To open or not to open

Certex argues that external appearance is not a good indicator of the internal wires. Despite the clean appearance of the outside strands (bottom picture, top), wire breaks were found in the extracted core (bottom picture, bottom) and in the insides of the external strands (top picture)

A question from the audience at the Crane Safety 2004 conference about wire rope prompted two opposing answers. Speakers from Bridon rope said users should open up the rope to check internal wires; those from Pfeifer Seil-und Hebetechnik said they should only examine the exterior. Here, they present their arguments in detail.

For

Charles Gillespie, Certex (UK)

About the author: Charles Gillespie is currently Sales and Marketing Manager of Certex (UK) Ltd and has 18 years experience of working in the wire rope and lifting industry.

When a patient goes to a doctor, they can often reach a diagnosis by careful questioning and an analysis of the symptoms. With a wire rope, evidence of 'illness' is not so obvious. Ropes can't communicate, they may look fine and there may be no outward symptoms. Yet, unbeknown to the operator, a rope could only be hours away from a catastrophic failure. It is, therefore, essential to examine the physical condition of a rope and this invariably means 'opening them up'.

Simple constructions, such as six or eight strand ropes, hold most of their strength in the outer strands, with only 6-10% of the product strength being contained in the 'invisible' core. If this is the case, it may seem superfluous to carry out an internal inspection of this type of rope.

Yet nothing could be further from the truth and it is the good condition of this part of the rope that is paramount to its overall effectiveness. This is because the core provides support to the outer strands and ensures that the strand gaps are maintained, thereby reducing the effects of friction or abrasion.

This is even more relevant when dealing with multi-strand ropes, such as Bridon's Endurance Dyform 34LR and the Endurance 50 DB, which have a much higher proportion of their strength (up to 50%) held within the invisible core.

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Many people also fall into the trap of assuming that if a rope looks all right on the outside then it will be fine inside too – a misconception often reinforced by over-reliance on industry guidelines.

International Standards such as ISO 4309 lay down criteria (see tables 1 & 2) which detail the maximum allowable wire breaks visible on the outside of the rope and recognize the difference between a standard rope and a multi-

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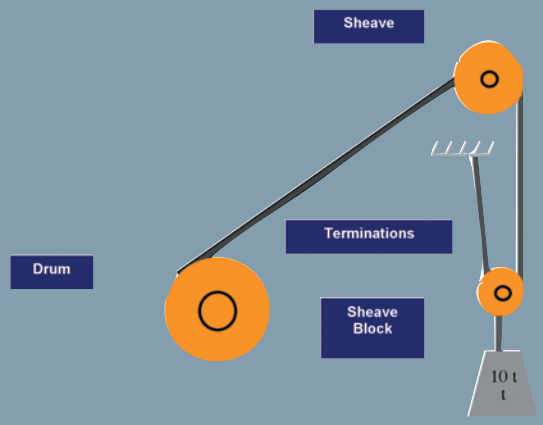
Areas of rope to examine



The diagram shows the areas where the rope is likely to deteriorate first. The length of rope running over sheaves and the hook block are the heavily worked parts of the rope and the examination should concentrate on these. The state of the drum anchorage is also important and the are immediately adjacent to any termination is likely to experience degradation.

strand variety.

Given that these tables err on the side of caution, it might seem safe to assume that if you have a small number of external wire breaks then you can remove the rope before it reaches an unsafe condition. However, while it is important to take into account all visual clues when examining a rope, it is unwise to rely on this method alone.

Modern cranes, particularly those using plastic sheaves, are designed to be much kinder to the wire rope than some of the older designs and thus wear and external wire breaks are minimized. However, this can lull operators into a false sense of security, because the inside of the rope is still subject to inter-strand contact and friction.

This is why a cursory external examination can show a perfect rope on the outside but inside it is a different matter. Several times in my career, I have been presented with broken ropes that only a few days before had been given a clean bill of health.

The first thing that happens when we receive such a rope is look at the condition inside and sure enough, although the rope is pristine on the outside, the inside shows a 'Christmas tree effect' of broken wires.

So, this leads us back to internal inspections, which are a cheaper, more effective, and more practical method of inspection for shorter lengths of smaller diameter ropes.

It is also a process that can be carried out by any competent person who has received the right training. The method described below is the one followed by engineers from wire rope and lifting gear companies such as Bridon Ropes and Certex (UK) Ltd.

How to examine ropes running over sheaves

Important – The rope must not be under any tension during this process.

1) **Attach clamps approximately 100mm to 200mm apart**
2) **Contra-rotate clamps to unlay outer strands**
3) **Ensure that the strands are not excessively moved, thus avoiding any permanent deformation**
4) **Manipulate the strands with probe to facilitate examination**

Once the examination is complete:
1) **Apply dressing**
2) **Apply additional reverse torque to re-bed strands on core**

What to check for?

- **Presence of any broken wires**
- **Presence of any inter-wire pressure or friction marks**
- **Degree of corrosion**
- **State of internal lubrication**

How to examine ropes at termination

Important – The rope must not be under any tension during this process.

1) **Attach clamp. Usually only one clamp is necessary**
2) **Rotate clamp to unlay outer strands**
3) **Manipulate strands with probe to facilitate examination**
4) **Ensure that the strands are not excessively moved, thus avoiding any permanent deformation**
5) **Manipulate the strands with probe to facilitate examination**

Once the examination is complete:
1) **Apply dressing**
2) **Apply additional reverse torque to re-bed strands on core**

Carrying out this simple process will enable any crane operators to gain the most from their ropes while avoiding any unnecessary accidents or damaging expensive equipment.
-Charles Gillespie

Examination toolkit

Only a few specialized tools are required to carry out the inspection, including:

- **'T' needle (flat spike with rounded edges) or a modified screwdriver for displacing outer strands to view the internal state of the core**
- **Tape measure for measuring lay length**
- **Chalk/electricians tape for marking any areas that require further examination**
- **Cleaning materials (solvent) for removing debris or grease**
- **Cheese wire (to remove debris/foreign matter from rope surface)**
- **Safety gloves**
- **Notebook & pencil (or tape recorder)**
- **Pliers for the removal of protruded parts of any broken wires**
- **Clamps (wood or steel)**

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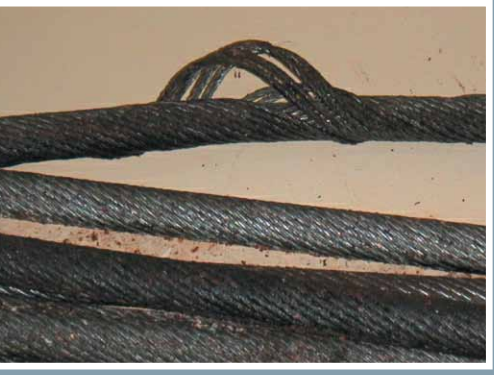
To open or not to open

Against

Dr. Ing. Frank Jauch, general manager, wire rope, Pfeifer Seil-und Hebetechnik

Picture 1: Grouping of wire breaks



Picture 2: Basket deformation (Birdcaging)

Picture 3: Core or strand protrusion Contact between rope and crane construction points

Picture 4: Kink

Picture 5: Contact between rope and crane construction points

Steel wire ropes that are used in modern cranes are specially-produced high-tech products. The crane rope is a heavily used part and must be then seen as a consumable product. A change is necessary when it is shown that the rope is heavily worn, or damage has occurred during normal operations. At this point the rope has reached its discard criteria point. National standards (Germany DIN 15020 *Grundsätze für Seiltriebe, Überwachung und Gebrauch*, page 2) or international standards (ISO 4309 *Cranes – Wire ropes – Care, maintenance, installation, examination and discard*) are the best references for end-users to carry out orderly and correct examination and maintenance of wire rope in a running rope application environment. Through correct system security and maintenance, the life expectancy of the rope, winch and sheave will increase.

We strongly recommend that opening the rope should only be carried out by a trained expert, as an inexperienced technician can do more harm than good.

Examination and maintenance of wire rope according to the discard criteria laid down in the national or international standards (e.g. wire breaks, groupings of wire breaks, strand fracture, deformation, mechanical fatigue or corrosion) should only be carried out by properly trained and certified personnel. Our many years of experience have shown that outer visible wear is a reliable indicator of damage of the wire rope when:

- The rope and rope connections are those used by the manufacturer
- The rope is properly used
- Periodical rope maintenance and inspections are carried out.

Through this procedure the correct state of the rope wear can be obtained. This article does not include all possible forms of damage but only a representation. Personnel charged with the maintenance and examination of wire ropes must be familiar with the national or international standards to correctly determine the state of the rope.

Single wire breaks and groups of wire breaks are typical signs of fatigue, wear and tear for a wire rope. Knowledge of the rope's construction is required to determine the level of fatigue. The number of visible wire breaks is measured to a length of 6x or 30x the rope's diameter. This figure determines whether the rope wear can be attributed to wire breaks. From practical experience it is known that at the beginning of the rope's operational lifetime, the rope operates without wire break problems. After the first breaks have been detected it has been proved that the wire breaks increase proportionally faster. This happens because the fatigue on the wire rope material increases the longer it is in use, so more wire breaks occur. This means that periodical maintenance and examination must be carried out within shorter intervals.

More typical discard criteria of wire ropes are deformation, including:

- Basket deformation (birdcaging) (Pic 2)
- Core or strand protrusion (Pic 3)
- Kinks (Pic 4)

With such damage it is of the utmost importance that the rope running system – e.g. sheaves, winch and rope running scheme – should be examined. The causes are very often found here. The examination of the rope damage alone does not shed light on the cause of the damage in the first place.

Mechanical fatigue is defined as outside forces that influence the rope's mechanical properties during normal operations. Besides normal mechanical fatigue attributed to multi-layer spooling, »

Picture 6: Crushed rope

Picture 7: Incorrect spooling

there are also atypical influences, including contact between rope and crane's construction points (Pic 5) and crushing during operation (Pic 6). This can occur due to incorrect spooling. (Pic 7)

Highly complex multi-layer spooling systems are to be found in modern mobile, crawler, and tower cranes because of the high number of rotations per spool layer and the number of layers that are in operation. Combined with the precise alignment between rope and drum, wear and fatigue is inevitable. In the so-called 'areas of elevation', friction between the ropes and the drum can lead to wear concentration. In this situation the working life of the rope can be extended by shortening the rope at the winch fixing point. The shortening can only take place before any wire breaks have occurred.

These examples show that it is quite possible for an expert to carry out an examination of the state of the rope using visual criteria. ISO 4309 includes not only the visual method of examining the outer wires, but also the examination of layers underneath. Opening the rope requires a high level of experience and patience. But it can be useful in certain situations in determining the state of the inner rope construction in selected areas, when this is thought to be the source of the problem. We strongly recommend that this operation should only be carried out by a trained expert, as an inexperienced technician can do more harm than good.

Whilst changing a rope, do not forget to check the sheave profile, because the sheave groove has to be larger than the actual rope diameter. If this is not the case, this can lead very quickly to deformation, and to a quicker than expected rope breakdown, especially with hoisting rope. Picture 2 shows possible damage that can be caused by this action. If a negative print is visible on the sheave then the sheave has to be replaced.

Discard criteria based on the number of visible broken wires (ISO 4309)

1. For six and eight-strand ropes on metal sheaves

Number of load-bearing wires in outer strands	Typical rope construction	Visible broken wires over a length of: 6d	30d
50	6x7 (6/1)	2	4
51-75	6x19 (9/9/1)	3	6
101-120	6x25 (12/6+6f/1)	5	10
161-180	6x36 (14/7&7/7/1)	7	14
201-220	6x41 (16/8&8/8/1)	9	18

2. For multi-strand ropes

Total number of load-bearing wires	Typical rope construction	Visible broken wires over a length of: 6d	30d
< 100	3-strand ropes; 4-strand ropes	2	4
≥ 100	3-strand ropes; 4-strand ropes	2	4
At least 10 outer strands	3-strand ropes; 4-strand ropes	2	4

A non-destructive alternative

UK crane builder Lloyds Konecranes has launched a non-destructive testing service that scans crane ropes spooled on the crane. Although the service is primarily intended for electric overhead travelling factory cranes, Lloyds Konecranes also offers to check wire rope on mobile and tower cranes.

'I think there's an opportunity for it in places like paper mills and press shops where they change their ropes as a matter of course on a regular basis to offset the danger of failure through internal wear,' says Derek Reece, KCI Konecranes Benelux general manager.

Lloyds Konecranes claims to be the first crane service agent to use the technology, long required for cablecar ropes. The device is being developed and marketed by German wire rope firm Casar in conjunction with the University of Stuttgart's Institute of Materials Handling.

Despite NDT's claimed benefits, both Pfeifer and Certex seem sceptical.

Roger Burgstall, export manager, Pfeifer Seil-und Hebetechnik:

It takes a skilled engineer to be able to read a plot for breaks in a lifting rope. You have a printout, but it doesn't mention the number of breaks. You have to be able to recognise whether a peak is a break. If the calculation of the crane design and running scheme and sheaves and drum and diameter ratios are okay according to the standards, then the indication of broken wires on the outside of the rope will be sufficient to know whether the rope is in good working condition or not.

Charles Gillespie, sales and marketing manager, Certex (UK):

Non-Destructive Testing (NDT) is a proven method of examining long lengths of wire rope but its purpose is to aid visual inspection rather than act as a substitute.

NDT incorporates the use of either electromagnetic or permanent magnetic equipment – using magnetic-flux and/or magnetic flux leakage principles – and is capable of detecting discontinuities and/or changes in the cross-sectional area of ferromagnetic wire ropes.

This method can be used for short lengths of wire rope but is expensive and should only be carried out by a skilled operator. It also requires the rope to be taken out of situ so that every millimetre of rope can be passed through a test head.

While NDT is a valuable aid for determining where there may be a degradation in the wire rope, it is still necessary to examine the area where a problem has been indicated.