoists" or ANSI A120.1, "Safety Requirements for Powered Platform for Exterior Building Maintenance." The manufacturer or a PE must certify such hoisting systems for the intended use.

19.21 Requirements for Piledrivers

19.21.1 Boilers and Pressure Vessels. Boilers and pressure vessels used in piledriving operations must conform to the requirements and standards set forth in applicable ASME Boiler and Pressure Vessel Code.

19.21.2 Hoisting Equipment. Cranes used to drive or extract piling must conform to the requirements and standards set forth in applicable parts of this section.

19.21.3 Floating Piledrivers. Hulls for floating piledrivers must be at least as wide as 45 percent of the height of the lead above water. Protect the operating deck to prevent suspended piling from swinging or drifting in over the deck.

19.21.4 Hoist Drums. Do not equip piledriver hoist drums with dogs that automatically disengage by relieving the load or by rotating the drum.

19.21.5 Hose Connections. Secure hose connections to piledriver hammers, ejectors, or jet pipes with at least a 0.25-inch chain with a minimum working load of 3,250 pounds or with equivalent devices.

19.21.6 Driving Leads. Provide pile driving leads with fixed ladders and attachment points for safety harness lanyards.

19.21.7 Landings and Headblocks. Install fixed ladders or stairways for access to landings and headblocks. Provide piledriver leads with stopblocks to prevent the hammer from being raised into the headblock.

19.21.8 Blocking Device. When employees must work under the hammer, place a blocking device in the leads that can support the hammer.

19.21.9 Guying. Use adequate guylines, outriggers, thrustboards, counterbalances, or rail clamps to stabilize piledrivers during operation.

19.21.10 Moving Piledrivers. When moving the piledriver, lower the hammer to the bottom of the leads.

19.21.11 Hoisting Piling. Hoist piling using a closed shackle or similar positive means of attachment to the loadline and keep employees in the clear. Use taglines to control unguided piles and "flying hammers."

19.21.12 Pulling Pile. Use extractors to pull piling that you cannot pull without exceeding the safe load rating of the pulling rig. When pulling piling, do not elevate the crane boom more than 60 degrees from the horizontal.

19.21.13 Overhead Protection. Position overhead protection, equivalent to 2-inch planking, so as not to interfere with the operator's view.

19.21.14 Headblock Guards. Install guards to prevent the line from jumping out of the headblock.

19.21.15 Jacked Piles. When driving jacked piles, excavation for access pits must conform to the requirements in the "Excavation Operations" section. Provide access ladders and erect bulkhead curbs to prevent material from falling into the excavation.

19.21.16 Cutting Piling. Do not trim piles within a distance from the pile driver of twice the length of the longest pile.

19.22 Helicopter Operations

19.22.1 Requirement. Operators and aircraft must be licensed and must comply with the applicable requirements of the Federal Aviation Administration (FAA), the Department of the Interior Office of Aircraft Services, ANSI B30.12, "Handling Loads Suspended from Rotorcraft," and this subsection.

19.22.2 Briefing. Before each day's operation, conduct a briefing for pilots and ground personnel and discuss in detail the plan of operation.

19.22.3 Loads. Secure suspended loads with pressed sleeves, swaged eyes, or equivalent means to prevent hand splices from spinning open or cable from loosening. Tag lines must be short enough so they cannot be drawn into the rotors.

19.22.4 Cargo Hooks. Use self-locking cargo hooks equipped with a quick release device that can be activated from the pilot's location. Electrically operated cargo hooks must have the electrical activating device designed and installed to prevent accidental operation. Also equip these hooks with an emergency control to release the load. Test the hooks before each day's operation to ensure that they function properly.

19.22.5 Personal Protective Equipment. Employees receiving the load must wear safety goggles and hard hats fitted with chinstraps. Employees must not wear loose-fitting clothing that may become snagged on the hoist line.

19.22.6 Downwash. Remove or secure material and loose gear within 100 feet of the lift or delivery site.

19.22.7 Operator Responsibility. The helicopter pilot is responsible for the size, weight, and manner in which loads are connected to the helicopter. Do not make the lift if the pilot considers it unsafe.

19.22.8 Hooking and Unhooking. Employees must not perform work under the hovering helicopter, except as necessary to hook and unhook loads. Provide a safe means of access and egress for employees to approach the hook to engage or disengage cargo slings.

19.22.9 Static Charge. Unless ground personnel use a grounding device to dissipate the static charge, they must wear rubber gloves.

19.22.10 Weight Limitations. The weight of the load and rigging must not exceed the aircraft manufacturer's rating, considering altitude and ambient temperatures existing at the time.

19.22.11 Ground Lines. Do not attach hoist wires or other gear, except for pulling lines or conductors that "payout" from a container or roll off a reel, to any fixed ground structure or allow wires or other gear to foul on any fixed structure. Use only pulling lines or conductor stringing systems designed with stress release hardware, so located that it protects the aircraft against overload and line entanglement with rotors.

19.22.12 Visibility. When dust or other conditions reduce visibility, ground personnel must exercise special caution to keep clear of the rotor blades. The employer must reduce the possibility of dust to the extent practical.

19.22.13 Approaching Helicopters. Permit only authorized personnel to approach within 50 feet of a helicopter with turning rotor blades. People approaching or leaving a helicopter with the blades turning must keep within full view of the pilot and assume a crouched position. Persons must stay out of the area from the cockpit or cabin rearward unless the pilot authorizes them to enter that area.

19.22.14 Radio Communication. Provide reliable radio communication between the pilot and a designated member of the ground crew during all loading, unloading, and rigging operations.

19.22.15 Hand Signals. When personnel use hand signals, they must use standard "Helicopter Hand Signals." The signal person on the ground must be distinguishable from other ground personnel.

19.22.16 Inspection and Maintenance. Assign only FAA-certified personnel, experienced on the type of aircraft being maintained, to inspect or repair helicopters. Provide maintenance personnel with lighting systems that meet minimum requirements set forth in ANSI/IES RP7, "Practice for Industrial Lighting." During inclement weather, carry out repair work in enclosures adequate to protect personnel against the elements. An appropriate pilot must flight-test all repairs pertaining to safety of flight before returning the aircraft to service.

Attachment 19-1

Inspection Elements for Hoisting Equipment

Elements for Startup Inspections

1. Inspect all control mechanisms for maladjustment interfering with proper operation.
2. Inspect all control mechanisms for excessive wear of components and contamination by lubricants or other foreign matter.
3. Inspect all operator aids, motion, and load limiting devices, and other safety devices for malfunction and inaccurate settings.
4. Inspect all chords and lacing.
5. Inspect all hydraulic and pneumatic systems - with particular emphasis on those that flex in the normal operation of the crane.
6. Inspect hooks and latches for deformation, chemical damage, cracks, and wear.
7. Inspect rope for proper spooling onto the drum(s) and sheave(s) and inspect rope reeving for compliance with the crane manufacturer's specifications.
8. Inspect electrical apparatus for malfunctioning, signs of excessive deterioration, dirt, and moisture accumulation.
9. Inspect the hydraulic system for proper oil level.
10. Inspect tires for recommended inflation pressure (mobile cranes).
11. Inspect wedges and supports for looseness or dislocation (climbing tower cranes).
12. Inspect braces and guys supporting crane masts; inspect anchor bolt base connections for looseness or loss of preload (tower cranes and derricks).
13. Inspect derrick mast fittings and connections for compliance with manufacturer's recommendations.
14. Inspect barge or pontoon ballast compartments for proper ballast; inspect deckloads for proper securing; inspect chain lockers, storage, fuel compartments, and battening of hatches; inspect firefighting and lifesaving equipment to ensure it is in its proper place and is functional; and sound hull void compartments for leakage (floating cranes and derricks).

Elements for Periodic Inspections

1. Inspect foundation and supports to determine their continued ability to sustain imposed loads.

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2. Inspect braces supporting crane masts (towers) to determine that they are in a safe condition; inspect anchor bolt base connections for tightness or retention of preload; and inspect wedges and supports of climbing cranes for tightness and proper positioning.
3. Inspect guys for proper tension.
4. For derricks, inspect all chords and lacing, tension in guys, plumb of the mast, and derrick mast fittings and connections for compliance with manufacturer's recommendations.
5. Inspect crane structure and boom and jib members and their connections for deformation, cracks, or corrosion.
6. Inspect bolts, rivets, nuts, and pins for tightness.
7. Inspect for proper tension (torque) of high strength (traction) bolts used in connections and at the slewing bearing.
8. Inspect power plants for performance and compliance with safety requirements.
9. Inspect electrical apparatus for proper functioning and signs of excessive deterioration, dirt, and moisture accumulation.
10. Inspect hydraulic and pneumatic tanks, pumps, motors, valves, hoses, fittings, and tubing for proper functioning and the absence of damage, leaks, and excessive wear; inspect hydraulic and pneumatic systems for proper fluid/air levels.
11. Inspect all control mechanisms for adjustment for proper operation, and to determine that there is no excessive wear of components and no contamination by lubricants or other foreign matter.
12. Inspect drive components such as pins, bearings, wheels, shafts, gears, sheaves, drums, rollers, locking and clamping devices, sprockets, drive chains or belts, bumpers, and stops for the absence of wear, cracks, corrosion, or distortion.
13. Inspect all crane function operating mechanisms for proper operation, proper adjustment, and unusual sounds.
14. Inspect travel, steering, holding, braking, and locking mechanisms for proper functioning and excessive wear or damage.
15. Inspect tires for damage or excessive wear.
16. Inspect brake and clutch system parts, linings, pawls, and ratchets for excessive wear.
17. Visually inspect all running ropes, counterweight ropes, and load trolley ropes, if provided. Pay particular attention to boom hoist ropes and sections of

rope subject to rapid deterioration, such as at flange points, crossover points, and repetitive pickup points on drums. Concentrate visual inspections on discovering gross damage, such as the following, which may be an immediate hazard:

- Distortion of rope such as kinking, crushing, unstranding, birdcaging, main strand displacement, or core protrusion
- General corrosion
- Number, distribution, and type of visible broken wires
- Broken or cut strands
- Core failure in rotation resistant ropes (take care when inspecting rotation-resistant ropes because they are susceptible to damage from misuse and deterioration when used on equipment with limited design parameters)
- Reduction of rope diameter below nominal diameter because of loss of core support, internal or external corrosion, or wear of outside wires
- Severely corroded or broken wires at end connections and severely corroded, cracked, bent, worn, or improperly applied end connections.

Take care when inspecting rope sections such as the following, which are subject to rapid deterioration: sections in contact with saddles, equalizer sheaves, or other sheaves where rope travel is limited; sections at or near terminal ends where corroded or broken wires may protrude; sections subject to reverse bends; and sections normally hidden during routine visual inspections, such as parts passing over outer sheaves.

18. Inspect sheaves for cracks in the flanges and spokes.
19. Inspect rope for proper spooling onto drums and sheaves and proper reeving.
20. Inspect hooks and latches for deterioration, chemical damage, cracks, and wear.
21. Inspect crane operator aids (safety devices) and indicating devices for proper operation.
22. Inspect motion-limiting devices for proper operation with the crane unloaded (inch each motion into its limiting device at slow speed with care exercised) and inspect load-limiting devices for proper operation and accuracy of settings.
23. Inspect load, boom angle, load or load moment indicating wind, and other indicators for proper operation and accuracies within the tolerances recommended by the manufacturer.
24. Inspect safety and function labels for legibility and replacement, if necessary.

25. For a floating plant: inspect ballast compartments for proper ballast; deckloads for proper securing; chain lockers, storage, fuel compartments for safety; battening of hatches; tie-downs for barge-mounted land cranes for wear, corrosion, and tightness; cleats, bitts, chocks, fenders, capstans, ladders, stanchions for corrosion, wear, deterioration, and deformation; sound hull void compartments for leakage; and take four corner draft readings.

Elements for Frequent Inspections

1. Inspect braces supporting crane masts (towers) for safe condition, anchor bolt base connections for tightness or retention of preload, and wedges and supports of climbing cranes for tightness and proper positioning.
2. Inspect guys for proper tension.
3. For derricks, inspect all chords and lacing, tension in guys, plumb of the mast, and derrick mast fittings and connections for compliance with manufacturer's recommendations.
4. Inspect electrical apparatus for proper functioning and signs of excessive deterioration, dirt, and moisture accumulation.
5. Inspect hydraulic and pneumatic tanks, pumps, motors, valves, hoses, fittings, and tubing for proper functioning and damage, leaks, and excessive wear; and inspect hydraulic and pneumatic systems for proper fluid/air levels.
6. Inspect all control mechanisms for adjustment for proper operation, for excessive wear of components, and for contamination by lubricants or other foreign matter.
7. Inspect all crane function operating mechanisms for proper operation, proper adjustment, and unusual sounds.
8. Visually inspect all wire running ropes, counterweight ropes, and load trolley ropes, if provided. Pay particular attention to boom hoist ropes and sections of rope subject to rapid deterioration, such as at flange points, crossover points, and repetitive pickup points on drums. Concentrate visual inspections on discovering gross damage, such as the following, which may be an immediate hazard:
 - a. Distortion of rope such as kinking, crushing, unstranding, birdcaging, main strand displacement, or core protrusion;
 - b. General corrosion;
 - c. Number, distribution, and type of visible broken wires;
 - d. Broken or cut strands;

- e. Core failure in rotation resistant ropes (take care when inspecting rotation-resistant ropes because of their susceptibility to damage from misuse and deterioration when used on equipment with limited design parameters);
 - f. Reduction of rope diameter below nominal diameter because of loss of core support, internal or external corrosion, or wear of outside wires; and
 - g. Severely corroded or broken wires at end connections and severely corroded, cracked, bent, worn, or improperly applied end connections.
9. Inspect rope for proper spooling onto drums and sheaves and proper reeving.
 10. Inspect hooks and latches for deterioration, chemical damage, cracks, and wear.
 11. Inspect crane operator aids (safety devices) and indicating devices for proper operation.
 12. Inspect motion-limiting devices for proper operation with the crane unloaded (inch each motion into its limiting device at slow speed with care exercised) and load limiting devices for proper operation and accuracy of settings.
 13. Inspect load, boom angle, load or load moment indicating, wind, and other indicators for proper operation and accuracies within the tolerances recommended by the manufacturer.
 14. Inspect safety and function labels for legibility and replacement.
 15. For a floating plant, inspect ballast compartments for proper ballast; deckloads for proper securing; safety of chain lockers, storage, fuel compartments; and battening of hatches. Sound hull void compartments for leakage.

Attachment 19-2

Crane Performance and Load Testing Requirements Tables with Associated Testing Elements

Requirements for Crane Performance Tests

1. Performance testing includes both operational performance testing and load a.

Table 1.—Crane performance testing requirements - no-load tests

Type of crane	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11
Portal, tower, and pedestal	■ (1)	■	■	■	■	■	■				
Floating cranes and derricks	■ (1)	■	■	■	■	■	■				■
Derricks	■ (1)	■	■	■	■ (2)	■	■				
Construction	■ (1)	■	■	■	■	■	■	■			
Mobile (3)	■ (1)	■ (4)								■	■
Overhead, gantry, monorail, and underhung	■ (1)							■	■		
Base-mounted and overhead hoists	■ (1)							■		■	

Notes: (1) conduct for main, auxiliary, and whip hoists, as applicable; (2) conduct rotation tests through no carrier and position the boom at the minimum working radius; (4) conduct fixed boom or telescopic boom, as appropriate.

Table 2.—Crane load testing requirements

Type of crane	L1	L2(2)	L3(2)	L4(2)	L5	L6(2)	L7	L8	L9(2)	L10	L11	L12	L13	L14	L15	L16	L17	L18	L19	L20	L21	
Mobile and locomotive(1,5)		■z	■	■	■z	■					■ (6)						■	■				
Overhead, gantry, monorail, and underhung		■	■	■		■b			■b						■b	■			■	■		
Portal, tower, and pedestal (1)	■	■	■	■	■	■	■	■	■	■	■	■	■	■								
Derricks(1)	■	■	■	■	■	■	■	■	■	■	■ (3)	■	■	■								
Floating cranes and derricks (1)	■	■	■	■	■	■	■	■	■	■	■	■										
Construction	■	■ (4)	■ (4)	■	■ (4)	■ (4)			■ (4)	■	■	■	■	■	■							
Base-mounted and overhead hoists		■	■	■		■b			■b						■b							■

Notes: (1) for variable-rated cranes, perform the applicable variable-rated crane tests in addition to the applicable tests for fixed-rated cranes; (2) perform complete tests on each hook; extend outriggers or stabilizers as specified by the manufacturer; level crane as specified by the manufacturer's load chart; rotate the boom 90° from the longitudinal axis of the crane carrier and position the boom at the minimum working radius; (3) rotate the maximum degrees allowed by manufacturer; perform test with boom fully retracted and fully extended.

Tests marked with "b" or "z" indicate an additional test element unique to the type of crane.

2. Comply with the following sequence and limitations when conducting performance tests:

- a. Test rigging first.
- b. Conduct the operational performance test before the load performance test.
- c. Test the main hoist before testing the auxiliary or whip hoists.
- d. Raise test loads only to a height sufficient to perform the test.

3. Operational performance testing. Operational performance testing must include the tests specified in table 1 to this appendix, as defined below.

- X1 = Load hoist operation and limit switch test. (1) Raise the load hook through all controller points, stopping below the upper limit switch (where applicable), (2) slowly raise the load hook into the upper limit switch to establish that the limit switch is operating properly, (3) slowly raise the hook through the upper limit switch by using limit switch bypass (where applicable), (4) lower the load hook below the upper limit switch using all the lowering control points, (5) slowly lower the load hook into the lower limit switch to establish that the limit switch is operating properly.
- X2 = Boom hoist operation and limit switch test, fixed boom. (1) Raise the boom through all controller points, stopping below upper limit switch; (2) slowly raise the boom into the upper limit switch; (3) lower the boom below upper limit switch and raise the boom through the limit switch by using the limit switch bypass (where applicable); (4) lower the boom through all controller points, stopping above the lower limit switch (where applicable); (5) slowly lower the boom into the lower limit switch (where applicable); (6) raise the boom above the lower limit switch and lower the boom through the limit switch by using the limit switch bypass (where applicable).
- X2t = Boom hoist operation and limit switch test, telescopic boom. In addition to test X2, conduct the following: (1) extend and retract telescoping boom sections the full distance of travel; (2) check the radius indicator by measuring the radius at the minimum and maximum boom angle.
- X3 = Luffing drum pawl test. (1) Check luffing drum pawl for proper engagement in ratchet gear and with limit switch; (2) ensure the luffing drum pawl is disengaged; (3) check the luffing drum pawl limit switch (if installed) for proper operation by operating the boom hoist and manually (at the pawl) activating the limit switch; (4)

check that the boom hoist motor shuts off, the brake engages, and the indicator lights operate correctly (where applicable).

Caution: *Do not engage pawl in the ratchet gear.*

- X4 = Rotation lock test (wind lock, spud lock). (1) Engage the rotation lock and inspect to ensure full engagement; (2) check that rotation lock limit switches (clockwise and counterclockwise) prevent engaging rotation drive (where applicable); (3) operate the rotation lock bypass (clockwise and counterclockwise) to ensure proper operation (where applicable).

Caution: *Use only enough power to check the operation of the bypass; ensure the rotation lock is disengaged before continuing the test.*

Note: *You may manually operate applicable switches to check for correct operation instead of engaging rotation lock*

- X5 = Rotation test. Rotate clockwise and counterclockwise with boom at minimum radius.
- X6 = Travel test. Conduct operation travel test as prescribed in L14, except without load.
- X7 = Deadman control test. Test all deadman controls (where installed): (1) start each motion, (2) release deadman control—motion should stop.
- X8 = Trolley test. (1) Trolley the allowable length of the trolley runway using all control points; (2) operate the trolley into the limit switches at slow speed; (3) bring the trolley back, and, by using the limit switch bypass, move the trolley into the outboard rail stops; (4) repeat the above procedure for inboard limit switches and rail stops.
- X9 = Bridge test. (1) Operate the bridge travel controller through all points in both directions; (2) operate the full distance of the runway and slowly contact the runway rail stops with the crane bridge bumpers.
- X10 = Other motions test. Test other motions, including swing, by operating through one cycle (one full revolution of the major components).

X11 = Boom stop test. See attachment 19-3.

4. Load performance testing. Load performance testing must include the tests specified in table 1, as defined below.

L1 = Stability test. During tests L2m, L3m, L5, and L11, observe roller clearance and roller lift-off from the roller path.

L1v = Stability test, variable-rated crane. Conduct tests L2m, L3m, and L11 with the test load on the main hoist at the maximum radius of the crane; observe roller clearance and roller lift off from the roller path.

L2m = Load and boom hoist static test, main hoist. (1) Raise the test load to clear ground and hold for 10 minutes with the boom at the maximum radius; (2) rotate the load to check the bearing operation; (3) do not engage the boom or load hoist pawl; (4) observe if lowering occurs; lowering indicates a malfunction of the boom or hoisting components or holding brakes.

L2a = Load hoist static test, auxiliary hoist. (1) Raise the test load to clear the ground and hold for 10 minutes without hoist pawl engaged; (2) rotate load to check bearing operation - observe if lowering occurs; lowering indicates a malfunction of the hoisting components or holding brakes.

L2w = Load hoist static test, whip hoist. (1) Raise the test load to clear the ground and hold for 10 minutes; (2) rotate load to check operation of bearing; observe if lowering occurs; lowering indicates a malfunction of the hoisting components or holding brakes.

L2z = load hoist static test, main hoist, mobile crane. (1) Raise the test load to clear the ground with the boom at the minimum radius and hold for 10 minutes without the boom and load hoist pawls engaged; (2) rotate load and hook to check bearing operation; (3) observe if any lowering occurs; lowering indicates a malfunction of the boom or hoisting components, brakes, or outriggers.

Note: For hydraulic cranes, perform the test with the boom fully retracted and fully extended.

L3m = Load hoist dynamic test, main hoist. (1) Raise and lower the test load on each hoist controller point and visually observe smooth control between points; (2) lower the test load to unload the hoist components, wait 5 minutes and then continue testing.

- L3a = Load hoist dynamic test, auxiliary hoist. Raise and lower the test load on each controller point and visually observe smooth control between points.
- L3v = Load hoist dynamic test, main hoist, variable-rated crane. Conduct test L3m at the maximum radius of the crane.
- L3w = Load hoist dynamic test, whip hoist. Raise and lower the test load on each controller point and visually observe smooth control between points.
- L4 = Wire rope test. During either the static or dynamic test, where possible, test the entire working length of the wire rope.
- L5 = Boom hoist operating test. Visually watch for smooth rotation between boom controller points: (1) starting from the maximum radius, raise the boom to minimum radius using all boom controller points; (2) lower the boom through all controller points.
- L5z = Boom hoist operating test, mobile crane. Operate the boom from the minimum radius to the maximum radius for the load applied; for hydraulic cranes, perform the test with the boom fully retracted and fully extended; perform the test at both the maximum test load for crane and for the maximum test load at maximum radius of the crane.
- L6 = Hoist foot brake test (hydraulic or mechanical brake). Lower the test load, using the first control point, then apply the foot brake—this should stop the lowering motion of the test load.

Caution: *This is not applicable to load-sensitive reactor type hoist controls.*

- L6b = Hoist load brake. (1) Raise the test load approximately 1.5 meters (5 feet); (2) with the hoist controller in the neutral position, release (by hand) the holding brake—the load brake should hold the test load; (3) again, with holding brake in the released position, start the test load down (first point) and return the controller to the off position as the test load lowers—the load brake should prevent the test load from accelerating.

Note: *It is not necessary for the load brake to halt the downward motion of the test load.*

- L7 = Boom foot brake test (hydraulic or mechanical brake). (1) Start with the boom near the maximum radius and with the test load approximately 0.6 meters (2 feet) from the ground surface; (2) lower the test load using the first control point of the boom hoist; (3) apply the foot brake—this should stop the lowering motion of the boom and load.

Caution: *This is not applicable to load-sensitive reactor type hoist controls.*

- L8 = Automatic boom brake (where applicable). This brake prevents a "free" boom in case the clutch fails, the boom hoist control fails, or the foot brake fails: (1) Raise the boom to minimum radius and, with the test load approximately 100 millimeters (4 inches) above the ground, set the boom foot brake firmly; (2) release the mechanical boom dog; (3) release the boom clutch by operating the boom hoist control; (4) slowly release the foot brake to the free position; (5) hold the test load with automatic brake for 5 minutes, then lower the test load by applying the boom hoist clutch and lowering with the controller operation.

- L8v = Automatic boom brake, variable-rated crane (where applicable). Conduct test L8 at the maximum radius of the crane.

- L9 = Load hoist loss of power (panic test). This test is designed to test the reaction of a hoisting unit in the event of a power failure during a lift. (1) Hoist the test load approximately 3 meters (10 feet) above the ground at maximum allowable radius; (2) slowly lower the test load and, with the controller in the slow lowering position, disconnect the main power source by pushing the main power stop button(s); (3) return the controller to the neutral position—the test load should stop lowering when the controller is in the neutral position.

Caution: *Do not perform this test on cranes that do not have powered-down boom and load hoists.*

- L9b = Load hoist loss of power (panic test). This is a test to check the reaction of a hoisting unit in the event of a power failure during a lift. (1) Hoist the test load to a convenient distance above the surface; (2) slowly lower the test load and, with the controller in the slow lowering position, disconnect the main power source and return the controller to the neutral position—the test load should stop lowering when the controller is in the neutral position.

Note: *Vent air-operated hoists during this test.*

- L10 = Boom hoist loss of power (panic test). This is a test to check the reaction of the boom hoist in the event of a power failure during a lift. (1) Hoist the test load approximately 3 meters (10 feet) above the ground with the boom near maximum radius; (2) slowly lower the boom, disconnect the main power source by pushing the main power stop button(s), then return the controller to the neutral position—the boom should stop lowering when the controller is in the neutral position.

Caution: *Do not perform this test on cranes that do not have powered down boom and load hoists.*

- L11 = Rotation test. Start with the boom at the maximum radius and rotate left and right 360 degrees.

Note: *If test area does not permit, two complete revolutions of the swing pinion is adequate.*

Caution: *Exercise care when rotating loads over the water. Ensure that during the initial load-test, the floating crane has adequate draft readings per design data.*

- L12 = Rotate brake test. Rotate left and right at slow speed and apply brakes, individually, periodically during rotation. Each brake should stop the rotating motion in a smooth, positive manner.

- L13 = Travel motion test. Conduct this test with the boom at the maximum allowable radius, positioned at 90 degrees, with the crane rails and boom dog engaged.

Caution: *Operate the crane at very slow travel speeds; ensure the track and supporting foundation are sound and free of any obstructions over the test travel areas (not applicable to floating cranes).*

- L14 = Travel operation test. (1) With the test load raised to clear the ground, the boom centered between the crane rails, and the boom dog engaged, travel in one direction a minimum of 15 meters (50 feet); (2) operate the controller through all controller points—the crane should accelerate and decelerate smoothly, and all motions should be smooth and positive; (3) repeat in the opposite direction.

- L15 = Trolley motion test. (1) Raise the test load to clear the ground and move the trolley to the maximum allowable radius. Do not move the trolley beyond the trolley limit switch; (2) hold the test load for

10 minutes; (3) lower the test load to the ground until the hoist lines are slack; (4) wait 5 minutes, raise the test load and trolley the allowable length of the trolley runway.

- L15b = Trolley motion test. Using extreme caution, operate the trolley with the test load (if space is available) for the full distance of the bridge rails; observe proper brake operation.
- L16 = Bridge motion test. Using extreme caution, operate the bridge with the test load (if space is available) for the full distance of the runway and watch for any binding of bridge trucks and for proper brake operation.
- L17 = Hydraulic crane slippage. (1) Lift the test load at maximum radius and allow time for fluid and component temperatures to stabilize; (2) hold the load for 10 minutes without the operator using the controls—there must be no significant lowering of the load, boom, or outrigger beams resulting from components or systems malfunction or failure during the test.
- L18 = Free-rated load test. This is a test to check the stability of the crane and the operation of the crane carrier, wheels, tires, and brakes under load. Note: Retract outriggers before beginning free-rated load test. (1) Hoist the maximum free rated test load at its maximum radius over the rear of the crane?; (2) rotate through the "over the rear" working arc and travel a minimum of 15 meters (50 feet) with the test load over the rear of the crane with the boom parallel to the longitudinal axis of the crane carrier; (3) hoist maximum free rated test load at its maximum radius over the side; (4) rotate through the full working range and travel a minimum of 15 meters (50 feet) with test load over the left side of the crane carrier with the boom 90° to the axis of travel; (5) rotate through the full working range and travel a minimum of 15 meters (50 feet) with the test load over the right side of the crane carrier with the boom 90 degrees to the axis of travel.
- L19 = Primary and secondary holding brakes. For cranes with primary and secondary holding brakes (configuration of crane in which a primary brake actuates when the controller returns to the neutral position and the secondary brake actuates a few seconds later) or eddy current hoist dynamic load brakes. (1) During either the static or dynamic test, raise the test load and observe the proper timing sequence in the application of the primary and secondary brake when controller is returned to neutral (visually observe both hoist holding brakes to ensure correct position); (2) raise test load

approximately 0.3 meter (1 foot), hold for 10 minutes, and inactivate the secondary holding brake while testing the primary holding brake - observe for noticeable lowering of test load that may occur which must indicate malfunction of hoisting components or brakes; (3) re-engage secondary holding brake and release the primary holding brake and hold for 10 minutes - observe for noticeable lowering of test load that may occur which must indicate malfunction of hoisting components or brakes; (4) re-engage the primary holding brake - recheck proper operation of time delay and ensure smooth positive stopping.

- L20 = Hoist dynamic load brake (eddy current). Check lowering speed against specifications to ensure correct brake operation. (NOTE: Eddy current brakes must not stop motion.)

- L21 = Swing test (where applicable). Swing the test load (where space is available) through the working range at maximum radius, stopping the load at several points: there should be no excessive drift of jib or trolley at any of these points (the significance of drift must be evaluated).

Attachment 19-3

Boom Stop Testing Requirements

Boom stop tests must follow these steps.

Step 1: Make sure an appropriate operator's manual is available.

Step 2: Make sure the crane is level, and the outriggers (if so equipped) are in place.

Step 3: Check the boom and boom stops for misalignment, bent parts, and other physical damage.

Step 4: Check the boom stop pins (at connections) for lubrication, wear, and damage.

Step 5: Check the boom angle indicator with an inclinometer for accuracy.

Step 6: Check the boom hoist disengaging device for proper adjustment and alignment in accordance with the operator's manual.

Step 7: Make sure that the boom stops and boom hoist disengaging device are set up to operate properly. Physically boom up the boom just to the points listed (described in subparagraphs a. and b. below), as long as the boom does not go beyond the point of operation of the boom hoist disengaging device. This test is not intended to override the boom hoist disengaging device.

- a. For cantilever or scissors types, this is the point just before the boom and boom stops touch.
- b. For telescoping types, this is the point just before compression.