CraneWorks

Wire Rope Inspection

Ken Overton (Safety Engineering Services), CraneWorks Magazine (July-August 1994 Issue)

From childhood, most of us have been taught to think of a machine as a device with gears, shafts, belts, cams, pulleys and assorted whirring parts but this is not necessarily so. For example, wire rope is not just a piece of wire. It is a complicated machine.

A typical 6x25 classification wire rope has 150 wires in its strands. As the rope bends, all these wires move independently and together in a very complicated pattern around the core. Clearances between wires are balanced when a rope is designed so that internal movement and adjustment of wires and strands is permitted when the rope bends. These clearances will vary as bending occurs, but are similar to clearances found in automobile engine bearings.

Understanding and accepting this concept will give the wire rope user a greater respect for the rope and will enable you to use it more efficiently and effectively, thus achieving better performance and longer useful life from the rope.

Getting started

As with other machines, periodic inspections of wire rope are necessary. As the rope is used, it gradually loses strength. The purpose of an inspection is to determine whether a wire rope retains sufficient capability to perform the work to be done before the next scheduled inspection. The very fact that regular inspections are required by certain governmental regulations is, in a sense, of secondary importance since the need to perform inspections exists anyway. OSHA document 29CFR1926-550 [1991], ANSI document B30.5 [1968], and SAE document J959 [1966] each contain regulatory information on wire rope inspections. Copies of these regulations can be obtained from your local library, rigging supply house or from your wire rope supplier.

The primary rule for conducting wire rope inspections on equipment is that each wire rope must be considered individually. This individual treatment is particularly important when inspecting standing ropes, which are considered supporting or structural members. For example, pendant lines that support long crane booms are frequently made up of several sections of individual ropes. Each rope must be inspected and pass on its own merits.

Because different inspection criteria frequently apply, standing ropes should be inspected separately from the running, or operating ropes on the same machine or installation. In real-world situations, parts of both running and standing ropes may need to be inspected on the same trip to some high or inconvenient location on an installation. When this occurs, each rope must be given individual attention, and inspected according to its particular criteria. Also, the information on the condition of each rope must be recorded separately.

It must be emphasized that a proper inspection cannot be made when a wire rope is supporting a load or when it is in motion because a taught line can hide broken wires or damaged cores. This applies to both standing and running lines. To inspect boom pendant lines for example, the boom must be down with the lines relaxed. The only possible exception to this rule might be certain types of conveyor and tramway ropes.

Several tools are recommended to aid in wire rope inspection including an awl and a marlin spike; a caliper; a steel tape; two groove gauges (for sheaves and drums); chalk; wiping cloths; writing material; and operator's manual, machine maintenance manual and other inspection criteria for ready reference.

Frequency of inspections

The responsibility for wire rope inspections rests with several people. Since the crane operator is responsible for the movement of the load once it is picked off the ground, a professional operator will make sure the machine can make the lift safely. Daily inspections of the wire rope are part of the pre-lift inspection needed to verify the safety of the lift. Professional crane operators will insist on daily inspections, conduct them and record the results themselves.

Government regulations also require machine owners and/or users to conduct regular, proper inspections, and to keep a written record of such inspections. These rules are the result of field experience, and the burden of this requirement has been rightfully placed on owners and users. The frequency of this type of inspection depends on the type of machine the rope is used on and the application. You must follow the guidelines included in the operation and safety instructions provided by the manufacturer of your specific machine and the recommendations included in OSHA 29CFR1926 and ANSI B30.5. All of the guidance you will receive from these documents underscores the wisdom of professional crane operators and machine users who insist on daily or work shift, visual and physical inspections of all of the elements of the wire rope system and the maintenance of complete written records. Note and follow the OSHA regulations which are quite specific with reference to written and signed reports on thorough, periodic inspections.

Critical Points

There are certain points along any given rope which should receive more attention than others, since some areas will be subjected to greater internal stresses or greater external forces and hazards. Carefully select the most critical points for close inspection -- points where failure would be most likely to occur. The same critical points on each installation should be compared at each succeeding inspection (See figure A). Critical points to consider on most installations include:

Figure A: There are certain critical points on any wire rope that should receive more attention than others. Carefully select those points for close inspection.

PICK UP POINTS - These are sections of a running rope which are repeatedly placed under stress when the initial load of each lift is applied. An example are the sections in contact with sheaves.

END ATTACHMENTS - At each end of the rope, two things must be inspected: the fitting that is attached to the rope and the condition of the rope itself where it enters the attachment (See figure B, page 26). In addition, standing ropes should also be checked 18 to 24 inches from their attaching points due to wear from vibration.

All end attachments have one characteristic in common. To some degree, they restrict the free movement of wires at the end of the rope, resulting in broken wires at the point where restriction occurs. A single broken wire is usually reason to question continued use of the rope, and more than one is usually cause for rejection. Broken wires may be more difficult to locate at end fittings than in other sections of rope. An awl, used to pick and probe at the point where strands enter the end attachment, can often expose broken wires not otherwise visible (See sidebar on page 10). Make sure you check government regulations and manufacturer's recommendations for specific rejection criteria regarding broken wires in end attachments for both running and standing lines.

Another problem frequently encountered at end fittings is corrosion or rust. Corrosion can easily conceal broken wires, and if left to accumulate, can erode the surface of wires weakening them. It also can restrict normal wire movement increasing the possibility of broken wires. Inspection of rope ends should also include the condition of the actual attachment. Check for worn eyes, missing thimbles, bent or opened hooks and worn clevis pins.

EQUALIZING SHEAVES - The section of a rope which is in contact with and adjacent to equalizing sheaves, such as those found on boom hoist lines, should receive careful inspection.

HEAT EXPOSURE - Be especially watchful for signs that a rope has been subjected to extreme heat, or to repetitive heat exposure. Wire rope is usually lubricated to protect it from corrosion and internal friction. However, most lubricants have melting points of 120 degrees to 140 degrees. If rope is used in temperatures above this, fiber cores can dry out and char. Plastic cores are also affected by extreme heat. Pronounced strength reduction occurs in carbon steel rope with steel wire cores above 400 degrees, and tensile strength reduces on stainless steel ropes at temperatures above 800 degrees.

Never use a cutting torch to cut wire rope. It can cause deterioration of the core as well as individual wires for several feet in either direction from the point of the cut, resulting in a severe loss of strength. Refer to the manufacturer's guidelines regarding heat exposure and follow their inspection criteria.

ABUSE POINTS - Ropes are frequently subjected to abnormal scuffing and scraping, such as by contact with the cross members of a boom. Look for bright spots on the rope which indicate such action may be taking place. An often overlooked abuse point occurs where rope runs over roller bars that do not roll properly. Machinery that has been stored for a long time without regular maintenance will likely have this abuse point. Extreme flattening of the wire rope is the result. It must be kept in mind that minor (and frequently major) differences exist between installations, even on machines of a similar design. Therefore, points on each rope selected for close examination will necessarily require the best judgment of the inspector.

Inspection of drums and sheaves

In addition to inspecting critical points, inspection of the equipment over which wire rope operates is necessary. Proper maintenance of this equipment has an important bearing on rope life. For example, worn grooves and poor sheave alignment will have a deterioration effect.

DRUMS - Carefully inspect the general condition of the drum and the condition of drum grooves. Also, check the manner in which the rope spools onto the drum. Inspection criteria for drums will usually specify the minimum number of dead wraps to remain on the drum (Oregon-three wraps, California-two wraps); condition of grooves on grooved drums and the condition of the surface on smooth drums; condition of the flanges at the ends of the drum; rope end attachments; spooling characteristics of the rope; and the rope condition, particularly at pick up points on the rope.

Grooves must be the proper contour and checked with a groove gauge for normal tolerances. Bottoms of grooves should be smooth; drums that become imprinted with the rope's tread, or are excessively rough, should be corrected or replaced. Grooves should be spaced so that one wrap of rope does not scrub the next wrap as it spools onto the drum.

Spooling is that characteristic of a rope which affects how it wraps onto and off a drum. Spooling is affected by the care and skill with which the first layer of wraps is applied on drums with two or more layers. Wraps must be tight, and a loose condition must be corrected promptly. It is important to examine a rope for kinks or other damage when loose or irregular spooling has been observed.

Drum crushing is a condition that causes deterioration of the rope (See figure C, page 26). Sometimes crushing is inevitable on a given drum winding, as is deformation of the outer wires in the rope, usually described as peening. Peened wires are flat with lips on each side of the flattened area. Peening displaces metal on the surface of the rope causing stress least three rope lays long so that an average lay length can be determined. Many inspectors have found that a crayon or marking stick and a roll of adding machine tape are ideal.

Changes in the length of the lay are usually gradual throughout the working life of the rope. It is important to compare current lay measurements with previous inspection results to note any sudden changes in the pattern can be the signal of impending doom. When the lengthening of a lay is noted with loss of rope diameter, internal break-up, or core destruction, should be suspected. However, if lengthening of the lay occurs without loss of rope diameter, the rope is probably unlaying, and further examination should be made to determine the cause. Unlaying sometimes results from operating a rope without having both ends secured to prevent rotation. An end swivel attachment permits rotation and thus unlaying. For that reason, Lang Lay cable should not be used in a one part line.

Another common cause of unlaying is worn sheaves. When the bottom of a sheave groove wears, it can restrict normal movement as the rope enters and leaves the groove in the sheave; the result can be a twist build-up which . can change the length of the lay.

If the immediate cause of unlaying can't be determined, recognize that it is an abnormality, and make notes for future reference.

Responsibility of inspection

Never assume that the wire rope you're using has been well treated, lubricated, inspected and used with the correct size sheaves. Remember that wire rope is a complicated machine that requires care and maintenance. Select a competent worker and carefully train him or her to inspect, care for (clean, store and lubricate), and reeve the wire rope you use. This individual must be totally proficient in the wire rope arena plus be able to maintain, authenticate and furnish to proper authorities the required records for review when requested. This individual is your company representative, and it is your responsibility and obligation, after all, to provide a safe workplace. This action is but a part of that duty.

Finding broken wires

Probably the most common sign of rope deterioration and approaching failure is broken wires, and inspection criteria are specific as to the number of broken wires allowable under various circumstances.

It is normal for a properly designed and used running or operating rope to exhibit broken wires as it approaches the end of its useful life. Under ideal conditions, the first wires to break would be the outside wires at the crowns of the strands where surface wear is expected to occur. On standing lines or ropes, wire breakage may not be so easily observed. It is important that a diligent search be made for broken wires, particularly in critical areas such as pick up points where stress is concentrated.

The first step in looking for broken wires is to make sure the surface is clean enough that breaks can be seen. Wipe the wire carefully with a cloth in a heavily gloved hand. If necessary, scour with a wire brush to clean grease from the valleys between the strands.

A thorough search for broken wires cannot be made when a rope is in tension or is supporting a load. Relax the rope, move pick up points off sheaves, and flex the rope as much as possible. With a sharp awl, pick or similar device probe between wire and strands, lifting any wires which appear to be loose. If you find a number of broken wires approaching the maximum number permitted per strand or per rope lay, extend the search to other sections of the rope. Also, take diameter and lay measurements in the area. Compare the measurements with base data obtained earlier and recorded in your operator's manual. If internal wire breaks or core damage

Information for this article was compiled from a variety of sources including: Wire Rope Users Manual, American Iron and Steel Institute; Yellow Strand Wire Rope Handbook, Broderick and Bascom; Riggers Handbook, Broderick and Bascom; United States Steel Tiger Brand Wire Rope Engineering Handbook; CF&I Roebling Wire Rope Handbook, CF&I Steel; American Wire Rope/Columbia Steel Company; Techreport #107, Wire Rope Corp. of America, Inc.; Technidata, Leschen Red Strand Wire Rope.

Illustrations from Techreport #107. For a complete copy of Techreport #107, write to Wire Rope Corporation of America, Inc., P.O. Box 288, St. Joseph, MO 64502.