Know-how saves ropes

The crane operator's knowledge, experience, care and attention is the most important point when operating a modern crane. Dr Frank Jauch, general manager of Pfeifer's wire rope department, says that how operators use a crane's ropes, sheaves, and multilayer drum have a vital influence on the job, and the crane's service life

New, high capacity cranes with long boom lengths require equally modern high performance steel wire ropes. Modern crane ropes are much more high-tech products than those used twenty years ago. These long years of continuing development led to an advancement of the important parameters of the ropes like the tensile strength of wire, the fill factor and the construction design. The potential use of special wire ropes has veered away more and more from conventional wire ropes.

The basic properties and the special potential of high performance steel wire ropes are intimately related to the system in which the rope is used. The wire rope is no longer an independent product, but an integral element to the system. This system consists of the rope itself, the sheaves, the drum, the reeving and the termination.

The high performance, reliability and fatigue life of these 'system component ropes' is affected by the other system parts, operating conditions, the conditions and the maintenance of all of the system components, and the experience, care and attention of the crane operator.

How each of the system components (the high performance steel wire rope, sheaves, and drum) function and are operated will affect the entire system.

The rope

High performance steel wire ropes are classified in two groups: rotation resistant and non rotation resistant.

Rotation resistant ropes are designed to generate reduced levels of torque and rotation when loaded. Ropes of this type may have different levels of rotation resistance, e.g. torque and rotation when loaded. Pfeifer uses the term high performance rotation resistant ropes to indicate the higher quality performance it believes its ropes offers. These compensate the torque over a particular load spectrum and are used as hoisting ropes for high lifting heights and for unguided loads on single falls. Pfeifer's high performance rotation resistant ropes can be used with or without a swivel.

Non rotation resistant ropes are used typically as luffing ropes or pendant ropes. Under load, non rotation resistant ropes generate high levels of torque. Both ends of the rope must be firmly secured to avoid rotational effects. It is prohibited to use these ropes attached to a swivel or have both ends rotate freely under load. If this is not observed serious injury, considerable damage or death may occur.

Both groups of high performance steel wire ropes can be produced as compacted or not compacted ropes, as Lang lay or regular lay, and with or without a plastic coated steel core.

International Standard ISO 4309 acts as a guide for many aspects of the use and care for wire ropes, including discard criteria. The safe use of wire rope is qualified by a number of different criteria that have to be considered together. The most frequent discard criteria are the number of visible broken wires due to wear and/or bending fatigue, and the different deformations of the rope structure.

Flattening on the surface of wire ropes

The sheave

To minimise constraint forces on the rope, the diameter of the new sheave groove is slightly bigger than the diameter of the new rope. The sheaves, operating in the crane, are subject to wear regardless of which material is used. Different wear of sheaves depends on the use. The more often they are used, the higher the wear. As sheave condition has a significant influence for the entire rope lifetime, the sheaves have to be inspected at regular intervals.

Sheave groove conditions can be split into three typical cases. In the first , the groove is correct. The groove surface is smooth, with a diameter of approximately 1.06 times the nominal rope diameter. The template (measuring, for example, 30mm

Extending rope life

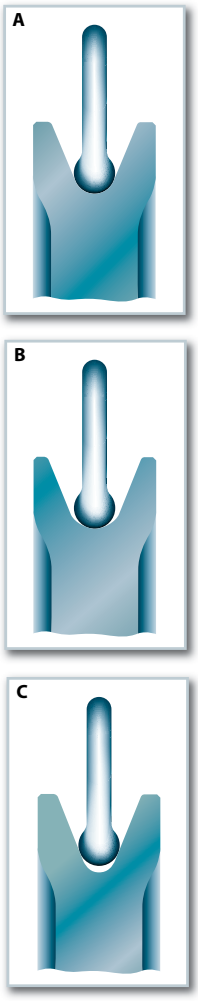
- **Shorten rope by half a diameter before discard criteria reached**
- **Where possible, shorten rope to minimum required for the job**

for a 28mm rope) fits well.

In the second case, the groove is too wide. In general, the increased pressure in the groove base will reduce the lifetime of the rope. But, for practical purposes, in the majority of cases there is nothing that can be done.

In the third case, the groove is too narrow. Sheave wear is caused by previously-used ropes cutting into the sheave. Sheaves in this condition will reduce the rope lifetime and downgrade the performance of the installed new rope. The new rope is exposed to heavy compression in the radial direction. For high performance rotation resistant ropes in particular, bad sheave conditions are a great threat. This stress leads very quickly to wire breaks and/or structural changes, such as basket deformation, protrusion of the core, or waviness. The rope imbalance of high performance rotation resistant ropes is indicated by differences in length between the rope core and the outer layer of strands. Such damages are typical discard criteria, according to ISO 4309. The crane owner can prevent this damage by replacing the sheave or re-machining the groove.

All used sheaves must be checked by using tools before the new rope is to be installed. As long as the sheave groove is smooth and the sheave groove diameter is larger than the actual wire rope diameter, nothing more needs to be done.



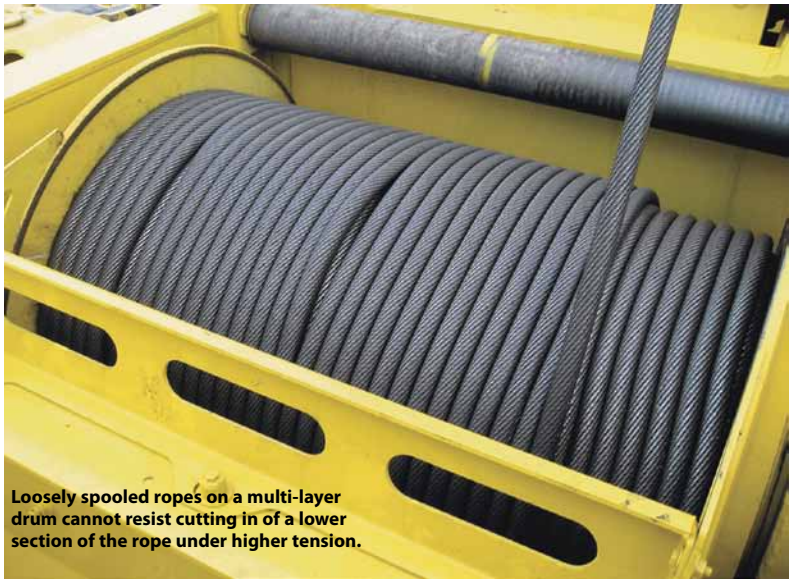
Diagrams showing a sheave and measuring template. It should sit neatly in the groove (A). If the sheave is too wide (B) or too narrow (C), the measuring tool will not sit neatly and the sheave may damage the rope.

Inspection checklist

- **Check sheave groove internal diameters with template**
- **Check number of visible broken wires in rope on crossover areas**
- **Check winding and tension in lower layers of the drum**

The drum

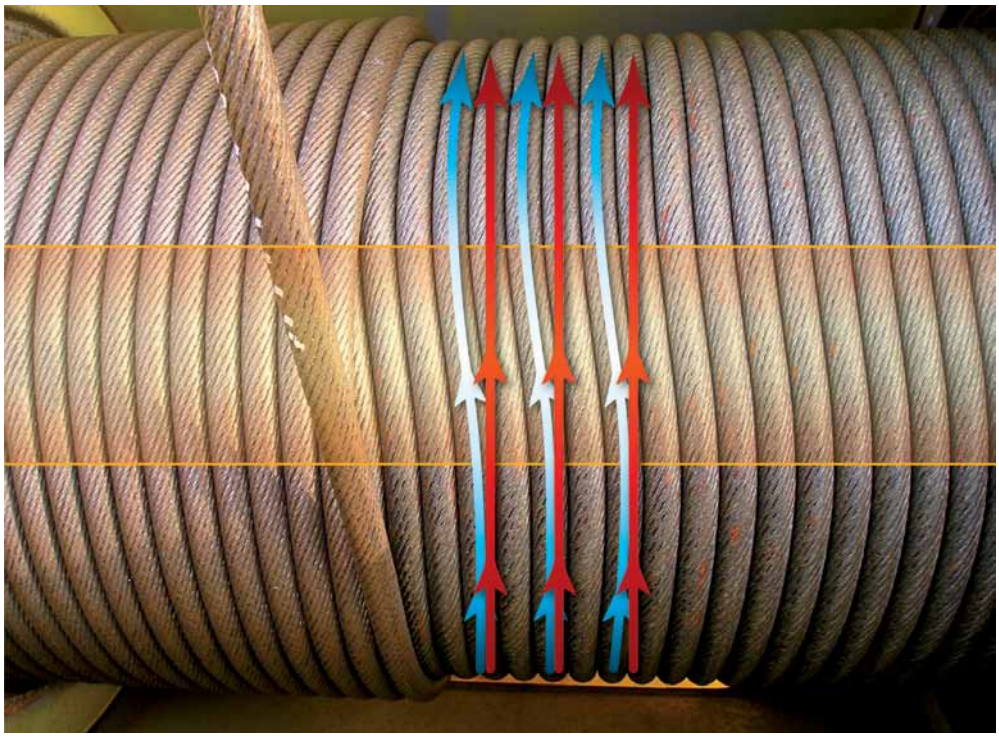
For multiple-layer spooling (the basic requirement for modern cranes) a special type of drum has been used for years. This special type of drum, commonly known as the Lebus drum after the company that originally invented the system and still manufactures it today, is characterised by two zones, the parallel track and the crossover area, offset by 180°.



Loosely spooled ropes on a multi-layer drum cannot resist cutting in of a lower section of the rope under higher tension.

Multi-layer spooling makes high demands on the rope and the drum. If working correctly, the load is evenly distributed between the individual layers due to the pyramid building up in the parallel track. However, the crossing of the rope lines between the lower and the upper layer in each crossover area causes unavoidable mechanical wear. The abrasion that results is revealed by flat surfaces on the wires.

A regular inspection of wear in the wire rope in each of the two crossover areas of each layer is necessary. If wear is clearly visible, and/or single wire breaks are determined, action is required to avoid early discard caused by unnoticed broken wires. The rope lifetime can be extended if the rope end, which is attached to the drum, is shortened before the rope reaches the discard criteria. By shortening the rope, those parts in the crossover areas that are worn out will be moved into the parallel track where no further wear will be added. The right rope length to be cut depends on the actual drum characteristic. A reasonable value is approximately one-sixth of the circumference of the drum measured in the first layer. For example, if the drum



As wire ropes wind on to a drum, the layers naturally tend to cross over themselves and rub, causing damage. In the diagram, blue lines track the path of the lower layer of rope, and the red lines track the path of the next layer.

circumference is 1,800mm, the rope end should be shortened by approximately 300mm. The rope end can be shortened once more later, but no more than twice. The rope end has to be securely seized before cutting.

Multi-layer spooling is a very sensitive process that is influenced by many different factors to do with the machine, the rope or the operation. The most common cause for spooling failure is the slackening of the, often too long unused, lower layers. Gaps between the windings are the typical sign. Typically in such a situation, the rope windings can be easily moved by hand.

Undesirable effects of permanent spooling failures can be subject to restrictions in the crane operation and rope defects. A fatal error is the cutting in of the rope when under heavy tension.

Rope tension

A regular inspection of the winding of the rope is essential. In case of any failures, the complete rope has to be immediately and carefully unwound and rewound under pretension. The operator should take note of the hook block used, in order to be able to get the reeving necessary. For the amount of pretension, a rope tension of 10% of safe working load (SWL) has been approved. The rope has to be examined for any damage, such as broken wires or deformation, during that procedure. If the above mentioned pretension is not obtainable, a lower tension is still helpful to improve the multiple layer spooling behaviour and to reduce rope damage.

Unfortunately there is not any general advice possible on how often it is necessary to renew wire rope pretension. It depends on the actual operating conditions, including the length of the rope used compared with to the length installed, the maximum rope force needed and the difference between pretension and the maximum rope force. Increasing the number of falls used in the reeving is a common way to reduce the danger of rope cut-in by reducing the rope force. The lost of lifting speed is negligible compared with the better performance.

An essential recommendation, based also on long term experience, is to avoid disproportionate use of different sections of the rope that the crane is equipped with: as much as possible every part of the rope should be used equally. Most rope damage occurs when only part of the rope is used for a long period. The unused rope sections lose the pretension and will be destroyed by the rope under load running over or cutting in.

Rope wear is substantially reduced when the whole rope length is used. The unused rope parts, if damaged, are very often the reason to renew the whole rope. In such cases the best solution would be a rope length adapted for the long term job. This is something the tower crane industry has done successfully for many years. In the mobile and crawler crane industry, where cranes are mainly designed for a wide range of general hook duties, this is not possible. On jobs like windmill erection, where the crane is used repeatedly for the same lifts, our recommendation for the crane operator is to follow the above described procedures. Wherever applicable, use adapted rope length. The results of both are improved crane operating conditions and extended rope lifetime.