USER’S MANUAL
WIRE ROPE

Handling, Installation and Maintenance of Steel Wire Ropes

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Wire ropes cross sections

Figure 1.1

| 35(W)x7 | 35(W)xK7 | 4xK36 | 4xK36 | 4x39 |

Type of lay.

Figure 1.2
Installation of wire rope

⚠️ Uncoiling and unreeling

Uncoil or unreel wire rope properly in order to preserve its balance and symmetry. Movement over sharp corners or small radii causes a spiral or cork-screw appearance and will damage the rotation resistant rope. Hold outer end of the rope on floor or ground. Turn coil on end. Roll coil along the floor letting rope trail behind or mount the coil on a turntable and pull away the free end in a straight line. Do not lay the coil on its side and uncoil by pulling rope end, this can disturb the balance of the rope and lead to loops and kinks. If uncoiling outdoors, do not roll through grit, sand or other abrasive material.

⚠️ Figure 2

Pass a suitable bar or pipe through the center holes of the reel, and lift the reel so it is supported by the inserted shaft. Use a timber brake or some similar device against the reel flange to apply enough tension to the rope to insure snug, uniformly controlled winding and prevent formation of loops at the storage reel. If uncoiling outdoors, do not roll through grit, sand or other abrasive material.

⚠️ Figure 3
Figure 3.1: Winding on drum depending on rope lay & drum rotation.
Installation procedure of rotation resistant wire rope in the crane

The troublefree and long service life of every multi stranded rotation resistant wire rope depends 100% on its proper installation in the crane.

Proper installation is a kink-free and torque free installation. To achieve that, a few simple and well known procedures must be followed. For instance laying the new wire rope on the deck so kinks, if existing, are removed before connecting the old wire rope to the new one. The installation of the new rope and removal of the old rope from the crane winch / drum must take place in one continuous operation making also sure that no accumulated internal stresses are transferred to the new rope. This is achieved with the use of pulling stockings or cable grips. The stockings, one at each rope side, must be placed at least 3 mtrs apart and must be joined with a heaving line rope or a seizing wire. These connecting materials will absorb the tensions of the old rope and will not transfer them through to the new rope.

Figure 4

From this point onward, special attention must be given to the coupling of the socket/thimble fitted onto the wire rope, to the crane itself. In no case loose rope must be left still laying on the deck, when the socket/thimble is to be attached, otherwise kinks will form and after a short period of operation on the crane the rope will swell and will eventually be destroyed. For that reason the socket/thimble end before being attached to the crane must be allowed to hang loose so that all kinks are relieved from the wire rope and no more can be formed.

Of same importance (after the proper installation) is the «running in» period, during which some windings and unwindings must be effected initially with half the maximum working load gradually increasing to the full, so that rope is allowed to adjust itself to the new operating conditions.

In conclusion, the proper installation, the running in period and the proper lubrication and inspection guarantee a long service life and troublefree operation.

Rope installation (see figure 5)

Mount reel of rope on stand in line with and as far as possible away from the first sheave or drum.

1. The reel of the wire rope and the first sheave must rotate in the same direction to avoid "reverse bends" which cause "twisty" rope.
2. Avoid large fleet angles between the shipping reel and the first sheave. The rope may roll in the sheave causing it to unlay. This is particularly important for all parallel lays, Lang lays and rotation resistant rope constructions.
3. Avoid reeving the rope through small deflection sheaves and also avoid changing the plane from vertical to horizontal direction (torsions will be induced in the rope). Never let the rope become loose/slack while unreeling it.

Only the installation of an untwisted rope will guarantee a trouble-free operation.
Proper winding of wire rope on the winch

Equally vital and of great importance is the winding of the new wire rope under tension on the ship's winch. The first layers must be wound tightly so that the upper ones do not wedge through the lower layers when load is applied and thus crush and destroy the rope.

The proper tensioning load should be approx 2% of the minimum breaking load of the rope. If a tensioning device is not present or is impossible to apply the tensioning load using a special device, please use a wooden board in order to "brake" the unwinding reel. Do not use pressure on the rope itself in order to generate the required tension as structural damage and permanent deformation on the rope might occur. Another solution is to wind the whole length of the rope on the winch, then unwind it until the first layer appears and then lift a load equal to the 2% of the rope's minimum breaking load so that the required tension level is achieved and then continue to wind the rope on the winch.

Break in Period

After installing a new rope, it is necessary to run it through its operating cycle several times under light load and at reduced speed. This allows the rope to adjust itself to the working conditions and enable all strands and wires to become seated. Depending on rope type and construction, some rope stretch and a slight reduction in rope diameter will occur as the strands and core are compacted. The rope is less liable to be damaged when full load is applied.

The initial stretch (constructional stretch) is a permanent elongation that takes place due to slight lengthening of the rope lay and due to a slight decrease in rope diameter. Constructional stretch generally takes place during the first 10-20 lifts, and increases the rope length by between 1/2% for fiber core rope, approx. 1/4% for 6-strand steel core rope, and approaches zero for compacted ropes.

Equipment Testing

In many cases the crane equipment has to be tested prior to use. During the test, the equipment gets purposely overloaded to varying degrees. The magnitude of overloading depends on the type and capacity of the crane and which governing authority certifies the equipment. The test may impose an overload of between 10% and 100% of the crane's rated capacity.

Under no circumstances must the crane be tested prior to the break in procedure of the wire rope. If you overload a rope which has not yet been broken in, you may inflict permanent damage to the rope.

Equipment with multiple layer windings call for additional caution. As mentioned before, severe overloads of the top layers may damage the lower ones or may crush the rope. If possible, test the crane with the rope spooled in the first drum layer only. If the crane is equipped with a smooth drum, special care must be taken to ensure that the rope does not cross-wind over itself when testing the crane. After testing (overloading), you have to repeat the spooling procedure.

Figure 6
Twisting of strands

Some rotation may occur in the initial cyclic operation. This rotation may result from the cabling of the parts of rope forming the reeving or from the following causes:

- Torque induced during installation of rope
- Torque induced by the operating arrangements of reeving
- Torque induced by the drum

⚠ Untwisting of hoisting rope

Untwisting of crane pulley block with rotation-stable fixed point: a) Determination of direction of twist

- Bring boom horizontally to its lowest position and the pulley block down to its lowest position
- Determine direction of twist of pulley block from crane cabin

Figure 7

If pulley block twists counter-clockwise the rope has to be twisted clockwise at the fixed point. (Reverse if pulley block twists clockwise.) (see figure 7)

Required steps/procedures (see figure 8)

- Move the boom into its parking position
- Set down the pulley block
- Avoid an intense sagging of the rope at the reeving
- Wind a sling round the end of rope behind sleeve.

- Put a "chainfall" (at least 1 ton) or a "come-along" (Clydesdale) (see figure 9) at the top of the crane. It has to work in the same direction as the rope.
- Try to keep the tightened rope at the height of fixed point by using chainfall (or come-along)
- Attach sling to chainfall (or come-along) and stretch rope in such manner it is slacked at the fixed point.
- Wind a chain round the rope behind sleeve so that you can twist the rope with the aid of a crowbar. (see figure 10) Loosen the screws at fixed point and remove the rope
- With the aid of chain and crowbar bring a torsion of at least 180° to 360° into the rope reverse to the twisting direction of pulley block.
- To put crowbar into next position fasten rope to thimble hole by using another crowbar if rope reeving are hindering.
- Attach rope to fixed point and grip the screws
- Remove all auxiliary devices and run the boom from lowest position to highest position 5-6 times

Exclusively by running the boom, the induced torsion can get into the rope reeving. (Running the lifting device causes movement of the wrong rope reeving.) Check twist of pulley block again. If any twist has remained, repeat the above procedures.

Auxiliary means:
Chains, 2 slings, chainfall or come-along (Clydesdale) 1 ton, 2 crowbars, wrench (fixed point).

⚠ Do not exceed working load limit.
Storage

Wire ropes should be stored under a roof or a weatherproof covering so that moisture cannot reach them. Similarly, acid fumes or any other corrosive atmosphere must be avoided in order to protect the rope from rust. If a reel is to be stored for a long period, it can be covered with a protective cloth. If not covered, the outer layers of rope should be generously coated with rope lubricant.

In case a rope is taken out of service and stored for future use, it should be placed on a reel after it has been thoroughly cleaned and re-lubricated. Used ropes should be given the same storage considerations as new ropes.

Wire rope in storage should be kept away from steam or hot water pipes, heated air ducts, or any other source of heat which can thin out lubricant and cause it to drain out of rope.

Wire rope inspection

⚠️ Deformations/ Defects

A wire broken under a tensile load that exceeds its strength is recognized by the "cup and cone" configuration at the fracture point (a). The necking down of the wire at this point shows that failure occurred while the wire retained its ductility. Shear-tensile fracture (b) occurs in wire subjected to a combination of transverse and axial loads. Fatigue breaks are usually characterized by squared-off ends perpendicular to the wire either straight across or Z-shaped (c&d).

![Deformations/Defects](image1)

Various types of deformations

The following conditions can be caused by a sudden release of tension and the resulting rebound of the rope from its overloaded condition. The strands and wires will not return to their original position. These conditions can also result from the rope operating through a tight groove.

![Various types of deformations](image2)

Basketlike distortion
Figure 12.2

Loosening of rope structure (inner core)

Figure 12.3

Kinks, bends or local crushing (also called "dog-leg")

Figure 12.4

Improper handling, rope rotation, sudden release of a load or core slippage can cause a "popped core".

Figure 12.5

A "birdcage" is damage to the rope structure due to a sudden release of the load.
The deformation is in the shape of a curl - as if it had been around a circular shaft. On close examination, the wires show two types of breaks - the normal tensile cup and cone and the shear break which appear as having been cut with a cold chisel on an angle.

If special rope damage is found, the cause has to be determined and eliminated before a new rope is installed. If in doubt, discard rope or consult our company for further assistance.

⚠️ For safety reasons crane ropes have to be discarded if showing one of the above criteria.

Rope inspection summary

Any wire rope that has broken wires, deformed strands, variations in diameter or any change from its normal appearance must be considered for replacement. It is always better to replace a rope when there is any doubt concerning its condition or its ability to perform the required task. The cost of wire rope replacement is quite insignificant when considered in terms of human injuries, the cost of down time, or the cost of replacing broken structures.

Wire rope inspection includes examination of basic items such as:

- Rope diameter reduction
- Rope lay
- External wear
- Internal wear
- Peening
- Scrubbing
- Corrosion
- Broken wires

⚠️ Some wire rope sections can break up without any visible warning.

Sections where this occurs are usually found at end terminations, and at points where the rope enters or leaves the sheave of boom hoists, suspension systems, or other semi-operational systems. Because of the "working" that takes place at those sections, neither appreciable external wear nor crown breaks will appear. Under such conditions the core fails thereby allowing adjacent strand nicking. When this happens, valley breaks are likely to appear and the rope should be removed.

If preventive maintenance is performed diligently, rope life can be prolonged. Cutting off an appropriate length of rope at the end termination before the core degrades, and valley breaks appear, minimizes degradation at these sections.

⚠️ Use and care of wire rope

What follows is a brief outline of the basic information required to safely use wire rope

- Wire rope will fail if WORN OUT, OVERLOADED, MISUSED, DAMAGED, OR IMPROPERLY MAINTAINED.
- In service, wire rope loses strength and work capability. Abuse and misuse increase the rate of loss.
- The MINIMUM BREAKING STRENGTH of wire rope applies ONLY to a NEW, UNUSED rope.
The Minimum Breaking Strength should be considered the straight line pull with both rope ends fixed to prevent rotation, which will **ACTUALLY BREAK** a new, **UNUSED**, rope. The Minimum Breaking Strength of a rope should **NEVER BE USED AS ITS WORKING LOAD**.

To determine the working load of a wire rope, the **MINIMUM** or **NOMINAL** Breaking Strength **MUST BE REDUCED** by a **DESIGN FACTOR** (formerly called Safety Factor). The Design Factor will vary depending upon the type of machine and installation, and the work performed. **YOU** must determine the applicable Design Factor for safe use. For example, a Design Factor of "5" means that the Minimum - or Nominal Breaking Strength of the wire rope must be **DIVIDED BY FIVE** to determine the maximum load that can be applied to the rope system.

Design Factors have been established by **DIN, ISO, CEN, OSHA, ANSI, ASME** and similar government and industrial organizations.

No wire rope should ever be installed or used without full knowledge and consideration of the Design Factor for the application.

**WIRE ROPE WEAR OUT.** The strength of a wire rope slightly increases after the break in period, but will decrease over time. When approaching the finite fatigue life span the breaking strength will sharply decrease. Never evaluate the remaining fatigue life of a wire rope by testing a portion of a rope to destruction only. An in-depth rope inspection must be part of such evaluations.

**NEVER** overload wire rope. This means **NEVER** use the rope where the load applied is greater than the working load determined by dividing the Minimum Breaking Strength of the rope by the appropriate Design Factor.

**NEVER** 'SHOCK LOAD' a wire rope. A sudden application of force or load can cause both visible external damage (e.g. bird caging) and internal damage. There is no practical way to estimate the force applied by shock loading a rope. The sudden release of a load can also damage a wire rope.

Lubricant is applied to the wires and strands of a wire rope when manufactured. This lubricant is depleted when the rope is in service and should be replaced periodically.

Regular, periodic **INSPECTIONS** of the wire rope, and keeping of **PERMANENT RECORDS SIGNED BY A QUALIFIED PERSON**, are required by **OSHA** and other regulatory bodies for almost every rope installation. The purpose of inspection is to determine whether or not a wire rope may continue to be safely used on that application. Inspection criteria, including number and location of broken wires, wear and elongation, have been established by **DIN, ISO, CEN, OSHA, ANSI, ASME** and other organizations.

**If in doubt, replace the rope.**

When a wire rope has been removed from service because it is no longer suitable, it **MUST NOT BE RE-USED IN ANOTHER APPLICATION.**

Every wire rope user should be aware of the fact that each type of fitting attached to a wire rope has a specific efficiency rating which can reduce the working load of a rope assembly or rope system, and this must be given due consideration in determining the capacity of a wire rope system.

Some conditions that can lead to problems in a wire rope system include:

- Sheaves that are too small, worn or corrugated can cause damage to a wire rope.
- Broken wires mean a loss of strength. Kinks permanently damage a wire rope.
- Environmental factors such as corrosive conditions and heat can damage a wire rope.
- Lack of lubrication can significantly shorten the useful service life of a wire rope.
- Contact with electrical wire and the resulting arcing will damage a wire rope.
Discard criteria for wire ropes - when to replace wire rope-based on number of broken wires

<table>
<thead>
<tr>
<th>Standard</th>
<th>Equipment</th>
<th>Number of broken wires in running ropes</th>
<th>Number of broken wires in standing ropes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Also remove for 1 valley break</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASME/B30.2</td>
<td>Overhead &amp; Gantry Cranes</td>
<td>Replace ropes within a specified period (as stated by the competent person)</td>
<td>Discard ropes immediately</td>
</tr>
<tr>
<td></td>
<td>CLASS 6X19</td>
<td>CLASS 8X19</td>
<td>CLASS 6X19</td>
</tr>
<tr>
<td></td>
<td>Broken wires randomly distributed among the outer strands</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>More than 12 per rope lay</td>
<td>More than 15 per rope lay</td>
<td>More than 24 per rope lay</td>
</tr>
<tr>
<td></td>
<td>Broken wires predominating in one or two outer strands</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>More than 6 per rope lay</td>
<td>More than 8 per rope lay</td>
<td>More than 8 per rope lay</td>
</tr>
<tr>
<td></td>
<td>Adjacent broken wires in one outer strand</td>
<td>4</td>
<td>More than 4</td>
</tr>
<tr>
<td></td>
<td>Valley breaks</td>
<td>1 per rope lay</td>
<td>More than 1 per rope lay</td>
</tr>
</tbody>
</table>

When to replace wire rope-based on number of broken wires (EN12385-3, ISO 4344, ISO 4309 standards)

ISO 4344

<table>
<thead>
<tr>
<th>Condition</th>
<th>Replace ropes within a specified period (as stated by the competent person)</th>
<th>Discard ropes immediately</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLASS 6X19</td>
<td>CLASS 8X19</td>
<td>CLASS 6X19</td>
</tr>
<tr>
<td>Broken wires randomly distributed among the outer strands</td>
<td>More than 12 per rope lay</td>
<td>More than 15 per rope lay</td>
</tr>
<tr>
<td>Broken wires predominating in one or two outer strands</td>
<td>More than 6 per rope lay</td>
<td>More than 8 per rope lay</td>
</tr>
<tr>
<td>Adjacent broken wires in one outer strand</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Valley breaks</td>
<td>1 per rope lay</td>
<td>More than 1 per rope lay</td>
</tr>
</tbody>
</table>
### ISO 4309

<table>
<thead>
<tr>
<th>Class</th>
<th>Rope category number RCN</th>
<th>Number of outer strand and total number of load bearing wires in the outer layer of strands in the rope</th>
<th>Number of visible broken outer wires</th>
<th>Sections of rope working in steel sheaves and/or spooling on a single-layer drum (wire breaks randomly distributed)</th>
<th>Sections of rope spooling on a multi-layer drum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Over a length of 6d</td>
<td>Over a length of 30d</td>
<td>Over a length of 6d</td>
</tr>
<tr>
<td>4x39</td>
<td>21</td>
<td>4 strands n ≤ 100</td>
<td>2</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>18x7</td>
<td>23-1</td>
<td>71 ≤ n ≤ 100</td>
<td>2</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>35(W)x7</td>
<td>23-2</td>
<td>101 ≤ n ≤ 120</td>
<td>3</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

**Accessories:**

**Rope lay length:** Approx equiv to 6 X D (D is the nominal rope diameter)

**Fracture of strands:** If a complete strand fracture occurs, the rope must be immediately discarded (ISO 4309 §6.4).
The maintenance of steel wire ropes

Relubricating steel wire ropes

During production, the rope receives intensive lubrication. This in-process treatment will provide the rope with ample protection against corrosion and is meant to reduce the friction between the elements which make up the rope as well as the friction between rope and sheaves or drums. This lubrication, however, only lasts for a limited time and should be re-applied periodically. German Standard DIN 15020 specifies: "Steel wire ropes must be relubricated at regular intervals, depending on their use, particularly along the zones subjected to bending. If, for operational reasons, relubrication cannot be carried out, shorter service life of the rope is to be expected and the inspection intervals have to be arranged accordingly."

When choosing the lubricant, it must be ensured that it is in accordance with the recommendations of the rope manufacturer.

Removing broken wires

If, during an inspection, ends of broken wires are detected, which might cross adjacent wires and destroy them when running over sheaves, these broken wire ends must be removed. Under no circumstances should the broken wire ends be pinched off with a pair of nippers (figure 14). The best method is to move the wire ends backwards and forwards until they break deep in the valley between two outer strands (figure 15). With thicker wires a tool should be moved backwards and forwards on the surface of the rope, thus bending the wires until they break.
# Diagnostic guide to common wire rope degradation

<table>
<thead>
<tr>
<th>Mode</th>
<th>Symptoms</th>
<th>Possible causes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fatigue</strong></td>
<td>Wire break is transverse—either Straight across or Z shape. Broken Ends will appear grainy.</td>
<td>Check for rope bent around too small a radius; vibration or whipping; wobbly sheaves; rollers too small; reverse bends; bent shafts; tight grooves; corrosion; small drums &amp; sheaves; incorrect rope construction; improper installation; poor end terminations. (In the absence of other modes of degradation, all rope will eventually fail in fatigue.)</td>
</tr>
<tr>
<td><strong>Tension</strong></td>
<td>Wire break reveals a mixture of cup and cone fracture and shear breaks.</td>
<td>Check for overloads; sticky, grabby clutches; jerky conditions; loose bearing on drum; fast starts, fast stops, broken sheave flange; wrong rope size &amp; grade; poor end terminations. Check for too great a strain on rope after factors of degradation have weakened it.</td>
</tr>
<tr>
<td><strong>Abrasion</strong></td>
<td>Wire break mainly displays outer wires worn smooth to knife edge thinness. Wire broken by abrasion in combination with another factor will show a combination break.</td>
<td>Check for change in rope or sheave size; change in load; overburden change; frozen or stuck sheaves; soft rollers, sheaves or drums; excessive fleet angle; misalignment of sheaves; kinks; improperly attached fittings; grit &amp; sand; objects imbedded in rope; improper grooving.</td>
</tr>
<tr>
<td><strong>Abrasion Plus Fatigue</strong></td>
<td>Reduced cross-section is broken off square thereby producing a chisel shape.</td>
<td>A long-term condition normal to the operating process.</td>
</tr>
<tr>
<td><strong>Abrasion Plus Tension</strong></td>
<td>Reduced cross-section is necked down as in a cup and cone configuration. Tensile break produces a chisel shape.</td>
<td>A long-term condition normal to the operating process.</td>
</tr>
<tr>
<td><strong>Cut or Gouged Or Rough Wire</strong></td>
<td>Wire ends are pinched down, mashed and/or cut in a rough diagonal shear-like manner.</td>
<td>Check on all above conditions for mechanical abuse, or either abnormal or accidental forces during installation.</td>
</tr>
<tr>
<td><strong>Torsion or Twisting</strong></td>
<td>Wire ends show evidence of twist and/or cork-screw effect.</td>
<td>Check on all above conditions for mechanical abuse, or either abnormal or accidental forces during installation.</td>
</tr>
<tr>
<td><strong>Mashing</strong></td>
<td>Wires are flattened and spread at broken ends.</td>
<td>Check on all above conditions for mechanical abuse, or either abnormal or accidental forces during installation. (This is a common occurrence on the drum.)</td>
</tr>
</tbody>
</table>
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