Teufelberger · Redaelli

ORIGINAL OPERATION & MAINTENANCE INSTRUCTIONS

for Steel Wire Ropes used on cranes, hoists and lifting appliances

EN

Together in Motion

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CONTENTS

⚠ WARNING

The use of these products can be hazardous. Therefore, never use our products for purposes other than those they were designed for. Customers shall ensure that all persons using these products are familiar with their correct use and the related necessary safety precautions. Please bear in mind that any of these products can cause harm, when they are used incorrectly or overstrained.

1. TEUFELBERGER-REDAELLI - LEADING IN HIGH PERFORMANCE STEEL WIRE ROPES WITH ADDED VALUE

The essence of Teufelberger-Redaelli

We at **Teufelberger-Redaelli** understand your day-to-day challenges and solve them together with you. We develop and produce high performance steel wire ropes that create added value by enhancing the efficiency and safety of your applications. Expect more: of our innovative steel wire ropes, our services, our experienced experts in development, application engineering, and sales – all around the globe. Being a family enterprise, we attach great importance to successful, long-standing business relationships. Our commitment does not begin and end solely with the supply of premium quality steel wire ropes, but we also accompany you throughout your work processes when it comes to optimizing efficiency and costs.

Service and support prior to and after steel wire rope selection

We know that high performance steel wire ropes are able to unleash their full potential only if crane systems have been set up optimally and if the ropes have been installed correctly. Therefore, we also provide support during project planning, installation, and subsequent careful handling to maximize rope lifetimes. After all, the purchasing costs are just the tip of the iceberg.

Application-specific (field-proven) expertise and product portfolio

At Teufelberger-Redaelli you don't need to worry about making the right choices, as we can handle that for you. Our specialists know what matters in connection with your application and are therefore able to provide you with a clear product recommendation. Every single application requires a specific, custom-tailored solution. Rotation-resistant and non-rotation-resistant high performance steel wire ropes from Teufelberger-Redaelli are used for a variety of applications such as:

- heavy-duty lifting applications in construction, cargohandling in harbors and on ships, and in niche industries – cranes in offshore and onshore applications
- mining
- ropeways for the transport of passengers and goods
- forestry cranes and winches
- personal protective equipment against falls from a height

Four manufacturing sites for steel wire ropes and a combined total of more than 425 years of rope-making experience tally up to a unique wealth of expertise and an unmatched and proven production standard. The resulting high degree of flexibility allows us to keep delivery times to a minimum.

2. INTRODUCTION TO THIS MANUAL

2.1. SCOPE OF THIS DOCUMENT

This document establishes principles for the care and maintenance, and inspection and discard of Teufelberger-Redaelli steel wire ropes used on cranes, hoists and lifting appliances.

ⓘ As a manufacturer and supplier of wire ropes with many years of experience, our recommendations are nonbinding but based on experience.

- ▶ Please note the special characteristics of your system.
- ▶ Contact us to find the optimal rope for you, based on the latest experience.
- ▶ Typing and printing errors excepted.
- ▶ Lang's lay ropes shall be used for multiple layer winding (on the drum) or shall be subjected to regular, non-destructive (MRT magnetic rope testing) inspection.

2.2. TARGET GROUPS OF THIS DOCUMENT

The following table summarizes the groups this document is aimed at, with a brief description of the type of information the manual does supply to help them understand the product.

Target group	Provided information
OEM	Product handling, installation, maintenance and usage
Installer	Product handling, installation and maintenance
End User	Product usage and maintenance

Table 1 - Target groups of this document

2.3. REFERENCES DOCUMENTS

The reference documentation to this manual is the following:

Documentation	Description
Rope certificates	Containing specific technical rope data
Rope data sheets	Containing general technical rope data
Contract	Containing the contractually agreed data
Accessories catalogues	Containing the accessories technical information

Table 2 - Reference documents

2.4. TYPOGRAPHIC CONVENTIONS

The table below summarizes typographic conventions and/or styles used in this document so that it can be read and understood more easily.

Convention	Meaning
✓ Prerequisite	Preceding condition required before an action.
▶ Action	Single action.
▷ Preventive measure ▷ Suggested action	Warning: Conditional action. Information box: Suggested action.
1. Step	One of a sequence of actions.
– Sub step	Additional steps of an action or a step.
Intermediate result	Result of a step.
➥ Result	Result of an action or a sequence of actions.
• List	List of elements.
– Sub list	Additional elements of a list entry.

Table 3 - Typographic conventions and styles of this document

⚠ **DANGER! Type and source of a hazardous situation, which, if not avoided, will result in death or serious injury.**
Possible consequences (optional).
▷ Preventive measure.

⚠ **WARNING! Type and source of a hazardous situation, which, if not avoided, could result in death or serious injury.**
Possible consequences (optional).
▷ Preventive measure.

⚠ **CAUTION! Type and source of a hazardous situation, which, if not avoided, may result in minor or moderate injury!**
Possible consequences (optional).
▷ Preventive measure.

NOTICE! Type and source of a hazardous situation that is not related to personal injury!
Possible consequences (optional).
▷ Preventive measure.

ⓘ Useful suggestion or additional information.
▷ Suggested action.

Importance of retaining the instructions for use
▶ Read these instructions carefully before using the product.
▶ Keep these instructions for future reference.

3. HEALTH, SAFETY AND ENVIRONMENT

3.1. MANAGEMENT OF HEALTH, SAFETY AND ENVIRONMENT ISSUES

Effective management of health, safety and environmental (HSE) issues result in the inclusion of HSE considerations into corporate and facility-level business processes in an organized, hierarchical approach.

3.2. PRECAUTIONS / SAFETY INSTRUCTIONS

The product has been designed and produced according to the latest technology and recognised safety rules. The product can be used in a completely safe way, as long as the recommendations and instructions contained in this manual are strictly followed.

Teufelberger-Redaelli denies any responsibility relevant to possible damages to either persons or objects deriving from operations carried out on the products while disregarding the instructions quoted in this chapter.

- Ensure that only authorised and specifically trained personnel installs, uses and maintains the product.
- Strictly observe the safety rules to prevent any dangerous situation.
- Prior to using the equipment on which the product is installed, carry out the following operations:
  - Carefully read the User Manual.
  - Inquire about the operation and the position of specific emergency stop buttons on the related equipment.
  - Inquire about the safety protections and devices available on the equipment, their position and their operation.
- Before any intervention, check the following:
  - The general switch of the equipment is OFF and due prevention measures have been taken (signs, locking device etc.) to avoid any accidental starting of the installation in the course of the intervention.
  - Ensure that operators are safe during the installation procedures by positioning or checking the correct movement of the machine's rotating parts the main switch in the ON position.
- Disconnect the equipment before starting installation or maintenance work.
- During maintenance, inspection, and repair, observe the instructions in the specific warning notices.
- Ensure that the personnel is informed about potential dangers that may occur during installation, use and maintenance.
- Always pay attention and work with maximum caution.
- If under exceptional circumstances any protections shall be opened partially or completely, or shall be removed to allow a special technical maintenance intervention: Put all protections involved back in place immediately after the completion of the operations.
- During resetting to original working conditions, verify that standard safety conditions are once again guaranteed at the end of the operating procedure.

- ▶ Ensure that foreign objects are not left on or inside of the equipment at the end of the intervention (mechanical pieces, tools or devices used during the operating procedure).
- ▶ Ensure that the equipment on which the product is installed is operated properly, in accordance with the instructions given in their manual.
- ▶ Ensure that the personnel knows the correct use of any safety device provided for the related equipment.

3.3. INTENDED USE

The product has been developed with the sole purpose of performing operations for the application as indicated on the title page.
Using the product for any purpose other than the intended use is considered as misuse of the product. Teufelberger-Redaelli denies any liability for possible consequences of misuse.

3.4. OCCUPATIONAL PROTECTIVE MEASURES

⚠ **CAUTION! During processing of wire ropes, such as cutting, welding, grinding and cleaning, dust and fumes may be produced which contain elements that may affect the health of exposed workers.**

- ▷ Protective equipment should be worn during operations creating eye hazards.
- ▷ A welding hood should be worn when welding or burning.
- ▷ General and local exhaust ventilation should be used to keep airborne dust or fumes below established occupational exposure standards (OES's).
- ▷ Operators should wear approved dust and fume respirators if OES's are exceeded.

⚠ **CAUTION! Despite all accuracy during manufacturing, broken wires could occur and may have sharp ends. These sharp ends may lead to injuries.**

- ▷ Use gloves and other protective equipment when required.

⚠ **CAUTION! Surface of wire ropes may be hot when exposed to elevated temperatures**

- ▷ Use gloves and other protective equipment when required.

3.5. EMERGENCY MEDICAL PROCEDURES

Inhalation

▷ Remove to fresh air; get medical attention

Skin

▷ Wash areas well with soap and water.

Eyes

▷ Flush well with running water to remove particulate; get medical attention.

Ingestion

▷ In the unlikely event that quantities of rope or any of its components are ingested, get medical attention.

3.6. SAFETY INFORMATION – FIRE OR EXPLOSION HAZARD

In the solid state, steel components of the rope present no fire or explosion hazard. The organic elements present, i.e. lubricants, natural and synthetic fibres and other natural or synthetic filling and covering materials are capable of supporting fire.

3.7. PRODUCT AND PACKING MATERIAL DISPOSAL

The product and packing material can be disposed off by the owner, by Teufelberger-Redaelli or by authorized third parties according to local regulations.

▶ Adhere to local and environmental friendly rules to dispose of the packing material and the used ropes.
▶ To prevent serious damage to the environment or injury to people: Do not leave any packing material or supplied products in the environment.

4. ROPE SELECTION

4.1. DEFINITIONS

4.1.1. WIRE ROPE

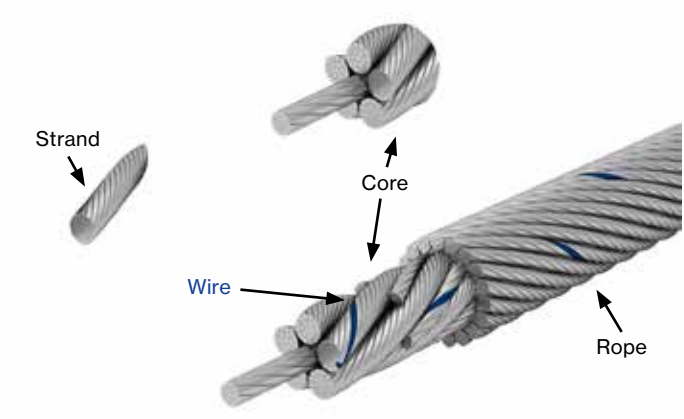


Figure 1 - Elements of a wire rope

A steel wire rope is a complex machine part and dependent upon its type may contain a number of discrete materials. It is a mechanical component that transmits force and shifts along its axis.

The main component of steel wire ropes is carbon steel, which may, in some cases, be coated with zinc or zinc alloy Zn95/Al5. Besides the outer strands the other components of a typical steel wire rope are the core, which may be also of carbon steel or, alternatively, made of either natural or synthetic fiber; the rope lubricant(s); and any internal filling or external covering where applicable.

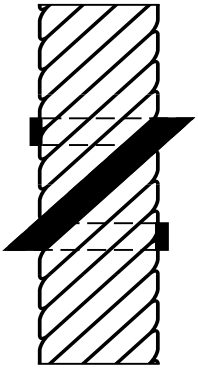
The elements of the wire rope are arranged in a helical shape to yield the principal characteristics:

- Ability to support axial load (high resistance wires)
- Flexibility (thin wires adapted to the winding with small diameters)
- Anti-rotation behavior (appropriate disposition of strands in directions opposite to each other)
- Ease of handling (combination of thin wires, disposition of strands and their preformation)
- Resistance to dynamic stress (due to acceleration or deceleration)
- Resistance to transverse pressure

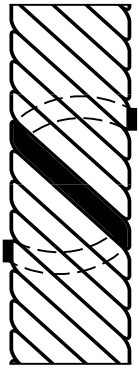
ⓘ Rope produced from carbon, coated or stainless steel wires in the as-supplied condition is not considered a health hazard. Concerning the plastic material and the lubricant we refer to the safety data sheets from the supplier.

⚠ **CAUTION! During processing of wire ropes, such as cutting, welding, grinding and cleaning, dust and fumes may be produced which contain elements that may affect the health of exposed workers.**

4.1.2. DIRECTION OF LAY

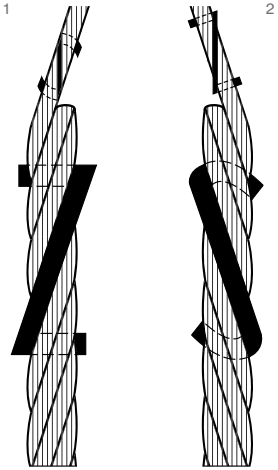


1 Right lay (z)

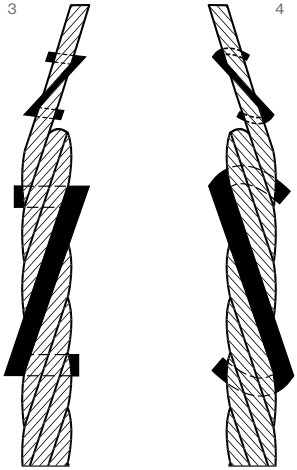


2 Left lay (s)

Figure 2 - Lay direction



1 Right Hand Ordinary Lay (sZ or RHRL)
2 Left Hand Ordinary Lay (zS or LHRL)



3 Right Hand Lang Lay (zZ or RHLL)
4 Left Hand Lang Lay (sS or LHLL)

Figure 3 - Lay (wire ropes)

Usually the lay of the wires in the strand is indicated first (lower case letter), followed by the lay of the strands in the wire rope (upper case letter).

4.1.3. STRANDS

The wires are the main components of a wire rope. In so called stranded wire ropes (see chapter 4.1.7) these wires are formed to strands. During rope making, the individual strands are then closed to the final wire rope. Besides different strand designs (see Table 4), the main characteristics of a strand are its diameter and lay length.

Different strand types are used to serve the following purpose:

- Optimal filling of the desired section
- Linear support between the layers
- Guarantee of the necessary resistance to transverse pressure

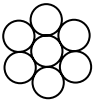
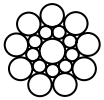
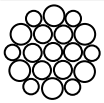
Form	Description	Symbol	Examples
	Single layer	N	1-6
	Seale	S	1-9-9
	Warrington	W	1-6-6+6
	Filler	F	1-6-6F-12
	Warrington-Seale	WS	1-6-6+6-12 (as shown here) 1-7-7+7-14 (most common)

Table 4 – Basic strand types (examples)

- Normal (N): The lay length of each wire layer may be different.
- Seale (S): The number of wires of the outer layer is the same as of the inner layer. The lay length is the same for all wires.
- Warrington (W): The number of wires of the outer layer is twice the number of wires of the inner layer. The lay length is the same for all wires.
- Filler (F): The number of wires of the outer layer is twice the number of wires of the inner layer, including additional filler wires.
- Warrington-Seale (WS): The Warrington-Seale strand consists of a central Warrington strand design and an additional outer wire layer (similar to the Seale design). The Warrington-Seale design is one of the most common strand designs.

4.1.4. SUPERFILL® COMPACTION TECHNOLOGY

SUPERFILL® is a cold deformation process for strand compaction which has been developed in close cooperation with universities and independent research institutions. Each rope strand is compacted in a specific procedure with the aim of significantly improving the rope's properties:

- Up to 30% higher breaking forces than non-compacted ropes
- Prolonged service life based on reduced internal stress due to the creation of larger contact zones between the wires and equalizing the distribution of pressure on the wires.
- Use of smaller rope diameters with the same breaking force (benefit for modern crane design)
- Smooth rope surface resulting in a reduced abrasion on rope, sheaves and drums
- A constant wire rope diameter over long rope lengths and augmentation of the dimensional stability with regard to transversal forces

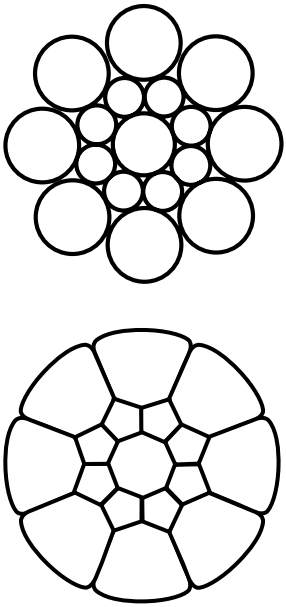


Figure 4 - SUPERFILL® compaction technology

4.1.5. DUOFILL® COMPACTION TECHNOLOGY

DUOFILL® is a special double compaction technology, developed by Teufelberger-Redaelli. Each individual rope strand as well as the entire rope itself are compacted by a special manufacturing process in order to achieve the following advantages:

- Highest breaking strength due to maximum compaction
- Improved service life for multilayer applications with extreme line pulls due to the very smooth surface
- Advanced resistance against crushing due to high dimensional stability

4.1.6. ROPE CORE

The rope core is the central element of a stranded wire rope around which the strands are laid in a helical shape. It is usually made of fiber (FC) or steel wires (WSC, IWRC).

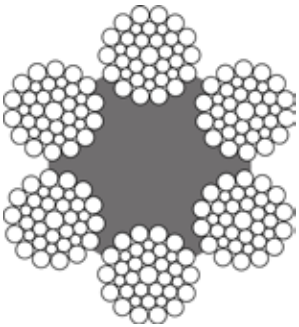


Figure 5 - Fiber cores (FC)

Fiber cores (FC) can be made of either natural fibers (NFC) or synthetic fibers (SFC) and have the advantage that they can store a relatively large amount of lubricant. During the service life of a wire rope, the diameter of the fiber core will reduce. Therefore, the clearance between the strands shall be large enough to either avoid strand to strand contact or at least prevent any strong pressure arising between them. The endurance of the wire rope is influenced to a great extent by the dimension and the form of the fiber core.

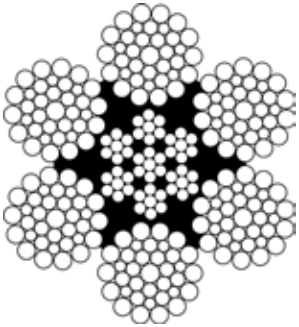


Figure 6 - Independent wire rope core (IWRC)

Steel cores are manufactured of steel wires either as a wire strand core (WSC) or more common as an independent wire rope core (IWRC). A wire strand core (WSC) is only used for very small ropes or for multi-strand ropes. In contrast to wire ropes with fiber cores, wire ropes with independent wire rope cores have only very slight clearance between the outer strands to prevent lateral strand movements when the rope is running over sheaves. The main advantage of a steel cores compared to fiber cores is the higher radial stability and breaking force of the wire rope.

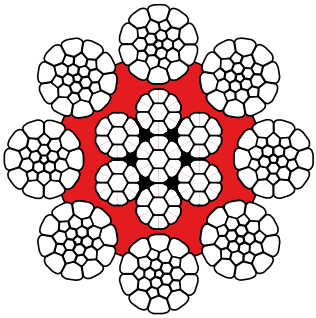


Figure 7 - EPIWRC

The steel wire rope core can be covered with solid polymer (EPIWRC) – Teufelberger-Redaelli PLASTFILL® technology.

This technology guarantees that the outer strands are equidistantly and well bedded into the plastics as in the case of fiber cores.

ⓘ Materials used in rope core do not present a health hazard during handling of the rope in its as-supplied condition.

⚠ **CAUTION! The principal hazard is through inhalation of fumes generated by heat, for example when the rope is being cut with a disc cutter. Under these conditions, natural fibers are likely to yield carbon dioxide, water and ash, whereas synthetic materials are likely to yield toxic fumes.**

4.1.7. ROPE TYPES

Wire ropes can be differentiated into many different types. Apart from “Spiral Ropes” which are rarely used for lifting appliances, the most important rope type for these applications are “Stranded ropes”.

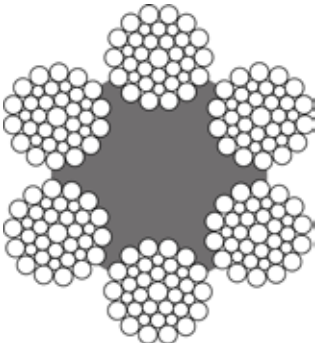


Figure 8 - Stranded rope

Stranded ropes are formed by laying the strands together helically, in one or more layers around a core. A high number of strands ensures a high flexibility and resistance to transversal pressure and wear. The compacted strands provide a smoother and bigger surface and create extended contact areas among the wires.

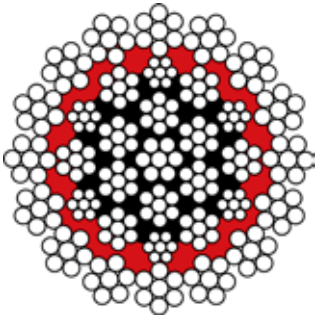


Figure 9 - Rotation resistant rope

Rotation-resistant ropes

Rotation resistant ropes are a special type of stranded ropes that are designated for supporting loads without turning protection. Therefore they should be rotation-resistant to a great extent. This is achieved by opposite lay directions of steel core and outer strands layer in addition to balanced distribution of cross sections in these rope components.

Teufelberger-Redaelli ropes are torque balanced to a great extent and provide best in class properties at this specific parameter.

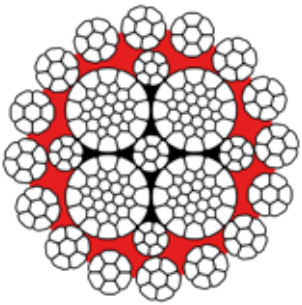


Figure 10 - High performance rope

High performance ropes

Many applications need ropes with special features, i.e. special ropes for industrial and offshore lifting where a particular strand compaction, increase of metallic area or non-rotation and low residual torque behavior is requested.

4.1.8. ROTATIONAL PROPERTIES

In general, all kind of stranded wire ropes where strands are wound in a helical shape around a core have a tendency to unlay under load or generate a torque if rotation is prevented. This behavior is determined by the design of the rope and the possible combination of properties opens a large variety of different characteristics. The strongest tendency to rotate can be found in single layer ropes especially in lang lay, where the torque of the rope is amplified by the torque of the strands. Multi-strand ropes are all more or less rotation-resistant and have at least two layers of strands laid helically around a core. The direction of the outer strands is opposite to that of the underlying strand layers. Such ropes are low- or nearly non-rotating and suitable to be used e.g. in single fall lifting operations.

According to the definition of FEYRER (University of Stuttgart) a rope can be considered as rotation-resistant if it has a rotational property less than or equal to 1 turn on a length corresponding to 1000 times the nominal rope diameter when a force of approx. 15-20% of the MBF is applied.

The rotational characteristic of a rope can be described by the following fundamental factors:

- Torque factor

The torque factor determines the relationship between the wire rope tension and the corresponding torque, assuming that the wire rope end will be prevented from rotating. This parameter can be considered as the cause of rotation and is usually indicated by using a non-dimensional value.

- Rotation factor

The rotation factor determines the relationship between the wire rope tension and the corresponding rotation, assuming that the wire rope end will be free to turn. This parameter can be considered as the resistance of the wire rope against rotation and it is usually indicated by the amount of rotation per lay length under a load of 20% of the rope's minimum breaking force.

For guidance on rope selection in regard to the rotational properties of a wire rope and the usage of swivels see 4.3.4

4.1.9. RADIAL STIFFNESS

Radial stiffness is an essential rope characteristic in many applications, for example on multi-layer winch drums, where the rope is subjected at the same time to the pulling force of the traction winch and to the compression of the adjacent layers.

An excessive wire rope deformation can generate a heavy flange shear stress, while an excessive wire stiffness can cause a drum hoop stress. In both cases, severe damage to the winch may occur.

From an operational viewpoint ropes with a low radial deformation and thus high geometric stability are crucial for the use in demanding multi-layer applications with a high number of layer and wraps per layer on the drum.

Wire ropes with fiber core are most sensitive to compression effects, while SUPERFILL® and PLASTFILL® ropes have a much higher diameter stability towards pressure.

4.1.10. LUBRICATION

Lubrication on ropes during the manufacturing process may expire and needs re-lubrication with recommended lubricants, particularly in zones subject to bending (see chapter 8.2).

Correct lubrication provides protection against corrosion as well as internal and external friction over a certain period of time.

⚠ **CAUTION! Potential hazards!**

Lubricants may present hazards (even though minimal) to the workers.

- ▷ Minimize skin and eye contact and also avoid breathing their vapors and mists
- ▷ Wear appropriate protective clothing (e.g. gloves, glasses, etc.)
- ▷ Avoid unnecessary contact with oil
- ▷ Maintain high standards of personal hygiene
- ▷ Never put oily rags or tools into pockets, especially trousers
- ▷ Never use dirty or spoiled rags for wiping oil from the skin
- ▷ Never wear oil soaked clothing
- ▷ Never use solvents such as paraffin, petrol, etc. to remove oil from the skin
- ▷ Obtain first aid treatment for any injury, however slight

4.1.10.1. ENVIRONMENTALLY ACCEPTABLE LUBRICANTS (EAL)

EALs are designed and manufactured to significantly reduce their environmental impact compared to that of a conventional lubricant. To protect the US coast and inland waters, they must comply with the Vessel General Permit for Discharge Incidental to the Normal Operation of Vessels (VGP), which may considered as a general standard for EALs. The VGP states that lubricants must meet strict requirements with respect to three main criteria to be classified as EAL; these are biodegradability, eco-toxicity and bioaccumulation.

- Biodegradability is the rate at which a lubricant would dissolve into its harmless components if it were to be released into the sea.
- Eco-toxicity refers to how toxic a lubricant would be if released into the sea.
- Bioaccumulation is the aspect that even chemicals with low eco-toxicity can be dangerous when consumed by animals.

Teufelberger-Redaelli is able to supply EALs that are fully compliant with the VGP. Please contact us for further recommendations for your specific applications.

4.1.11 COATING PROTECTION

Different coating protection can be used:

- Zinc coated ropes are protected against corrosion.
- Inox ropes are used where non-magnetic and ecological protection is needed.
- Zinc-aluminium (Zn95Al5) coating.

4.1.12. PLASTFILL®

PLASTFILL® is a plastic impregnation technology which adds specific characteristics to the rope with a positive impact on the lifetime.

- The lubricated steel core is enclosed in a tight synthetic coat.
  - Advantages: long service life through permanent lubrication, resistance against radial pressure and lateral pressure, higher breaking forces through reduced stress in the rope.
- The strands are embedded in the synthetic coat during the closing process.
  - Advantages: exact strand position with consistent clearances for reduced internal abrasion, equal load shares at all components due to optimized construction.

ⓘ Filling and covering materials do not present a health hazard during handling of the rope in its as-supplied condition.

⚠ **CAUTION! The principal hazard is by the inhalation of toxic fumes when the rope is being cut by a disc cutter.**

4.2. ROPE TERMINATIONS

Rope terminations shall accomplish typically the following needs:

- pulling-in and pulling-out of the rope into the machinery / structure in which it shall be installed
- rope connection to the machinery / structure to which it shall be connected
- connection to the transportation and storage drum, safe handling and installation.

For further information on rope terminations refer also to EN 13411 and EN ISO 1684.

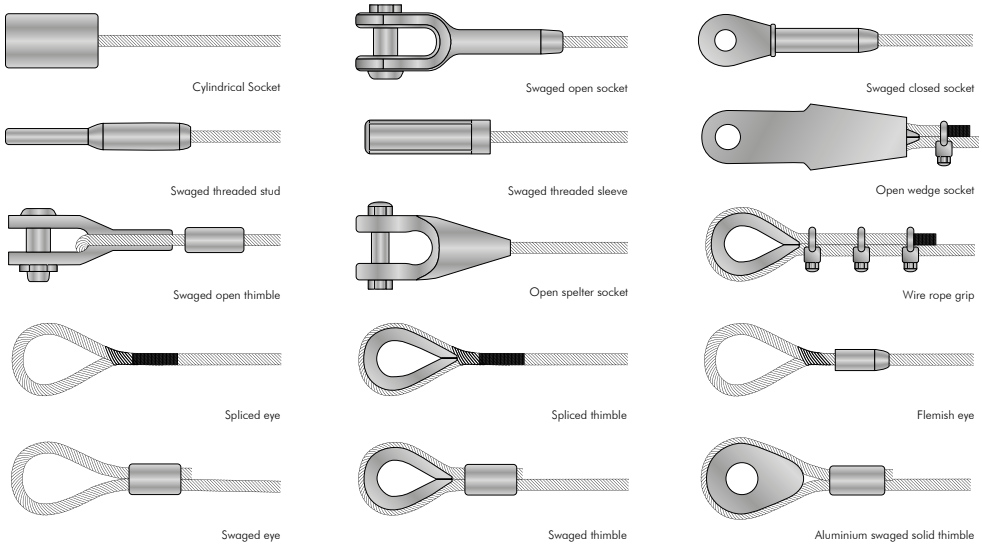


Figure 11 - Rope terminations

4.2.1. SEIZING

Wire of annealed galvanized iron wound under tension using a special tool on the endings of the wire rope. For stranded wire ropes, usually one binding is used that is twice as long as the diameter (2 d). Spiral ropes (OSS), locked coil ropes (FLC, HLC) and stranded spiral rope (Hercules) two bindings are used that are twice as long as or longer than the diameter.

Figure 12 - Serving

Figure 13 - Plain welding

4.2.2. PLAIN WELDING

Transversal welding of the ending of the wire rope in order to permanently block all constructive components of the wire rope (wires and strands), usually with an additional safety binding.

Figure 14 - Weld with chain links

4.2.3. BECKET WELD, LOOP WELD, BECKET WELD WITH CHAIN LINKS

Like plain welding, but with welding on a proof-load chain link or similar for installation purpose only which can guide the end of the wire rope during installation.

Figure 15 - Tapering

4.2.4. TWIST WELDING / TAPERING

The ends of the wire rope are rotated on an appropriate machine after heating the cutting point for twisted welding of the single strands.

Figure 16 - Soldered end with becket loop

4.2.5. SOLDERED END WITH BECKET LOOP

Eye which is obtained by attaching the steel core of the wire rope to itself. This eye is used for installation purpose of the wire rope only.

Figure 17 - Splicing

4.2.6. SPLICING

Connection of rope(s) by coupling the strands of the opposite ends. The length of the used strands is defined in the standards of the specific application.

4.2.7. SPLICED EYE

Eye which is obtained by inserting strands into the wire rope. For the allowed length of splicing, refer to the standard EN 13411.

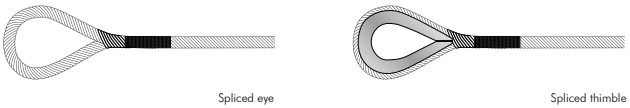


Figure 18 - Spliced eye

4.2.8. FERRULE SECURED EYE WITH OR WITHOUT THIMBLE (COUPLING)

Eye which is obtained by attaching the ends of the wire rope to themselves using an aluminum ferrule. For identifying the correct type of thimble for the specific application, refer to the standard EN 13411.

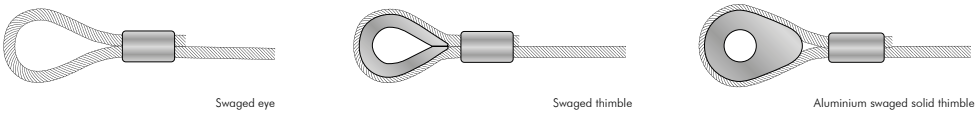


Figure 19 - Ferrule secured eye

4.2.9. FLEMISH EYE

End termination where the rope end is split in two parts of three and 3 strands plus steel core each, which are laid back together again in the opposite direction, to form a soft eye, which can be provided on demand with various types of thimbles.

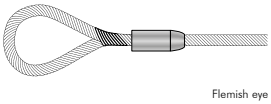
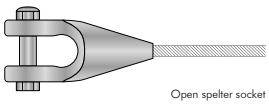


Figure 20 - Flemish eye

4.2.10. END TERMINATION WITH SPELTER SOCKET



End termination which is obtained by pouring two-component resin or metallic alloys (with zinc, tin, or lead) into conical grooves predisposed for opened ends, thus increasing the adherence and the resistance under load between wire rope and melted material.

Figure 21 - Spelter sockets

4.2.11. WEDGE SOCKET

This end termination anchors the loose rope end to the lifting system without using special end terminations, thus allowing dismounting, shortening and remounting.

When using special steel wire ropes the efficiency can be less than 80%

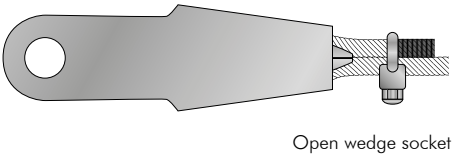


Figure 21a - Symmetric wedge sockets

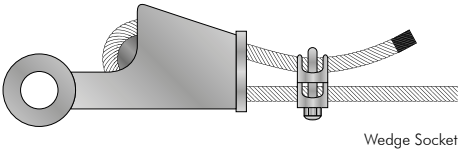


Figure 21b - Asymmetric wedge socket

4.2.12. U-BOLT GRIPS

U-Bolt wire rope grips for wire ropes that are folded to form an eye. Various types of clamps are used for different applications. The number of clamps to be used and the length of the detachment are determined by the type and the diameter of the wire rope (EN 13411-5).

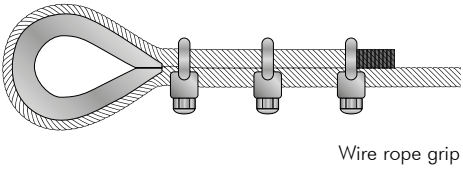
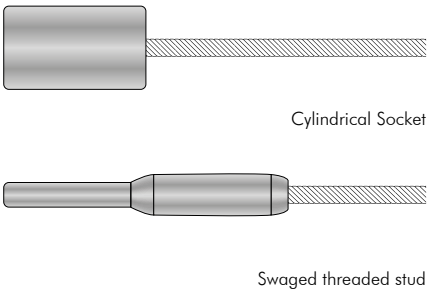


Figure 21c - U-bolt grips

4.2.13. SWAGED STEEL FITTINGS

For this type of end termination steel fitting of various shapes are swaged on to the wire rope end.



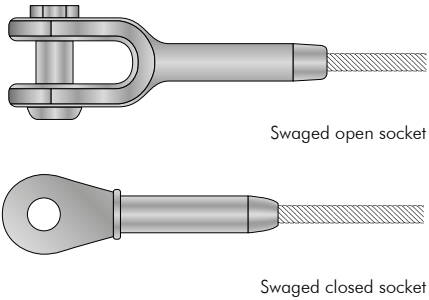


Figure 21d - Swaged steel fittings

4.2.14. EFFICIENCY GRADES OF TERMINATIONS

The efficiency grade is the relation between minimum breaking force (MBF) of the wire rope and the load which is used for verifying the grade of damage of the termination.

The standard (EN 13411) does not refer the safety factor to the breaking force of the wire rope, but to the effective breaking force of the wire rope and its rope termination system.

To determine the breaking force of the wire rope and its rope termination system, use the following table which shows the efficiency grades of the most commonly used terminations:

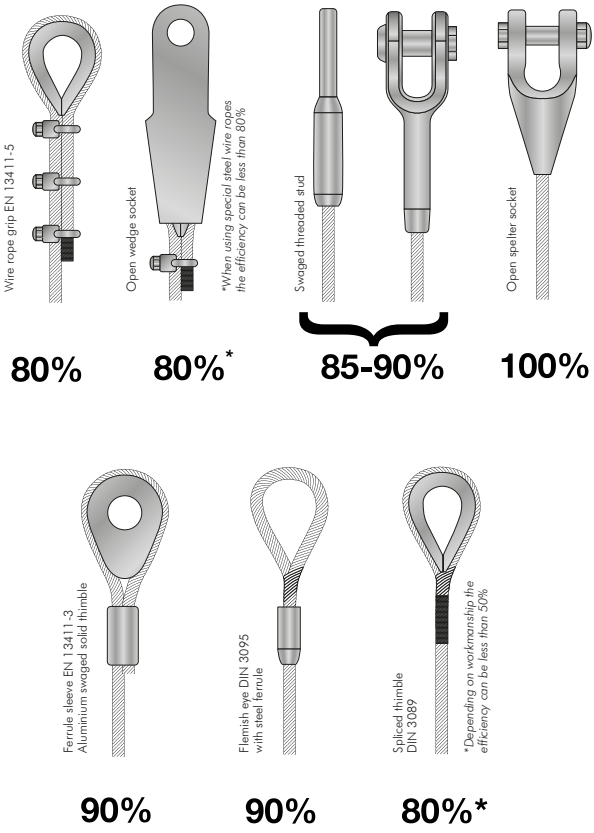


Figure 22 – Types of wire rope end terminations and respective efficiency factors

Termination type	Referenced standards	Application range of the wire rope	Termination efficiency factor K_T
Splicing of eyes for wire rope slings	EN 13411-2	Diameters < 60 mm Diameters ⩾ 60 mm	0.80 0.70
Ferrules and ferrule-securing	EN 13411-3	All diameters	0.90
Metal and resin socketing	EN 13411-4	All diameters	1.00
U-bolt wire rope grips	EN 13411-5	All diameters	0.80
Asymmetric wedge socket	EN 13411-6	All diameters	0.80
Symmetric wedge socket	EN 13411-7	All diameters	0.80
Swage terminals and swaging	EN 13411-8	All diameters	0,90
Note: A terminal efficiency of 90% is equivalent to a termination efficiency factor, K_T of 0.90			

Table 5 - Termination efficiency factor K_T

4.3. GUIDANCE ON ROPE SELECTION

Based on many years of experience, resulting from close co-operation with leading crane manufacturers and customers using high-performance wire ropes, the following points should be considered when selecting a wire rope:

4.3.1. BASIC ROPE CHARACTERISTICS

Especially consider rope characteristics like breaking force, galvanization, plasticized steel core, expected lifetime and general quality factors which influence the rope performance.

The minimum breaking force of a rope shall reach the level specified for a special crane as shown in the crane specification document.

⚠ **CAUTION! The use of a rope with less than the specified minimum breaking force is not allowed and may have serious consequences!**

4.3.2. WIRE FINISH IN RELATION TO CORROSION

Galvanized ropes can be used in any case and can always replace ungalvanized (bright) ropes. The opposite way – replacing galvanized with ungalvanized ropes – is not recommended and may even be dangerous under certain circumstances, as the rope loses the positive effect of galvanization (higher corrosion resistance leading to a longer service life, especially in maritime environments). A galvanized rope is requiring periodic lubrication as well as a bright rope.

4.3.3. DIRECTION OF LAY AND TYPE

4.3.3.1. LEFT OR RIGHT LAY

The direction of lay of a rope is crucial for the performance and the lifetime of a wire rope. The correct lay can also be found in the crane specification document. If you are not sure which lay is needed, you can also contact our technical experts.

4.3.3.2. CHOICE OF ROPE LAY DIRECTION IN MULTILAYER APPLICATION

Definition of MULTILAYER spooling:
The ropes are spooling in multilayer application if more than one layer is spooled on the drum.

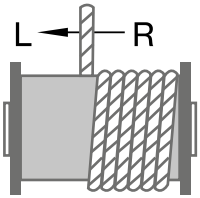
Hoist rope
These ropes should be rotation-resistant ropes (non-rotating) which are torque balanced. Due to this behavior rotation resistant rope will build a tight bottom layer, even on plain drums independent of the position of the anchor point of the drum and lay direction (as long as the fleet-angles are within the recommendations).

ⓘ For hoist ropes either right hand lay or left hand lay ropes can be used on the plain barreled drum without influencing the spooling behavior.

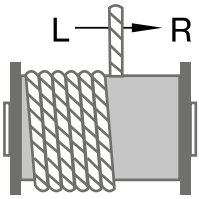
Luffing rope/stay rope (neck rope)
For this application a non-rotation resistant rope (6 strand or 8 strand) should be used. As this construction intends to rotate if loading will be initiated the usual recommendation (i.e. ISO 4308) for plain barreled drums shall be followed.

ⓘ For luffing ropes/neck ropes the right hand lay should be installed on a drum with the anchor point on the left side (overwind spooling) and vice versa.

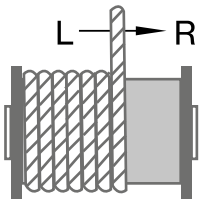
For luffing ropes/neck ropes the right hand lay should be installed on a drum with the anchor point on the left side (overwind spooling) and vice versa.



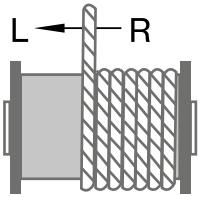
a) Right-hand-lay rope - underwind



b) Left-hand-lay rope - underwind



c) Right-hand-lay rope - overwind



d) Left-hand-lay rope - overwind

Figure 23 - correct method for locating the rope anchorage point on a drum

4.3.3.3. LANG'S LAY OR ORDINARY LAY

Ordinary lay normally can be used for most applications. To allow the use of a Lang's lay rope, this shall be specified in the crane specification document. Ropes in Lang's lay can reach a longer service life under certain circumstances. Just ordinary lay wire ropes running over sheaves with grooves made of steel show reliably visible wire breaks as a wire rope discard criterion.

⚠ **WARNING! Lang´s lay ropes shall not be used in single layer spooling and/or just on plastic sheaves.**

▷ Only use Lang's lay ropes either in multi-layer spooling on winch drums or in combination with Magnetic Rope Inspection (MRT).

⚠ **CAUTION! All ropes, regardless of their type of lay that are exclusively used on plastic sheaves, may not show sufficient visible wire breaks as a discard criterion.**

▷ Contact the manufacturer of the lifting appliance or TEUFELBERGER-Redaelli technicians for further advice.

4.3.4. ROTATIONAL CHARACTERISTICS AND USE OF SWIVEL

4.3.4.1. DEFINITION OF ROTATION-RESISTANT WIRE ROPE

Reference: Klaus Feyrer; Wire Ropes - 2nd ed.; Springer 2015; par. 2.4.2.3:

"A wire rope counts as non-rotating if the twist angle rests smaller than 360°, considering a length L of 1000 times **d**, during the tensile loading **S/d^2** between 0 to 150 N/mm².”

Where: **S:** load
d: rope diameter
L=1000***d**: considered length

4.3.4.2. GUIDANCE FOR THE USE OF SWIVELS

a) Rotational property less than or equal to 1 turn/1 000d lifting a load equivalent to 20 % of Fmin – a swivel can be used;
b) rotational property greater than 1 turn but no greater than 4 turns/1 000d lifting a load equivalent to 20 % of Fmin – a swivel may be used subject to the recommendations of the rope manufacturer and/or approval of a competent person;
c) rotational property greater than 4 turns/1 000d lifting a load equivalent to 20 % of Fmin – a swivel should not be used.

NOTICE! Material quality loss!
With 6- or 8-strand ropes as well as low-rotation ropes swivels are not allowed. These types untwist under load if the ends of the ropes are not fixed. This causes high tension in the wires and therefore reduces fatigue life.

4.3.5. FLEET ANGLES

When the distance between winch and sheave (or within the sheaves) is too short and the deflection or fleet angle is getting bigger, a rope is forced to twist around its axis before it reaches the sheave bottom. Please see chapter 6.5.3 for further information about it.

4.3.6. CHECK CROSS REFERENCE

Teufelberger-Redaelli can offer alternative special wire ropes for most rope types available on the market. To select a proper rope type, please specify the original rope type. Our rope experts will then select a rope that will reach the performance of the mentioned rope in any case.

4.3.7. CHECK METRICS (SIZE CONVERSION)

Be careful when converting the imperial into metric size, especially in case you require e.g. a 1" rope. We offer tailor made ropes in imperial sizes.

4.4. IMPORTANT ROPE PROPERTIES

Depending on the application, it is important to know the basic as well as short-/ and long-term effects of a wire rope in order to avoid problems in later operation or to detect them in time.

4.4.1. CHANGE IN LENGTH UNDER LOAD

Every wire rope elongates under a load due to its double helix structure. Ordinary lay ropes may behave differently compared to Langs lay ropes.

4.4.2. CHANGE IN LENGTH AFTER A PREVIOUS LOAD

As a result of the setting effects (diameter reduction) the wire rope does not return to its original length. The extra length is only initial and immediately recedes when bending (spooling onto a reel). A constancy can only be expected after a longer period of use. Ordinary lay ropes may behave differently compared to Langs lay ropes

4.4.3. CHANGE IN LENGTH DUE TO ALTERNATING BENDING STRESS

Multiple bending of a rope over sheaves or drums also results in additional elongation of a wire rope. Ordinary lay ropes may behave differently compared to Langs lay ropes.

4.4.4. CHANGE IN LENGTH DUE TO AMBIENT TEMPERATURES

Depending on the temperature range, additional elongation or shortening of the rope is to be expected.

4.4.5. CHANGE IN LENGTH DUE TO FLUCTUATION TENSION

Depending on the amplitude and position of the amplitude, additional length changes occur. Ordinary lay ropes may behave differently compared to Langs lay ropes.

4.4.6. TORQUE OF NON-ROTATION-RESISTANT ROPES

Due to the unidirectional geometrical structure of the rope, a torque is generated immediately under load, which tries to bring the strands into a parallel state. This must be prevented under all circumstances. Langs lay ropes have a higher rope torque compared to ordinary lay ropes.

4.4.7. DIAMETER REDUCTION UNDER LOAD

It is important to note that initially the rope diameter is reduced due to setting effects. Torque-based end connections (clamps, locknuts, etc.) must be re-adjusted if no self-regulation exists.

4.4.8. ANGLE OF ROTATION/ROPE TWIST

a) Non-rotation-resistant rope constructions reduce their internal torsional stresses (torque) by releasing a twist when used with unsecured end terminations. This leads to structural changes which cause significant negative changes in rope properties.
b) Rope twist between the end terminations that are secured against rotation on both sides. This effect occurs with very long vertical suspensions, such as in underground mining or subsea lifting, and must be considered separately

4.4.9. LATERAL PRESSURE STABILITY

In the case of rope crossovers, e.g. in multi-layer winding, an ovalization behavior occurs depending on the transverse pressure stability and structure of the rope.

4.4.10. BENDING STIFFNESS / EFFICIENCY

The bending stiffness of a rope changes depending on the number of individual elements such as wires and strands, their deformations due to compacting and/or swaging, the lubricant used, the corrosion protection of the individual wires and the ambient temperature. The nominal wire tensile strength has no measurable influence on the bending stiffness. The double helix structure (rope construction) of the rope primarily determines the bending stiffness.

4.5. CONFORMITY TO MACHINERY DIRECTIVE 2006/42/EC

Following the “Guide to application of the Machinery Directive 2006/42/EC - Edition 2.2 “ see (https://ec.europa.eu/docsroom/documents/38022/attachments/1/translations/en/renditions/native) the following aspects need to be taken into consideration in regards to ropes:

- **The obligations set out in the articles of the Directive apply to ropes designed and constructed for lifting purposes as part of lifting machinery or lifting accessories.**
- Ropes designed for purposes **other than lifting are not subject to the Machinery Directive** as such.
- However, ropes that are designed, constructed and specified by the manufacturer for **dual or multiple purposes including lifting purposes are subject to the Directive.**
- Ropes in the sense of the Directive are the products **first placed on the market by rope manufacturers in the form of bulk reels, drums, rolls, coils or bundles.** They may be supplied by the, rope manufacturer to distributors, to manufacturers of lifting machinery or lifting accessories, or to users.
- The **distributor or user does not become a manufacturer** in the sense of the Directive **by cutting individual lengths** for incorporation into lifting machinery or lifting accessories. Therefore the obligations set out in the articles of the Directive do not apply again to lengths of rope cut from the products already placed on the market by the rope manufacturer. Such lengths are to be **considered as components of the lifting machinery or the lifting accessories** into which they are incorporated.
- However **distributors** of ropes **must ensure that the relevant EC Declaration of Conformity**, the reference of the **certificate** setting out the characteristics of the rope and the **manufacturer's instructions are supplied with the cut length of rope** to manufacturers of lifting machinery or lifting accessories or to users.
- TEUFELBERGER-REDAELLI demonstrates by **following the harmonised standards** mentioned below that its ropes manufactured in the form of bulk reels, etc. when first placed on the market, are in compliance with the Machinery Directive 2006/42/EC.
  - EN ISO 12100-1 Safety of machinery - Basic concepts, general principles for design - Part 1: Basic terminology, methodology (ISO 12100-1:2003)
  - EN 12385-1+A1 Steel wire ropes - Safety - Part 1: General requirements
  - EN 12385-2+A1 Steel wire ropes - Safety - Part 2: Definitions, designation and classification
  - EN 12385-4+A1 Steel wire ropes - Safety - Part 4: Stranded ropes for general lifting applications

5. PACKING, TRANSPORTATION, HANDLING AND STORAGE

⚠ **WARNING! Incorrectly supervised handling and storage procedures may result in serious injury to persons in the working area of installation and as well as those persons directly involved in the handling and installation!**

▷ Handling & storage of the rope should be carried out in accordance with a detailed plan and should be supervised by a competent person.

5.1. IDENTIFICATION OF THE PRODUCT

For identification of the product, refer to the related contractual ropes data sheet, label (or marking), delivery note and certificate.

NOTICE! Product marking and identification!
Missing or wrong product marking and mismatches between certificates and purchase specifications may lead to confusion and incorrect installation!

▷ Verify that the marking on the rope or its package matches the relevant certificate. If not properly marked, coils or reels shall be labeled immediately according to the delivery note.
▷ Ensure that the correct rope has been supplied by checking that the description on the certificate is in accordance with that specified on the purchase order and to the marking on the reel.
▷ Make sure that the rope delivered meets the purchasing specification, especially in terms of: rope diameter, end termination, lay direction, ropes construction, MBF.
▷ Retain the certificates in a safe dry place for identification of the rope when carrying out subsequent periodic statutory examinations in service. (We refer to statutory requirements).

ⓘ **In case of mismatches or doubts:**
▷ Take notes and pictures of the situation.
▷ Contact your sales representative in Teufelberger-Redaelli.

ⓘ **The rating of a component of a machine or lifting accessory is within the responsibility of the designer of the machine or accessory. Any re-rating of a lifting accessory shall be approved by a competent person. (See ISO 4309).**

5.2. ROPE PACKING

Ropes can be delivered on various supports and in different packaging:

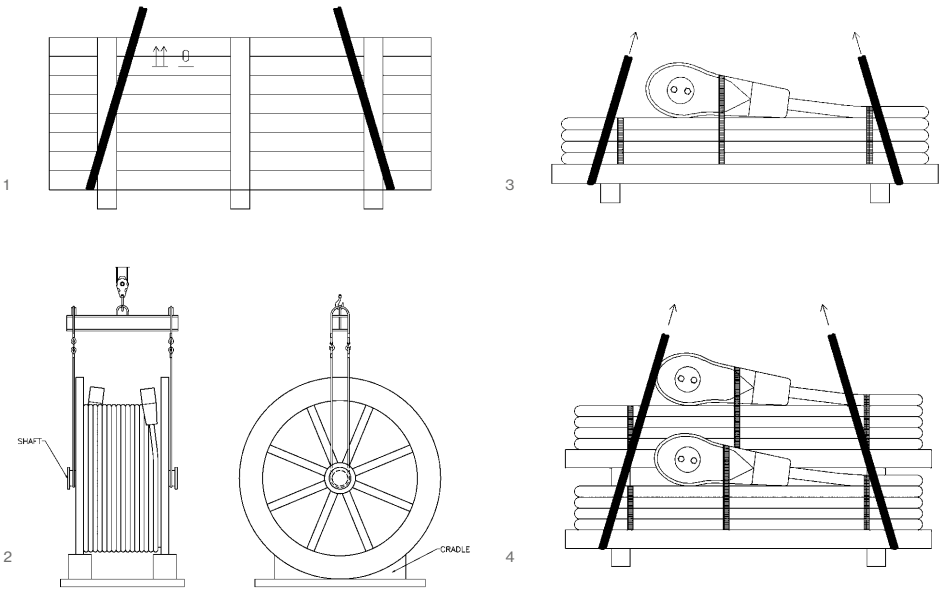


Figure 24 - Supports
1 Crate
2 Reel/Drum (with cradle
3 Single coil on pallet
4 Multiple coils on pallets

5.3. ROPE HANDLING

The lifting system shall ensure the necessary stability during hoisting of the package. The choice of the lifting equipment depends on the rope size, length and gross weight, and on specific customer requirements. Bigger packages shall be handled by means of cranes and related lifting devices, smaller packages can be handled by forklifts or other suitable devices.

A reel or drum is delivered with a wooden or steel cradle which is not permanently connected to the reel. The bent nails or wire hooks connecting the cradle with the reel are installed only for aligning the reel with the cradle. In special cases, the reel is protected or placed in a container to avoid damage during handling, transportation and storage phases.

The lubrication protects the product for the duration of the transport and an initial period of use, depending on the environmental conditions. Teufelberger-Redaelli's standard packaging is suitable for a maximum of 12 months (including handling, transport, storage and installation operations). For longer periods a specific packaging or specific operational procedures are required.

⚠ WARNING! Danger due to wrong handling!

Heavy packaging may cause serious injuries or death!

▷ Use appropriate and correctly dimensioned fixing gear.

▷ Use appropriate and correctly dimensioned lifting equipment.

▷ Make sure that handling is done by transportation specialists.

NOTICE! Material damage!

Direct contact with the ground or other elements can damage the product.

▷ Prevent any direct contact of the product with the ground or other elements.

Steel parts of a lifting device can damage the product.

▷ Avoid direct contact with any steel part of the lifting device, for example the hook of a crane or the forks of a forklift truck as well as the structure, and the ground

▷ To avoid damage when lifting coils or reels, synthetic slings are recommended. Reels are preferably lifted by using a shaft inserted through the bore hole.

Dust, water and other external agents can damage the product.

▷ Cover crates, reels or coils during transportation.

5.3.1. REEL AND DRUM LOADING AND UNLOADING

✔ In case of small reels or drums, lift the package with a forklift for rope handling.

✔ In case of big reels use upper lifting slings, a lifting beam and grommets or a lifting shaft and lower lifting slings suitable to lift the weight involved.

1. Use the upper lifting wire rope slings to connect the lifting beam to the crane hook.
2. Move the crane over the wire rope reel and lower the beam assembly to engage the grommets in the reel side groove.
   – or –
   Move the lower lifting slings to a shaft inserted into the reels axis bore.
3. In case of reel relocation, fix the cradle to the reel or to the lifting shaft by means of textile or steel ropes to prevent that it is falling down during lifting.
   If necessary, disconnect the cradle from the reel before lifting.
4. Ensure that the slings are not in direct contact with the rope to be moved.
5. Carefully lift the reel.

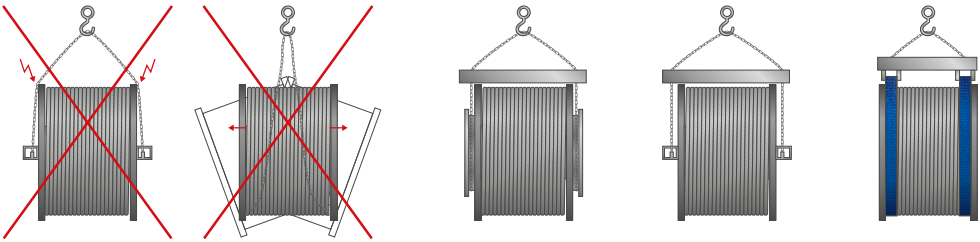


Figure 25 - Handling reels

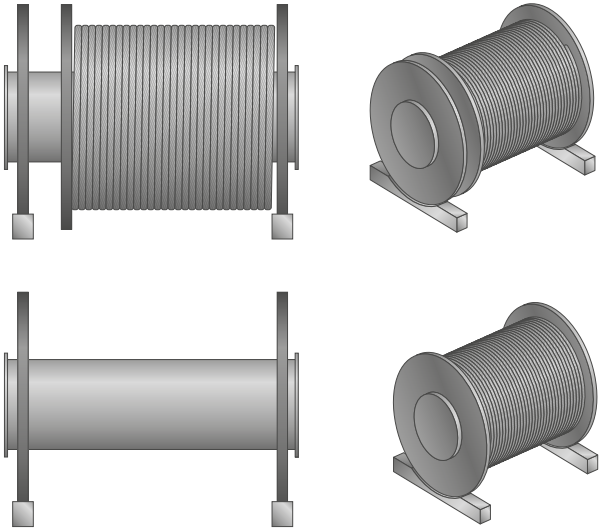


Figure 26 - Examples of reels

5.3.2. TRANSPORT

⚠ WARNING! Wrong transport and installation!

Incorrect transport or installation may cause serious injuries to people or damage to material.

▷ Ensure that only qualified personnel transports and installs the product.
▷ Wear personal protective equipment according to the local safety procedures (work clothing, helmet, gloves, eye protection, safety shoes).

1. Transport the product in the delivered position (do not tilt the product).
2. Fix the crates, reels or coils with appropriate fixing gear in order to prevent unexpected movements.
3. Transport the product with a suitable truck or other suitable transporting/shipping systems.

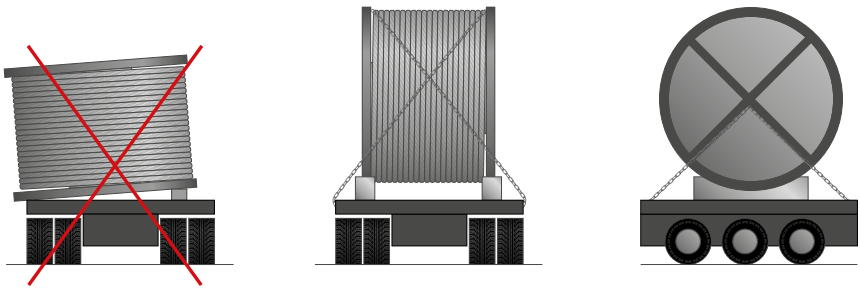


Figure 27 - Transport

5.3.3. DELIVERY INTEGRITY

The following checks shall always be performed at product arrival and before unpacking the rope.

1. Check the integrity of the packaging paying special attention to the following:
   - Damage due to transportation and product handling
   - Corrosion
   - Correct lubrication of the product
   - Where applicable, check the correct positioning of the accessories in accordance to the technical specifications of the packaging
2. Check the integrity of the product label on the packaging and the correctness of the information.
3. Check the complete delivery according to the packing list.
4. Check the rope-related documentation, particularly the following:
   - Nominal diameter
   - Minimal breaking forces
   - Rope type
   - Lay direction
   - Lay type
   - Wire coating
   - Rope length
   - Description of accessories provided with the rope or separately
   - The certificate of conformity of the rope which includes all data for the identification of the product. (eg. Serial-No)

The rope shall only be used if the user has a valid certificate.

ⓘ **In case of damage or doubts:**

▷ Take notes and pictures of the situation.

▷ Record any such damage on the delivery note.

▷ Contact your sales representative in Teufelberger-Redaelli.

5.4. STORAGE

All storage areas shall fulfil the following requirements:

- Equipped with hard floor. Avoid that the rope is in direct contact with the ground.
- Free of chemicals, steam or any other corrosive agents that can affect the product.
- Indoor warehouses shall be at ambient temperatures, dry, clean, dust-free, well-ventilated and covered.
- Adjacent areas shall be separated by means of hurdles, barricades, barriers or fences.
- Adjacent areas shall be surveyed, and users shall issue reports of any damage.

NOTICE! Material damage!

Storage at elevated temperatures, in damp, corrosive or dusty environments, or if contaminated by soil or chemical contact, rope properties may suffer serious harm.

▷ Never store wire ropes at elevated temperatures, nor expose them to dust, dirt or acids.

Objects positioned over the product can damage it.

▷ Never stack up objects over the product.

▶ Secure the stored product against moving.

▶ Store the product in the delivered position (do not tilt the product).

▶ Ensure that the protection from the manufacturer remains unimpaired.

5.4.1. LONG-TERM STORAGE

ⓘ Contact Teufelberger-Redaelli for further information on long-term storage.

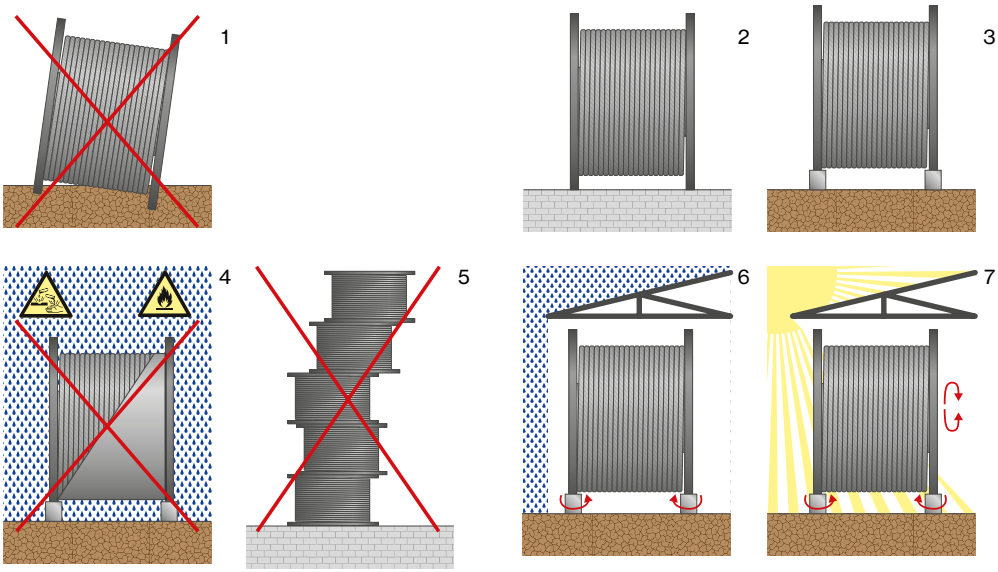


Figure 28 - Storage

If you need to store the product for longer periods (> 2 months):

1. At the beginning and the end of the storage period, note the condition of the product and the packaging on the identification card.
2. Prior to utilization, a rope subjected to prolonged storage shall be inspected for oxidation / corrosion / dirt and eventually cleaned, dried and re-lubricated in accordance with Teufelberger-Redaelli recommendations.
3. Protect the endings of the product from humidity, dust and other damages.
4. Store the product in the delivered position (do not tilt the product).
5. Position the reels on suitable supports (cradle) to prevent the reel arms from sinking into the ground, and to allow a certain elevation of the ropes above the ground.
6. Cover the product to protect it from dust and humidity with breathable waterproof material (not plastic) to avoid the formation of humidity and condensation.
7. Ensure proper ventilation to the product without allowing water to enter it.
8. Visually check the product.
9. With an ambient temperature of > 25 °C: check the product every 2 months to detect any trace of corrosion or inadequate lubrication.
10. Rotate the product 180° every 6 months to avoid lubricant draining. In case of corrosion or if the rope is dry in any point: clean and lubricate the respective areas.
11. Inspect the product at periodical intervals and, if necessary, re-lubricate with grease compatible with the manufacturer's instructions.

NOTICE! Material quality loss!
Incompatible re-lubrication may render the manufacturer's lubricant ineffective, thus critically harming the rope quality!
▷ Guidance on the right re-lubrication is given in chapter 8 and/or in the crane manufacturer's maintenance instructions.

ⓘ **If wire ropes are left unused in shut-down plants, renewed cleaning and lubrication may be required when operation is resumed.**
▷ Wire ropes withdrawn from operation and stored for later re-use require careful cleaning and lubrication prior to spooling.
▷ Store ropes under same conditions as new ropes.

6. INSTALLATION

6.1. PRELIMINARY CHECK

Only qualified personnel who know the respective safety standards may perform the preliminary check.
✔ All machines and tools to be used are in their place.
✔ The power supply is turned off.
▶ Visually check the product to ensure that there are no signs of damage from storage or transport.
▶ Ensure that, on the installation site, a secure installation of the product is possible.
▶ Ensure that all alignments are correct.
▶ Refer to the User Manual of the equipment.

6.2. CHECKING THE PRINCIPAL CHARACTERISTICS OF THE STEEL WIRE ROPE

6.2.1. DIAMETER

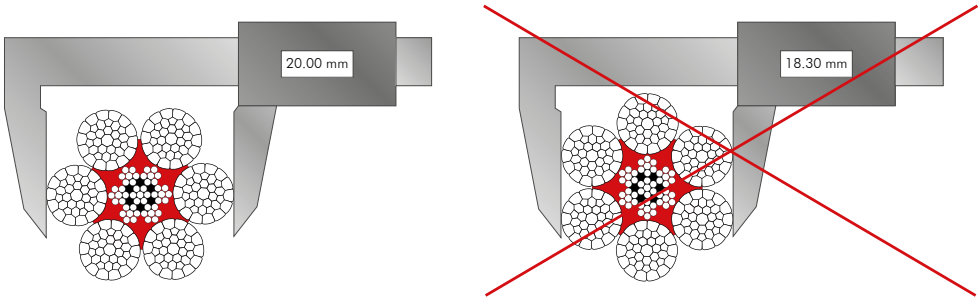


Figure 29 - Checking the diameter

The diameter of a wire rope is the diameter of the circle around it. The section of the wire rope is different to the one of a regular cylinder. To measure the rope diameter, the rope shall be straight and unloaded (or with maximum tension of 5% of the minimum breaking force). Two different sets of measurements are taken, spaced at a minimum distance of one meter, and in two different planes perpendicular to each other. The measuring calipers (available from Teufelberger-Redaelli) shall cover at least two strands.. The rope diameter is the average of these four measurements.

▶ Use the average value to evaluate the dimensional conformity to the tolerances specified in the referenced standards or specifications.

The difference between the highest and the lowest value of the four measurements gives an indication of the ovality of the wire rope.

ⓘ In case of uneven numbers of external strands, the sliding calipers with wide plates shall be long enough to cover at least two strands.

Figure 30 - Sliding calipers with wide plates

6.2.2. ROPE LAY LENGTH

The lay length is the distance along the rope that a strand uses to make a single revolution around the core of the rope.

There are two possible methods for measurement

- Direct method
- Indirect method Direct method:

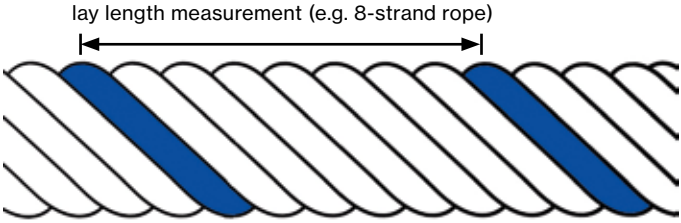


Figure 31 - Lay length measurement, direct method

– Direct method - measurement of rope lay length by counting the strands
(Note: n is the number of outer layer strands)

Depending on the number of external strands, the following steps shall be taken to measure the lay length:

1. Ensure that the wire rope is straight.
2. Mark the point on the strand on which the counting of the strands begins.
3. Mark a second reference point corresponding to the last counted strand (n + 1) or if the same strand appears in the same position.
   The precise distance between the two marked points is the length of the lay length (n x m + 1).

For a more precise result, use a higher number of lay lengths on the wire rope (at least 3). Thus, mistakes while reading the alignment of the reference points can be reduced.

– Indirect method - measurement of rope lay length by imprint on paper

1. Lay a piece of thin paper on the wire rope.
2. Let a hard object run over the paper to make imprints of the strands appear on it.
3. Mark the imprints and count a number of imprints corresponding to the number of external strands + 1.
   The distance between the imprints is the lay length.

For a more precise result, measure more lay lengths (at least 3) and divide the result by the number of measurements.

6.2.3. FIRMNESS OF ROPE STRUCTURE

Firmness depends on the force with which the strands of the external layer of the wire rope remain cohesive.

▶ Insert a slot - screwdriver and rotate it between the external strands forcing their extension.
  – The head of the screwdriver enters relatively easy into the strands.
  – The rotation of the screwdriver may require a major effort.
  – When the screwdriver is pulled out, the strands shall return to their original position instantaneously.
  – Resistance to rotation of the blade of the screwdriver means that the tension of the strands is sufficient to provide a firm outer layer.
▶ In case that the rope structure remains open and doesn't return to their original position after extracting the screw driver, inform Teufelberger-Redaelli personnel for further advise.

This method is limited to ropes with a diameter smaller less or equal to 30mm.

ⓘ If it is possible to insert the whole blade of the screwdriver, the tension between the strands is not correct.

6.2.4. CHECKING THE END CONNECTIONS

▶ Ensure that the rope's end connections correspond to the ones in the User Manual of the equipment or that are conform to what ordered.
▶ Verify the correct execution and proper condition of the end connections by visual examination.

6.2.5. INSPECTION OF THE ROPE REEVING SYSTEM

Check the groove diameter and condition of rope sheaves, deflection sheaves and drums. Grooves in rope drums, rope and compensation sheaves shall fit rope diameters. The minimum groove diameter should never be smaller than the actual rope diameter. The range according to ISO standard is between +5% and +10% of the nominal diameter. The idea nominal diameter is +7.5%. The groove diameter is checked with special groove gauges (see Fig. 32).

New wire ropes may be larger in diameter than old ropes, having the last thinned through use. When installing a new wire rope, this may not fit into the groove, because the latter could have been imprinted and worn by the previous installed rope. Ropes running in narrow sheave grooves will present less endurance. For the groove base to comply with ISO 16625, EN 12385-3 or API 2C and API 9B for worn groove radii at sheaves., worn grooves may need to be refurbished prior to rope installation.. Further the conditions shall be provided for the grooving's at the drum, too.

⚠ WARNING! Lateral deformation of the rope!
Excessive lateral deviation on the sheave may lead to serious damage to the wire ropes with consequent reduction of the safety.

▷ Never use sheaves with grooves whose corresponding diameter is smaller than the actual diameter of the wire rope.sheaves

The correct dimensioning of the groove is fundamental for the lifetime of the wire rope.
✔ The diameter of the groove is larger than the diameter of the rope.
✔ The groove is not worn.
✔ The groove allows slight lateral deformation of the rope.

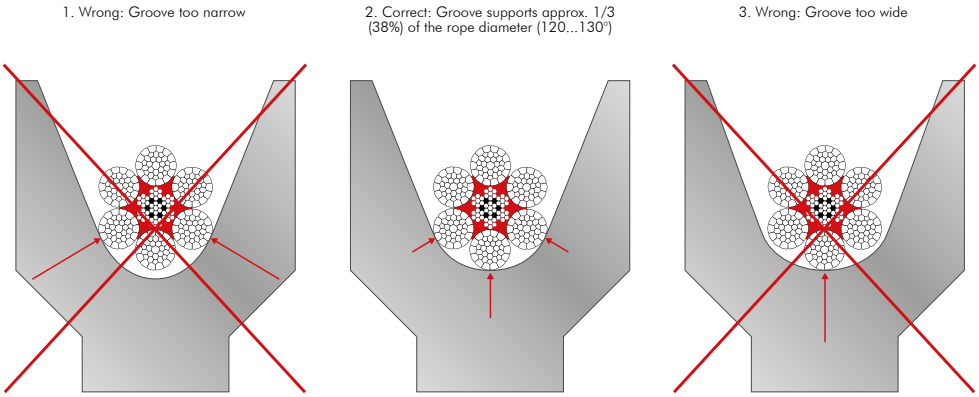


Figure 32 - Grooves

- If you install a new wire rope in a worn groove, the wire rope may not adapt perfectly to the groove profile. Compare the dimension of the wire rope to the dimension of the worn groove.
- Always verify that the sheave and the drum have a section that supports the stress of the wire rope.
- If the corresponding diameter has become too large or too small, the groove should be refurbished or the sheave replaced.
- Sheaves should rotate easily and the bearings shall be in good condition.
- The rope sheaves shall be aligned in the direction of rope travel and shall not have any burrs. Furthermore, the bearings of the rope sheaves shall not have any lateral play.shall.
- The drums shall be checked for cracks and the rope guards and drum wedges shall be in perfect condition.
- Check the alignment of the sheave according to the initial configuration of the machine.
- In case of fleet angles of 1.5° between rope and sheave according to manufacturer's limits, contact the rope manufacturer for information on the dimensioning of the groove and the selection of the correct rope type.

Figure 33 - Sheave gauges

Winding drums and sheaves shall be checked periodically to ensure that all these components rotate correctly in their bearings. Stiff or worn-out sheaves or rollers cause severe damage to the rope.

Ineffective compensation of sheaves may give rise to unequal loading in the rope reeving.

Example how to figure out the actual groove diameter with groove gauges.

Figure 34 - act. groove diameter 25.0mm

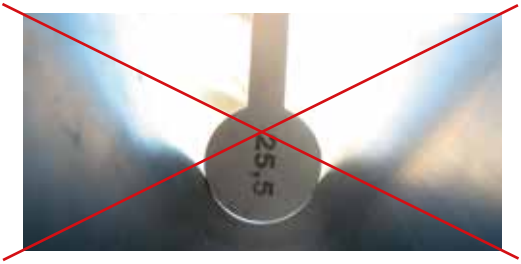


Figure 35 - groove diameter smaller than 25,5 mm

Example for a Ø 25 mm rope:
The actual groove diameter of a rope with nominal diameter 25mm shall be 26.5 mm which corresponds to +7,5% of the nominal rope diameter.

Example of sheaves that have negative impressions in the groove shall be changed.

Figure 36 - negative impression of a used sheave

6.2.6. SPECIAL CHECKS FOR ROPE DRUMS

- Check the condition of the drum.
- If the drum is grooved, check the radius and the groove with a correctly installed rope.
- In case that groove shells are used, Check the condition of the shells of the drums. When replacing the shells, ensure that the grooves of the shells are matching to allow the correct winding of a new rope.

6.2.7. CHECKING THE PROTECTIVE DEVICES OF THE ROPE

- Ensure that all protective devices along the rope are correctly fixed and in good condition.
- Check the condition of all wear plates and of the drum rolls which protect the structure components.

6.3. UNCOILING

⚠ DANGER! Unsuitable safety equipment!

Failure to wear suitable personal protective equipment (PPE) may constitute a serious health hazard and cause injuries:

- skin problems resulting from excessive exposure to certain lubricants;
- respiratory defects from inhaling gases when cutting ropes or embedding them in sockets;
- eye injuries caused by sparks, wire fragments, wire and rope ends;
- burns produced by sparks, molten lubricants or metals;
- other injuries caused by a backlash of wire and rope ends.

▷ Wire ropes shall be uncoiled or unwound by trained personnel or under supervision.

⚠ WARNING! Danger due to incorrect handling!

Incorrect handling of wire ropes may be extremely dangerous. Critical damage to ropes may seriously endanger both persons and the equipment. The use of wire ropes not corresponding to the OEM's instructions may cause serious danger to personnel and rope conveying equipment.

▷ Uncoil ropes progressively, cutting the securing metallic straps with great care.

▷ Remove metallic straps one by one, as the rope is uncoiled.

⚠ CAUTION! Danger of injury!

Uncontrolled release of the outboard end from the reel or uncontrolled opening of coil servings may cause injury. The wire rope will tend to fly in an abrupt and violent movement. The rope should not receive any twist or turn. Pulling over sharp edges or through tight radii can seriously damage the rope.

▷ Do not stand in line with the outer end.

▷ Ensure that the wire rope is not damaged during installation.

▷ Uncoil or unwound with maximum care on order to maintain rope geometry.

▷ Support the rope by an adequate device such as sheaves or wooden material if it shall be drawn over fixed parts during installation.

▷ Never pull the rope from coils sideways or over the flange of a reel.

NOTICE! Material damage!

Too much bending may damage the product by accelerating the bending fatigue.

▷ During uncoiling operations, never bend stranded ropes with a D/d ratio smaller than 12.

▷ Use wooden supports or rollers in order to avoid any direct contact of ropes with the ground.

- Check the wire rope for defects caused by improper handling or storage.
- Place the reel over the pay-off.
- After installation and before removing the lifting tools, ensure that there is no reel rotation due to its eventual unbalanced weight.
- Disconnect the outer rope end from the reel taking care to prevent rope reactions.
- Ensure that the braking system, if any, engages at least 2 opposite reel rays, and is capable to withstand the required pulling force.
- Connect the rope end to the pulling rope by a suitable connection capable to withstand the required pulling force.
- Ensure that the pulling force does not exceed 5% of the rope diameter in tons, using 1 braking device, or 10% of the rope diameter in tons, using 2 braking devices (one at each rope side). For higher direct breakings, special reels are available upon request and in compliance to the client specific drawing.
- During the rope installation allow a higher and correct rope back tension on the final drum (See 6.10).
- Use an adequate capstan or a reel stand with a braking device that does allow the indicated back tension.

The use of capstan allows the direct rope installation from the transportation reel to the crane's drum. Otherwise the rope shall be spooled on the laying reel first and then on the final drum. In this last case, pay attention to potential end connections and their correct position during installation.

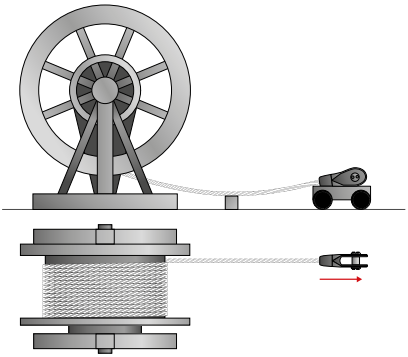


Figure 37 - Unreeler

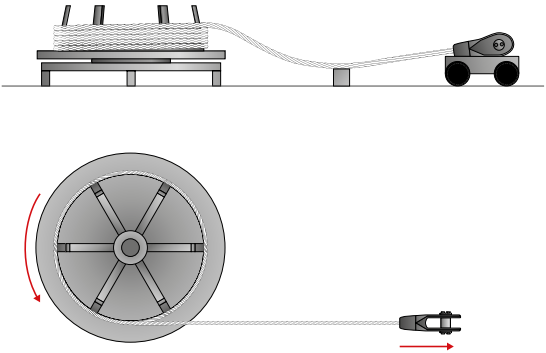


Figure 38 - Uncoiler

ⓘ In the absence of any unspooling equipment, the rope shall be unrolled flat on the ground (see Fig. 38).

Figure 39 - proper unwinding off a coil

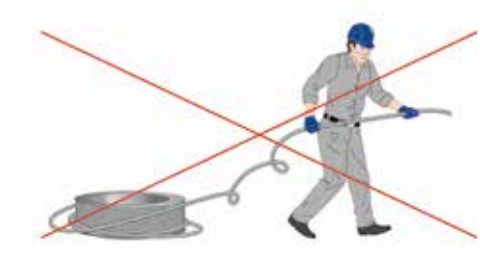


Figure 40 - improper unwinding off a coil

Figure 41 - correct unwinding off a bobbin

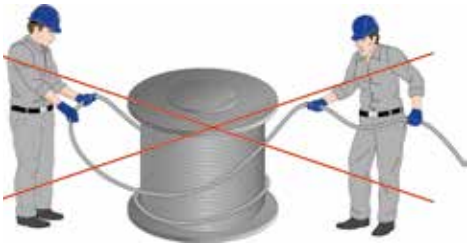


Figure 42 - incorrect unwinding off a bobbin

Uncoiling a rope from a drum also requires great care:

- Jack up the drum on a frame using a rod inserted through the drum's center hole.
- Uncoil the rope from the drum under controlled tension to avoid the formation of loops, by applying a manual brake to the drum flange or using a special brake device.

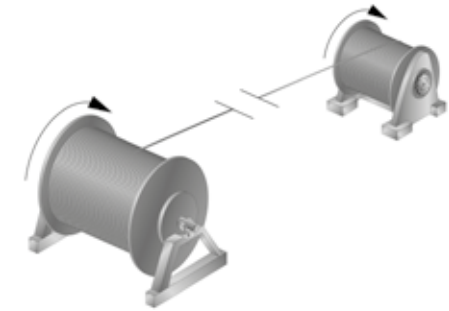


Figure 43 - correct tensioned unwinding using a winch

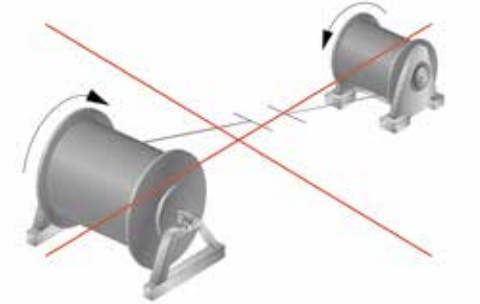


Figure 44 - incorrect tensioned unwinding using a winch

⚠ WARNING! Danger due to incorrect handling!

Loops formed during unspooling may seriously damage the rope. Under load, loops contract and produce a kink which irreparably deforms the rope. A kink may significantly reduce the wire rope's breaking force and cause danger to personnel and rope conveying equipment.

6.4. END CONNECTION PREPARATION

It could be required, in some cases, to prepare a specific end connection on the supplied rope. Refer to the instructions listed here below for this procedure.

For special rope types, refer to the standards and regulations or contact the manufacturer.

⚠ WARNING! Danger due to incorrect rope cutting!
Serious injury to people or damage to the rope result from incorrect rope cutting operations. Single wires may protrude. The moving of the wire rope during cutting may lead to damage to the abrasive disk or other used material and, consequently, to injuries to the workers and the people in adjacent areas

▷ Strictly observe the instructions given below.
▷ Ensure that only qualified personnel cuts the rope.
▷ Before cutting, secure the rope and fix it on both sides of the cutting section so that both ends remain in the same position and do not unlay.

⚠ WARNING! Danger due to harmful dust and smoke!
Carbon steel wires are considered to bear health hazards. During further processing of these carbon steel wires (soldering, cleaning, tapering) dust, smoke, sparks, separated wire particles and toxic fumes may occur.

▷ Wear personal protective equipment according to the local safety procedures (work clothing, helmet, gloves, eye protection, safety shoes).

If installation requires cutting a wire rope, make sure to apply proper seizings before cutting ends, a minimum of one seizing to each side (see illustration below). Special care shall be taken when applying seizings to rotation-resistant and multi-strand ropes. These seizings shall be equal to a minimum of two rope diameters in length.

✔ All anchoring components are appropriate.
✔ All anchoring components are clean and in perfect condition in accordance with the User Manual of the machine on which the rope shall be installed.
✔ If the anchoring components support a load: All anchoring elements are in perfect condition in accordance with the manufacturer's manual.

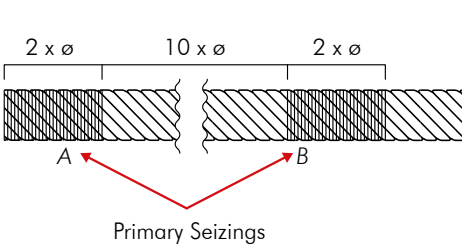


Figure 45 - Rope end with seizings

- ▶ If endings of partial length shall be soldered or tapered, pay attention to solder or taper all wires and strands.
- ▶ Use a diamond blade metal saw, an abrasive disc cutter or hydraulic rope cutter.

⚠ **WARNING! Danger due to incorrect rope cutting!**
Failure to correctly secure the rope end is likely to lead to slackness, distortions, premature removal from service and a reduction in the breaking force of the rope.

- ▷ After cutting, the rope cross-sections of non-preformed ropes, multilayer ropes and parallel closed ropes shall be welded, brazed or fused and tapered such that all wires and strands in the rope are completely secured.
- ▷ Ensure that any fittings such as clamps or fixtures are clean and undamaged before securing rope ends.

6.5. REEVING

Before installing a new rope, assess whether to pull the wire rope through the entire reeving, or to wind it on the rope drum as a first step and pull it through the reeving as a second - an exceptional procedure requiring sufficient drum capacity. If one inner end of the new rope ends in a fitting (e.g. a thimble), the only possibility is to pull the free end through the reeving.

When winding a rope on a plain barreled drum, subsequent turns shall be coiled tightly. Sufficient rope tension facilitates the operation.

6.5.1. FIRST TIME INSTALLATION

When fitting a new rope, turns should not be put into or taken out of the rope. If the rope is not installed by using the old rope, we recommend using a textile auxiliary rope or a thin, rotation-resistant rope. Stranded ropes shall have the same direction of lay as the new rope.

Wire rope socks shall be sufficiently long to prevent the ropes from slipping out.

When using an auxiliary rope to install the new rope, the rope sock shall have an eyelet. The auxiliary rope, which may be a fiber rope, shall have sufficient tensile strength.

If the new rope is introduced using the old rope, a rope sock open on both ends is used.

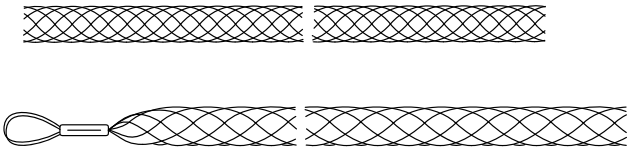


Figure 46 - Wire rope sock

NOTICE! Material quality loss!
If the installation goes over large heights, the wire rope shall be prevented from rotating.
▷ Do not use auxiliary sheave blocks with a D/d ratio smaller than 12.

6.5.2. REPLACEMENT INSTALLATION

6.5.2.1. INSTALLATION OF THE NEW ROPE WITH THE AID OF AN OLD ONE

If installing the new rope by the aid of an old one, one method is to fit a wire rope sock to each of the rope ends. Always ensure that the open end of the sock is securely attached to the rope by a serving or alternatively by a clip. Connect the two ends via a length of fiber rope or a small ROTATION-RESISTANT rope of adequate strength in order to avoid turn being transmitted from the old rope into the new rope. One way of joining the old and the new rope is by using a wire rope sock fitted over rope ends, which shall be secured with tape or a clip (see Fig. 45).

⚠ **WARNING! Danger due to incorrect material handling!**
Though rope junction provides a certain amount of tensile strength, the rope may break when passing over sheaves, thus creating a safety risk and possibly damaging the new rope or the equipment as a whole.

▷ Do not weld together old and new ropes.

ⓘ If the old rope is used as pilot rope, make sure that no rotations are transmitted to the new rope.

6.5.2.2. INSTALLATION OF THE NEW ROPE BY THE AID OF AUXILIARY ROPE

Alternatively, a length of fiber or steel rope of adequate strength may be used in the system as a pilot / messenger line. Monitor the rope carefully as it is being pulled into the system.

⚠ **WARNING! Danger due to incorrect material handling!**
Failure to monitor during this operation could result in injury.

▷ Make sure that the system is not obstructed by any part of the structure or mechanism which may cause the rope to come free.
▷ Do not use a swivel during the installation of the rope in such a case.

ⓘ If ropes will be delivered with becket loop / Teufelberger-Redaelli Pull-eye / chainlink for reeving purposes, please note that this connection can be only used while installation procedure.

6.5.3. STRINGING

⚠ **WARNING! Wrong transport and installation!**
Incorrect wire rope installation may cause serious injuries to those involved with installation and subsequent operation or damage to material.

▷ Wire ropes may only be installed with due care and step by step by technical experts and/or trained persons under competent expert supervision.
▷ Thoroughly follow all safety measures.
▷ Wear personal protective equipment according to the local safety procedures (work clothing, helmet, gloves, eye protection, safety shoes).
▷ Make sure that the stringing equipment is safe for rope installation and that it cannot be started accidentally.
▷ Refer to and follow the system OEM's operating manual and instructions.
▷ Make sure to carefully plan the sequence of rope installation and instruct installation personnel accordingly.
▷ Verify the availability of tools and auxiliary equipment required for rope installation.

▶ During installation, ensure that the wire rope does not suffer from torsions, distortions, abrasions and other influences.
▶ Installation requirements may vary according to the type of installation. In all cases, prepare the following:
- A horizontal platform with anchoring elements to fix the coil.
- Appropriate winches, capstans and other traction aids

NOTICE! The reel on which the rope is delivered can only support a direct unwinding force!
Drums may collapse and / or the rope may be damaged if a high tension is applied!

▷ Wooden reels shall not be used directly for installation.
– During rope installation, allow a higher and correct rope back tension on the final drum (See chapter 6.10).
- Supplementary components for the application of the rope depending on the properties of the ground
  – These components shall prevent the rope from getting into contact with the ground or obstacles. Diameter and groove (if applicable) shall be adapted to the rope's diameter.

When ropes are manufactured, ropes are wound on a reel, thus acquiring a preferred bending direction.

When mounting a rope, the rope should retain the same bend to avoid damaging the rope or reducing its service life (see Fig. 46).

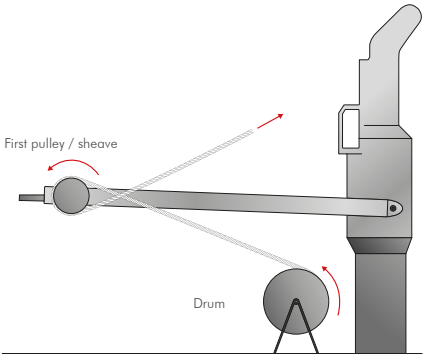


Figure 47 - side view: The fleet-angle between the reel and the first pulley/ sheave is depending on the distance of those two components

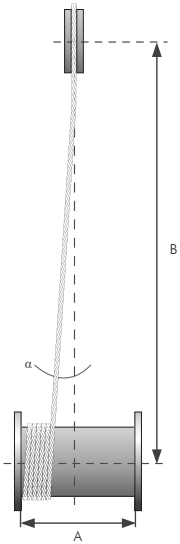


Figure 48 - top view of resulting fleet-angle depending on the distance of the reel and the first pulley / sheave

NOTICE! Material quality loss!
Rotation-resistant ropes, for example, may even be damaged at fleet angles α higher than 2°!

▷ Guidance on the correct installation to avoid fleet angles can be found as follows:
During assembly, the reel should be mounted at maximum distance from the first sheave or the drum and without deflection, as deflection may cause the rope to twist (see Fig. 47).

Rotation resistant ropes	α ≤ 2°	B/A ≥ 15
Non-rotation resistant ropes	α ≤ 4°	B/A ≥ 7

E.g. for a reel with 1m distance between the flanges (A), the distance between the reel and the first sheave (B) shall be minimum 15m for a rotation resistant rope.

6.6. MULTILAYER SPOOLING

If multilayer spooling is required on the equipment's winch drum, ensure that the new wire rope is under tension as it is coiled on the drum. Proper tension on the rope increases it´s radial stability (recommended tension see 6.9), thus significantly reducing wear in the lower rope layers on the drum.

Some rope systems require drum winding of the rope onto the drum under tension during initial installation. Rope tension should be as high as possible, but not more than recommended above of the minimum breaking force. Such back tension can be achieved by applying a brake to the reel as the rope is drawn off or by using a capstan winch. Please note that it is necessary to order conventional reels for the described installation procedure. Cross reels are unsuitable.

Brakes or tensioning apparatus shall not be applied to the rope directly to avoid twisting or deformation of the rope, causing irreparable damage.

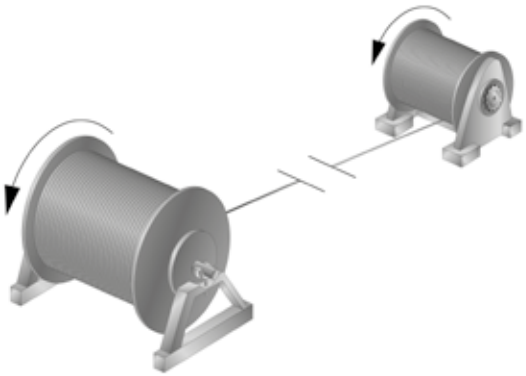


Figure 49 - correct method for locating the rope anchorage point on a drum

NOTICE! Material quality loss!
Loose or uneven spooling on the drum may cause excessive wear, crushing and deformation of the rope. Loose winding, when spooling under load, may subsequently cause outer rope layers to cut into layers below, resulting in irreparable rope damage. The outer layers may even be pulled in and trapped.

▷ Pull out the rope from layers below by subsequent uncoiling.
▷ Wind up the rope first, then pull it completely through the reeving (to the dead wraps) and subsequently wind it on the drum under minor back tension.

ⓘ In case assistance is necessary in relation to correct choice of rope lay direction in the crane system:
▷ Contact your sales representative in Teufelberger-Redaelli.

6.7. RECOMMENDATION FOR OPTIMAL SPOOLING OF ROPES IN MULTILAYER APPLICATION ON PLAIN BARRELED DRUMS DURING INSTALLATION

- Make sure that you use fully compacted ropes. These are more resistant against radial deformation.
- Install the ropes with proper tension (see 6.9), avoiding loose layers (especially on first wraps/layer on the drum).
- Rope entrance on the drum shall be smooth as the very first rope wrap shall be very tight on the drum flange. Avoid sharp edges in this area!. (see Fig. 50)

Figure 50 - entrance of the rope on the drum

- When upwinding the first turn ensure a close contact to the drum by the use of a plastic hammer in order to avoid any damages on the rope.
- If first layer is fully spooled onto the drum please check next to the rope entrance if there is any remaining gap between last wrap on the first layer and drum flange (see Fig. 53). The gap should not be larger than ½ of the rope diameter. If gap is larger please install a shim-plate according to crane manufacturer's recommendation to close that distance. If gap is smaller than half of the rope diameter, install shim-plate only in case of spooling problems. Take under consideration that the rope diameter will decrease during operation! Calculation of rough shim-plate size can be done by Teufelberger-Redaelli. The usage of shim-plate (see Fig. 51 and 52) will influence the fleet-angle (fleet-angle gets reduced)!

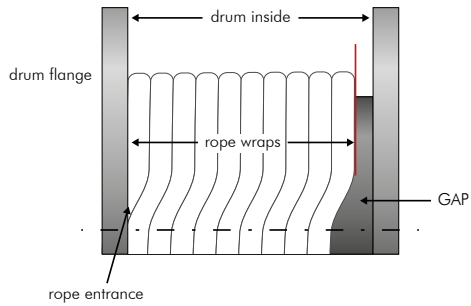


Figure 51 - gap check after first layer fully spooled on sheave

Figure 52 - shim-plate on drum

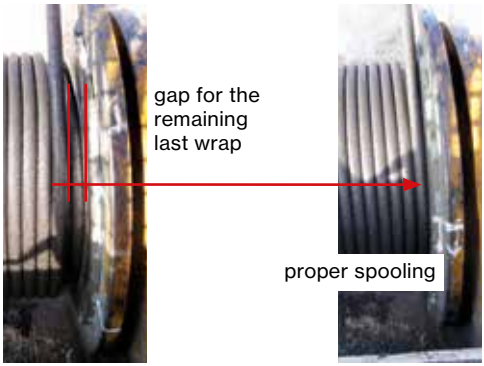


Figure 53 - proper spooling of first layer in order to avoid gaps to shim-plates that can cause rope crushing

- Please note that the gap can vary because of the existing drum - and rope tolerances, so tack the shim-plates only instead of solid welding
- Additionally for boom hoist ropes in langs lay tighten the rope structure in the safety wrap area with the help of twisting the end of the rope at the anchor point side (see 6.8)i).
- Use just the number of turns that are necessary for the operation of the crane and regarding to safety wraps, follow crane manufacturer´s manual and applicable regulations (API).
- Avoid using 1st rope layer as guidance layer because of the risk of crushing. If necessary to do so unspool every 100 working hours until the safety-wraps and re-spool under tension as mentioned above.
- If the last wrap at any layer does not fit the whole way all around the drum because of a narration of the gap (see Fig. 54), the rope will build up a hill to rise above this constriction , which causes distortions at the next layer's spooling.

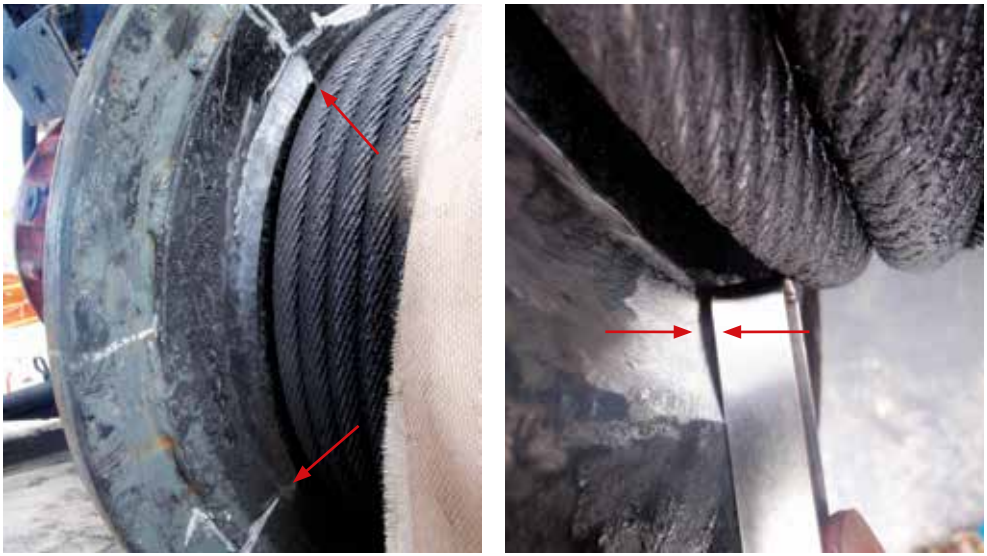


Figure 54 - Constriction that can cause rope distractions

– If the design of the crane generates too small fleet-angles (0°<α<0,5°) at the drum in direction to the first sheave, the rope may climb up the drum's wall (compare figure 55) before it collapses upon itself into an unsystematic configuration with gaps between the wraps, - the basement for irregular spooling of the next layer. A rope-kicker will support the wire rope finding its way into the valley of the prior layer right in time instead climbing up the drum's wall.

Figure 55 - coiling up the drums wall due to small fleet-angles

- Please consider a time for rope training for a new installed rope in order to make wire/strand settings happen follow manufacturer's regulations.
- Avoid slack rope in the system because of the risk to get loose wraps/layers with the result of crushing.
- Make sure that the rope is constantly very well lubricated which reduces friction between each wraps and layers of rope.

6.8. RECOMMENDATION: ROPE INSTALLATION ON MULTILAYER DRUMS FOR BOOM-HOIST ROPES IN LANGS LAY

Before fixing the rope at the anchor point, twist the rope around its axle into the "tight" direction before with a suitable twisting device. Make sure, that the twist does not turn back, while fixing the rope.

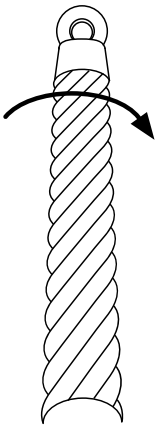


Figure 56 - example of a dead end: two different views, but one rope

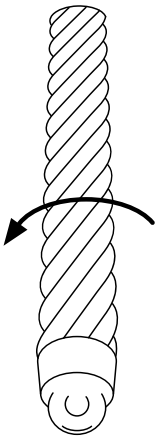


Figure 57 - Lay Type of rope: ordinary right

Fixing the rope at the anchorpoint of the drum:

Figure 58 - Secure the rope at the position within the anchor point of the drum

One person of the team shall take care that the twist does not turn back while fixing the rope. After fixing the rope within the anchor point, the twisting device shall be removed from the rope!

6.9. UP-WINDING UNDER TENSION

The first layer shall have an adequate tension of at least 2,5-5% of the minimum breaking force or - for heavy operation - 10% of the rope tension of the safe working load (SWL).

The pre-tension for upwinding is depending on the safety factor and the D/d ratio of the drum, see graph.

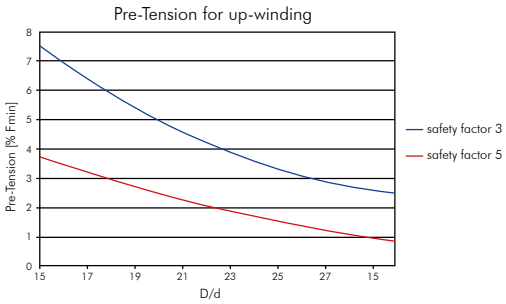


Figure 59 - relationship between pre-tensioning and D/d ratio of the drum

Figure 60 - Proper spooling (no gap between the wraps)

6.10. AFTER FINISHING INSTALLATION

6.10.1. ROPE TRAINING

Rope training is very much dependent on the particular application for which the ropes are used. The following procedure is intended to be used on most of common crane types in the construction and maritime industry. In case of doubt or special applications please consult TEUFELBERGER-REDAELLI for more specific recommendations.

The force applied on the components of the wire rope (wires, strands, and core) during manufacturing differs from the force applied on the wire rope during service. Thus, the relative position of the components is different from the position achieved under service (e.g., tension, bending, rotation). The various rope components do not respond in the same way to the load. Therefore, it is necessary to proceed to rope training, consisting in running in the new rope by operating the equipment slowly a number of times, thus permitting the new rope to adjust itself gradually to working conditions

1. Do not exceed the nominal working value during training, preferably use a low load of approx. 10% of the working load limit (WLL).
2. Before operation: Lower the rope in single fall configuration to the same depth required for abandonment, and leave the rope in this position for a few minutes in order to allow the elimination of its inertial movement.
3. Rewind the rope on the winch. Check that the new rope is spooling correctly on the drum and that no slack or cross laps develop.
4. If necessary, apply as much tension as possible to ensure tight and even coiling, especially on the first layer. Ensure that the as-manufactured condition of the rope is maintained throughout the whole of the handling and installation operation.
5. To achieve a full balance, lower and rewind the rope at least 3 times. The rope reaches its proper mechanical and geometrical adjustment in terms of torque and rotation stability.
6. During the last winding, paint a line on each layer of rope which will be used as reference to monitor the rope rotation.
7. Measure the rope lay length at various points of the rope (i.e. every 250 m). The torsional properties of the rope are determined. Thus, it is easier to estimate its behavior under different load/depth conditions.
8. Lower one length of rope to check that the markings do not rotate significantly in respect to their position. Some rotation will still occur due to fleet angles, sheave friction etc.

6.10.2. COMMISSIONING

- After installation and training: ensure that the geometrical parameters of the rope have not changed and that behavior of the rope is normal.
- After installation: any limit switch, if fitted, shall be checked and re-adjusted, if necessary.
- After installation: note the use related rope installation data on the respective certificate of the rope (type, position, registration number, use, installation data and other traceability information).
- Sign and archive the certificate.
- Verify all alignments.
- For information on the fleet angles of the ropes, refer to the related product data sheet.

6.11. FIRST OPERATION

6.11.1. TWISTING A SHEAVE BLOCK

Some rotation may occur in the initial cycles of operation. This rotation may result in the twisting of the parts of rope forming the reeving or from the following features:

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

6.11.2. UNTWISTING A HOISTING ROPE

Untwisting of the crane sheave block with a rotation-stable fixed point:

Determination of direction of twist

Bring the boom into horizontal to its lowest position and the sheave block down to its lowest position. Then determine the direction of twist of the sheave block from the crane cabin.

If the sheave block twists counter-clockwise, the rope shall be twisted clockwise at the fixed point. (Reverse if the sheave block twists clockwise.)

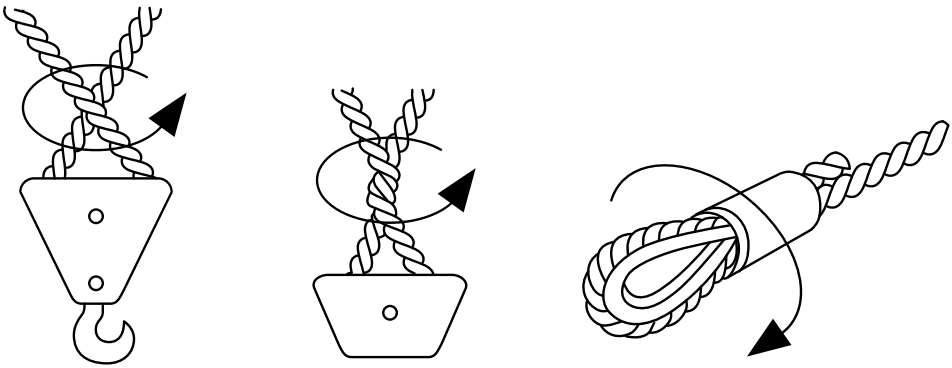


Figure 61 - how to untwist a hoisting rope

7. INSPECTION AND PERIODIC MAINTENANCE

⚠ DANGER! Rope failure due to wrong or missing maintenance!
The failure of a wire rope may cause serious injury or death! Wire ropes will fail if worn-out, shock loaded, overloaded, misused, damaged, improperly maintained or abused!

- ▷ Always inspect a wire rope for wear, damage or abuse before use.
- ▷ Never use a wire rope which is worn-out, damaged or abused and has exceeded its discard criteria.
- ▷ Never overload or shock load a wire rope.
- ▷ Refer to applicable directives, regulations, standards and codes concerning inspection, examination and rope removal criteria.
- ▷ If the condition of the rope is not according the installation manual, please stop working immediately.
- ▷ Read and understand the guidance on product safety given in this brochure; also read and understand the machinery manufacturer's handbook.

⚠ WARNING! Wrong maintenance safety procedures!
Incorrect wire rope maintenance may cause serious injuries to those involved with installation and subsequent operation or damage to material.

- ▶ Before carrying out any maintenance, disconnect the main switch and block it by means of a specific padlock.
- ▶ Use the safety equipment related to the ropes and all of its accessories.
- ▶ Take special care whenever the machine and its components are disassembled.
- ▶ Follow the maintenance sheet for periodic examinations of wire ropes, sheaves and drums. Always check the components visually and physically.
- ▶ Follow the maintenance instructions during use and during storage.
- ▶ Note/write down the correct application of the maintenance works and eventual abnormal situations or damages.
- ▶ Check the rope diameter during each inspection and maintenance.
- ▶ Any appreciable change in condition shall be reported and the rope examined by a competent person in accordance with 7.5.1

Only qualified and authorized personnel with special tools may examine and repair the ropes after the following cases:

- Accidents with the rope or the machine on which the rope is installed
- Installation or uninstallation of the machine
- Before reoperation after a long downtime

7.1. REQUIRED INSPECTION TOOLS

The following tools and materials are useful for the inspection:

- Awl and marlinspike
- Sliding caliper with wide plates (fig 30)
- Steel tape measure
- Sheave gauges (fig. 33)
- Filler gauge
- Pitch cylinders (fig 63)
- Screwdriver
- Chalk
- Ruler
- Cleaner and wiping cloths
- Pencil and paper
- Manufacturer's handbook or operator's manual for the machine involved
- Copies of pertinent governmental and other inspection criteria and specifications

– For correct inspection adequate measuring tools are required. Teufelberger-Redaelli offers all special sheave gauges, filler gauges, sliding caliper with wide plates to ensure proper wire rope diameter measurement on request.

7.2. MAINTENANCE AFTER A LONG-TERM STORAGE

✔ A thorough check of the rope conditions and maintenance needs shall be performed.

1. Completely clean the rope.
2. Let the rope dry completely.
3. Lubricate the rope.

Periodical inspection and maintenance

▶ Follow ISO 4309, API 2D or other local applicable regulations or legal requirements for inspection criteria.

▶ Wear personal protective equipment according to the local safety procedures (work clothing, helmet, gloves, eye protection, safety shoes).

▶ Unload the rope before any maintenance or inspection work unless described differently in the User Manual or other official documents.

▶ Only carry out maintenance or inspection work if the control units of the machine are not manned and the adjacent area is cordoned off or warning signs have been placed.

▶ If the control units of the machine are manned, the authorized person shall be able to communicate easily with the driver or controller of the machine.

- If adequately extensive operational experience details are available, the moment in time for the renewal of the wire rope can be estimated in advance, within the framework of a preventive maintenance program, providing that the operating conditions do not change, and that the type of rope remains the same. The determining factors for discarding remain however the criteria specified in chapter 9.
- Carefully examine any deterioration that could result in a potential loss of original rope strength, and determine whether further use of the rope would constitute a safety hazard.
- Determine the frequency of detailed and thorough inspections taking the following factors into account:
  - Expected rope life as determined by maintenance records, and experience on the particular installation or similar installations
  - Environment conditions
  - Percentage of capacity lifts
  - Frequency rates of operation, and exposure to shock loads
- In case of wear, check the rope more frequently because the wires are at a higher risk of deterioration.
- Ensure that the rope on the storage winch is always under tension. If the rope will be slack, its residual torque will try to untwist it which generates kinks.
- Clean and re-lubricate the rope.
- Check the grooves for wear.
- Rework the sheaves if they show imprints.
- In case of wire ropes on sheaves or drums working with high or sudden loads, examine the deviation points and the sections that are exposed to the loads over longer periods.
- Pay special attention to the zones adjacent to the highest point of the rope.
- Replace the rope if its condition entails any possibility of a failure.
- Replace the rope or shorten the inspection intervals if the rate of deterioration of the rope is such that it will not remain in safe condition until the next scheduled inspection.
- Check for the following:
  - External or internal corrosion
  - Local damage
  - Crushes
  - Torsions
  - Ruptures
  - Slackening of wires or strands

7.3. RECOMMENDED INSPECTION INTERVALS

7.3.1. DAILY

- Before work: Visually check the wire rope to detect deformations or deteriorations.
- Visually check the end connection points.
- Check that the rope runs correctly.
- When in doubt, ask competent maintenance personnel.

7.3.2. WEEKLY

- If the wire rope is in continual use, make a thorough inspection once a week or more often if necessary.
- Observe all wire ropes in continuous service during normal operation and check them visually.

7.3.3. MONTHLY

- Check the whole wire rope.
- Pay special attention to sections with major deteriorations, wear and wire damage.
- Check all wire ropes in use completely.

7.4. INSPECTION PREPARATIONS

- Refer to all applicable regulations to confirm the proper procedure for tracking and maintaining reports.
- Adhere to local regulations for removal.
- Contact the equipment and rope manufacturer for specific design tolerances.
- Ensure that the equipment operator and inspector have confirmed the specific tolerances before inspection.
- Before beginning an examination of an installation, identify the following on top of the report:
  - Equipment location
  - Machine number
  - OEM equipment manufacturer
  - Model
  - Page number
  - Date of inspection
  - Name and signature of the inspector.
  - Split the body of the report into 3 key sections allowing for separate reporting on ropes, sheaves and drums.

- ▶ Provide enough space to report on all the individual parts normally found on each piece of equipment.
- ▶ If necessary, add sheets and number each one appropriately.
- ▶ Keep a record of each rope (including date of fitting, size, construction, length, defects found during inspections and duration of service).
- ▶ When an inspection is complete or as soon as the inspector finds a reason to decommission the rope and or associated sheaves and winches, complete the form and sign the document.
- ▶ Keep the document on file for future reference.
- ▶ Fill in at least the columns proposed in the following subsections.

7.5. OUTLINE OF THE INSPECTIONS

7.5.1. WIRE ROPE INSPECTION

Retrieve the related documentation (manuals, standards, certificates, declaration of conformity, etc) of the wire rope prior to the inspection and make yourself familiar with it. Inspect the wire rope in reference to the applicable standards and user manuals.

Wire ropes shall be inspected for the following:

- Rope type (identifying information)
- Broken wires
- Measured diameter
- Lay length
- Additional damage
- Drum spooling

There are differences between installations, even on machines of a similar design. Compare the same critical inspection points on each installation at each succeeding inspection.

- ▶ Check the entire length of the rope or the rope length involved by use/service.
- ▶ Carefully check the critical inspection points:
  - Pick-up points (sections that are repeatedly under stress when the initial load of each lift is applied, e.g., sections in contact with sheaves)
  - End rope terminations (condition of the rope where it enters the holder and the fittings)
  - Equalizing sheaves
  - Winches, how the rope spools onto the winch and the grooves
  - Points exposed to heat
  - Points subjected to wear (bright spots indicate scuffing or scraping)
- ▶ To check the core, examine the rope as it passes over the sheaves.
  - The strands have a tendency to open up slightly which allows to look at the core.
- ▶ Regularly check for any variation in diameter and lengthening of rope lay.
- ▶ Measure the diameter across the crowns of rope strands, so that the true diameter is the widest diameter at any given point on the ropes circumference (see chapter 6.2.1).

ⓘ A variation of lay length in a wire rope in use may be an indication for anomalies. It depends on magnitude of the deviations, which are in turn related to the specific application. The operating conditions may be inappropriate leading to geometrical variances with negative impact on the wire rope. The measurement of lay lengths in different points of the wire rope helps to identify the origin of anomalies.

- ▶ Only qualified personnel may mount the wire rope
- ▶ Ask Teufelberger-Redaelli personnel for mounting, inspecting and maintaining the Teufelberger-Redaelli wire rope.
- ▶ Check that the rope doesn't show any sign of waviness (see chapter 9.6)
- ▶ Periodically check all load bearing wire ropes and fittings for the following criteria:
  - Abrasion
  - Wear
  - Fatigue
  - Corrosion
- ▶ Examine each wire rope individually.
- ▶ If possible, examine standing ropes and operating ropes separately.
- ▶ Visually check the rope during operation.
- ▶ Check chapter 9 for troubleshooting about the typical rope damage and the respective discard criteria.

7.5.2. SHEAVE INSPECTION

Sheaves shall be inspected for the following:

- Sheave type (material and configuration)
- Sheave position
- Gauge and groove columns to log if the sheave gauge fits or not. If necessary, use an undersized or oversized gauge to determine how far the sheave groove is out of the specification range.
- Alignment
- Overall condition of the rope sheaves
- Specific damage (observed problems not yet listed)

A proper fitting sheave groove should support the rope over 135...150° of rope circumference.

- ▶ Ensure that the contour of the gauge matches the contour of the bottom of the groove.
- ▶ Examine the following parameters for each rope:
  - Groove depth, width and contour (with a groove gauge): When the gauge for worn grooves fits perfectly, the groove is at the minimum permissible contour. If it gets narrower, replace it.
  - Groove smoothness
  - Groove hardness (if applicable on steel sheaves)
  - Broken or chipped flanges
  - Cracks in hubs, spokes etc.
  - Signs of rope contact with guards

7.5.3. WINCH AND DRUM INSPECTION

Winches and drums shall be inspected for the following:

- Specific configuration or style of winch
- Gauge and groove columns to log if a groove gauge fits or not. If necessary, use an undersized or oversized gauge to determine how far the drum grooves are out of the specification range. In case of gauge overlap, use 2 gauges to check the winch pitch.
- Check of the winch pitch
- Severity of corrugations
- Overall condition of the winch
- Specific damage (observed problems not yet listed)

▶ Always use 2 gauges allocated side-by-side in 2 adjacent winch grooves.
Even though both the gauges properly follow groove contours, when used side-by-side they indicate that grooves are too close and that the winch pitch is less than the rope diameter. Two gauges which overlap reveal that wraps of rope will scrub when spooling onto or off the winch.

▶ Check the grooves:
- Check with a groove gauge that normal tolerances apply.
- Ensure that the bottoms of the grooves are smooth.
- Replace drums that become imprinted with the rope's tread or are excessively roughened.
- Ensure that the grooves are spaced so that one wrap of rope does not scrub the next one as it spools onto the drum. This spacing is referred to as the drum groove pitch and is the actual distance between the center line of one groove and the center line of an adjacent groove.
- Measure the drum pitch counting the number of grooves between the flanges and use a tape measure to determine the width. Divide the value by nb. of grooves for the individual groove pitch and compare it to the actual rope diameter.

ⓘ As a general recommendation for grooved drums, the pitch shall be 0,5% to 2% larger than the nominal rope diameter.

▶ Check the following:
- Minimum number of dead wraps to remain on the winch.
- Condition of flanges at the ends of the winch.
- Rope condition, particularly at pick-up points on the rope.

▶ Check the spooling characteristics of the rope:
- Ensure that the wraps are tight.
- Examine the rope for kinks or other damage when loose or irregular spooling has been observed.

▶ Check the winches for general damage:
- If the installed ropes show any signs of damage, contact a rope specialist for recommendations on a construction which will reduce this condition.

▶ Check the end rope terminations of the rope:
- The end rope terminations restrict the free movement of the wires at the end of the rope. Ensure that there is no breakage of the wires at the point where the restriction is.

- Pick and probe with an awl at the point where strands enter the end rope terminations to expose broken wires.
- Ensure that there is no corrosion or rust at the end fittings.
- Check the condition of the actual rope termination.
- Report worn eyes, missing thimbles, bent or opened hooks, worn clevis pins and any other type of distortion, abrasion or noticeable damage.
- Sheave bearings and shaft: With the rope relaxed, rotate the sheave by hand to determine the fit of the bearing and the effectiveness of its lubrication. If necessary, align it.
- Out-of-round condition
- Alignment with other sheaves

7.5.3.1. RECOMMENDATIONS FOR GROOVED DRUMS FOR MULTILAYER SPOOLING

Influences on the quality of multilayer spooling

- Tolerance range of the actual rope diameter
- Number of outer strands / rope construction
- Type of rope lay (ordinary / lang´s lay)
- Rope resistance against radial deformation
- Line pull
- Drum geometry (pitch, width, etc.)
- Fleet-angle
- Number of wraps in one layer
- Number of layers
- Line speed

ⓘ An important factor of proper multilayer spooling is the correct relation between actual diameter and actual drum pitch (or drum width on plain barreled drums).

Relation of actual drum pitch to actual rope diameter

The relationship between the rope diameter and the pitch of the drum groove is important. This relation is called “play”, and it is defined as the difference between pitch and rope diameter. Usually this value ranges between 0.5-2.5% of rope diameter.

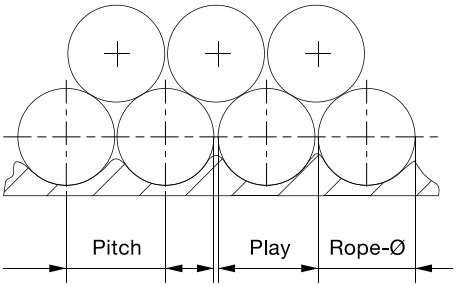


Figure 62 - Play = Pitch – Rope-Ø = (for a new applied rope)

Figure 63 - recommended measuring of drum pitch

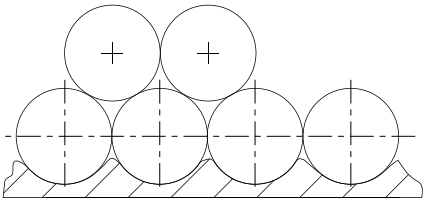


Figure 64 - No play between wraps results in addition wear

Figure 65 - Increased rope wear caused by too narrow spooling

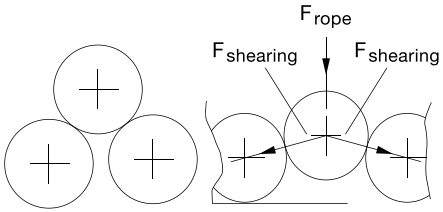


Figure 66 - danger of cutting in

Figure 67 - loose spooling of rope in the outer layers

Drum measurement

Figure 68 - drum ground should be visible for proper measurement

7.5.4. COMMENTS

- Specific notes, recommendations
- Outright rejection of the inspected item

8. STRATEGIC AND PREVENTIVE MAINTENANCE

To detect defects of the wire rope like broken wires or loss of steel area, MRT (Magnetic Rope Testing) shall be used besides visual observation and pull tests.

- ▶ At the beginning of the life cycle of the wire rope, inspect the wire rope using MRT.
- ▶ Document the result.
- ▶ Repeat the MRT on a regular basis in order to detect potential damages.

8.1. CLEANING

Dirt shall be removed from the rope before re-lubrication.
Externally clean the ropes by using rotating wire brushes and an air blast drying system or a rope porcupine sleeve.

⚠ WARNING! Injuries!
When cleaning the rope with a cloth, fibers may get stuck on broken wires or defective parts of the rope, which may cause injuries.

- ▷ Use protective gloves.
- ▷ Use instead wire brushes to clean the rope.
- ▷ Never clean ropes in the vicinity to sheaves, drums, etc to avoid to avoid the risk of coming into contact with it.

⚠ WARNING! Injuries!
When cleaning the rope with a wire brush, dust, smoke, sparks, separated wire particles and toxic fumes may occur.

- ▷ Use protective goggles and respiratory protection.

8.2. RE-LUBRICATION

Depending on operation, wire ropes shall be lubricated at regular intervals. When ropes eventually turn dry by use and grease wears off, re-lubricate to enhance durability.

Teufelberger-Redaelli ropes are greased during manufacture to reduce friction within the rope and prevent corrosion. Periodical lubrication of wire ropes enhances their endurance and may reduce corrosion. For example, a ‘dry’ rope unaffected by corrosion but subject to bending fatigue is likely to achieve only 30% of that normally attained by a ‘lubricated’ rope.

⚠ WARNING! Potential hazards!
Do not carry out any inspection, examination, re-lubrication/lubrication, adjustment or any other maintenance of the rope whilst it is suspending a load, unless otherwise stated in the OEM's instruction manual or other relevant documents.

▷ Never clean the wire rope without recognizing the potential hazards associated with working on a moving rope.

⚠ WARNING! Injuries!
Do not carry out any inspection or maintenance of the rope if the appliance controls are unattended.

▷ Isolate the surrounding area or post warning signs within the immediate vicinity.
▷ With attended appliance controls, the authorized person shall be able to communicate effectively with the driver or controller of the appliance during the inspection process.

NOTICE! Material damage!
Solvents may dissolve or wash out the manufacturer's lubricant, causing large quantities of lubricant to accumulate on the rope surface. This presents a hazard to rope conveying equipment requiring a minimum of friction between rope and sheave.

▷ Assess with TEUFELBERGER-REDAELLI the list of compatible re-lubrication media.

NOTICE! Material quality loss!
Ropes not re-lubricated at the required intervals can have a significantly shorter life span than ropes undergoing regular lubrication.

NOTICE! Material quality loss!
Do not use unapproved or non-recommended rope lubricants. It is better not to re-lubricate the rope than to apply a non-appropriate lubricant or under conditions that are not ideal (e.g., wet ropes).

▷ Use a lubricant that is compatible with the manufacturer's lubricant previously applied.
▷ Ask the rope manufacturer which form, which oil or grease manufacturer you can use for which product.
▷ For a compatibility check of the lubricant you want to use, please provide a material & safety data sheet for final approval.

Re-lubrication guidelines
Ropes are usually re-lubricated by using a brush, cloth or the like. Approved solvent-based lubricants can be sprayed on. Drip-feed lubricators or high-pressure lubricating machines (MASTO or similar) can be used in special cases. (see also Fig. 69)

NOTICE! Material damage!

High-pressure lubricators should only be handled by qualified personnel adhering to manufacturer's instructions.

- The rope shall be clean and dry prior to re-lubrication.
- Before stopping the winch for a long period, fully re-lubricate longer used rope length with specific re-lubrication systems. The lubricant flows between the strands, also inside the rope.
- Only apply small amounts of lubricant to allow a periodical examination of the wire rope's surface.
- Re-lubricate steel wire ropes particularly along the zones subjected to bending.
- If for operational reasons re-lubrication cannot be carried out: schedule the inspection at shorter intervals (expect the wire rope to be less durable).
- If only a little lubricant is required, apply pressure spray nozzles.
- In case of wound wet ropes used in marine environments, lower the rope to the sea to re-lubricate it. Thus, salt water will not be pushed and trapped inside the rope by the lubricant flow which prevents internal corrosion. The speed of the rope shall be slow enough to allow the lubricant to dry before entering the water.
- Before putting the rope in service: let the lubricant dry completely.

Figure 69 - pressurized lubrication

Figure 70 - automated lubrication located at sheave (symbolic illustration)

Figure 71 - manual lubrication located at sheave (symbolic illustration)

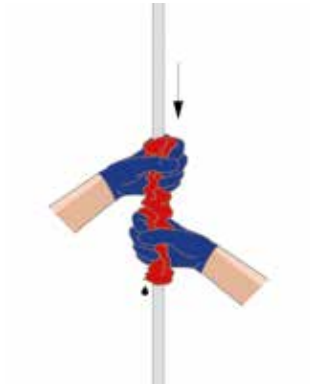


Figure 72 - manual lubrication with greased cloth (symbolic illustration)

8.3. REMOVAL OF BROKEN WIRE ENDS

Protruding wire ends may damage neighboring wires and affect the normal travel through a sheave of the wire rope, which may lead to localized deterioration. Therefore they should be removed. It is not advisable to nip ends off with pliers but to grip them, bending them backwards and forwards until the wire breaks in the valley between two strands.

When a broken wire is removed from the rope as part of a maintenance exercise, its location should be recorded for the information of the rope inspector.

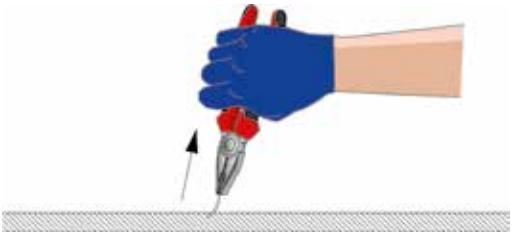


Figure 73 - How to remove a protruding wire (symbolic illustration)

8.4. SLIP AND CUT (PROCESS)

If wear mainly occurs when the rope is reeved on the Lebus® drum in multiple layers, rope life may be increased by cutting off one length according to 1/3 or 1/6 of drum circumference. This procedure can help to extend the lifetime of the wire rope.

ⓘ In order to guarantee maximum lifetime Teufelberger-Redaelli recommends operating always on the 1st layer, too. Safety wraps should be as less as possible, however, still in accordance with international standards (ISO, API, etc.) plus 1 wrap additionally for possible slip + cut process.

8.5. ROPE SHORTENING

▶ To translocate the points of the system that are most exposed to deterioration, shorten the rope. At ordering phase, suitable extra length of rope shall be foreseen, in order to permit periodic shortenings to extend rope lifetime. The wire rope may be shortened if only short rope sections, e.g. the one that climbs to the second layer on the drum, are seriously damaged, while the rest of the rope is still in perfect condition.

1. Shorten the rope.
2. Shift the rope at the fixing point using a span that removes the respective area of the rope. An adjacent section will now be subjected to the wear.

8.6. ROPE REPLACEMENT

To replace the rope completely, refer to the Manual of the equipment on which the rope is installed.

9. TROUBLESHOOTING AND DISCARD CRITERIA

Damaged wires are a normal sign of wear during and at the end of a wire rope's lifetime. Localizing the damage may be an indicator for mechanical deficiencies of the equipment. Wear of wires is caused by abrasions, pressure and friction. Sections with multiple damages may indicate mechanical problems of the machine.

Particularly damages that occur during the first period of use can be caused by the following:

- Inadequate rope type
- Inadequate installation
- Faulty rope termination between rope and machine

When the damage rate of the rope increases, the lifetime of the rope is nearing its end.

▶ Replace the rope If the applicable discard criteria is reached

Particularly the following damages occur:

- Damaged wires
- Reduction of the diameter
- "Stiffening" of the rope

ⓘ In order to solve these problems action should be taken by experienced personal. For further questions or information on other possible damages, please contact Teufelberger-Redaelli.

9.1. GENERAL

This chapter covers the discard criteria following related standards (e.g. ISO 4309). Some of them can be evaluated with a severity rating which means partial rope damage, and that can be later combined at any given position to evaluate the total rope damage. When the cumulative severity rating at any position reaches 100%, the rope should be discarded.

For evaluating some discard criteria is necessary to know the rope type, application, construction and rope category number (RCN), which can all be found in manufacturer's certificates.

9.2. BROKEN WIRES

Figure 74 - Crown wire breaks

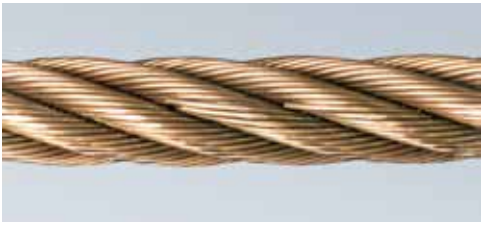


Figure 75 - Valley wire breaks

Potential causes:

- Too small groove radius
- Sliding on edge(s)

9.2.1. VISUAL INSPECTION

⚠ WARNING! Risk of injury by running rope!

Carrying out inspections or examinations while the rope is running has the high risk of causing injuries.

▷ Never carry out any inspection or examination without recognizing the potential hazards associated with working on a moving rope.

- ▶ Use a spike or screw driver to gently probe the strands for any wire breaks that do not protrude.
- ▶ Check as the rope runs at a slow speed over the sheaves, where crown wire breaks may be easier to see.
- ▶ Examine the rope near the end connections.
- ▶ Check all grooves with gauges
- ▶ Search for abrasion on the crane
- ▶ Check if all sheaves in the reeving are free to rotate
- ▶ Review operating conditions
- ▶ Keep a detailed inspection record of the wire breaks and other types of damage to determine the elapsed time between breaks.
- ▶ Note the area of the breaks and carefully check these areas in the future.
- ▶ Thoroughly determine the overall condition of the rope: the plastic covering crown wires is generally applied in a thin coat and tends to wear quickly in areas which pass over sheaves and drums.
- ▶ As the rope and plastic open up, check the surface area and the interstrand contact points.
- ▶ Check areas where plastic has peeled, regardless of the location of the "window".
  - – Remove as much plastic from these areas as possible to allow for efficient and effective inspection techniques. Due to the nature of plastic-filled ropes, the number of valley breaks cannot be clearly determined.
- ▶ Examine compacted ropes with special care, especially in the areas passing over drums and sheaves, or in areas where problems existed in previous ropes.
- ▶ Carefully check eventual “flaws” in a wire.
- ▶ Use some type of magnifying device to determine if a flaw is actually a break.
- ▶ If a break has occurred, thoroughly check the area for additional breaks, both on the crown and in the valleys.
- ▶ Carefully search for broken wires, particularly in critical areas such as pick-up points where stresses are concentrated.
- ▶ To ensure that the surface is clean enough that breaks can be seen, wipe with a cloth and if necessary, scour with a wire brush to clean grease from the valleys between strands.
- ▶ Move the pick-up points off the sheaves.
- ▶ Flex the rope as much as possible.
- ▶ With a sharp awl, pick and probe between wires and strands, lift any wires which appear loose or move excessively.
- ▶ If you find a number of broken wires approaching the allowable maximum permitted per strand or per rope lay, extend the search to other sections of the rope.
- ▶ Take diameter and lay measurements in the area.
- ▶ If internal wire breaks or core damage is suspected, examine the rope internally.

9.2.2. DISCARD CRITERIA

How to evaluate severity rating in regards to broken wires:

1. Determine the nature of broken wires from Table 6 in order to obtain the number of wire breaks at discard which equals to a 100% severity rating. In case that there is a reference to Tables 7 or 8, by using RCN, type of operation, spooling type and lay direction the maximum number of allowable broken wires can be obtained.
2. Use the results of the visual examination for broken wires on a section that equals to 6d or 30d and determine the most damaged part of the rope.
3. The severity rating is than calculated by the actual maximum number of broken wires in relation to the maximum permissible one for a given section of rope (6d or 30d).

Example: 22mm 6×36WS-IWRC sZ rope (RCN 09) operating on an overhead hoist (classification M4) and spooling on a single-layer drum with randomly occurring wire breaks (case 1 of Table 6).

From Table 7, the number of outer wire beaks signaling discard is 9 in 6d and 18 in 30d. Therefore, if 2 broken wires are found in 6d (but no more than 18 in 30d), this equals to a severity rating of rounded 20% (2/9).

	Nature of visible broken wire	Discard criteria
1	Wire breaks occurring randomly in section of rope which run through one or more steel sheaves and spool on and off the drum when single-layer spooling or occurring at sections of rope which are coincident with the cross-over zones when multilayer spooling	See Table 7 for single-layer and parallel-closed ropes and Table 8 for rotation-resistant ropes.
2	Localized grouping of wire breaks in sections of rope which do not spool on and off the drum.	If grouping is concentrated in one or two neighbouring strands it might be necessary to discard the rope even if the number is lower than the values over a length of 6d which are given in tables 7 and 8.
3	Valley wire breaks	Two or more wire breaks in a rope lay length (approximately equivalent to a length of 6d).
4	Wire breaks at a termination	Two or more wire breaks.

Table 6 - Discard criteria for the various natures of visible broken wire

RCN rope category number	Total number of load-bearing wires in the outer layer of strands in the rope [i] n	Number of visible broken outer wires [ii]					
		Sections of rope working in steel sheaves and/or spooling on a single-layer drum (wire breaks randomly distributed)				Sections of rope spooling on a multi-layer drum [iii]	
		Classes M1 to M4 or class unknown [iv]				All classes	
		Ordinary lay		Lang lay		Ordinary and lang lay	
		Over a length of 6d [v]	Over a length of 30d [v]	Over a length of 6d [v]	Over a length of 30d [v]	Over a length of 6d [v]	Over a length of 30d [v]
01	n ⩽ 50	2	4	1	2	4	8
02	51 ⩽ n ⩽ 75	3	6	2	3	6	12
03	76 ⩽ n ⩽ 100	4	8	2	4	8	16
04	101 ⩽ n ⩽ 120	5	10	2	5	10	20
05	121 ⩽ n ⩽ 140	6	11	3	6	12	22
06	141 ⩽ n ⩽ 160	6	13	3	6	12	26
07	161 ⩽ n ⩽ 180	7	14	4	7	14	28
08	181 ⩽ n ⩽ 200	8	16	4	8	16	32
09	201 ⩽ n ⩽ 220	9	18	4	9	18	36
10	221 ⩽ n ⩽ 240	10	19	5	10	20	38
11	241 ⩽ n ⩽ 260	10	21	5	10	20	42
12	261 ⩽ n ⩽ 280	11	22	6	11	22	44
13	281 ⩽ n ⩽ 300	12	24	6	12	24	48
	n > 300	0,04 x n	0,08 x n	0,02 x n	0,04 x n	0,08 x n	0,16 x n

NOTE Ropes having outer strands of Seale construction where the number of wires in each strand is 19 or less (e.g. 6×19 Seale) are placed in this table two rows above that row in which the construction would normally be placed based on the number of load bearing wires in the outer layer of strands.

(i) For the purposes of the international standard ISO 4309, filler wires are not regarded as load-bearing wires and are not included in the values of n.

(ii) A broken wire has two ends (counted as one wire).

(iii) The values apply to deterioration that occurs at the cross-over zones and interference between wraps due to fleet angle effects (and not to those sections of rope which only work in sheaves and do not spool on the drum).

(iv) Twice the number of broken wires listed may be applied to ropes on mechanisms whose classification is known to be M5 to M8 [ISO 4301-1:1986].

(v) d = nominal diameter of rope

Table 7 - Number of wire breaks, reached for exceeded, of visible broken wires occurring in single-layer and parallel-closed ropes, signaling discard of rope

RCN rope category number	Number of outer strands and total number of load-bearing wires in the outer layer of strands in the rope [i]	Number of visible broken outer wires [ii]			
		Sections of rope working in steel sheaves and/or spooling on a single-layer drum (wire breaks randomly distributed)		Sections of rope spooling on a multilayer drum [iii]	
		Over a length of 6d [iv]	Over a length of 30d [iv]	Over a length of 6d [iv]	Over a length of 30d [iv]
21	4 strands n ⩽ 100	2	4	2	4
22	3 or 4 strands n ⩾ 100	2	4	4	8
23-1	71 ⩽ n ⩽ 100	2	4	4	8
23-2	101 ⩽ n ⩽ 120	3	5	5	10
23-3	121 ⩽ n ⩽ 140	3	5	6	11
24	141 ⩽ n ⩽ 160	3	6	6	13
25	161 ⩽ n ⩽ 180	4	7	7	14
26	181 ⩽ n ⩽ 200	4	8	8	16
27	201 ⩽ n ⩽ 220	4	9	9	18
28	221 ⩽ n ⩽ 240	5	10	10	19
29	241 ⩽ n ⩽ 260	5	10	10	21
30	261 ⩽ n ⩽ 280	6	11	11	22
31	281 ⩽ n ⩽ 300	6	12	12	24
	n > 300	6	12	12	24

NOTE: Ropes having outer strands of Seale construction where the number of wires in each strand is 109 or less (e.g. 18 x 19 Seale - WSC) are placed in this table two rows above that row in which the construction would normally be placed based on the number of load bearing wires in the outer layer of strands.

(i) For the purposes of the International Standard ISO 4309, filler wires are not regarded as load-bearing wires and are not included in the values of n.

(ii) A broken wire has two ends (counted as one wire).

(iii) The values apply to deterioration that occurs at the cross-over zones and interference between wraps due to fleet angle effects (and not to those sections of rope which only work in sheaves and do not spool on the drum).

(iv) d = nominal diameter of rope

Table 8 - Number of wire breaks, reached for exceeded, of visible broken wires occurring in rotation-resistant ropes, signaling discard of rope

9.3. DECREASE IN ROPE DIAMETER

Diameter reduction is a critical deterioration factor and a sign for an impending internal breakdown. The wire ropes are protected in a way that allows to indicate possible damage from the external wires.

Figure 76 - Local reduction in rope diameter (sunken strand)

Figure 77 - Uniform diameter reduction may be caused by external wear

Possible causes

- Too small groove radius
- Sliding on edge(s) passing over the drum and sheaves
- Heavy line pull - fatigue wear of a result of long time operation
- Contacting an abrasive medium
- Excessive abrasion of the outside wires
- Internal or external corrosion damage
- Initial pull-down
- Normal wear
- Internal rope damage (core or rope center failure)
- Lengthening of the rope lay
- Crushing
- Shock-loading
- High stranding

9.3.1. INSPECTION PROCEDURE AND SUGGESTIONS

⚠ **WARNING! Risk of injury by running rope!**

Carrying out inspections or examinations while the rope is running has the high risk of causing injuries.

▷ Never carry out any inspection or examination without recognizing the potential hazards associated with working on a moving rope.

▶ Ensure that all components are in proper working order and of the appropriate diameter of the rope.
▶ Check all flanges, sheaves, bearings, rollers and fairleads.
▶ Check all grooves with gauges.
▶ Search for abrasion on the crane.
▶ Check if all sheaves in the reeving are free to rotate.

9.3.2. DISCARD CRITERIA

The discard criterion values for uniform decrease in rope diameter for sections of rope which spool on a single-layer drum and/or run through a steel sheave are shown in Table 9. They do not apply to those sections of rope which are coincident with crossover zones or other sections of rope which are similarly deformed as a result of spooling on a multi-layer drum.

If there is an obvious local decrease in diameter, such as that caused by failure of a core or rope center, the rope shall be discarded.

Rope type	**Uniform decrease of the diameter (expressed as % of nominal diameter)**	**Severity rating**	
		Description	%
Single-layer rope with fibre core	Less than 6 %	No damage	0
	6 % and over but less than 7 %	Slight	20
	7 % and over but less than 8 %	Medium	40
	8 % and over but less than 9 %	High	60
	9 % and over but less than 10 %	Very High	80
	10 % and over	Discard	100
Single-layer rope with steel core or parallel-closed rope	Less than 3,5 %	No damage	0
	3,5 % and over but less than 4,5 %	Slight	20
	4,5 % and over but less than 5,5 %	Medium	40
	5,5 % and over but less than 6,5 %	High	60
	6,5 % and over but less than 7,5 %	Very High	80
	7,5 % and over	Discard	100
Rotation-resistant rope	Less than 1 %	No damage	0
	1 % and over but less than 2 %	Slight	20
	2 % and over but less than 3 %	Medium	40
	3 % and over but less than 4 %	High	60
	4 % and over but less than 5 %	Very High	80
	5 % and over	Discard	100

Table 9 - Uniform decrease in diameter signaling discard of rope - Rope spooling on a single-layer drum and/or running through a steel sheave

Actual uniform decrease in diameter, expressed as % of nominal diameter, is calculated like that:

$[(d_{ref} - d_m)/d]$
where
d_{ref} is the reference diameter (the actual one reported in rope certificate);
d_m is the measured diameter (measured as described in chapter 6.2.1)
d is the nominal diameter.

Example: 40mm 6×36-IWRC rope (single-layer rope with steel core) having d_{ref} = 41,2mm and d_m = 39,5mm at the moment of inspection.

The diameter decrease is equal to: (41,2 – 39,5)/40 = 4,25%.

From Table 9, the severity rating for uniform decrease in diameter is 20% towards discard (i.e. slight).

9.4. FRACTURE OF STRANDS

Figure 78 - Strand fracture

Possible causes

- Local concentration of damage at on particular strand that leads to its complete fracture
  - Such damages could be for eg:
    - Wire breaks
    - Wear and abrasion
    - Mechanical damages

9.4.1. DISCARD CRITERIA

If a complete strand fracture occurs, the rope shall be immediately discarded.

9.5. CORROSION

Corrosion may occur internally before there is any visible external evidence on the rope's surface.

Plastic impregnated core ropes provide only improved corrosion resistance since they apply a structural barrier against the environment.

Figure 79 - External corrosion

Possible causes

- Environmental conditions
- Lacking or ineffective lubrication
- Moisture trapped inside the rope ➔ lubricant may become ineffective over time

Figure 80 - Fretting corrosion due to inter-strand contact

Possible causes

- Strand to strand contact due to insufficient clearance (gap) between the strands
- Reduction of rope diameter
- Fretting refers to wear and sometimes corrosion damage at the asperities of contact surfaces

⚠ **WARNING! Potential hazards!**

Fretting corrosion is a strong indication for inter-strand contact. There is a high risk of valley wire breaks that are hidden and hardly detectable by visual inspection.

▷ See valley wire breaks 9.2.2
▷ See discard criteria for fretting corrosion 9.5.2

9.5.1. INSPECTION PROCEDURE AND SUGGESTIONS

⚠ WARNING! Risk of injury by running rope!

Carrying out inspections or examinations while the rope is running has the high risk of causing injuries.

▷ Never carry out any inspection or examination without recognizing the potential hazards associated with working on a moving rope.

When assessing the extent of corrosion, it is important to recognize the difference between corrosion of the wires and any corrosion on the rope surface that is associated with the oxidation of foreign particles.

Therefore, before making an assessment, the rope sections undergoing inspection shall be wiped or brushed clean. The use of solvents for cleaning should be avoided.

- ▶ Visually check for any signs of corrosion damage as evidenced by rope bleeding or roughing.
- ▶ Frequently measure the diameter. An increase in diameter can result from internal or fretting corrosion.
- ▶ Check the lay of the rope. As the plastic is thinner over the crown wires, a thorough inspection may determine a lengthening of the lay.
- ▶ Especially when trying to determine the lengthening of the lay, check areas where the plastic pulls away from the rope. While peeling in and of itself is not an indication of rope deterioration and is a factor of normal wear, peeling in areas where no abrasion exists may indicate a problem.
- ▶ Review frequency, amount and type of service re-lubrication.
- ▶ In case of slight discoloration caused by rusting, lubricate the rope.
- ▶ If the rope shall be replaced mainly due to corrosion, consider selection of galvanized rope.
- ▶ If interior damage, broken wires or core failure is suspected, carefully open a section of rope for internal examination without kinking or grooving the rope.
- ▶ Carefully work a marlin spike beneath two strands and rotate the spike to expose the core and underside of strands.
- ▶ Use an awl to probe for broken wires and examine inner surfaces.
- ▶ If the rope has an independent wire rope core (IWRC), look for broken wires on the undersides of strands where the strands contact the IWRC.
- ▶ Look for excessive nicks or broken wires in the strands caused by contact between adjacent strands or with IWRC.
- ▶ Examine the IWRC for broken wires.
- ▶ If a spike has been inserted properly and carefully, and internal condition does not show cause for removal, remove the spike and return the strands to their original working positions without distorting the rope or impairing future usefulness.

9.5.2. DISCARD CRITERIA

Type of corrosion	Condition	Severity rating	
External corrosion [i]	Signs of surface corrosion but can be wiped clean	Superficial	0%
	Wire surface rough to touch [ii]	High	60%
	Wire surface heavily pitted and slack wires [i]	Discard	100%
Internal corrosion [iv]	Obvious visible signs of internal corrosion, i.e. corrosion debris extruding from the valleys between the outer strands [iii]	Discard: 100% or if deemed practicable by the competent person, internal examination with MRT in accordance with the procedure described in chapter 6.3 and Annex C of ISO 4309.	
Fretting corrosion	The process of fretting involves the removal of fine particles of steel from the wires due to dry wires and strands constantly rubbing together and then oxidizing and creating internal corrosion debris, which manifests itself as a dry powder, similar to a red rouge.	Evidence of such a characteristic should be further investigated and if there is any doubt about its severity, the rope should be discarded (100%).	

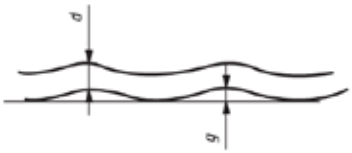
(i) For any other intermediate condition, an assessment should be made as to its severity rating (i.e. contribution towards the combined effect).

(ii) The oxidation of zinc-coated wires can result in a wire surface which is also rough to the touch, but the overall condition might not be as serious as wires which are not coated. In such cases, the inspector may consider applying a lower contribution towards the combined effect to that given above in this table.

(iii) Assessment of internal corrosion is subjective without MRT. However, if there is any doubt about the seriousness of any internal corrosion, the rope should be discarded.

Table 10 - Discard criteria for corrosion and intermediate severity ratings

9.6. WAVINESS



Key
d nominal rope diameter
g gap

Figure 9 — Waviness of rope

Figure 81 - Waviness of rope causing gaps

Possible causes

- Too small groove radius
- Too large fleet-angle
- Untwisting during installation
- Core imbalance
- Lack of straightness (screw effect)

9.6.1. INSPECTION PROCEDURE AND SUGGESTIONS

Figure 82 - How to measure waviness

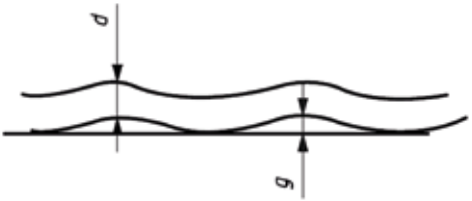
- ▶ Check all grooves with gauges
- ▶ Check reeving
- ▶ Check flange of the sheaves for damage areas
- ▶ Measure severity of waviness with the aid of a ruler (Fig. 82)

9.6.2. DISCARD CRITERIA

The rope shall be discarded if, under any condition, either of the following conditions exists:

a) On a straight portion of rope, which never runs through or around a sheave or spools on to the drum, the gap between a straightedge and the underside of the helix is 1/3 × d or greater;

b) On a portion of rope, which runs through a sheave or spools on to the drum, the gap between a straightedge and the underside of the helix is 1/10 × d or greater.



Key
d nominal rope diameter
g gap

Figure 83 - parameters to evaluate waviness

9.7. BASKET DEFORMATION

Figure 84 - Basket deformation

Possible causes

- Untwisting during time in service
- Shock loading
- Too small groove radius
- Movement in lay length

9.7.1. INSPECTION PROCEDURE AND SUGGESTIONS

▶ Mark the rope and search for influences in the reeving
▶ Review operating conditions
▶ Check all grooves with gauges

9.7.2. DISCARD CRITERIA

Ropes with a basket or lantern deformation (see Figure 84) shall be immediately discarded or, provided the remaining length of rope is in a serviceable condition, have the affected section removed.

9.8. CORE/STRAND PROTRUSION OR DISTORSION

Figure 85 - Core protrusion

Figure 86 - Protrusion of inner rope

Figure 87 - Strand protrusion/distortion

Possible causes

- Shock loading
- Too large fleet-angle

9.8.1. INSPECTION PROCEDURE AND SUGGESTIONS

▶ Review operating conditions
▶ Control reeving

9.8.2. DISCARD CRITERIA

Ropes with core or strand protrusion (see Figures above) shall be immediately discarded or, provided the remaining length of rope is in a serviceable condition, the affected section shall be removed.

9.9. PROTRUDING WIRES IN LOOPS

Figure 88 - Wire protrusion in loops

Possible causes

- Loop formations can be (but may not be) caused by insufficient clearance between the wires in the strand. Lack of clearance will prevent these wires from moving relative to their neighbours, causing overloading and yield

9.9.1. DISCARD CRITERIA

Ropes with protruding wires, usually occurring in groups on the opposite side of the rope to that which is in contact with a sheave groove, shall be immediately discarded.

Evidence of a single king wire from the core that protrudes between the outer strands of the rope may not necessarily be a reason for discard, provided that it can either be removed or does not interfere with other elements of the rope during operation.

9.10. LOCAL INCREASE IN ROPE DIAMETER

Figure 89 - Local increase in rope diameter due to core distortion

Possible causes

- Core swelling or distortion
- Absorption of moisture
- Outer strands imbalance ➔ incorrect orientation

9.10.1. DISCARD CRITERIA

If the rope diameter increases by 5% of the nominal diameter or more for a rope with a steel core or 10% or more for a rope with a fiber core during service, the reason for this shall be investigated and consideration given to discarding the rope.

9.11. FLATTENED PORTION AND CRUSHING

Figure 90a - Flattened portions

Figure 90b - Flattened portions

Figure 91 - Rope crushing

Figure 92 - Mechanical damage

Possible causes

- Usage of wrong wire rope construction
- Improper wire rope installation (e.g. rope not installed under tension)
- Loose first layer / wraps on the drum ➔ rapid deterioration
- Rope break-in failure or procedure absent ➔ poor spooling conditions
- Mechanical damage

9.11.1. INSPECTION PROCEDURE AND SUGGESTIONS

- Ensure that the wire rope is correctly installed.
- Check the tightness of the rope of each layer and wrap.
- Check how many wraps are remaining on the drum while the boom is in boom rest position (dead wraps should be just as much as required as safety wraps acc. to the standards but as less as possible).
- If there is an indication of rope-crushing try to shift the cross over point (crushed area) with the help of slip & cut (see chapter 8.4).
- Reinstall the rope with tension; for luffing ropes tighten the rope structure with the help of twisting.
- Check D/d ration
- Check the tightness of the rope structure (test with screw driver)

9.11.2. DISCARD CRITERIA

Flattened portions of rope which run through a sheave are likely to deteriorate more quickly and exhibit broken wires. In such cases, but depending on the extent of the flattening, consideration may be given to discarding the rope.

Flattened portions of rope in standard rigging can suffer a greater degree of corrosion than other non-affected portions, more so when the outer strands open up and allow ingress of moisture. If retained in service, they shall be inspected more frequently; otherwise, consideration should be given to discarding the rope.

It is possible for flattened portions of rope, which result from multi-layer spooling, to not give rise to discard, providing the numbers of broken wires associated with the flattening do not exceed the values given in Tables 7 and 8.

9.12. KINK (HIGH STRANDING) OR TIGHTENED LOOP

Figure 93 - Positive kink

Figure 94 - Negative kink

Figure 95 - Kink (tightened loop)

Possible causes

- Low D/d ratio

9.12.1. DISCARD CRITERIA

Ropes with a kink or tightened loop shall be immediately discarded.

9.13. BEND IN ROPE

Figure 96 - Rope bends

Possible causes

- External contact to structure over which the rope was pulled
- Too small coiling radius respectively too small D/d ratio

9.13.1. DISCARD CRITERIA

Portions of rope with a severe bend which run through a sheave are likely to quickly deteriorate and exhibit broken wires. In such cases, the rope shall be immediately discarded.

If the degree of bend is not considered to be severe and the rope is retained in service, it shall be inspected more frequently; otherwise, consideration should be given to discarding the rope.

The decision as to whether or not the bend is severe is subjective. If there is a fold in the rope on the underside of the bend, this should be considered severe, whether or not the rope runs over a sheave.

9.14. DAMAGE DUE TO HEAT OR ELECTRIC ARCING

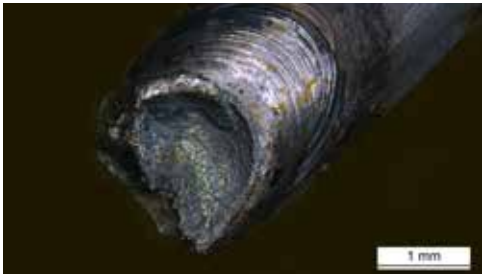


Figure 97 - Electric arcing

Possible causes

- Heat damage from high temperatures
- Incorrectly grounded welding lead in conductor ropes
- Contact with electrical cable
- Lightning strike
- Using a wire rope to ground an electric arc welder

Arcing occurs when an electrical current passes either to a wire rope or from a rope to another object. This creates a local area of heating that changes the properties of the wire rope (strength – fatigue resistance).

9.14.1. DISCARD CRITERIA

Ropes that are not normally operated at temperature, but have been subjected to exceptionally high thermal effects, externally recognizable by the associated heat colours produced in the steel wires and/or a distinct loss of grease from the rope, shall be immediately discarded.

If two or more wires have been affected locally, due to electric arcing, the rope shall be discarded. This can occur at the point where the current enters or leaves the rope.

9.15. LENGTHENING OF THE ROPE LAY

Possible causes

- Core destruction
- Wear
- Diameter reduction
- Worn sheaves
  - When a sheave groove bottom wears, it may restrict normal movement as the rope enters and leaves the groove: the result may be a twist build-up which can change the lay length.
- Rope operation without having both ends secured to prevent rotation
  - An end swivel rope termination permits such rotation and unlaying.

9.15.1. INSPECTION PROCEDURE AND SUGGESTIONS

⚠ **WARNING! Risk of injury by running rope!**

Carrying out inspections or examinations while the rope is running has the high risk of causing injuries.

▷ Never carry out any inspection or examination without recognizing the potential hazards associated with working on a moving rope.

An abrupt change in lay length can be a signal of an impending problem.

▶ Measure the rope lay measurements after the initial loading, for comparison purposes at succeeding periodic inspections (see chapter 6.2.2).

▶ Try to determine the cause for unlaying.

▶ Note the unlaying for future reference if the immediate cause cannot be determined.

▶ In case lengthening of rope lay occurred consider rope replacement or consult a competent person or TEUFELBERGER-REDAELLI

9.16. SHOCK LOADING

Shock loading is caused by the sudden release of tension on the wire rope and its resulting rebound from being overloaded. In such cases parts of the rope may exceed the yield strength and a permanent elongation occurs. Thus, the load shares in the cross section are distributed differently. This may lead to other phenomena's like change of rotational properties, torsional stress, change in flexibility, etc.

▶ In case shock loading occurred consider rope replacement or consult a competent person or TEUFELBERGER-REDAELLI

10. REQUIRED ORDERING INFORMATION

10.1. REPLACEMENT OF A ROPE OF THE SAME TYPE

Enquiries to Teufelberger-Redaelli should include the following data:

- Teufelberger-Redaelli order confirmation No. or your P.O. No.

10.2. REPLACEMENT OF A ROPE OF A DIFFERENT TYPE

Enquiries to Teufelberger-Redaelli for new steel wire ropes should include the following minimum data. Data marked with an asterisk are mandatory.

- Reference data:
  - Project name and number
  - Application type*
- Wire rope data:
  - Reference standard*
  - Rope class or construction*
  - Rope grade
  - Lay direction and type*
  - Surface (bright/zinc coated/Zn95Al5)*
  - Compacted strands (Y/N)*
  - Nominal diameter and tolerance*
  - Expected diameter under tension
  - Nominal length and tolerance*
  - Minimum breaking force*
  - Minimum aggregate breaking force
- Rope packing:
  - Reel type (steel, wooden, special)
  - Standard, seaworthy or other packing type
- Other:
  - Required certifications
  - Required documentation (manufactures standard, special, API etc.)

11. DECOMMISSIONING

Only qualified personnel who knows the standards ISO 4309 and EN 12385 may decommission the product.

- Refer to all safety regulations related to the product.
- Respect the disassembly instructions.
- Wear personal protective equipment according to the local safety procedures (work clothing, helmet, gloves, eye protection, safety shoes).during disposal.
- Pay attention during removal of damaged wire ropes which could tear during replacement.
- Pay attention when removing worn wire ropes or damaged (protruding) wires from drums and sheaves. Permanent distortions or wound parts may cause injuries.
- For wire ropes used in plastic or non-metallic sheaves, refer to the User Manual of the application or contact the manufacturer for specific replacement criteria.
- Note the data and the reason of replacement on the product's certificate for future reference.
- Store discarded wire ropes in a safe place and identify them as removed and worn ropes that may not be used again.
- Dispose of the product following local requirements.

SERVICE HOTLINE

We are your competent service partner and will provide you help and answers within 24 hours: +43 (0) 7242 615 1388 or apptec.wr@teufelberger.com

TEUFELBERGER Seil Ges.m.b.H.
Böhmerwaldstraße 20
4600 Wels, Austria
Telephone: +43 (0) 7242 615-0
Fax: +43 (0) 7242 60501
E-Mail: wirerope@teufelberger.com
Customer Service: apptec.wr@teufelberger.com

REDAELLI TECNA S.P.A.
Via Alessando Volta, 16
I-20093 Cologno Monzese (MI, Italy)
Telephone: +39 02 25307219
Fax: +39 02 25307212
E-Mail: wireropes@redaelli.com
Customer Service: service@redaelli.com

www.teufelberger-redaelli.com

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