Original Operation & Maintenance Instructions for Steel Wire Ropes
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<td>63</td>
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1 Premise

1.1 Thank you dear valued customer

Thank you for choosing a Redaelli steel wire rope. We know that you, the customer, are the reason we are in business. Your satisfaction is our number one priority. With this in mind, we have produced this product in the way to be of the highest quality, performance and reliability. All our products are conform to the latest national and international rules specified in the related certificates. They have all been individually tested as per our QA procedures. Redaelli is synonymous for highest quality and reliability worldwide.

This User Manual will assist you in the handling and maintenance of this product. If after reading the following pages you are unsure or uncomfortable about safely using our wire ropes, we urge you to seek additional information through our website or to directly use the contacts shown in the present manual.
2 Introduction to this manual

2.1 Scope of this document

This document shows you how to correctly install and set up Steel Wire Ropes.

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.

<table>
<thead>
<tr>
<th>Target group</th>
<th>Provided information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installer</td>
<td>Product installation and maintenance</td>
</tr>
<tr>
<td>End User</td>
<td>Product usage</td>
</tr>
</tbody>
</table>

2.3 References documents

The reference documentation to this manual is the following:

<table>
<thead>
<tr>
<th>Documentation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rope data sheets</td>
<td>Containing all technical rope data</td>
</tr>
<tr>
<td>Contract</td>
<td>Containing the contractually agreed data</td>
</tr>
<tr>
<td>Accessories catalogues</td>
<td>Containing the accessories technical information</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Convention</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓</td>
<td>Prerequisite: Preceding condition required before an action.</td>
</tr>
<tr>
<td>▶</td>
<td>Action: Single action.</td>
</tr>
<tr>
<td>1. Step</td>
<td>One of a sequence of actions.</td>
</tr>
<tr>
<td>− Sub step</td>
<td>Additional steps of an action or a step.</td>
</tr>
<tr>
<td>Intermediate result</td>
<td>Result of a step.</td>
</tr>
<tr>
<td>← Result</td>
<td>Result of an action or a sequence of actions.</td>
</tr>
<tr>
<td>• List</td>
<td>List of elements.</td>
</tr>
<tr>
<td>− Sub list</td>
<td>Additional elements of a list entry.</td>
</tr>
</tbody>
</table>

⚠️ 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.

2.5 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. For the latest updates on Redaelli’s HSE policy and recommendations, refer to www.redaelli.com.

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. 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 have to be opened partially or completely, or have to 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).
3 Health, safety and environment

- 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.
Redaelli denies any liability for possible consequences of misuse.

3.4 Residual risks
3.4.1 Broken wires
Despite all accuracy during manufacturing, some broken wires may have sharp ends. These sharp ends may lead to injuries.
  ▶ Wear protective gloves.

3.4.2 Overheating
Overheating of the product can lead to injuries.
  ▶ Wear protective gloves when touching the ropes.

3.4.3 Corrosion
Corrosion may damage the product.
  ▶ Periodically check the layer of the protective coating.

3.5 Product and packing material disposal
The product and packing material can be disposed of by the owner, by Redaelli or by authorized third parties.
  ▶ 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 About the product

4.1 Identification of the product

For identification of the product, refer to the related contractual ropes data sheet.

4.2 Description of the product

4.2.1 Definitions

Wire rope

![Diagram of wire rope elements]

Fig. 1: Elements of a wire rope

1 Core
2 Wire
3 Strand
4 Wire rope

A wire rope is a mechanical component that transmits force and shifts along its axis.

The elements of the wire rope are arranged in a spiral 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 (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 starting or stopping)
- Resistance to transverse pressure
4 About the product

**Winding**

![Winding Image]

Fig. 2: Winding (strands)

1. Right winding (z)
2. Left winding (s)

![Lay Image]

Fig. 3: Lay (wire ropes)

1. Right regular lay (sZ)
2. Left regular lay (zS)
3. Right lang lay (zZ)
4. Left lang lay (sS)

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

**Strands**

The wires are the main components of a wire rope and form a strand. During rope making, the single strands are coupled to a wire rope. Besides the possible configurations, the geometrical characteristics of a strand are its diameter and lay length.

The configurations are used for the following:
- Optimal filling of the desired section
- Linear support between the layers
- Guarantee of the necessary resistance to transverse pressure
Each layer of the wires may spread out according to the previous layer, followings some basic configurations:

- Normal (N): There is no connection to the number of wires of the former layer. The lay length of each layer is different.
- Seale (S): The number of wires of one layer is the same as of the previous wire. The lay length is the same for all the wires.
- Warrington (W): The number of wires of one layer is twice the number of wires of the previous layer. The lay length is the same for all the wires.
- Filler (F): The number of wires of one layer is twice the number of wires of the previous layer, including additional filling wires.

<table>
<thead>
<tr>
<th>Form</th>
<th>Description</th>
<th>Symbol</th>
<th>Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Single layer</td>
<td>7</td>
<td>1-6</td>
</tr>
<tr>
<td></td>
<td>Seale</td>
<td>19S</td>
<td>1-9-9</td>
</tr>
<tr>
<td></td>
<td>Warrington</td>
<td>19W</td>
<td>1-6-(6+6)</td>
</tr>
<tr>
<td></td>
<td>Filler</td>
<td>25F</td>
<td>1-6-(6F)-12</td>
</tr>
<tr>
<td></td>
<td>Warrington-Seale</td>
<td>31WS</td>
<td>1-6-(6+6)-12</td>
</tr>
<tr>
<td></td>
<td>Seale-Filler</td>
<td>46SF</td>
<td>1-9-9-(9F)-18</td>
</tr>
</tbody>
</table>

Tab. 1: Strand types
Strand compaction

Strand compaction is a cold deformation process which is used to achieve the following:
- Augmentation of the resistant part of the wire rope to equalize the diameter
- Creation of larger contact zones between the wires
- Obtaining an external surface that is more regular, larger, smoother and less permeable
- Equalizing the distribution of the tension on the wires
- Augmentation of the dimensional stability with regard to transversal forces
- Higher resistance to wear and abrasion, thus increasing the life time of the wire rope

During stranding, one rotation of the stranding machine forms one lay length of a strand. The lay length of compacted strands is longer than the lay length of non-compacted strands, thus allowing to obtain a more elastic wire rope and reducing the loss of stranding.

<table>
<thead>
<tr>
<th>Stranding type</th>
<th>Load factor %</th>
<th>Gain %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Normal</td>
<td>Compacted</td>
</tr>
<tr>
<td>7S</td>
<td>76,0</td>
<td>93,6</td>
</tr>
<tr>
<td>19S</td>
<td>80,8</td>
<td>93,5</td>
</tr>
<tr>
<td>25F</td>
<td>83,5</td>
<td>94,0</td>
</tr>
<tr>
<td>36WS</td>
<td>82,7</td>
<td>89,5</td>
</tr>
</tbody>
</table>

Core

The core is the central component around which the strands are wound.

Fig. 5: Core
4.2.2 **Rope types**

The product according to the data sheet can be one of four main families of steel wire ropes:

**Stranded ropes**

Stranded ropes are formed by laying the strands together helically, in one or more layers around a core. Compacted strands provide a bigger metallic area than conventional strands with round wires at the same wire rope diameter; thus offering higher minimum breaking loads for the same wire rope diameter.

A high number of strands ensures a high flexibility and resistance to transversal pressure and wear. The compacted strands provide a smoother and wider surface and create extended contact areas among the wires.

**Locked coil ropes**

Full locked coil ropes have a locked outer layer with z-shaped wires or h-shaped and round wires. Locked coil ropes preform perfectly where strength, rotation resistance and reduced stretching are necessary. They are used in static applications such as tensostructures for bridges or stadiums, track ropes for bicable aerial cableways, Koepe hoists, but are not necessarily limited to these applications.

**Spiral ropes**

One or more layers of helically laid wires around a centre wire form spiral ropes, which are often used for static applications such as bridges, stadiums, general tensostructures, and offshore applications such as permanent mooring lines of Floating Production Storage and Offloading Units (FPSOs), drilling rigs, windmill towers in offshore fields.
Special 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 no rotation and low residual torque behaviour are requested.

Fig. 9: Special rope

4.2.3 Rope characteristics

Behaviour of steel wire ropes depends on some specific technical characteristics that can be summarized in a set of parameters.

Rotational stability

Ropes can be built with low or high rotational stability, depending on the characteristics of the specific application. Low rotational behaviour is, e.g., mandatory for applications where single fall is a must.

The rotational properties of the product can be described using some fundamental factors (characteristics of the rope).

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 twisting. It can be considered as the cause which produces the rotation and it is usually indicated using a non-dimensional value.

Rotation factor

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

Axial stiffness

Axial tension will generate, based on the design of the rope, a torque leading to a rotation of the rope.

Radial stiffness

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

Radial stiffness correlates pressure and radial deformation.
Fig. 10: Correlation of pressure and radial deformation

**Bending stiffness**

Bending stiffness is an essential characteristic of each wire rope which is related to the force that the wire rope exerts when it is bent in round shape. The bending force depends on the diameter of the rope and on the force factor depending on the wire rope configuration.

Fig. 11: Bending force as a result of the correlation of different rope characteristics

**Fleet angle**

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. Generally, the maximum angle for special hoisting ropes should never exceed 1.5° to 2° to avoid distortion of the steel wire rope.
Lubrication

Lubrication on ropes, received during the manufacturing process, may expire and needs re-lubrication with recommended lubricant, particularly in zones subject to bending (see chapter 7.2.2, p. 47). Correct lubrication provides protection against corrosion and internal and external friction for a certain period of time.

Coating protection

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

Plastic impregnation and external sheeting

Plastic impregnation and external sheeting adds specific characteristics to the rope with positive impact on the life time. It prevents water from entering the rope and lowers the wear caused by friction between the single wires.

<table>
<thead>
<tr>
<th>Figure</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Core</td>
<td>The plastic is extruded on the outside of the core.</td>
</tr>
<tr>
<td></td>
<td>Cut clear</td>
<td>All layers are under plastic, so that the nominal diameter of the wire rope is reached.</td>
</tr>
<tr>
<td></td>
<td>Coextrusion (external)</td>
<td>The two external layers are under plastic, so that the nominal diameter of the wire rope is reached.</td>
</tr>
<tr>
<td></td>
<td>Longitudinal line</td>
<td>A longitudinal extrusion is applied along the axis of the wire rope.</td>
</tr>
</tbody>
</table>

Tab. 2: Plastic impregnation and external sheeting
4.3 Rope terminations

Rope terminations have to accomplish typically the following needs: pulling-in and pulling-out of the rope into the machinery / structure in which it must be installed, rope connection to the machinery / structure to which it must be connected; connection to the transportation and storage drum, safe handling and installation.

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

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). For closed ropes, coiled ropes and Hercules ropes two bindings are used that are twice as long or longer than the diameter.

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.

Becket weld, loop weld, becket weld with chain links

Like plain welding, but with applications for welding of a nut or a ring which can guide the ending of the wire rope during mounting.
**Twist welding / Tapering**
The endings of the wire rope are rotated on the appropriate machine after heating the cutting point for twisted welding of the single strands.

**Soldered end with becket loop**
Eye which is obtained by attaching the core of the wire rope to itself using an extruded coupling. This eye is only used during installation of the wire rope.

**Splicing**
Connection of the two endings by coupling the strands of the opposite endings. The length of the used strands is defined in the standards of the application.

**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.

**Coupled eye with or without thimble (extruded coupling)**
Eye which is obtained by attaching the endings of the wire rope to themselves using an extruded aluminum coupling. For identifying the correct type of thimble for the specific application, refer to the standard EN 13411.

**Flemish eye**
Eye which is obtained by attaching the core of the wire rope to itself by applying a truncated cone coupling. This eye is only used for installation of the wire rope according to EN 13411.

**Ferrule**
Ending which is obtained by pressing the wire rope end.

**Ending with spelter, bridge or cylindrical socket**
Ending which is obtained by blasting two-component resin or metallic alloys (with zinc, tin, or lead) into conical grooves predisposed for opened endings, thus increasing the adherence and the resistance under load between wire rope and melted material.

**Asymmetric wedge socket**
One of the most commonly used systems for attaching wire ropes to cranes. This ending anchors the loose wire end to the lifting system without using special endings, thus allowing dismounting, shortening and remounting.

**Locking clamps**
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).

**Efficiency grades of terminations**
The efficiency grade is the relation between minimum breaking load (MBL) 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 load of the wire rope, but to the effective breaking load of the wire rope and its rope termination system. To determine the breaking load of the wire rope and its rope termination system, use the following table which shows the efficiency grades of the most commonly used terminations:
4 About the product

<table>
<thead>
<tr>
<th>Termination type</th>
<th>Referenced standards</th>
<th>Application range of the wire rope</th>
<th>Efficiency grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spelter, bridge or cylindrical socket</td>
<td>EN 13411-4</td>
<td>All diameters</td>
<td>1.00</td>
</tr>
<tr>
<td>Talurit or pressed steel sleeves</td>
<td>EN 13411-1</td>
<td>All diameters</td>
<td>0.90</td>
</tr>
<tr>
<td>Asymmetric wedge socket</td>
<td>EN 13411-6</td>
<td>Wire ropes with resistance &lt; 1960 N/mm²</td>
<td>0.85</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wire ropes with resistance &gt; 1960 N/mm²</td>
<td>0.80</td>
</tr>
<tr>
<td>Manual splicing</td>
<td>EN 13411-2</td>
<td>Diameters &lt; 60 mm</td>
<td>0.80</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Diameters &gt; 60 mm</td>
<td>0.70</td>
</tr>
<tr>
<td>Clamp</td>
<td>EN 13411-5</td>
<td>All diameters</td>
<td>0.80</td>
</tr>
</tbody>
</table>

Tab. 3: Efficiency grades according to EN ISO 16841

4.4 Description of the application

4.4.1 Offshore

Oil & gas companies put particular requirements on their equipment suppliers. Special offshore cranes, winches, and systems using wire ropes in general require wire ropes that match the characteristics of the equipment.

Fig. 12: Examples: Equipment used in offshore applications

4.4.2 Cranes and industrial

The industrial lifting sector needs high level of performance. Multistrand high-tech ropes and non rotating high-tech crane ropes fit these needs and deliver at the same time high performance in terms of load capacity, life time, wear, fleet angle and crushing resistance.
4.4.3 Mining
Underground and surface mining have very severe requirements regarding performance in terms of load capacity, weight requirements, life time, wear, fleet angle and crushing resistance. Specific strand design, compacted strands, plastic coated cores and non rotating constructions of ropes are used for this application.

Fig. 14: Examples: Equipment used in mining
4.4.4 **Cable ways**

Cableways installations can be either for people or material transportations; both types of installation are required to operate in very specific conditions. People cableways have to target people’s safety first. In many cases they have to operate in extremely cold environments, and they are often required to operate with very little downtime. On the other hand, installations for material transport have to fulfilled heavy duty requirements in terms of production efficiency required by the plant in which they are installed. Therefore, the ropes for both type of installation have to undergo very strict rules in terms of design, material selection, testing and inspections.

![Examples: Equipment used in cableways](image1)

Fig. 15: Examples: Equipment used in cableways

4.4.5 **Tensosturctures**

For many decades, Redaelli has focused its resources on the development and production of systems for tensosturcture engineering; offering complete and innovative technical solutions. In recent years the Redaelli name has been linked with the construction of the Storebaelt Bridge in Denmark, the longest suspension bridge in Europe, the support of the Tower of Pisa, the cables for the Warsaw Stadium, and many other important and famous buildings all over the world.

![Examples: Applications of steel cables on tensosturctures](image2)

Fig. 16: Examples: Applications of steel cables on tensosturctures
5 Packing, transportation, handling and storage

5.1 Rope packing

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

Fig. 17: Supports

1. Crate
2. Reel (with cradle)
3. Single coil on pallet
4. Multiple coils on pallets

Dimensions of the packaging depend on the rope length.

5.2 Rope handling

The lifting system has to ensure the necessary stability during hoisting of the coils. The choice of the lifting equipment depends on the rope size and length, and on specific customer requirements. Bigger packages have to 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. Redaelli’s standard packaging is suitable for a maximum of 2 months (including handling, transport, storage and installation operations). For longer periods a specific packaging or specific operational procedures are required.
5.2.1 Reel and drum loading and unloading

- In case of small reels or drums, lift the pallet 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 its 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.

Fig. 18: Handling reels
Fig. 19: Examples of reels
Fig. 20: Example of correct handling of reels
5 Packing, transportation, handling and storage

5.2.2 Transporting

⚠️ 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 (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.

Fig. 21: Transport

5.2.3 Delivery integrity

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

ℹ️ In case of damage or doubts take notes and pictures of the situation.

▷ Contact your sales representative.

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 loads
   - 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.

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

In case of damage or doubts:

▷ Take notes and pictures of the situation.
▷ Contact your sales representative in Redaelli.

### 5.3 Storage

All storage areas must fulfill the following requirements:

- Equipped with hard floor.
- Free of chemicals, steam or any other corrosive agents that can affect the product.
- Indoor warehouses must be cool, dry, clean, dust-free, well-ventilated and covered.
- Adjacent areas must be separated by means of hurdles, barricades, barriers or fences.
- Adjacent areas must be surveyed, and users must issue reports of any damage.

**NOTICE! Material damage!**

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.

![Storage diagram](image-url)
Long-term storage

Contact Redaelli for further information on long-term 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. If the product has already been used, clean, dry and relubricate the product.
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.
6 Installation

⚠️ 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.
▷ Thoroughly follow all safety measures.
▷ Wear personal protective equipment (work clothing, helmet, gloves, eye protection, safety shoes, respiratory protection).

▷ During installation, ensure that the wire rope does not suffer from torsions, distortions, abrasions and other influences.

Ropes can be installed in 2 different ways:

- Installation with the help of an existing rope
- Installation with the help of an auxiliary rope

▷ In both cases: Ensure that both ropes have the same winding direction.

The use of auxiliary ropes with another winding than the wire rope itself may lead to rotations and geometrical deformations which may compromise the wire rope’s performance.

▷ 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
  - The steel reel on which the rope is delivered can only support a direct unwinding force. During rope installation, allow a higher and correct rope back tension on the final drum (2% of the rope minimum breaking force or 10% of the safety working load). Wooden reels may not be used for unwinding.
- Supplementary components for the application of the rope depending on the properties of the ground
  - These components must prevent the rope from getting into contact with the ground or obstacles. Diameter and groove must be adapted to the rope’s diameter.

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.
6.1.1 Checking the principal characteristics of the steel wire rope

Diameter

Fig. 23: Checking the diameter

1 Correct  2 Wrong

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. Therefore, the section of a wire rope is intended as the medium value of four measurements on the straight and unloaded wire rope (or with maximum tension of 5% of the minimum breaking load) on two orthogonal sections in a distance of at least one meter.

- Use the medium 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.

- Use a micrometer caliper suitable for the wire rope diameter and the number of lay lengths of the strands.

- Using wide plate calipers, ensure that the measurement is taken on the diameter of the defined circle.

In case of uneven numbers of external strands, it is impossible to use wide plate calipers to measure strands that are on the opposite of each other.

- Measure the medium diameter ($d_m$) of the wire rope.

- Multiply the obtained value with a factor from the following table.

<table>
<thead>
<tr>
<th>Number of strands</th>
<th>D/t</th>
<th>$d/d_m$</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>2.17</td>
<td>1.15</td>
</tr>
<tr>
<td>5</td>
<td>2.77</td>
<td>1.06</td>
</tr>
<tr>
<td>7</td>
<td>3.41</td>
<td>1.03</td>
</tr>
<tr>
<td>9</td>
<td>4.16</td>
<td>1.02</td>
</tr>
<tr>
<td>15</td>
<td>6.32</td>
<td>1.01</td>
</tr>
</tbody>
</table>

Tab. 4: Diameter measurement
**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:**

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 \((n \times m + 1)\).

For a more precise result, use a higher number of lay lengths on the wire rope. Thus, mistakes while reading the alignment of the reference points can be avoided.

**Indirect method:**

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 and divide the result by the number of measurements.

A variation of lay length in a wire rope in use is always a sign for anomalies. 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 Redaelli personnel for mounting, inspecting and maintaining the Redaelli wire ropes.

**Spacing**

The spacing between the strands of a new wire rope is essential, and may have variations in form.
To control the spacing, insert a feeler gauge between every couple of strands that are next to another.

**Preforming**

During the preforming process, the wires or strands are being deformed helically while closing the wire rope in order to get closer to the previous layer. The preforming process with a higher or lower intensity level grants a higher performance of the mechanical characteristics of the wires and strands and of the rope itself.

Even with the same geometrical characteristics and the same resistance, preforming has a big influence on the behaviour of the wire rope.

To verify the correct level of preforming, wind off a strand of a wire rope for at least one lay length, then wind it back in its original position.

The following 3 types of preforming can be defined:

- Perfectly preformed: The strand returns to its original position and firmly stays in this position.
- Preformed or slightly preformed: The strand returns to its original position, but with a tendency to be slack.
- Non preformed: The strand returns to its original position, but with a tendency to wind off again, if you let go.

**Geometrical check**

- For a geometrical check of the preforming, measure the height and the length of the helix of the strands that are wound off.
- Note the difference in lay length and in diameter of the wire rope in percent.
- Verify the correct uniformity of the preforming between the strands.

**Practical check**

- For a practical check of the preforming, beat the endings of the wire rope on the ground.
  - If the endings of the wire rope are correctly preformed, they remain unchanged and resist to winding off.
  - If the endings of the wire rope are insufficiently preformed and break up, binding or coiling are necessary to prevent decomposition.

**Rotational check**

- Wind off the wire rope for several meters from the coil.
- Verify the tendency and the extent of rotation of the ending around its own axis (opening or closing direction).
  - The rotation of the loose ending of the wire rope should be less than ¼ rotation for 300 d.

**Hardness**

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

- Insert a 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 must return to their original position instantaneously without any space left between them.
If it is possible to insert the whole blade of the screwdriver, the tension between the strands is not correct. Resistance to rotation of the blade of the screwdriver means that the strands and the core of the wire rope are adequately working together.

**Bending**

The bending proof is used to evaluate the cohesion of the components of the wire rope in mutual movements, especially to evaluate the correct cohesion between core and external strands in non-rotational wire ropes.

In dynamic environments, wire ropes are often exposed to bending forces, and are operated on pulleys or grooves which may lead to earlier ageing of the wire ropes, thus shortening the operating life.

- Bend the wire rope into a U-shape and let it run simulating the movement on a pulley.
- After straightening, no traces of bending may remain.

### 6.1.2 Checking the ending connections

- Ensure that the rope’s ending connections correspond to the ones in the User Manual of the equipment or that are conform to what ordered.
- Verify the good condition of the ending connections.

### 6.1.3 Checking the winding drum

**WARNING! Lateral deviation of the rope!**

Excessive lateral deviation on the pulley may lead to serious damage to the wire ropes with consequent reduction of the safety.

- Use pulleys with grooves of a diameter which is smaller than the diameter of the wire rope.

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.

- Check the condition of the drum.
- If the drum is grooved, check the radius and the groove with a correctly installed rope.
- 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.
- Ensure that the wire rope can rotate freely on all the winding drums of a pulley.
- Check the alignment of the pulley according to the initial configuration of the machine.

In case of deviation angles of 1.5° between rope and upper pulley according to specified limits, enlarge the dimensions of the groove and the angle of opening.

In case of deviation angles of 1.5° between rope and upper pulley 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.
6 Installation

- 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 pulley and the drum have a section that supports the stress of the wire rope.

![Fig. 26: Grooves](image)

1. Wrong: groove too narrow
2. Correct: groove supports approx. 1/3 (38%) of the rope diameter (120…130°)
3. Wrong: groove too wide

6.1.4 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.

6.1.5 Checking the correct winding direction

If the machine is equipped with coupled ropes with opposed winding directions, install them correctly on the respective drum according to ISO 4308.

6.2 Uncoiling

- 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 coils 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, which must be 2% of the rope minimum breaking force or 10% of the safety working load.
- Use an adequate capstan or a laying reel 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 must 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.

**NOTICE! Material damage!**

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

- During uncoiling operations, never bend FLC and OSS cables with a radius smaller than 30 times the cable diameter.
- Use wooden supports or rollers in order to avoid any direct contact of FLC and OSS cables with the ground.

⚠️ **WARNING! Danger due to incorrect material handling!**

Serious injury to people or damage to the rope result from incorrect uncoiling operations.

- Uncoil FLC and OSS cables progressively, cutting the securing metallic straps with great care.
- Remove metallic straps one by one, as the cable is uncoiled.

---

**Fig. 27:** Unreeler

**Fig. 28:** Uncoiler
6 Installation

6.3 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.

▷ Strictly observe the instructions given below.
▷ Ensure that only qualified personnel cuts and splices the rope.

⚠️ WARNING! Danger due to harmful dust and smoke!

Carbonate steel wires are considered to bear health hazards. During further processing of these carbonate steel wires (soldering, cleaning, tapering) dust and smoke may occur.

▷ Wear personal protective equipment (working suit, gloves, helmet, safety shoes, eye protection, respiratory protection).

✔ 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 has to be installed.
✔ If the anchoring components support a load: All anchoring elements are in perfect condition in accordance with the manufacturer’s manual.

Fig. 29: End connections

▶ Resocket the rope end in the following cases:
  – The rope shows an uneven distribution of the strands close to the socket.
  – The strands appear to be slack.
  – The lay length varies for more than 10% from the original amount.
▶ If endings of fragments have to be soldered or tapered, pay attention to solder or taper all wires and strands.
▶ Use a diamond blade metal saw or an abrasive disc to cut the rope.

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.
6.4 Rope training

The force applied on the components of the wire rope (wires, strands, and core) during production 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 different rope components do not respond in the same way to the load.

1. Do not exceed the nominal working value during training.
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.
4. 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.
5. During the last winding, paint a line on each layer of rope which will be used as reference to monitor the rope rotation.
6. 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.
7. 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.

6.5 Commissioning

- After installation and training: Ensure that the geometrical parameters of the rope have not changed and that behaviour of the rope is normal.
- 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 Installation

6.6 Installation of tensostructures (special case)

6.6.1 Installing the cables
Details of cables installation on tensostructures strongly depend on the type and particular geometry of the structure, as well as on the type of sockets used.

Sequence and procedure of cables installation and tensioning must be defined and agreed with the designer / construction consultant.

Installation on bridge structure
The following steps must be taken for a general cables installation on a bridge structure:
1. Lift the cable with a textile sling located at the end of the top socket.
2. Lift with a crane the upper socket until it approaches the connection plate.

![Fig. 30: Lifting activities](image)

3. Locate in the final position the top socket and anchor it to the structure.

![Fig. 31: Positioning and anchoring activities](image)
4. Move the lower socket close to its anchoring plate and connect it to the structure.
5. Once all cables are installed, perform the cables tensioning.

**Installation on stadium roofs**
The following steps must be taken for cables installation on a stadium roof:
1. Install and tension the bracing cables.
2. Lay down the cables.
3. Castings installation with clamps.
4. Position the hanger clamps.
5. Install the hanger and the diagonal cables.
6. Connect all the cable together according to project and specification.
7. Tighten all cable connectors screws with the required torque.
8. Install all temporary lifting device.
9. Install all hydraulic lifting devices.
10. Lift and pin all cable to the steel construction.

![Cables installation on stadium roofs](image)

**Fig. 32:** Cables installation on stadium roofs

⚠️ **WARNING! Danger due to wrongly performed installing operations!**

Incorrect installation may cause serious injuries to people or damage to materials.

▷ Before starting all site operations assess all possible risks through the proper documentation.
▷ Take all precautions to ensure the safety of all personnel involved in cable installing operations.

6.6.2 **Cables tensioning**

During the cable tensioning, a geometric survey of the structures must be done to check the displacements and compare to target stated in the designer procedures.

- Cables tensioning on tensostructure must be performed according to the tensioning procedure provided by designers, considering construction site condition and the erection sequence of the structures.
A tensioning system is generally composed of:

- Threaded bar, with nuts.
- Transverse beam or tensioning tool.
- Hollow jacks proper capacity.
- Oleodynamic pump.
- Calibrate pressure gauge.
- Hosepipes 700 bar.

![Diagram of tensioning system](image1.png)

**Fig. 33: Oleodynamic equipment**

Pressure is applied to the tensioning system by an hydraulic pump connected with hosepipes. The pressure is monitored using a digital calibrated manometer.

The tensioning system is installed on the couple of threaded bars located at side of adjustable socket, then the hydraulic jacks are placed on the bars and fixed with nuts. During cable tensioning, the jacks pull the bar and therefore the socket moves downwards and the socket thread can be tightened (or untightened, if necessary). This operation is repeated with force increases until the design force in the cable is reached.

![Image of hollow jack](image2.png)

**Fig. 34: Hollow jack**
The following steps must be taken for cables tensioning:
1. Install the tensioning device on the cable socket.
2. Arrange the oleodynamic equipment.
3. Increase progressively the pressure and adjust the socket.
4. Check the force of the cables through the gauge pressure.
5. Dismantle the tensioning system.

Fig. 35: Tensioning system
7 Maintenance

Only qualified and authorised 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 deinstallation of the machine
- Before reoperation after a long downtime
- Inserting spikes into the rope for closer internal inspection

Safety

- 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.

Tools

The following tools and materials are useful for the inspection:

- An awl and a marlin spike
- A calliper
- A steel tape
- Two groove gauges
- Chalk
- Wiping cloths
- Pencil and paper
- The manufacturer's handbook or operator's manual for the machine involved
- Copies of pertinent governmental and other inspection criteria and specifications

Tensostuctures

For tensostuctures, maintenance of cables must be in compliance with relevant local regulations. A specific inspection and maintenance plan may be issued for each project.

7.1 Maintenance after a long-term storage

- A thorough check of the rope conditions and maintenance needs has been performed.
  1. Completely clean the rope.
  2. Let the rope dry completely.
  3. Lubricate the rope.

7.2 Periodical inspection and maintenance

- Follow ISO 4309 for inspection criteria.
Maintenance

Steel Wire Rope

- Wear personal protective equipment (working suit, gloves, helmet, safety shoes, eye protection).
- 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 authorised person has to be able to communicate easily with the driver or controller of the machine.
- If the equipment is in constant use, give the rope a certain service time, and then renew the rope regardless of its condition. This method eliminates the risk of fatigue causing rope failure.
- 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 relubricate the rope.
- Check the grooves for wear.
- Remachine the sheaves if they show imprints.
- In case of wire ropes on pulleys 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 if the rate of deterioration of the rope is such that it will not remain in safe condition until the next scheduled inspection.
- If wires are reduced to half of their original diameter, replace the rope.
- Check for the following:
  - External or internal corrosion
  - Local damage
  - Crushes
  - Torsions
  - Ruptures
  - Slackening of wires or strands

Every day

- 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 Maintenance

Every week
- 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.

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

7.2.1 Register of checks
- 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.

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

- 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
- Specific damage (observed problems not yet listed)

Winch specific

- 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
- Specific damage (observed problems not yet listed)

Overall conditions

- Overall condition of the rope sheaves and winch

Comments

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

7.2.2 Relubrication

High pressure must be used for relubrication. Redaelli recommends the use of a high pressure lubricator (MASTO or similar).

It is better not to relubricate the rope than to apply a non-appropriate lubricant or under conditions that are not ideal (e.g., wet ropes).

✓ The rope is clean.
✓ The rope is dry.
✓ The lubricants are compatible with the rubber sealing.
✓ The lubricant is recommended by Redaelli.
▶ Only use approved and specific rope relubricant.
▶ Before stopping the winch for a long period, fully relubricate longer used rope length with specific relubrication 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.
▶ Relubricate steel wire ropes particularly along the zones subjected to bending.
▶ If for operational reasons relubrication cannot be carried out: Schedule the inspection at shorter intervals.
▶ If only a little lubricant is required, apply pressure spray nozzles.
▶ In case of wound wet ropes used in maritime environments, lower the rope to the sea to relubricate 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 must be slow enough to allow the lubricant to dry before entering the water.
7 Maintenance

- Before putting the rope in service: Let the lubricant dry completely.

7.2.3 Wire rope inspection

Visual inspection

Visually check the wire rope in reference to the standard ASME B30.5, section 5-2.4, and to the standard ISO 4309.

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 reduction in diameter and lengthening of rope lay as both conditions indicate core damage.
- Visually check the rope during operation.
- If the rope is worked over the nominal working load (kinks, lay length variations etc.), replace the rope.
- To check the rope for waving during rotation, relax the rope (storage winch).

Waviness

Fig. 36: Ruler

A geometrical distortion due to a core imbalance caused by different reasons.
A sign of waving is a lack of straightness (screw effect). Even small waving of a wire rope can be detected on the surface of the wire rope with the eye.
The wire rope is under a slight tension.

- Place a ruler on the axis of the wire rope for a length of more than 3 times its lay length.
- Use a calibrated feeler gauge to measure the deviation between ruler and wire rope.

Waving may cause vibrations on the wire rope which may spread on the structures on which it is mounted. In applications for transport of passengers at a higher speed, even low levels of waving may cause vibrations that can be more than just annoying, they can be dangerous.

For wire ropes used in lifting applications, waving values up to 1/3 \(d\) are acceptable. This anomaly has only little influence on the stability of the wire rope.

Follow ISO 4309 or contact Redaelli technicians for further information.

Rope and rigging inspection

- The rope is relaxed and not moving.
- Periodically check all load supporting 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.

7.3 Strategic / preventive maintenance

To detect defects of the wire rope like broken wires or loss of steel area, MRT (Magnetic Rope Testing) must 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.

7.3.1 Cleaning

- Externally clean the ropes using 3 rotating wire brushes and an air blast drying system or a rope porcupine sleeve.

7.3.2 Checking the fitting sheaves

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 (300 HB)
  - Broken or chipped flanges
  - Cracks in hubs, spokes etc.
  - Signs of rope contact with guards
– 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

7.3.3 Serving the wire ropes

The following tools are essential for serving the wire:

- A vice or other means for holding the rope.
- Serving mallets for stranded ropes and for locked coil ropes
- Brass mallet (or of other soft material) for stranded ropes and for locked coil ropes
  – The heads of the mallets should be shaped to enable them to sit on the rope.
  – The handles should be long enough to take a reel of wire.
- A reel capable of being mounted on the handles of the mallets and on which sufficient wire can be wound to complete a serving.
- Pliers and wire-cutters, for twisting wire ends together and cutting them short.
- A small soft-headed hammer, for tapping the coils of a serving into contact with one another.
- A heavy soldering iron, made from a copper block approximately 76 mm x 38 mm with one long face ground flat, for completing a soldered or wiped serving.

▶ For information on serving the wire rope, contact Redaelli.

7.3.4 Checking the winches

▶ 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 centre line of one groove and the centre line of an adjacent groove.
  – Measure the drum pitch counting 10 grooves and position a tape measure on the outside crown of the first and the 10th groove. Divide the value by 10 for the individual groove pitch and compare it to the actual 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.

### Measuring the rope diameter
- Measure the diameter across the crowns of rope strands, so that the true diameter is the widest diameter at any given point on the rope.
- To take a measurement, rotate the calliper on the rope.
- Record the rope diameter for future comparisons.
- If necessary, replace the rope due to the reasons to be investigated by a rope specialist.
- Always replace the rope in case of diameter reductions due to the following reasons:
  - Initial pull-down
  - Normal wear
  - Internal rope damage
  - Excessive abrasion of the outside wires (broken wires)
  - Internal or external corrosion damage (inner wire failure)
  - Lengthening of the rope lay
  - Crushing
  - Shock-loading
  - High stranding

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

### Troubleshooting and support
Damaged wires are a normal sign of wear at the end of a wire rope’s lifetime. Localizing the damage may be an indicator for mechanical errors 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:
- Wrong rope type
- Wrong 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.
Particularly the following damages occur:

- Damaged wires
- Reduction of the diameter
- “Stiffening” of the rope
- For information on other possible damages, refer to ISO 4309 or contact Redaelli.

### 7.4.1 Broken wires

For information on the number of allowable wire breaks per crane type, refer to ISO 4309.

- If the number of broken wires exceeds the number indicated in ISO 4309, replace the rope.
- Use a spike 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 (surface) wire breaks may be easier to see.
- Examine the rope near the end connections.
- 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.
- If 2 or more valley breaks are found in one lay-length, immediately replace the rope.
- Remove broken wires by moving the wire ends, if necessary using a tool, backwards and forwards until they break deep in the valley between 2 outer strands. Do not pinch the wire ends with a pair of pliers.
  The wire is more likely to break inside the rope where the ends will be tucked away.

#### Broken wires in plastic filled ropes

In plastic filled ropes, internal wire breaks are extremely difficult to detect, though occasionally a broken wire will protrude through the plastic.

- Thoroughly determine the overall condition of the rope.
  The plastic covering the crown (surface) wires is generally applied in a thin coat and tends to wear quickly in areas which pass over sheaves and drums.
- As the rope runs at a slow speed, check the rope in these areas.
- As the rope and plastic open up, check the surface area and the interstrand contact points.
- If a valley break is detected, immediately replace the ropes.
- 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.

#### Broken wires in compacted ropes

In compacted ropes, single wires do not protrude from the rope due to the compaction.

- 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.
- Refer to the general description of how to detect broken wires.
7.4.2 **Rope shortening**

- To translocate the points of the system that are most exposed to deterioration, shorten the rope. If possible, start with a longer rope than necessary and shorten it regularly. 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.

7.4.3 **Corrosion**

Corrosion signifies a lack of lubrication. It may occur internally before there is any visible external evidence on the rope's surface. Plastic impregnated core ropes provide only improved corrosion resistance by applying a structural barrier against the environmental conditions. Moisture is sometimes trapped in the rope and the lubricant may become ineffective over time.

- Visually check for any signs of corrosion damage as evidenced by rope bleeding or roughing.
- Frequently measure the diameter.
- 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.
- In case of slight discolouration caused by rusting: Lubricate the rope.
- If the rope is heavily corroded, replace it.
7.4.4 Deformation and damages

Replace the rope in the following cases:

- The wire count is broken.
- The rope diameter is not conform to the values indicated in ISO 4309 (even if this occurs at just one point).
- The rope is permanently crushed, twisted, flattened or bent.
- The core can be seen even at just one point.
- While in tension, there are one or more loose strands.
- The rope is corroded or worn.

In case of helical distortion: Replace the rope if the deformation exceeds the value set in ISO 4309.

Fig. 37: Examples for rope deterioration
7.4.5 Abrasion

Abrasion damage may occur when the rope contacts an abrasive medium or when it passes over the drum and sheaves.

- 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.
- If the rope is seriously damaged, replace it.
- For ropes with plastic core impregnation: Look for unusual wear in the plastic (damage to the wire rope).

7.4.6 Internal rope damage

Diameter reduction is a critical deterioration factor and a sign for an impending internal breakdown. Diameter reduction may be caused by excessive abrasion of the outside wires or internal or external corrosion damage.

The wire ropes are protected in a way that allows to indicate possible damage from the external wires.

Excessive abrasion of the outside wires – broken wires

Probably the most common sign of rope deterioration and approaching failure is broken wires. Inspection criteria are specific as to the number of broken wires allowable under various circumstances. It is normal for a properly designed and used running (or operating) rope to exhibit broken wires as it approaches the end of its service life.

Under ideal conditions, the first wires to break are the outside wires at the crowns of the strands where surface wear is expected to occur. On standing ropes, wire breakage may not be so easily observed.

- 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.
- Relax the rope.
- 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.

Internal or external corrosion damage - Inner wire failure

- The rope is completely relaxed.
- 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 2 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.

### 7.4.7 Lengthening of the rope lay

One rope lay is the length along the rope which a single strand requires to make one complete spiral or turn around the core. 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.
- Measure the rope lay with an ordinary blank paper on the rope and strike the rope with the side of a pencil, using a small angle iron as a guide.
  The rope’s print appears on the paper.
- By drawing a line through one strand of the print, count off the number of strands in the rope and then draw another line on the print at the place where the same strand appears again.
- Alternatively use a crayon or marking stick and a roll of calculator tape for making a print at least 3 rope lays long.
  An average lay length can be determined.
  Lengthening of rope lay with loss of rope diameter may be a sign for internal break-up or core destruction.
  Lengthening of rope lay without loss of rope diameter may be a sign for wear.

- Determine the cause for unlaying:
  - Operating a rope without having both ends secured to prevent rotation: An end swivel rope termination permits such rotation and unlaying.
  - Worn sheaves: When the bottom of a sheave groove wears, it can restrict normal movement as the rope enters and leaves the groove. The result can be a build-up of twist which can change the length of lay.

- Note the unlaying for future reference if the immediate cause cannot be determined.
- Check and record a new rope’s actual diameter under normal load conditions.
- During the life of the rope, periodically measure the actual diameter of the rope at the same location under equivalent loading conditions.
  Under normal conditions, after an initial reduction, the overall diameter will stabilize and slowly decrease in diameter during the course of the rope’s life.
  If diameter reduction is isolated to one area or happens quickly, immediately determine (and correct, if necessary) the cause of the diameter loss.
- If necessary, replace the rope.

### 7.4.8 Crushing

Crushing or flattening of the strands can be caused by a number of different factors on multilayer spooling conditions but can occur by simply using the wrong wire rope construction. Most premature crushing and/or flattening conditions occur because of improper installation of the wire rope.

In many cases failure to obtain a very tight first layer (the foundation) will cause loose or “gappy” conditions in the wire rope which will cause rapid deterioration. Failure to properly
break-in the new rope, or worse, to have no break-in procedure at all, will cause similar poor spooling conditions.

- Ensure that the wire rope is correctly installed.
- Check the wire rope.

### 7.4.9 Shock loading

Shock loading is caused by the sudden release of tension on the wire rope and its resulting rebound from being overloaded.

- If operative shock load is not foreseen, check the rope and, if needed, replace it.

### 7.4.10 High stranding

High stranding may result from the failure to properly seize the rope prior to installation or maintain seizing during wedge socket installation. Wavy ropes may occur due to kinks or a very tight grooving problem. Another possibility is simply introducing torque or twist into a new rope during poor installation procedures.

- Evaluate the continued use of the rope or increase the frequency of inspection.
- If necessary, replace the rope.

### 7.5 Required ordering information

#### 7.5.1 Replacement of a rope of the same type

Enquiries to Redaelli should include the following data:

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

#### 7.5.2 Replacement of a rope of a different type

Enquiries to 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
7 Maintenance

- Required documentation (manufactures standard, special, API etc.)

7.6 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.
▶ Use personal protective equipment 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 pulleys, 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.
8  Sockets

Besides of the standard sockets that can be supplied from the markets, Redaelli can deliver an extensive range of lifting accessories (sockets) internally designed by Redaelli, to suit our customer needs, which comply with the most stringent international standards can be found on Redaelli’s website: www.readaelli.com

The range of lifting accessories is continuously updated and increased.

Fig. 38: Examples (extract) of sockets/terminations for different applications
9 About the company

9.1 The sense of safety

Do you know that awkward feeling in your stomach when stepping into an overcrowded cable car? Or those moments driving across a long suspension bridge in a high wind? Whether gliding through a scenic winter landscape or being whisked up to the 31st floor of a skyscraper. It is in these moments of life that we depend on steel wires and wire ropes. Hopefully the manufacturer of those wires and wire ropes has laid great emphasis on safety aspects.

Our Company, Redaelli, is one of the global leaders in the production of steel wire ropes. We draw on almost 200 years of experience in our field and, as a result, we have established an excellent international reputation for our stringent safety policy.

“The sense of safety” is our mission and we take these words very seriously at every stage of our production and service chain. Safety does not only mean making products safe. To us, guaranteeing safety also means calculating the durability of a product in full operation. We want people that enter a cable car, cross a bridge or work under a crane, to feel safe, because they know that safety is our first priority.
### 9.2 Quality & Environmental Management System

In compliance with the principles on which the company’s strategic objectives are based, the policy for quality, environment, health and safety of Redaelli is inspired by ISO 9001, ISO 14001, and OHSAS 18001 and consists of ensuring:

- Continued compliance with the contractual specifications and standards of the product produced and service provided, and wherever possible overcoming the expectations of the customer.
- Continuous improvement of service’s quality provided by the technical and organizational activity of innovation in compliance with the environmental regulations.
- Continuous improvement of the effectiveness and efficiency of the production process and company’s organization through the implementation of all technological and organizational actions aimed to reduce to the minimum the non-conformities, the timing of production, waste, delays and rework.
- Utmost attention to the variables of health and safety at work and environmental protection during production activities by pursuing the constant integration between the provisions herein and as implemented by SGI company.
- Growth and consolidation within the corporate structure of skills and capabilities that make the company grow and ensure complete sharing of the mission and values expressed in this document;
- Compliance with the norms of the Ethical Code adopted by the company;
- Cooperation and transparency with the supervisory bodies as regards matters relating to the environment and safety.
9.3 The company

Founded in 1819, Redaelli started up as a steel drawing mill in the Lecco area in Italy. Around 1860 the original mill expanded into a larger factory and in 1870 it became a public limited company. By the 1980’s, Redaelli had begun to diversify its activities by expanding its product range into the design and construction of steel drawing and cabling machinery.

In July 2008 it sold its steel cord and prestressing sectors, and the Company, with ropes as its core business, became part of Severstal-Metiz group of companies. Now, Redaelli is a leading international manufacturer of steel wire ropes used in a variety of applications, including cableways, cranes, offshore, mining, and tensostructure engineering.

Its presence in so many different market sectors ensures ongoing growth in terms of production volumes and profitability, whilst its expansion policy outside Europe mainly in the Far East, USA, Emerging Markets, and with the subsidiary companies in Shanghai and San Paolo, is undergoing a consolidation process, which includes new fields of action and clients.

The Company is based in Milan, Italy and has plants and operations in Italy at Gardone Val Trompia (Brescia) and Trieste, more than 300 employees in total. A central corporate structure covers the functions of marketing and communications, raw material purchasing, finance and control, and quality assurance. This integrated organization allows Redaelli to efficiently and quickly react to market events and trends, use common technologies as a lever, have a better purchasing power, and optimize its financial resources.
9.4 **Ethical values - what we believe in**

**Integrity**
Recipients regulate their conduct in a professional and responsible way in order to resolve situations where potential conflicts may occur, ensuring that the behaviour is characterized by honesty, morality and fairness.

**Transparency**
Transparency is the key to all relationships that the recipients have to their interlocutors, pledging to provide clear, complete, timely and truthful info.

**Legality**
Recipients should adopt a conduct in full compliance with internal procedures, all regulations in force, both national and international.

**Impartiality**
Recipients operate in full compliance with each individual personal characteristics, by encouraging and rewarding integrity and sense of responsibility, respecting any difference and rejecting any possible discrimination based on age, health status, gender, religion, ethnic origin, political and cultural opinions as well as personal or social conditions.

**Prudence**
Recipients work with full risk awareness and with the objective of their sound management. This value is expressed through a prudent behaviour, especially when actions and decisions can be a detriment to people and things.