Care and inspection of wire rope

The applications of wire rope for crane hoists is an important “tool” and probably one of the least understood and most abused.

1. This data sheet discusses the inspection of wire rope and the precautions necessary to avoid accidents.

What is wire rope?

2. By definition, wire rope is a twisted bundle of drawn steel wires. It is usually composed of wires, strands and a core. The wires are drawn to a pre-determined size and laid together in various arrangements having a definite pitch (or lay) to form a strand. The required number of strands are helically laid or formed around the core, which may be a cause.

3. The size, number and arrangement of wires, the number of strands, the lay and the type of core in a rope are determined largely by the service for which the rope is to be used. Flexibility and abrasion are the most important considerations; other factors, such as load conditions, rope speeds, vibration, crushing, and equipment design also must be considered.

4. In general, the greater the number of wires in a strand and the greater the number of strands, the more flexible the rope. Flexibility should not be confused with bending fatigue resistance, (i.e., a fiber core rope is more flexible but frequently gives poorer service than an IWRC rope, particularly if sheaves are small and loads are heavy).

Hoisting ropes require flexibility and are usually made up of six or eight strands with 16-26 wires per strand for the 6 by 19 classification and 27-49 wires per strand for the 6 by 37 classification.

5. Flexibility is not a requirement for guy wires, highway guards and similar services; therefore, six strands of seven larger diameter wires (called six by seven) construction are suitable. The selection of wire rope for a particular service should be made in accordance with types recommended by engineers of wire rope
manufacturers. Some service conditions require rope with special qualities.

6. Wire strand cores may or may not be the same construction as the outer strands of the rope. Steel cores of either strand or IWRC give the most solid support and must be used when loads are heavy, there are shock loads and the temperatures are above 212°F.

7. Wire ropes may be zinc-coated or made from stainless steel wires to resist certain types of corrosion.

8. Practically all wire rope manufactured today is the preformed construction. This means the wires and strands have been preset during manufacturing into the permanent helical shape they take in the completed rope. Preforming improves the operating characteristics of rope and decreases the possibility of damage during handling. Because the wires of preformed rope tend to remain in position when broken, closer inspection is necessary to detect broken wires.

Deterioration of wire rope

9. Deterioration of wire rope is largely due to factors that may vary considerably in importance, depending on the conditions of service. For example, corrosion is often the principal cause of deterioration of mine hoisting rope in wet mine shafts because of moisture and the presence of acid in the water.

10. Other factors contributing to deterioration are:

   • Wear – particularly on the crown or outside wires, from contact with sheaves and drums
   • Corrosion – particularly of the interior wires, indicated by pitting and often caused by drying due to lack of lubrication and exposure to heat or moisture. This condition is difficult to detect and is highly dangerous. Corrosion also interferes with the movement of the wires and hastens fatigue failure.
   • Kinks – acquired during improper installation of new rope or caused by sudden release of the load and by knots made to shorten the rope, hoisting with slack in the rope, etc. A kink is a defect that cannot be removed or corrected.
   • Fatigue – the breakage of wires from flexure while operating under normal conditions. Repeated bending over sheaves under normal loads or even axial flexure.
   • Pendants eventually cause wires to break. The wire break is usually square across the wire, but frequently is the “Z” type. Heavy loads, corrosion and lack of lubrication accelerate fatigue failure. Operation on undersized sheaves and drums also hastens failure from fatigue.
   • Drying out of lubrication – often hastened by heat.
   • Overloading and over winding – not following safe working load charts.
   • Mechanical abuse – such as crushing and cutting wires or dragging ropes

11. The safety and efficiency of hoisting rope installations can be greatly increased by the use of sheaves and drums of the correct size and design, by proper lubrication, and by maintenance of the rope and the hoisting equipment.

12. There are established safety factors recommended for various types of service. Safe Working Load (SWL) is the ratio of nominal breaking strength of the rope divided by the load imposed upon it. SWL =

This ratio, sometimes referred to as the safety factor, is published in various publications. The American National Standards Institute, OSHA or other regulatory sources should be consulted.

13. The inspection of ropes for maintenance and replacement must be made in accordance with the American National Standard B30 Codes, which have now been incorporated by reference into the appropriate OSHA regulations.

14. In general, all running ropes (except elevator
ropes) in continuous service must be inspected once every working day, and a thorough inspection of all ropes in use should be made at least once a month with a full, written, dated and signed report of rope condition that should be kept on file. Trained and authorized designated personnel must make inspection. Inspection items for determination of need for cable replacement should include the following:

- Reduction of rope diameter
- Presence of broken wires and the degree of distribution or concentration
- Outside wire wear
- Evidence of heat damage from any cause
- Suspicion of lightning damage
- Failure to have bearings on hooks turn freely and thus cause rope to twist or not work according to design
- Corroded, fatigued or broken wires at end connections
- Corroded, cracked, bent, worn or improperly applied end connections
- Severe kinking, crushing, cutting or unstranding

15. No precise rules can be made for determining the exact time wire rope should be replaced. Safety mainly depends on the judgment of the qualified person who evaluates the strength remaining in a used rope after allowing for deterioration disclosed by inspection.

16. The following conditions are cited from a section of OSHA regulations as typical criteria to question rope safety:

- In running ropes, six randomly distributed broken wires in one lay or three broken wires in one strand of one lay
- Wear of one-third the original diameter of individual outside wires
- Kinking (not to be confused with dog legging), crushing, bird-caging or other damage resulting in distortion of the rope structure
- Evidence of heat damage from any cause, such as exposure to heat above recommended limits, (e.g., when used to soak heated billets, lift forgings or exposure to burning torches
- Excessive elongation or sharp reduction in diameter, which means replacement is necessary
- In standing ropes, more than two broken wires in one lay in sections beyond end connections, or more than one broken wire at an end connection
- Contact with an energized electrical conductor

17. All wire rope users should establish a time interval for rope replacement to allow wire ropes to be removed from service before failure occurs. However, such periodic replacements must not take the place of frequent inspection. Should rope failures occur or inspection reveal abnormal wire breakage or defects, the time interval between periodic replacements should be reduced. Used wire ropes should not be used to make wire rope slings.

18. A vital part of any wire rope program is the training of both operating and maintenance personnel to know how to inspect and recognize wire rope conditions. Adherence to the rule will result in safe wire rope use. The users should have a copy of the manufacturer’s recommendations for use and maintenance. Remember that most equipment is designed so the rope will go first. The rope is replaceable at a cost that is small relative to some more vital part of the machine.

**Wire rope load failures**

19. Failures of wire rope can result in fatal or disabling injuries where personnel are working close to loads carried by boom cranes at construction sites.
• Property damage can result from rope failures when suspended loads fall.
• Interruption of production usually results from wire rope failure.
• Wire rope failures often necessitate repairs and costly maintenance.

Methods of inspection

20. Inspection of wire rope must be performed on a regular basis, at two levels of responsibility; operator and maintenance. The first level is where the operator examines wire rope conditions daily within the scope of his training, usually at the beginning of his assigned work shift.

21. The operator should inspect these visible parts of a system at rest for:
• Rope appearance for kinks, breaks, wear, corrosion or other visible signs of weakening or deterioration
• Rope drum for position of cable in grooves, tracking, means of anchoring or drum wear or damage
• Sheaves and equalizers for alignment of ropes, guides or damaged or worn parts
• Hook block sheaves, guides and dead ends
• Slack rope conditions at sheaves

22. The operator should inspect visible parts of the system in motion for:
• Smooth payout of wire rope to and from drum
• Sheaves turning without binding or jerky appearance as a rope passes over them
• Wire rope not rubbing on stationary parts; proper alignment where rope enters sheaves
• Hook block sheaves turning smoothly without obstruction or rocking
• Ropes not rubbing on rope sheave guards
• Absence of rubbing, scraping or chattering noises during operation

23. The second level is at the maintenance level. Personnel in this group should be qualified to make normal maintenance repairs or rope replacements and should have the necessary tools and equipment to perform more thorough rope inspections. Inspections by such personnel should be periodic and in addition to inspections resulting from operator reports of actual rope damage or failure during operation.

24. For this second level of inspection, the equipment should be removed from service and more elaborate inspection techniques should be used to examine all parts of the ropes.
25. Personnel performing the inspection should:

- Lower hoist to unload rope sheaves
- Unwind all wire rope from the hoist drum to expose all parts of a rope, making sure that the rope does not rewind in the reverse direction
- Unload equalizer to expose wire rope and related sheave conditions
- Inspect sockets, dead ends, thimble joints and wire rope hardware
- Inspect all parts of the cable itself, cleaning wire rope only as required to complete an inspection; excessive removal of lubrication will lead to rope damage
- Re-lubricate to prevent corrosion and to prevent wear from friction and drying out of the core; lubricants that are fluid at normal temperatures and are fortified with polar additives and rust inhibitors can penetrate the rope and afford good protection even under wet operating conditions
- Check for ropes that have been operated dry; they should be replaced because there may be hidden damage that is not detectable by visual inspection
- Replace ropes that show signs of wear, damage, or corrosion beyond standards set for replacement

Sources of information

American National Standards Institute, 1899 L Street, NW, 11th Floor Washington, DC 20036
PD010 – ASME A17.1 Safety Code for Elevators and Escalators


Armco Steel Corp. 703 Curtis St., Middletown, OH 45042: Wire Rope Handbook and Catalog E; OSHA and Wire Rope.

Wire Rope User’s Handbook
Union a Wireco Worldgroup Brand
12200 NW Ambassador Dr Kansas City, MO, 64163-1244 fax: 816.270.4707
www.wirecoworldgroup.com

OSHA 29 CFR 1910.184 SLINGS

United States Steel Corp., 600 Grand St., Pittsburgh 15219: The AISE Steel Foundation; 11th edition (September 15, 1998)

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