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8.0 WIRE ROPE

8.1 Scope

This Hanford Site Hoisting and Rigging Manual (HSHRM) chapter specifies inspection and replacement requirements and acceptance criteria for wire rope on mobile cranes, overhead cranes, monorail cranes, jib cranes, and hoists that are used in lifting service.

Wire rope slings are not included in this chapter. For wire rope slings, see Chapter 9.0, *Slings*. Wire rope that has been removed from a crane or hoist shall not be used to fabricate slings.

8.2 General Requirements

8.2.1 Design Factors for Wire Ropes

The design factor (safety factor) is the nominal strength of the rope divided by the rated load.

8.2.1.1 Hoists and Overhead Crane Wire Ropes

On hoists and overhead cranes, the wire rope design factor is 5:1.

8.2.1.2 Mobile Crane Wire Rope

Mobile crane wire ropes have different design factors for the various ropes under both operating and boom erection conditions.

1. Operating Conditions
 - a. **3.5:1** for live or running ropes (including hoist rope) that wind on drums or travel over sheaves.
 - b. If rotation-resistant¹ rope is used, the design factor shall be no less than **5:1**. If the crane manufacturer recommends a higher design factor (example **7:1**) the crane manufacturer's recommendation shall be followed.
2. Under Boom Erection Conditions
 - a. **3:1** for live or running ropes
 - b. **2.5:1** for boom pendants or standing ropes.

8.2.2 Rotation-Resistant Rope

Use of rotation-resistant rope shall be approved by the manufacturer of the equipment on which it is used. Application of rotation-resistant rope requires special installation procedures, higher design factors, and special inspection and maintenance procedures.

¹ The term "nonrotating" wire rope, originally referred to 19 x 7 or 18 x 7 rope. "Nonrotating" has been replaced by the term "rotation-resistant" wire rope. Many other rotation-resistant ropes, besides 19 x 7 and 18 x 7, are currently available.

8.2.3 Requirement for Independent Wire Rope Core

Overhead cranes and hoists exposed to ambient temperatures at the rope in excess of 180 °F shall use rope with independent wire rope core (IWRC). Mobile cranes shall use IWRC rope regardless of temperature.

8.3 Inspection Requirements

Only inspection can determine whether or not rope must be replaced (see Table 8-1). Based on experience, and in accordance with wire rope inspection criteria in this section, a qualified rope inspector must determine the following:

3. If the rope's existing condition presents a likelihood of failure.
4. If the rate of deterioration of the rope is such that it will remain in safe condition until the next scheduled inspection by a qualified wire rope inspector.

CAUTION: Proper maintenance of the drums and sheaves over which ropes operate is important to rope life (e.g., worn grooves or poorly aligned sheaves can cause short service life for wire rope). If, during wire rope inspection, equipment maintenance problems are found, the inspector shall promptly notify the equipment custodian.

Table 8-1: Wire Rope Inspection Summary

Inspection Type	Equipment Type	Reference Section	Frequency	Performed By	Records
Frequent	All	8.3.1	Each day of use	Operator	Not required
Monthly	Overhead and gantry, crawler locomotive, and truck crane	8.3.2	Monthly	Wire rope inspector	Checklist or inspection report. Signed and dated.
Periodic	All	8.3.3	To meet conditions, but no less than annually. When returning to lift service.	Wire rope inspector	Inspection report. Signed and dated.
When equipment has been idle for 1 month or more	All	8.3.4 8.3.5	Before service.	Wire rope inspector	Inspection report. Signed and dated.

8.3.1 Frequent Inspection

Running ropes should be visually inspected once each working day by the equipment operator. This visual inspection shall consist of observing any rope that can reasonably be expected to be in use during the day's operations. These visual observations should be concerned with discovering gross damage that may be an immediate hazard, such as the following:

1. Rope distortion such as kinking, crushing, unstranding, birdcaging, main strand displacement, or core protrusion
2. Corrosion
3. Broken or cut strands

8.3.2 Monthly Inspection²

For crawler locomotive and truck cranes³ and for overhead and gantry cranes,⁴ a monthly inspection of running ropes shall be performed and documented by a qualified wire rope inspector. Documentation shall include the date of inspection, the signature of the person who performed the inspection and the identity of the ropes that were inspected. This documentation shall be kept readily available. A checklist near the operator's station is recommended. This inspection does not necessitate a breakdown of the crane. For overhead and gantry cranes, lower the hook block(s) to the floor or lowest attainable position. Inspect the rope(s) from the floor and bridge walkway or trolley floor where there is a means of access. For crawler locomotive and truck cranes, position the boom and load block(s) for good access to length(s) of running rope(s) that can reasonably be expected to be used in the existing boom/jib configuration. Hydraulic booms should be fully extended.

Visually inspect running ropes for any condition that could result in an appreciable loss of strength and thus constitute a safety hazard. Some conditions that could result in an appreciable loss of strength are the following:

1. Reduction of rope diameter below nominal diameter as a result of loss of core support, internal or external corrosion, or wear of outside wires
2. A number of broken outside wires and the degree of distribution or concentration of such broken wires
3. Worn outside wires
4. Corroded or broken wires at end connections

² Basis: OSHA 29 CFR 1910.179(m), *Rope Inspection*, and 29 OSHA CFR 1910.180(g), *Rope Inspection*.

³ Commonly called mobile cranes, this equipment type includes crawler cranes, locomotive cranes, wheel-mounted cranes of both truck and self-propelled wheel type, and any variations thereof which retain the same fundamental characteristics.

⁴ The overhead and gantry crane equipment classification includes semigantry, cantilever gantry, wall cranes, storage bridge cranes, and others having the same fundamental characteristics. These cranes have trolleys and similar travel characteristics. This classification does not include hoists, monorail hoists, or jib cranes.

5. Corroded, cracked, bent, worn, or improperly applied end connections
6. Severe kinking, crushing, cutting, or unstranding.

NOTE: A monthly inspection of running rope is not required if a periodic inspection of running and standing rope is accomplished during that month.

8.3.3 Periodic Wire Rope Inspection (Active Cranes and Hoists)

8.3.3.1 Periodic Inspection Intervals

A thorough inspection of running rope and standing rope shall be made at least annually or more frequently as determined by a qualified person. The inspection frequency shall be based on such factors as expected rope life, determined by experience on the particular equipment or similar equipment, severity of environment, percentage of capacity lifts, frequency of operation, and exposure to shock loads. Inspections need not be at equal calendar intervals and should be more frequent as the rope approaches the end of its useful life.

8.3.3.2 Inspector

Periodic wire rope inspections shall be performed by a qualified wire rope inspector (see Chapter 4.0, *Personnel Qualifications and Training Requirements*).

8.3.3.3 Inspection Area

The inspection shall cover the entire length of each rope. Only the surface wires of the rope must be inspected. No attempt should be made to open the rope. Any deterioration resulting in loss of original strength shall be documented and a determination made as to whether further use of the rope would constitute a hazard. As a minimum, ropes shall be inspected for the following:

1. Items listed for frequent wire rope inspection
2. Reduction of rope diameter below nominal diameter resulting from loss of core support, internal or external corrosion, or wear of outside wires
3. Severely corroded or broken wires at end connections
4. Severely corroded, cracked, bent, worn, or improperly applied end connections
5. Improper and insufficient rope lubrication
6. Evidence of heat damage from any source

8.3.3.4 Sections of Rapid Deterioration

Additional care shall be taken when inspecting sections of rapid deterioration, such as the following:

1. Sections in contact with saddles, equalizer sheaves, or other sheaves where rope travel is limited
2. Sections of the rope at or near terminal ends where corroded or broken wires may protrude

8.3.4 Inspection of Ropes Not in Regular Use

Rope that has been idle for a period of 1 month or more due to shutdown or storage of the hoist or crane on which it is installed shall be given a thorough inspection by a qualified wire rope inspector, which shall include running and standing ropes, and be equal to a periodic inspection, as described previously. (The condition of wire rope lubricant is a key concern.) This inspection shall be completed before the equipment is returned to service.

8.3.5 Inspection of Ropes Before Returning to Lift Service

Cranes that have been used for excavation or demolition work shall have a periodic wire rope inspection before being returned to lifting service.

8.4 Wire Rope Replacement Criteria

8.4.1 Wire Rope Replacement Criteria – Overhead and Gantry Cranes, Monorail Cranes and Hoists, Overhead Hoists and Mobile Cranes

No precise rules can be given for determination of the exact time for rope replacement since many variable factors are involved. Once a rope reaches any one of the specified removal criteria, it may be allowed to operate to the end of the work shift, based on the judgment of a qualified person. The rope shall be replaced after that work shift, at the end of the day, or at the latest time prior to the equipment being used by the next work shift.

8.4.2 Wire Rope Replacement Criteria – ASME Standards

Follow the criteria in each ASME Standard for Rope Replacement:

- ASME B30.2, *Overhead and Gantry Cranes*
- ASME B30.4, *Portal and Pedestal Cranes*
- ASME B30.5, *Mobile and Locomotive Cranes*
- ASME B30.6, *Derricks*
- ASME B30.7, *Base Mounted Drum Hoists*
- ASME B30.8, *Floating Cranes and Floating Derricks*
- ASME B30.16, *Overhead Underhung and Stationary Hoists*
- ASME B30.21, *Lever Hoists*

Table 8-2: Wire Rope Replacement Criteria Table

Pertinent ASME Standard	Number of Broken Wires in Running Ropes	Number of Broken Wires in Running Ropes	Rotation Resistant Ropes Broken Wires	Standing Ropes	Reduction in Nominal Rope Diameter
B.30.2 Overhead and Gantry Cranes	12 In one rope lay	4 In one strand of one lay	N/A	N/A	5%
B30.5 Mobile and Locomotive Cranes	6 In one rope lay	3 In one strand of one lay	2 in 5 rope diameters 4 in 30 rope diameters	3 or more in one rope lay 2 at end connections	5%
B30.16, Overhead Hoists/ Underhung Hoists	6 In 6 rope diameters	3 in 1 strand in 6 rope diameters	2 in 6 rope diameters 4 in 30 rope diameters	N/A	5%
B30.21 Lever Hoists	6 In 6 rope diameters	3 in 1 strand in 6 rope diameters	2 in 6 rope diameters 4 in 30 rope diameters	N/A	5%

Attention shall be given to end connections. Upon development of two broken wires adjacent to socket end connections, the rope shall be resocketed or replaced. Resocketing shall not be attempted if the resulting rope length will be insufficient for proper operation.

8.5 Wire Rope Receiving, Storage, and Maintenance

8.5.1 Receiving at the Work Site

When rope is received at the rigging loft, shop, or other work site it should be carefully checked for size, construction and core, to ensure that it matches the description on the tags, requisition, packing slips, purchase order, or invoice.

8.5.2 Rope Storage

If the rope is to be held for a considerable length of time (longer than 3 months) it must be protected from the elements. A dry, well-ventilated building is the proper storage place. Avoid closed, unheated, tightly sealed places. Wire rope shall not be stored in areas subject to elevated temperatures or subject to dust, grit, or a chemically laden atmosphere. If the delivery site precludes inside storage and the rope must be kept outside, the rope shall be covered with a waterproof tarp. The reel should be on a platform so as to keep it from direct contact with the ground.

8.5.3 Unreeling, Cutting, and Seizing

8.5.3.1 Unreeling

Unreeling or uncoiling of rope shall be done in a manner to avoid kinking or inducing a twist. (A rigging specialist should be consulted, if necessary.)

8.5.3.2 Cutting

Before cutting a rope, seizing should be placed on each side of the place where the rope is to be cut to prevent unlaying of the strands. (For preformed rope, one seizing each side of the cut. For nonpreformed rope, 7/8-inch diameter or smaller, two seizings on each side of cut; for larger diameter, three seizings each side of cut.)

8.5.4 Wire Rope Lubrications

8.5.4.1 Lubrication by the Rope Manufacturer

The lubrication ropes receive during manufacture is adequate only for initial storage and the early stages of the rope's service life.

8.5.4.2 Rope Lubrication on Active Cranes and Hoists

Rope on active hoists and cranes shall be maintained in a well-lubricated condition. It is important that lubricant be applied as part of the maintenance program. The lubricant must be compatible with the original lubricant, so the rope manufacturer should be consulted. The lubricant applied shall be of the type that does not hinder visual inspection. Rope sections that are located over sheaves, or otherwise hidden during inspection and maintenance procedures, require special attention when lubricating rope.

8.5.4.3 Lubrication Frequency

This HSHRM does not specify the time interval between lubrications. A thorough periodic inspection will indicate when lubrication is required and whether lubrication frequencies, as part of the maintenance program, must be adjusted.

8.6 Replacement Rope

8.6.1 Rope Replacement Frequency (Recommended)

Where equipment is consistently in use, it is recommended that wire rope be given a certain length of service (e.g., several hundred operating hours or a certain number of months) and then the rope replaced regardless of its condition. This method will eliminate the risk of fatigue causing rope failure.

8.6.2 Extra-Long Rope

If a longer rope than necessary can be installed, well-defined, localized abrasion and fatigue may be dealt with without discarding the whole rope. In such a case, one end shall be cut to expose a different section of rope to the place where the deterioration occurs. (This method is most applicable to running ropes on mobile cranes.)

8.6.3 Replacement Rope as Recommended by Equipment Manufacturer

Replacement ropes shall be of a construction recommended by the rope manufacturer or the crane or hoist manufacturer (see Section 8.2.2, *Rotation-Resistant Rope*). Replacement rope shall be the same size, grade and construction, and have a strength rating equal to the original rope furnished or recommended by the crane or hoist manufacturer. Replacement ropes shall be manufactured by a member of the Wire Rope Technical Board or acquired from the crane or hoist manufacturer by part number. Replacement ropes shall be acquired with signed test certification indicating actual breaking strength and origin of rope. Current wire rope test reports shall be kept in the equipment history/ maintenance file.

8.6.4 Terminal Ends

Terminal ends shall be prepared and socketed in the manner specified by the manufacturer of the wire rope or fitting.

8.7 Replacement Rope Installation

8.7.1 Before Initial Load Cycle

After wire rope replacement, and before the initial load cycle, a qualified inspector shall verify the following conditions.

1. The rope attachment points to the hoist drum and dead end (if applicable) are properly installed.
2. Fasteners are properly torqued.
3. Overhead cranes and hoists will have no less than two full wraps of rope on the drum when the hoist is at the lower limit. Mobile cranes will have an adequate rope length so that neither the load nor the boom lowering will result in less than two full wraps of rope on respective drums.
4. Reeving is in accordance with the manufacturer's recommendations.

8.7.2 Initial Cycle

After rope replacement and before returning the equipment to service, it is recommended that the hoist unit be cycled from maximum down position to maximum up position eight to ten times with 10 percent to 20 percent of rated load.

8.7.3 New Rope Stretch

On equipment having multiple part lines (other than rotation-resistant wire rope) a new rope will stretch and unlay slightly, causing turns to appear in the load block. The anchorage, if not fitted to a swivel, may be disconnected, the turns removed and reconnected.

8.7.4 Verification of Fasteners

After the initial load cycle has been completed, a qualified inspector shall verify that the fasteners on drum and/or dead end have been re-torqued.

8.7.5 Documentation of Rope Replacement

A wire rope replacement checklist (Attachment 8-1 or equivalent), signed and dated by a qualified inspector, shall document proper installation of replacement rope.

8.8 Qualification of Wire Rope**8.8.1 Qualification of Original Rope Supplied with new Equipment**

Original rope, supplied with new equipment, is qualified for service by the inspection performed on the new equipment.

8.8.2 Qualification of Replacement Rope

A completed wire rope replacement checklist, documenting the most recently installed replacement rope (Attachment 8-1 or equivalent), signed and dated by a qualified inspector, shall be in the equipment maintenance file. In addition to inspection records in the equipment maintenance file, replacement rope shall have certification from the rope manufacturer. The manufacturer's certification shall contain adequate information to identify the rope and should contain the following information:

1. Rope diameter (e.g., 1/2 inch)
5. Rope classification (number of strands X wires per strand) (e.g., 6 x 37)
6. Lay (e.g., right regular lay, or left lang lay)
7. Grade of wire (e.g., Improved Plow Steel, or Extra Improved Plow Steel)
8. Type of core (e.g., Independent Wire Rope Core, or Fiber Core)
9. Nominal strength (e.g., 10.7 tons)
10. Rope's purchase order number, if known.

Attachment 8-1: Wire Rope Replacement Checklist Example

WIRE ROPE REPLACEMENT CHECKLIST				
Equipment Identification and Location: _____				
Date of replacement rope installation: _____				
Rope Manufacturer: _____				
Diameter: _____	Strands: _____	Wires/strand: _____	Lay: _____	
Wire rope purchase order number: _____				
Grade of wire: _____	Type of core: _____	Nominal strength: _____		
PRIOR TO INITIAL LOAD CYCLE			OK	N/A
Rope attachment points properly installed				
Fasteners properly torqued Record torque value applied at drum attachment: _____ Record torque value applied at dead end: _____				
Overhead crane or hoist No less than two full wraps on drum with hook at lower limit				
Mobile crane Neither load nor boom lowering will result in less than two full wraps on the respective drum				
Reeving in accordance with manufacturer’s recommendation				
INITIAL LOAD CYCLE				
Initial load cycle performed (maximum down to maximum up position 8 to 10 times with 10% to 20% of rated load				
After Initial Load Cycle, re-torque impact rope attachment points (drum and dead end)				
Rope manufacturer’s certification placed in equipment maintenance file				
Comments:				
Qualified Inspector				
_____		_____		
(print name)		(signature)		
Place the most recently completed form in the equipment maintenance file.				