OPERATIONS MANUAL

STEEL WIRE ROPE

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Equipped for impact

Revision list

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E	Revision chapter 3	KRA/JSO	1-3-2021

Table 1: Revision list

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PREFACE

This manual contains the standard Steel Wire Rope manual which we supply to our clients.

This manual consists of the following:

- Chapter 1: "Introduction"
- Chapter 2: "Rope in Operation"
- Chapter 3: "Inspection of wire Rope and Related Components"
- Chapter 4: "Maintenance of Rope"
- Chapter 5: "Exchange of Rope"
- Chapter 6: "Troubleshooting"

WARNING

Wire rope may only be handled by persons who have read and fully understand the contents of this manual. This implies that the operators, maintenance engineers and all other personnel working with the system must have a sufficient level of education and/or training.

CONTACT DETAILS

In case of questions please contact the manufacturer at the address provided below. Please refer in all correspondence to the original order number Wire Rope.

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If this publication is not in your native language or if you have problems understanding the (con)text, please contact Huisman office for assistance.

The user manual is provided to help you establish operating conditions, which will permit safe and efficient use of your equipment.

The maintenance chapter is provided to help you establish maintenance routines, which will permit safe and efficient use of your equipment.

Personnel involved in maintenance have to be properly trained, experienced and knowledgeable with the equipment provided by Huisman. Huisman or any of its affiliated companies cannot be held responsible or liable for any failure due to lack of properly trained, experienced or knowledgeable personnel.

It is important that you operate/maintain your equipment in accordance with the user/maintenance manual/chapter and any additional information, which may be provided by Huisman. Address any questions of your equipment to Huisman, see Section : "Contact Details".

The maintenance chapter contains the minimal required maintenance that Huisman recommends. Huisman or any of its affiliated companies cannot be held responsible or liable for any failure due to lack of maintenance.

Only spare parts approved by Huisman must be used in case of replacements.

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IMPORTANT SAFETY INFORMATION

This section provides important safety instructions. Detailed safety information is given wherever appropriate in this manual.

- Prior to operating, maintaining or repairing the system, all instructions and safety regulations in this manual, must have been read and fully understood by all personnel who will be working with, or in the vicinity of, the Steel Wire Rope.
- Always restrict the use of the equipment to use strictly in accordance with this manual.
- The load specifications as well as the environmental conditions as described in this manual may NOT be exceeded. It is strongly advised to STOP the winch before the limits set forth in this manual or otherwise are reached. In case of any doubt on the definition of the operating conditions, do not hesitate to consult Huisman.
- External noise level from operations can be considerable. Use suitable hearing protection is deemed necessary.
- During sea travel, or when the maximum operating conditions are exceeded, the system must be sea fastened.

Operations:

- No persons are allowed near or on the system during operation without the prior knowledge and consent of the operator.
- The system may only be operated by an authorized operator, who is suitable trained and experienced in operating similar equipment, and who has full knowledge and understanding of the contents of this manual. Operators, maintenance engineers and all other personnel working with the system must have a sufficient level of education and / or training.
- The operator must have clear view of the system and its direct vicinity during operation.
- During sea travel, or when the maximum operating conditions are exceeded, the system must be sea fastened in accordance with internationally recognized standards.

Maintenance:

- Regular maintenance, service and inspection are required in order to guarantee safe use of the system for the duration of its lifetime. Maintenance may only be carried out by well-trained, certified and experienced personnel.
- Before starting maintenance or repair activities, make sure that all electrical power is disconnected and that all components are in a safe position. Always secure movable parts that could present a risk of injury or damage.
- Welding operations or any other heat treatment of the main structure can influence the system's integrity or fatigue life and may lead to serious damages to the equipment and its. All welding, grinding or cutting operations should never be undertaken without the prior written approval of Huisman.

SAFETY SYMBOLS

In this manual, the symbols and indications are used to highlight important parts of information. Below you find the explanation of the indication types.

WARNING

Indicates a hazardous or potentially hazardous situation which, if not avoided, could result in serious injury or death and considerable mechanical damage.

CAUTION

Indicates a potentially hazardous situation which, if not avoided, could result in minor injury or mechanical damage.

NOTE *Indicates important information of the system or the documentation which requires special attention.*

LIST OF ABBREVIATIONS

Abbreviation	Meaning
API	American Petroleum Institute
DIN	Deutsches Institut für Normung
DNV	Det Norske Veritas
EN	European Standards
IMCA	International Marine Contractor Association
ISO	International Organization for Standardization
IWRC	Independent Wire Rope Core
LF	Local Fault
Lloyd's CLAME	Code for Lifting Appliances in a Marine Environment
LMA	Loss of Metallic Area
MRT	Magnetic Rope Testing
NDE	Non Destructive Equipment
NEN	Nederlands Normalisatie Instituut
OEM	Original Equipment Manufacturer
PPE	Personal Protective Equipment
RCM	Rope Usage Monitoring
RLT	Remaining Life Time (of wire rope)
RUM	Rope Condition Monitoring
SWL	Safe Working Load

Table 1: List of abbreviations

1 INTRODUCTION

1.1 General Information

This document is focused on the safety aspects, wire rope construction, inspection, maintenance, handling and operation of wire ropes used on Huisman products.

1.1.1 Purpose

The purpose of this document is to provide an overview of best practice in the care of wire rope, which would be useful around the world. Although the manual is focused on a relatively small area of wire rope usage, a number of points relate to the care of wire rope generally is mentioned.

1.1.2 Codes, Regulation and standards

The rope is selected and applied according to the design code of the project. For care, maintenance and discard the ISO 4309 is recommended as it is the most complete and detailed wire rope standard available. For guidance, IMCA SEL 022 Rev. I can be also used for reference.

The manual content is not expected to be all inclusive and there may be additional local legislation, guidance, standards and also client requirements to consider, depending on flag state of the vessels involved, other jurisdictional issues and the location of the operation.

1.1.3 Terms of Use

Huisman recommends users to always consult Huisman or the wire rope manufacturer if there is a problem regarding operation of the wire rope in the Huisman products. The manual is intended for information and precaution only.

1.2 HEALTH AND SAFETY INFORMATION

As a general precaution, applicable for types of all working environment, the person who works with the operation of wire ropes shall have proper training and posses all necessary equipment and operating procedures to perform their job safely.

For health information, the steel wire rope contains different kind of materials. The main component of steel wire ropes is carbon steel, which may be galvanized or coated with zinc aluminium alloy. During any activities such as cutting, welding, grinding and cleaning, dust and fumes might be produced which contain elements that may affect the health of exposed workers. Fiber cores are composed by synthetic or natural fibers and do not present a health hazard when handled, except in the unlikely case that the core may have decomposed into a dust which may be inhaled.

The lubricants used in the manufacture of steel wire ropes normally present minimal hazard to the user, who should anyway take reasonable care to minimize skin and eye contact and also avoid breathing their vapors and mists.

To avoid the possibility of skin disorders, repeated or prolonged contact with mineral or synthetic hydrocarbons should be avoided and workers should always wear protective clothing and gloves.

General and local exhaust ventilation should be used to keep airborne dust or fumes below established occupational exposure standards and operators should wear approved dust and fume respirators if these values are exceeded.

In this manual, a lot of safety warning are presented in their respective section. The reader of this manual needs to read, understand, and implement all the warning which are given as a precaution to the unwanted accident. Huisman will not responsible in any accident or miscarriage which will happen because of the content of this manual.

2 ROPE IN OPERATION

2.1 INTRODUCTION

This chapter explains the standard practices for safe operation and maintaining maximum rope life.

2.2 AVOID SLACK IN THE ROPE

In any hoisting operation, there should be no slack in the wire rope when the load is applied. It will cause a shock load causing excessive stress in the rope. Shock loading is destructive and results in irreparable damage to the rope.

2.3 AVOID CLASHES

The user needs to be careful when operating the wire rope so that it will not mechanically clash into other components. Clashes can severely damage the wire rope.

2.4 TAKE ACCOUNT OF SIDE LEAD ANGLE

During operation, user needs to take account of the side lead angle of the equipment, for example, swinging offload or jib is not position above load. Large side lead angles can result in torsion build up and wear between the rope and the sheave groove.

2.5 AVOID TORSION BUILD UP

Building up the torsion while operating wire rope can result in permanent rope damage, such as a core protrusion and birdcage. The user has to avoid building up torsion in operating the equipment. It is recommended to unspool the winch at low line pull for releasing and spreading torsion build-up.

2.6 SLOWLY LIFT OR RELEASE THE LOAD

Accelerating or decelerating with a high speed can lead to over stressing of the rope. Wire rope will withstand considerable stress if the load is applied slowly. Lift or release the load slowly to prevent high dynamic loads in the rope.

NOTE *Only use the wire rope for the job for which it was intended.*

2.7 CAMERA ON HOISTING DRUM

Before hoisting with the drum, the user should always make sure and check if there is a camera installed outside and it is working correctly. This camera will give the user a clue on what is happening on the drum.

2.8 Avoid Cutting-in Of Wire Rope On Drum

This action is only applicable for multi-layers drum. The user needs to be aware when applying a high load while the rope is running on the outer layer. If the lower layers are spooled with a low line pull, cutting-in can occur. It is recommended to spool the lower layers in steps with a higher line pull.

The lower layer of the wire rope needs to be tensioned proportionally as well to prevent the cutting-in between the layers. See the following section for more information.

2.9 Winding and Unwinding Drum

When high loads are expected on the outer layer or when a drum is not used for a long period, it is recommended to have a pretension of at least 25% of the expected load on the layers laying below the outer layer. This action will help to reduce the crushing damage by higher layers to the lower layers of the winch. When rewinding again, make sure that the safety windings are still present on the drum.

If the first layers are not under tension, they might be wedged into the bottom layers under the load. This could seriously damage the rope.

Example:

A winch can pull 400mt on the inner layer, 290mt on layer 8 and 175mt on layer 15:

- If we want to lift 175mt on the outer layer, we will need at least 44mt pretension on all lower layers.
- If we want to lift 290mt on the layer 8, we will need at least 73mt pretension on all lower layers

2.10 Log Operational History

For keeping a good record of the wire rope, details of the wire rope's use in service should be documented. This record will be beneficial for inspection and maintenance plan as well. The Huisman Rope Usage Monitoring system can take care of this. See 3.4.1 Huisman wire rope usage monitor (RUM) - optional p.30 en see 3.5.4 Huisman wire rope condition monitoring p.33

3 INSPECTION OF WIRE ROPE AND RELATED COMPONENTS

3.1 INTRODUCTION

NOTE *Inspections should be carried out by qualified personnel.*

Inspection is the most important operational check to be made on hoisting and rigging equipment. It is always required to record all the inspection results. In this way, the change of the wire rope condition can be monitored. Huisman recommends to log the use of the equipment to have a good record of the use of the wire rope. Assurance of safety and economy in the use of the equipment dictate the requirement for a program of periodic inspection of all load supporting wire rope and fittings.

3.2 INSPECTION INTERVALS

The wire rope shall be inspected regularly (intervals depending on operation intensity, the period of time that the wire rope has been in service and/or the local rules):

Inspection	Comment	Interval
Extra wire rope inspection		Periodically or after an incident
		When wire rope has not been used for more than 3 months
	(drilling only)	Extra inspection directly after jarring operations
	(drilling only)	Extra inspection during and after a period of high swell conditions while using AHC and or PHC
Periodic wire rope inspection	Continuous operation	Daily
	Intermittent operation	Weekly
	Very seldom operation	3 Monthly
Sheave and drum inspection		During each wire rope exchange

All wire ropes will wear out eventually and gradually lose load capacity throughout their service life. That's why periodic inspections are critical.

Thorough examination of at least the full working length plus three wraps of the wire rope (including hook end termination) should be carried out at periods not exceeding twelve months, be recorded and take account of:

- Statutory requirements
- Type of appliance and/or design of the system
- Operational environmental conditions
- Method and frequency of operation
- Results of previous inspections and thorough examinations. ISO4309 provides good inspection record tables
- Experience with previous wire ropes on the equipment or system
- Analysis of usage history
- Previous wire rope history – this should include review of load records or data logger records where available

3.3 INSPECTION ZONES

In general the rope must be inspected visually. However, there are some critical zones which required special attention, such as:

1. Rope zones which are exposed to the highest number of cycles (Increased abrasion and wire breaks are expected in this kind of location). See 3.5.1 Broken Wires p.31
2. Loading points (All parts of the rope which are in contact with sheaves or winch drums are subject to high stresses).
3. Rope end connection (A lot of factors, such as the rope elasticity, rope geometry, additional pressure, additional tension caused by rope oscillations, and frequent moisture, make rope end connections susceptible to any potential wire breaks and corrosion).
4. Rope zones near heave compensation sheaves cause locally a high number of bending cycles. See 3.4.1 Huisman wire rope usage monitor (RUM) - optional p.30
5. Near winch drum flanges, where the wire rope changes layer. See 3.5.1 Broken Wires p.31 en see 4.5 Rope shifting on drum p.45
6. Contact points at the lebus groove crossings near the winch drum flanges. (Are subject to increased wear). See 3.5.1 Broken Wires p.31
7. Sheaves (Change of rope groove will affect the rope's service life). See 3.6.2 Sheaves p.34 and 3.6.3 Sheave bearings p.36
8. Rope zones exposed to aggressive agents or heat (Chemical or high temperature can considerably reduce the breaking strength of a wire rope).

More information regarding the inspection zones of wire ropes can be obtained in ISO 4309.

3.4 INSPECTION RECORDS

For a good practice and to help identifying critical locations on a wire rope for inspection, it is recommended that full records should be kept for each wire rope, from its installation to discard.

According IMCA SEL 022 Rev. I, for inspection records, it should record information including but not necessarily limited to the following:

- Confirmation and records of daily inspection should be kept
- A record of inspections, NDE and testing, should include:
  - earliest possible NDE trace;
  - result of six-monthly and annual thorough examination;
  - details of any length removed;
  - details of number of broken wires removed including location on rope and date of removal; Example of broken wire inspection sheet p.32
  - details of how damage is marked on the rope (e.g. paint mark);
  - details of how damage or deterioration was detected and whether it was acceptable;
  - location in system of tested sample;
  - results of internal examination;
  - details of the NDE machine;
  - details of pressure lubrication, if applicable;
  - details of re-termination;
  - results of tensile tests;
  - in storage inspection records.
  - data logger information from load monitoring systems: See also
  - 3.4.1 Huisman wire rope usage monitor (RUM) - optional p.30
  - 3.5.4 Huisman wire rope condition monitoring p.33
  - Post retirement inspections, see
  - 3.8.1 Post-Retirement Examination of Wire Rope Sections p.38

3.4.1 HUISMAN WIRE ROPE USAGE MONITOR (RUM) - OPTIONAL

Huisman can implement a PLC based system that shows the % of lifetime that is consumed over the length of the wire rope. The Huisman rope monitoring system combines data that is already available in the hoisting system. The analyzed data is processed such that it presents the actual usage of the wire rope. The usage is expressed as a factor of the average lifetime of the installed rope. The usage % is an advanced calculation where damage due to bending over sheaves as well as damage due to drum spooling is taken into account. Rope Usage Monitoring (RUM) can be used to gain detailed insight in where the most used rope sections are located and thus more focused wire rope visual inspections are possible. The outcome of the RUM looks like the example table below. It shows the amount of rope usage that has build up over the entire length of the wire rope as a percentage of the average life time of the wire rope. It may be clear that this way of wire rope monitoring is much more detailed than for example ton-miles counting which is common practice in the drilling industry up to now.

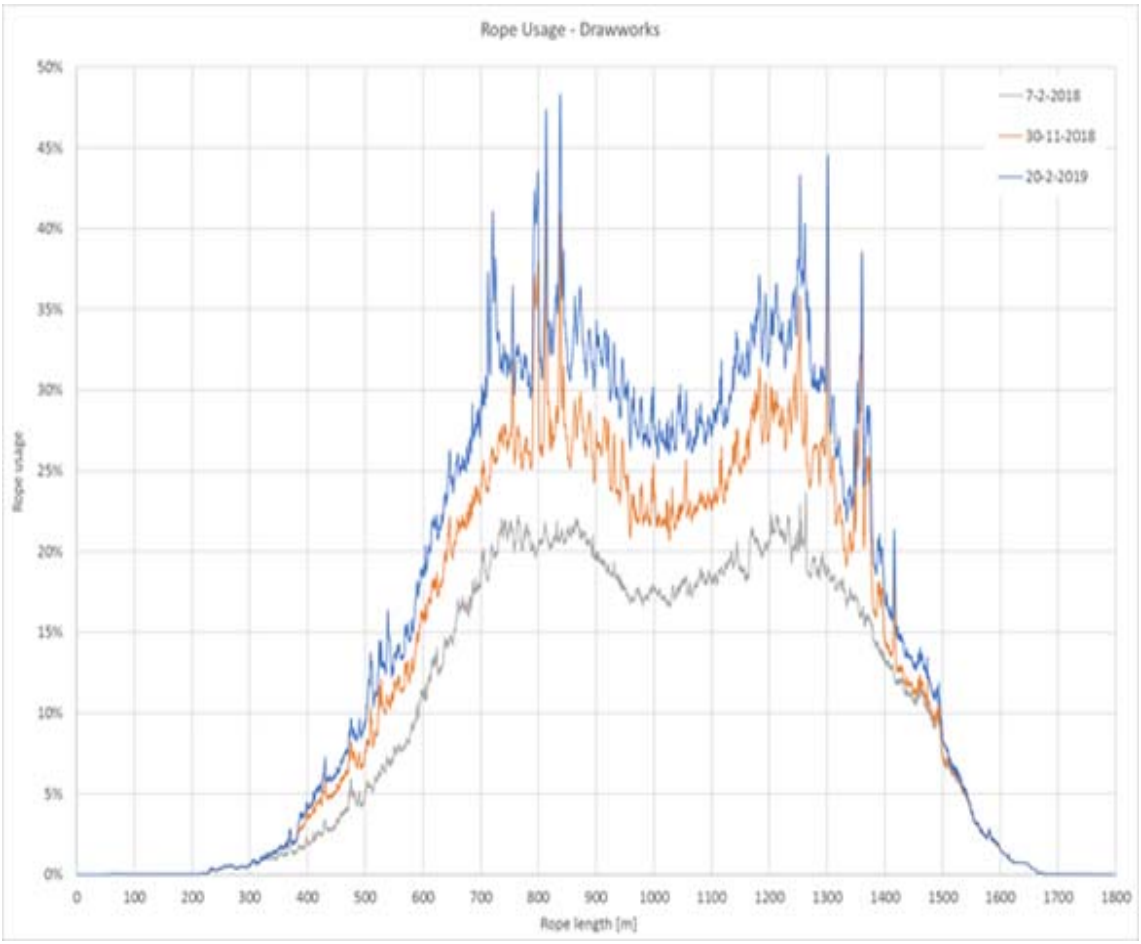


Figure 3-1: Rope Usage Monitor Graph

3.5 INSPECTION METHODS

3.5.1 BROKEN WIRES

One of the main indicators for rope wear is the amount of broken wires. The section here under shows locations where patterns of broken wires may develop.

As a general guideline there are some specific locations that need extra attention. Extra attention should be paid to the 3 wire wraps that are at each layer, next to the drum flanges. This is shown in the picture below:

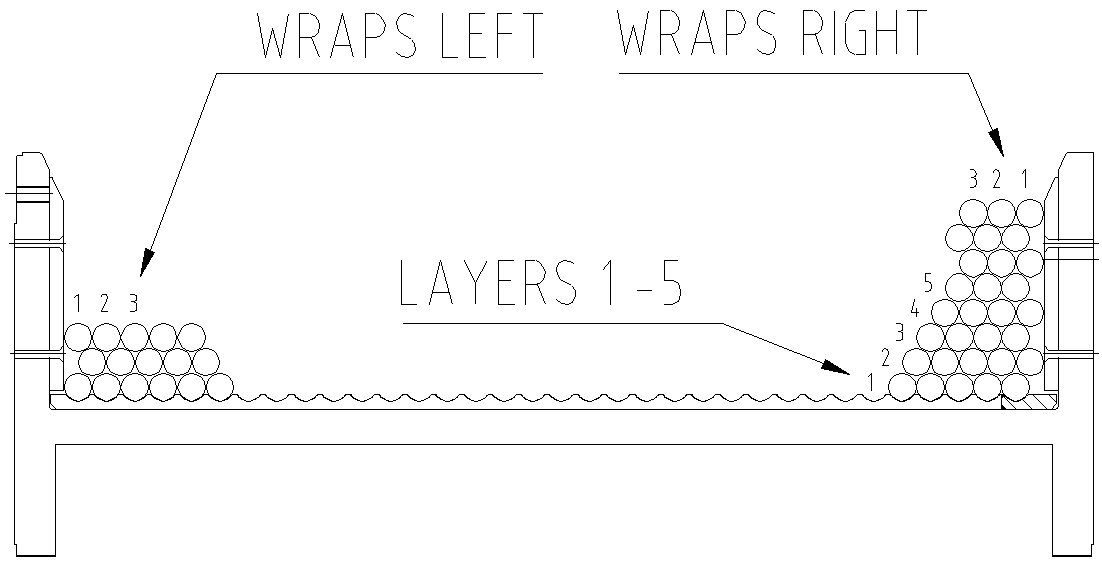


Figure 3-2: Drum layers and wraps

The wraps go around the drum and make two moves sideways per revolution. These rope crossings and the turning point where the wire changes direction are the critical areas to check for wire damage and wear. The results of the inspection can be entered in a table as shown in table 3.1 The check for wire damage can be combined with wire diameter checks around the same locations.

Example of broken wire inspection sheet

Vessel			Winch			Drum		1 / 2
Rope type			Installation date					
Follow up #			previous inspection date					
			Left 1	Left 2	Left 3	Right 1	Right 2	Right 3
Layer	Cross over zone	Remarks	Note the amount of broken wires, and if found broken wires make a paint spray mark to help find spots back later					
1	1							
	2							
2	1							
	2							
3	1							
	2							
4	1							
	2							
5	1							
	2							
6	1							
	2							
Layer	Location (L/R 1-2-3)	Description of wire rope wear following appendix C						

Figure 3-1: Wire rope inspection sheet

3.5.2 DIAMETER MEASUREMENT

For measuring the rope diameter, user has to know how to measure the diameter, log the line-pull and position of the wire rope and the exact location where the measurement has to be taken. After measuring the diameter, user has to log the measured diameter. For more detailed information of diameter measurement, refer to Appendix A: "Rope Construction" and Section A.1.7: "Diameter".

3.5.3 ELECTROMAGNETIC WIRE ROPE EXAMINATION

After a period in service, surface wear and/or a number of wire breaks will indicate the rope condition has deteriorated and discard may be imminent. Specific working conditions however, may lead to internal wire breaks and to internal loss of metallic area.

Electro-magnetic testing equipment available on the market allows - depending on individual design - indication or continuous recording of localized damage such as single broken wires, breaks or strands [through local fault (LF) signal], soldered and welded joints as well as pitting and even detection of reduced metallic area [through loss of metallic area (LMA) signal] caused by corrosion and abrasion over the whole wire rope length.

Electro-magnetic tests cannot, and must not, totally replace visual inspections. Yet, they provide valuable additional information on the condition of wire rope and must be regarded as a useful addition to the visual inspection (ISO 4309).

NOTE	*Wire rope examination through electro-magnetic testing should be carried out in accordance with a detailed plan and must be supervised by a competent person.*

3.5.4 HUISMAN WIRE ROPE CONDITION MONITORING

During an extensive R&D process Huisman developed a electromagnetic monitoring system that continuously monitors the majority of the wire rope condition. This sensor based system supervises the full length of the wire rope when the system is in operation. Any wire break will be detected and the operator will be warned. There will always be a limited section of wire that does not pass through the rope condition monitoring sensor.

Inspection results can be related to the measured rope usage monitoring system to determine the actual condition of the wire rope. Two dedicated MRT sensors make scans of the rope. The rope condition is expressed as a factor of the discard criteria according ISO4309. This way the usage can be compared with the measured condition resulting in a higher reliability of the rope condition assessment.

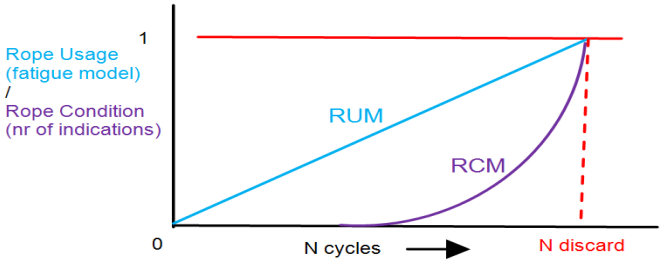


Figure 3-1: Rope Usage vs. Rope condition monitoring

For example a rope starts to show damage more rapidly at the end of its lifetime. In the largest first part of the rope lifetime there is only very little wear present. By solely measuring the rope condition the remaining lifetime can only be predicted accurately very close before discard.

In combination with the rope usage monitoring system a much better and accurate prediction can be made. Over time the fatigue model for usage can be adjusted by the measurements of the rope condition monitoring system. Especially if post retirement checks on the wire are carried out, see 3.8.1 Post-Retirement Examination of Wire Rope Sections p.38).

NOTE	*Due to the probabilistic nature of fatigue and other influencing factors, premature failures during the DWP cannot be ruled out.*

3.6 INSPECTION OF SHEAVES AND DRUMS

3.6.1 DRUMS

Check the general condition of the drum.

- If the drum is grooved, check the radius and pitch and ensure that the grooves will satisfactorily accommodate the size of the new rope
- Check the condition and position of the kicker plates or wear plates, if fitted, to ensure that the new rope will spool correctly on the drum
- Ensure that the rope entrance is smooth
- Inspect drum end connection.

3.6.2 SHEAVES

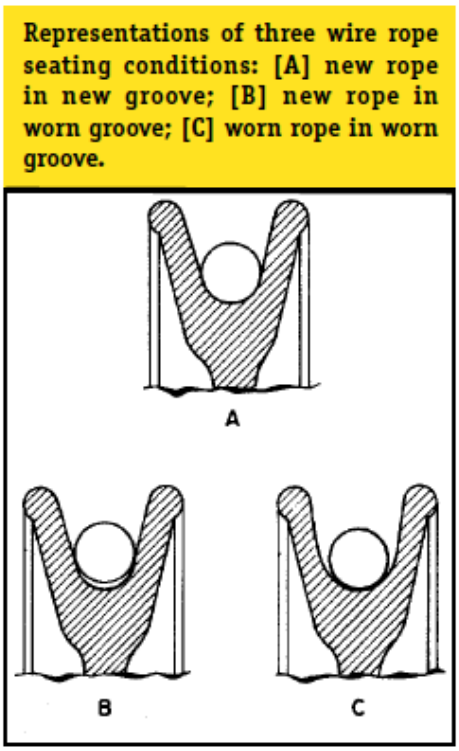


Figure 3-3: Wire rope seating

Check the groove diameter and condition of rope sheaves, deflection sheaves and drums. Grooves in rope drums, rope and compensation pulleys must fit rope diameters. The groove diameter should never be smaller than the actual rope diameter: ideally nominal diameter +5 - +6%.

The groove diameter is checked with special groove gauges (see Figure 3-4) which are available at Huisman. New wire rope may be larger in diameter than old rope, having thinned through use - when installing a new wire rope or when the groove is worn out.

Rope running in narrow sheave grooves will present less endurance. For the groove base to comply with ISO 4308 and API 2D, worn grooves may need to be machined out prior to rope installation. Furthermore, the drum groove conditions have to be provided.

Figure 3-4: Groove gauges

Ensure that every sheave rotates easily. Visual inspect the grooves to see if there are any changes on the surface.

If the radius has become too large or too small, the groove should be cladded/machined or the sheave replaced.

Example how to figure out the actual groove diameter with groove gauge (special tool which can be obtained via Huisman or any other third party company).

→ Sheave for nominal rope diameter 24.0 mm.

→ 26.5 mm which corresponds to +6% of the nominal rope diameter.

Actual groove diameter 25.0 mm

Worn-out sheave: simulated rope diameter → too small

Figure 3-5: Measuring groove diameter

3.6.3 SHEAVE BEARINGS

Winding drums and sheaves should be periodically checked to ensure that they rotate freely in their bearings.

Stiff bearings or worn-out sheaves can cause severe abrasion of the rope.Ineffective compensating of sheaves can give rise to unequal loading in the rope reeving.

Sheaves should rotate easily and should not show signs of excessive play (bearing wear). The sheaves must be in alignment with the rope traveling direction and should have no wobble and the sheaves should have no burrs.

Winch drums and sheaves shall be checked periodically to ensure that all these components rotate correctly in their bearings.

3.6.4 INSPECTION OF WIRE ROPE END CONNECTIONS

When doing an inspection of a wire rope, the end connections are also need to be inspected carefully. Standing ropes, under pulsating stresses, often fail along the transition zones between the wire rope and its end connections. For more information see Appendix B: "End Connections"..

Table 3-1: Inspection of Wire Rope End Connections

No	Items	Requirements	Action
1	Rope end connection on drums	It is not permissible for permanent use in the reeving systems.	- During the inspection, the bolts should be tightened up according the required torque. - If the condition is worrying, replace with another clamp - Examine correct arrangement of the wire rope clamps - Always allow sufficient gap between the clamps.
2	Wedge sockets	The socket must be arranged in the right way, make sure it is not fitted the wrong way around.	- It should be examined with regard to wire breaks along the zone where the rope leaves the socket and along the deflection zone. - The bolts of the safety block attached to the dead end must be tightened up.
3	Spelter sockets	It should not be treated with acid during the fitting of the end connection	- Carefully impregnate the zone with a lubricant after fitting. - Check if there is no corrosion - Check if there is no water trapped in the trumped shaped exit zone of the socket

For more information on the rope end connection and socketing procedures, refer to ISO 17758: Steel wire ropes - Socketing procedures and EN 13411: Termination for steel wire ropes.

3.7 INSPECTION TOOLS

This following tools shall be present when a rope inspection is carried out:

- A list of all discard criteria (3.8 Discard Criteria p.38).
- An utensil to write, such as a pen or pencil.
- A notepad, inspection form, or inspection list.
- All records from previous inspection.
- A wide jaw vernier calipers, for measuring rope diameters.
- A measuring tape, a steel rule, or a lay length gauge.
- A piece of white chalk and a piece of black wax crayon.
- A continuous role of paper strips.
- A screw driver or marlin spike.
- A measuring magnifying glasses with a thread counter.
- A cloth.
- Any cleaning solvent.
- A scraper.

3.8 DISCARD CRITERIA

A steel wire rope must be inspected and discarded according to the ISO 4309. All inspection criteria should be following the ISO 4309 standard. For reference, IMCA Sel 022 Rev. I can be also taken account.

For information, refer to Appendix C: "General Wear and Possible Rope Damage" for the possible cause of wire rope deterioration.

3.8.1 POST-RETIREMENT EXAMINATION OF WIRE ROPE SECTIONS

When a wire rope is retired from service or when a part of a wire rope is made available from either a slip and cut procedure or destruction test, an assessment of the wire rope condition should be undertaken, importantly for determining and recording the mode and extent of any internal deterioration that would otherwise have remained undetected in service. This information will be helpful for the competent person who will carry out the wire rope examination.

According to the IMCA SEL 022 Rev. I, the assessment should carry the following activities:

- Disassembling (un-laying) the wire rope. This information should then be recorded to determine or validate the discard criteria.
- Examine any significant internal deterioration which would render the wire rope unfit for further safe use. Deterioration can be in the form of any corrosion, broken wires and internal wear of wires.
- Asses the state and effectiveness of internal lubrication when the wire rope is being unlaid to form a brush.

If there is any doubt about the condition and suitability of the wire rope, seek for further advice from Huisman.

4 MAINTENANCE OF ROPE

WARNING

The maintenance of the wire rope shall be conducted by qualified personnel.

4.1 INTRODUCTION

A wire rope is a complex product which is very sensitive to wear and damage. Lack of proper maintenance or careless handling inevitably results in a reduced life time of the rope and will entail risk of considerable damage and/or serious injury.

To maintain safe operation and prolong the wire rope lifetime, proper maintenance of the wire rope must be conducted. Wire rope must be maintained at regular intervals.

For a wire rope to operate properly, all components which are used together with the wire rope must be in a good condition as well. All components which are related to the wire rope need to be carefully maintained so that they are adjusted to good conditions. Components, such as sheaves, drums, and lower block, that are used continuously during the wire rope operation, have to be maintained properly.

The maintenance described in this chapter only gives general guidelines on wire rope maintenance. The type of maintenance depends on the type of wire rope that is used. Therefore, Huisman also strongly advises that during the maintenance of a wire rope, information or advises from the wire rope manufacturer need to be taken account as well. The sequence of the wire rope maintenance should be done according to the sequence of the section this chapter.

4.2 CLEANING

WARNING

- Always use protective goggles when cleaning a wire rope
- No detergents or any other aggressive cleaners shall be used.
- Solvents may only be used in small quantities and for localized cleaning of the rope surface.
- Avoid mechanical damage to the rope by brushes.
- Ensure that there is no build up of heat between the cleaning device and the surface of the rope as a result of friction.
- Do not use copper brushes. Remains of the bristles may increase the rate of surface corrosion.

The wire rope may collect dirt and debris.Therefore, it is always recommended to perform regular cleaning on the wire rope, especially before an inspection, so the wire rope can be inspected easily.

- Clean excess lubricant and other impurities resulting from the installation of track ropes.
- Clean any impurities resulting from the installation of stranded ropes.
- After operation, the wire rope should be cleaned with clean water.
- Automatic devices with rotating brushes and air blast drying systems can be used for cleaning as well.

Figure 4-1: Automatic Device with Rotating Brush

4.3 REMOVAL OF BROKEN WIRES AND DEFECTS

CAUTION

Do not cut the broken wires with a plier, do bending or breaking the wire backwards and forwards until the wire breaks!

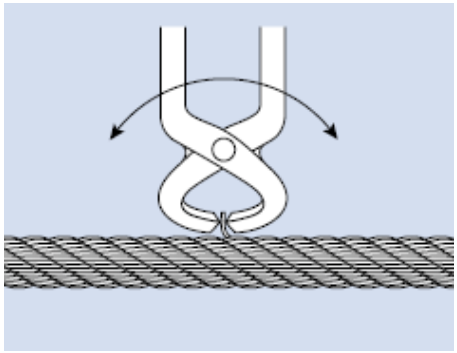


Figure 4-2: Removal of broken wire end

During an inspection, defects on the wire rope might be found. Defects such as wire breaks, rope fouling or rubbing on obstructions, presence of corrosive or abrasive substances must be dealt with promptly. It is essential to note the condition of the rope in the vicinity of a wire break, as more than one break within a short distance could indicate a more serious problem. As a wire rope ages, broken wires can start to appear, usually as a result of constant fatigue.

Protruding broken wires need to be broken off to prevent them from damaging the rest of the rope and to prevent injury to handlers. It is usually best to bend them from side to side with pliers (not cutting through the wire) until they break off within the lay of the strands of the rope (see Figure 4-2). When wires are broken off in this way, a record should be kept of their location on the rope. In this way, if wires continue to break in the same area it will indicate a potential danger in the rope's use. Investigation can then be made as to the causes of broken wires.

4.4 LUBRICATION

CAUTION

Always apply sufficient grease to the wire rope, do not apply too less or too much grease.

There are two benefits of doing an effective lubrications. It can enhance free movements between strands or layers of wires which helps to reduce the internal friction of the wire rope. It is able to reduce the ingress of sea water or any other potentially corrosive or abrasive materials as well. The lubrication can be done in two ways, based on both visual inspection and at regular intervals.

4.4.1 LUBRICATION BASED ON VISUAL INSPECTION

Wire ropes are originally delivered with corrosion preventing lubricant. This lubricant is not only on the outside of the wire rope, but also fills the space within the wire rope. During the service life of the wire rope, blank spots can appear on the wire rope due to strain, wear and environmental conditions. In this case the wire rope should be lubricated again. This can prolong the service life of the wire rope. So, this kind of lubrication is conducted based on visual inspection.

4.4.2 LUBRICATION AT REGULAR INTERVALS

Greasing intervals of the wire rope depend on operating and environmental conditions and therefore are hard to determine. The type of system, for example, heavy lift crane, drill rig, or A&R system, is also important for determining the inspection intervals. The operator needs to inspect the rope regularly according to the 'Inspection Intervals' and ensure that the rope is always well greased. A surplus of grease cannot harm the wire rope. However, It can cover the whole wire rope and therefore make it more difficult to inspect. It can be hazardous for personnel because of the slippery surfaces due to grease that has fallen off the wire rope. A lack of grease will harm the operation of the wire rope as well because it can cause slippage in the sheaves. Therefore, Huisman recommends to lubricate the wire rope with a appropriate amount of grease.

The frequency of maintenance is recommended by Huisman.However, the wire rope maintenance program should consider the crane type, frequency of usage, history of maintenance and wire rope manufacturers' recommendations. Huisman does recommend this following lubrication intervals:

Table 4-1: Lubrication Intervals

No	Type of Component	Usage	Intervals
1	Tugger wire or small crane	Continuous Operation	1x per day
		Intermittent operation	1x per week
		Incidental operation	1x per month
2	(Deep water) crane	General Operation	1x per 3 months
	A&R System		
	Deep water ropes		

Table 4-1: Lubrication Intervals

No	Type of Component	Usage	Intervals
3	Others	If a wire rope is taken back into use after a long period of inactivity (three months or more), it shall be inspected and re-greased prior to operation	

4.4.3 Choosing Proper Lubrication Type

Various types of greases are used for wire rope lubrication. These are the coating types that penetrate partially but usually do not saturate the rope core. Common grease thickeners include sodium, lithium, lithium complex and aluminum complex soaps. Greases used for this application generally have a soft semi-fluid consistency. They coat and achieve partial penetration if applied with pressure lubricators.

Petroleum and vegetable oils penetrate best and are the easiest to apply because proper additive design of these penetrating types gives them excellent wear and corrosion resistance. The fluid property of oil type lubricants helps to wash the rope to remove abrasive external contaminants.

Re-lubricating is mainly about the outside of the rope, so the valleys between the strands should be properly lubricated. The inside of a wire rope is hard to reach with lubricant. Re-lubricating should always be done with a lubricant which is approved by the wire rope supplier. Huisman always recommends the recommended lubricant in the grease schedule drawing in every project.

4.4.4 Performing The Lubrication

Greasing should preferably be done by moving the rope down to the sea (when it is dry), rather than up from the sea, at spots where the wire rope opens up (at the curves in the reeving e.g. sheaves). Greasing can be done manually by painting, dipping, spraying, dripping, swabbing, or by using an automatic lubrication system. A large variety of greasing methods exists.

The best result is obtained by using an automatic lubrication system that operates under high pressure, as this is the only means that can possibly penetrate the lubricant between the strands of the rope to the inside. However, it shall be realized that it is almost impossible to penetrate to the core of the rope by external greasing, even under high pressure.

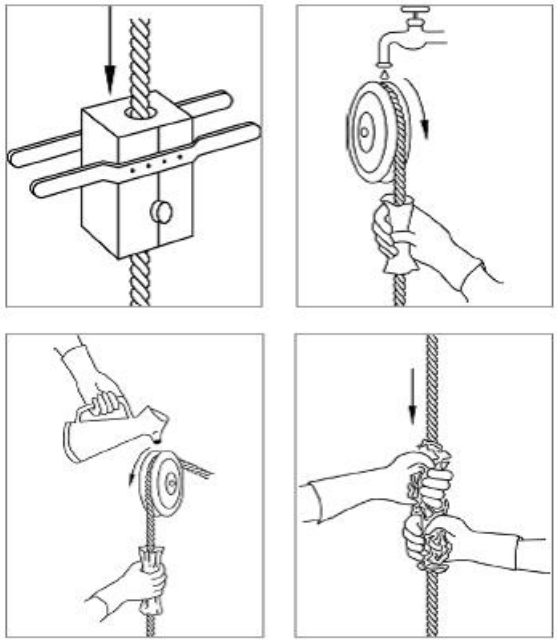


Figure 4-3: How lubrication should be done

4.4.5 LUBRICATION RECORDS

A record of lubrication (date, lubricant used and application method) should be kept. A good documentation record will help to manage the wire rope maintenance records and future maintenance plan.

4.5 ROPE SHIFTING ON DRUM

On a multi layer winch the rope wears most at the crossover section of the Lebus groove, near the drum flanges. To spread the damage caused by wear, it is advised to shift the rope at the drum by removing a piece of rope at the end, such that the most worn out pieces of wire rope are shifted away from the crossing zone. By moving the most worn out pieces away from the drum flange area, the wear will be spread. Therefore, it will prolong the lifetime of the wire rope.

If it is visible that wear is concentrated to specific locations which encounter a lot of bending or rubbing (Lebus crossings), rope life may be increased by cutting off one length according to 1/3 or 1/6 of the drum core circumference. Depending on the layout of the Lebus groove on the drum this procedure can be repeated up to 2-3 times.

NOTE *This procedure can be repeated up to 2-3 times depending on the layout of the Lebus groove.*

5 EXCHANGE OF ROPE

5.1 INTRODUCTION

This chapter describes the standard practice of using wire ropes. In this chapter the selection, handling and installation of wire ropes are explained.

5.2 SELECTION OF WIRE ROPE

Rope selection is about avoiding spooling problems, maintaining the rope stability, keeping torsion control, maintaining robustness of rope, optimizing the life time of rope, etc.

These effects and properties needs to be weight and compared. Therefore, rope selection can be considered the lead compromise for maximum wire rope performance.

Huisman selects the best rope for the system together with the rope suppliers. As the rope and our crane (winches) are in very close cooperation and often at the limits of operation, Huisman always recommend the client to purchase the spare ropes via Huisman.

5.3 HANDLING OF WIRE ROPE

CAUTION

Incorrectly supervised handling and installation procedures may result in serious injury to persons in the vicinity of the operation as well as those persons directly involved in the handling and installation.

CAUTION

Failure to wear suitable protective clothing and equipment may result in skin problems, bad health issue, physical injury, and any other hazardous damage.

These following action shall be taken when handling the wire rope:

- Handling and installation of the rope should be carried out in accordance with a detailed plan and should be supervised by a competent person.
- Wear suitable protective clothing such as coveralls, industrial gloves, helmet, eye protectors, long sleeves, fall safety and safety footwear (and respirator, particularly where the emission of fumes due to heat is likely).
- Check by measurement that the nominal diameter of the new rope conforms to the nominal size stated on the certificate.
- For verification purposes, measure the diameter by using a suitable rope vernier caliper fitted with jaws broad enough to cover not less than two opposite strands. Take two sets of measurements spaced at least 3-inches apart, ensuring that they are taken at the largest cross-sectional dimension of the rope. At each point take measurements at right angles to each other.

  The average of these four measurements should be within the tolerances specified in the appropriate standard or specification.

- For a more general assessment of rope diameter use a rope caliper.
- Examine the rope visually to ensure that no damage or obvious signs of deterioration have taken place during storage or transportation to the installation site.
- Check the working area around the equipment for any potential hazards that may affect the safe installation of the rope.

5.3.1 UNLOADING OF WIRE ROPE

When handling a steel wire rope, the first trouble often occurs immediately upon receiving it. The fork of the fork lift truck is either placed under the reel or inside the coil (see Figure 5-1).

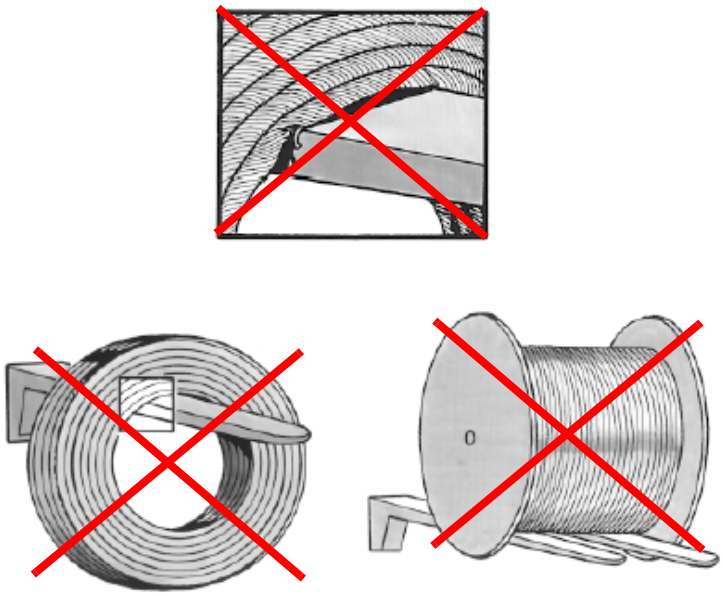


Figure 5-1: Incorrect handling

In both cases it might damage the surface of the rope. If possible, the rope, when received on coils or reels, should not have any contact with a metal hook or the fork of the fork lift truck.

Instead, it should be lifted by means of a wide textile webbing sling (see Figure 5-2). It is advisable to lift a reel by means of a shaft which is put through its axis bore (see Figure 5-3). If the fork of the fork lift truck is longer than the width of the reel, the reel can also be lifted at the flanges.

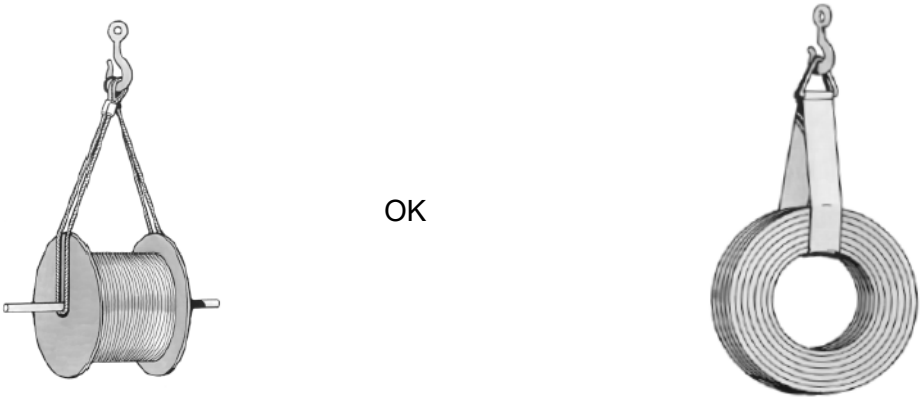


Figure 5-2: Correct handling (by textile webbing sling)

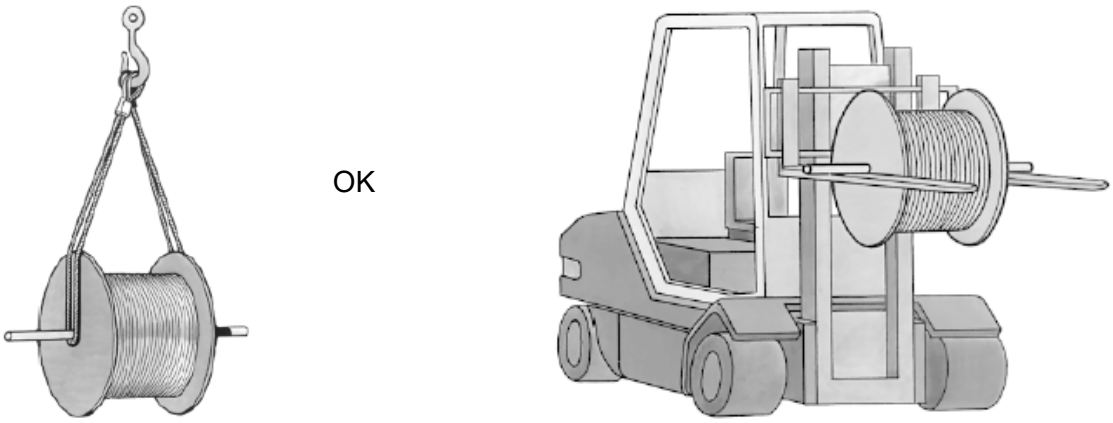


Figure 5-3: Correct handling (by shaft through axis bore)

5.3.2 UNREELING AND UNCOILING

Wire rope must be uncoiled or unwound by trained personnel or under supervision.

CAUTION

Incorrect handling of wire rope may be extremely dangerous. Critical damage to rope may seriously endanger both persons and the equipment. Always use the sufficient PPE!

Reels should be mounted on jacks, monitor free rotation of the reel as the rope unwinds. Timber should be applied as a lever to one of the flanges to act as a brake, keeping the rope tight and preventing the reel from overrunning.

When the ropes are supplied in coils, a turntable or swift should be used and the free end pulled out with sufficient tension as the swift, or turntable revolves (see Figure 5-4).

Over-winding should be avoided at all times to avoid kinking. Coils may also be unwound by securing the free outside end of the rope and then rolling the coil along the ground; care being taken at all times to ensure that the coil is held firmly together, avoiding tight coils or kinks.

CAUTION 	-	Uncontrolled release of the outer end from the reel or uncontrolled opening of coil servings may cause injury.
	-	Ensure that the wire rope is not damaged during installation.
	-	To maintain rope geometry, wire ropes must be uncoiled or unwound with maximum care. The rope should not receive any twist or turn.
	-	Pulling over sharp edges or through tight radii can seriously damage the rope and must be avoided.
	-	If the rope must be drawn over fixed parts during installation, these must be covered by adequate means such as sheaves or wooden material if necessary.
	-	The rope should never be pulled from coils sideways or over the flange of a reel to avoid serious or even irreparable damage to the rope.

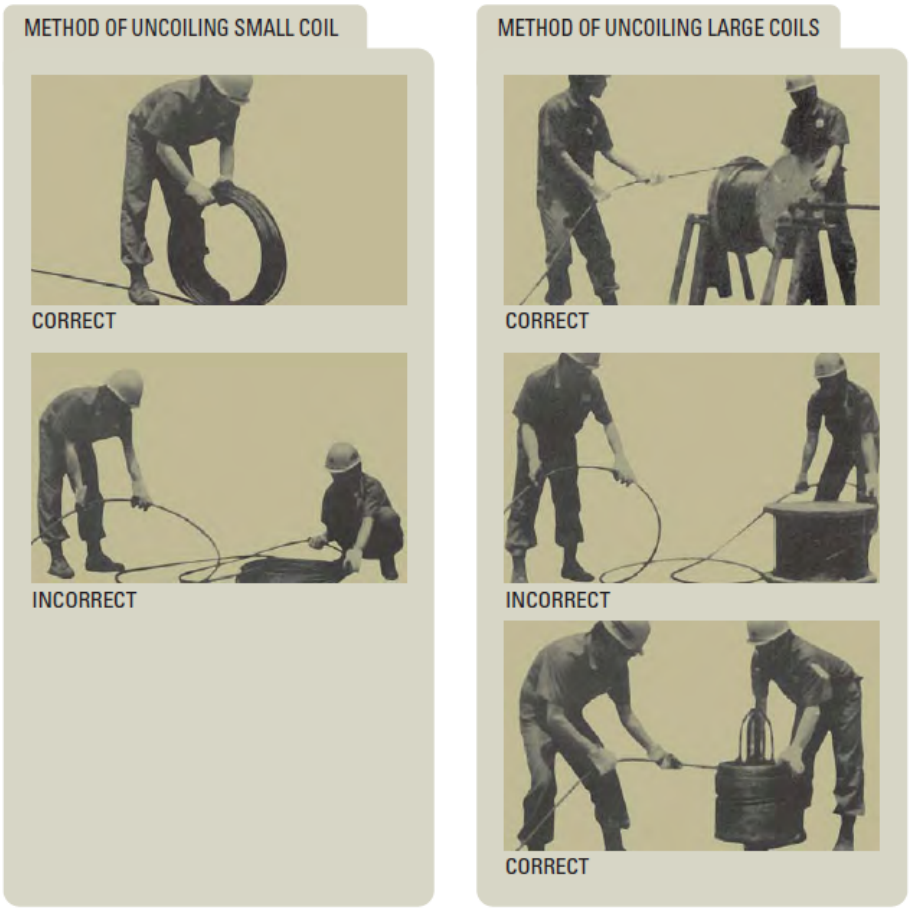


Figure 5-4: Unreeling and uncoiling

CAUTION 	-	In absence of any uncoiling equipment, the rope must be unrolled flat on the ground (see Figure 5-4).
	-	Uncoiling a rope from a drum also requires great care. The drum must be jacked up on a frame using a rod inserted through the drum's center hole. The rope is then uncoiled from the drum under controlled tension to avoid the formation of loops. This is achieved by applying a manual brake to the drum flange or using a special brake device. Loops formed during uncoiling may seriously damage the rope. Under load, loops contract and produce a kink which irreparably deforms the rope (see Figure 5-6).

5.3.3 SPOOLING ROPE ONTO A DRUM

During the manufacturing process every steel wire rope receives its preferred bending direction, when being drawn from the wire rope closer by means of a capstan. When delivered to the customer the rope is bent in that direction.

Make sure that it bends in the same direction when it is wound from the reel onto the drum (see Figure 5-5). If a rope is wound at the bottom of the drum, it should leave the reel at the bottom and vice versa: i.e. always reel from top to top and from bottom to bottom.

If this procedure is not strictly followed, the rope will either try to twist between reel and drum or it will later try to regain its preferred position when in practical service. In both cases structural changes of the rope may occur (see Figure 5-6).

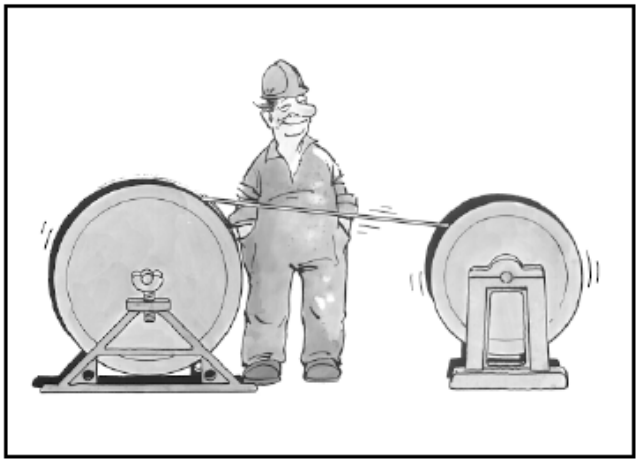


Figure 5-5: Correct spooling onto a drum

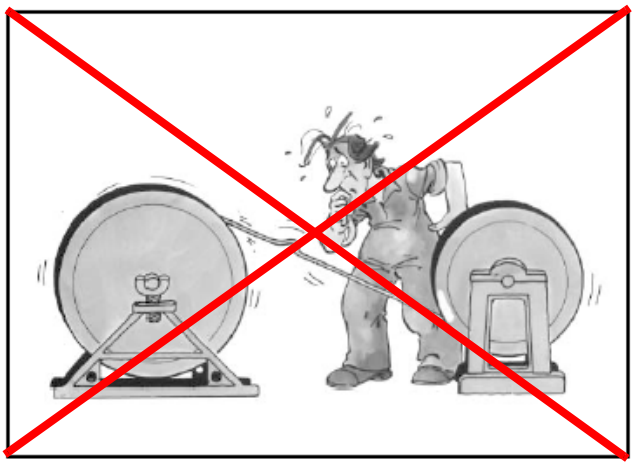


Figure 5-6: Incorrect spooling onto a drum

When wire rope is wound onto a sheave or drum, it should bend in the manner in which it was originally wound. This will avoid causing a reverse bend in the rope. Always wind wire rope from the top of the one reel onto the top of the other. Also acceptable, but less so, is re-reeling from the bottom of one reel to the bottom of another.

Re-reeling may also be done with reels having their shafts vertical, but extreme care must be taken to ensure that the rope always remains tight. It should never be allowed to drop below the lower flange of the reel. A reel resting on the floor with its axis horizontal may also be rolled along the floor to unreel the rope.

5.3.4 CUTTING STEEL WIRE ROPE

If installation requires cutting a wire rope, make sure to apply proper servings before cutting ends, a minimum of one serving to each side (see Figure 5-7). These servings must be equal to a minimum of two rope diameters in length.

Special care has to be taken when applying servings to rotation-resistant and multi-strand ropes. Before cutting, the rope has to be secured and fixed on both sides of the cutting section so that both ends remain in the same position and do not unlay. Wire ropes are preferably cut by using an abrasive disc cutter or hydraulic rope cutter.

CAUTION

When using an abrasive disc cutter, sparks and separated wire particles as well as toxic fumes may present a health hazard.

Before cutting the rope, a clear mark should be applied on the cut area and servings should be applied at each side of the mark.

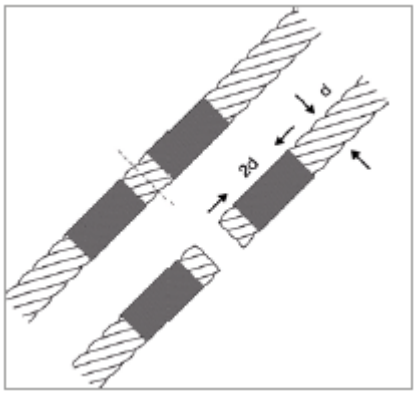


Figure 5-7: Cutting of a rope

5.4 STORAGE OF WIRE ROPE

Storage is a vital part of preservation and the following should be addressed within the storage and preservation plan:

- Examine the rope immediately after delivery to check its identification and condition and verify that it is in accordance with the details on the certificates and/or other relevant documents.
- Check the rope diameter and examine any rope terminations to ensure that they are compatible with the equipment or machinery to which they are to be fitted.
- Select a clean, well ventilated, dry, undercover location. Cover with waterproof material if the delivery site conditions preclude inside storage.
- Never store the rope in places which could be affected by chemical agents, corrosive matters, or accidental damage.
- Rotate the reel periodically during long periods of storage, particularly in warm environments, to prevent migration of the lubricant from the rope.

CAUTION

Never store wire rope in areas subject to elevated temperatures, such as very warm or humid environment, as this may seriously affect its future performance. In extreme cases its original as-manufactured strength may be severely reduced rendering it unfit for safe use.

- Ensure that the rope does not make any direct contact with the floor or ground and that there is a flow of air under the reel.

CAUTION

Failure to do so may result in the rope becoming contaminated with foreign matter and start the beginning of corrosion before the rope is even put to work.

- Support the reel on a simple A-frame or cradle, located on ground which is capable of supporting the total mass of rope and reel. The reel should be covered with waterproof material.

CAUTION

Failure to do so may seriously affect its condition making it unfit for safe use.

- Examine ropes in storage periodically and, when necessary, apply a suitable dressing which is compatible with the manufacturing lubricant. Contact the rope supplier, or supplier's documentation for guidance on types of dressings available, methods of application and equipment for the various types of ropes and applications.
- Periodic outer layer checks should be conducted to establish that no significant deterioration has occurred.
- When applicable, re-wrap the rope unless it is obvious that this will be detrimental to

rope preservation.

CAUTION

Failure to apply the correct dressing may render the original manufacturing lubricant ineffective and rope performance may be significantly affected.

- Ensure that the rope is stored and protected in such a manner that it will not be exposed to any accidental damage either during the storage period or when placing the rope in, or taking it out of storage.

CAUTION

Failure to carry out or pay attention to any of the above could result in a loss of strength and/or a reduction in performance. In extreme cases the rope may be unfit for safe use.

- Stock should be controlled to facilitate the use of the oldest wire rope first..

5.5 INSTALLATION OF WIRE ROPE

5.5.1 INSTRUCTION BEFORE START INSTALLING WIRE ROPE

Unless an alternative rope has been approved by Huisman, only one of the correct length, diameter, construction, type and direction of lay and strength (i.e. minimum breaking force), as specified by the manufacturer, shall be installed.

A record of the rope change shall be placed on file (incl. certificate).

NOTE *Ensure that the spooling direction versus wire construction is correct!*

5.5.2 PREPARATION FOR INSTALLATION

When installing steel wire ropes, extra care must be taken that the ropes are unwound from the ring or reel without torsions and any outer damage. The same applies to reeving the ropes into the system.

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

1. Ensure that the correct rope has been supplied by checking if the description on the certificate is in accordance with that specified in the purchaser's order.
2. Examine the rope visually to ensure that no damage or obvious signs of deterioration have taken place during storage or transportation to the installation site.
3. Check the working area around the equipment for any potential hazards that may affect the safe installation of the rope.
4. Check the condition of the rope-related equipment in accordance with the OEM's instructions. Include the following:
5. A new wire rope will need a proper pull eye welded on the end of the rope in order to allow for a safe reeving of the wire into the system. At huisman we have years of experience with reeving in large size wires as used in our hoisting equipment.

NOTE: A CHINESE FINGER IS NOT CONSIDERED SAFE ENOUGH FOR REEVING A WIRE IN A CRANE!

6. The reeving is usually done in stages. first a 20-25mm polyprop rope will be reeved through the sheaves. Then using this rope we run in a steel reeving wire of sufficient diameter. For a 50mm wirep rope we typically use about 12mm, with an open loop end on the position where the main wire gets connected. The open wire loop is then connected to the welded eye on the steel wire rope by means of a D-shackle with a flush bolt. For a 50mm wire rope the D-shackle pin should be no longer than 40-45mm over all.

7. While reeving in people should be watching close by at each sheave passage while in contact with the winch operator. The winch operator should pull in slow and pay constant attention to the wire tension until the main wire has arrived on the winch drum.
8. Then secure the main wire at a strong point. Keep enough slack wire present in order to allow for making the dead end connection later on. Now release the tension of the drum and remove the 12mm steel wire and the polyprop rope from the drum.
9. Connect the main wire to the dead end connection on the drum flange.
10. In case a wire is replaced, most of the time it will be needed to first remove the old wire in the same way as the new wire was inserted. so in that case first a 12-14mm steel wire rope and a polyprop rope will be needed. In case there is an option to pule the new wire by using the old wire: Make sure the pulling eyes welded on the end of the steel wires are in good condition. Then connect the old and the new wire with length of 10-20m of 12mm steel wire rope. This in order to allow for easier passage of the sheaves.

5.5.2.1 Drum and Grooves

- Check the general condition of the drum.
- If the drum is grooved, check the radius and pitch and ensure that the grooves will satisfactorily accommodate the size of the new rope.
- Check the condition and position of the kicker plates or wear plates, if fitted, to ensure that the new rope will spool correctly on the drum.
- Ensure that the grooving is of the correct shape and size for the new rope. If not, this may be remedied by machining out the grooves before a new rope is installed.
- Check that the groove shall have the clearance for the rope.
- Provide adequate circumferential support to allow for free movement of the strands and facilitate bending.
- Check the condition of the groove. When grooves become worn and the rope is pinched at the sides, strand and wire movement is restricted and the ability of the rope to bend is reduced.

5.5.2.2 Sheaves.

- Check if all sheaves are free to rotate and in good condition.
- Examine if there are sufficient strength remaining in the underlying material in the sheaves to safely support the rope before the new rope is installed.

5.5.2.3 Rope guards

- Check if any rope guards are correctly fitted and are in good condition.
- Check the condition of any wear plates or rollers which are protecting structural members.

5.5.2.4 Coils

WARNING

Never pull a rope away from a stationary coil as this will induce turn into the rope and kinks will form. These will adversely affect rope performance.

Place the coil (see Figure 5-8) on the ground and roll it out straight ensuring that it does not become contaminated with dust/grit, moisture or any other harmful material.

Figure 5-8: Coil placement

5.5.2.5 Others

- Do not use Chinese fingers to connect the rope
- Check the weld eye which is used to make connection to the other rope
- Check the wire rope runner
- Wire rope runner to be added with left hand on left hand wire and right hand on right hand wire
- Tighten end connection
- Reset empty drum switch.

5.5.3 INSTALLATION OF NEW WIRE ROPE

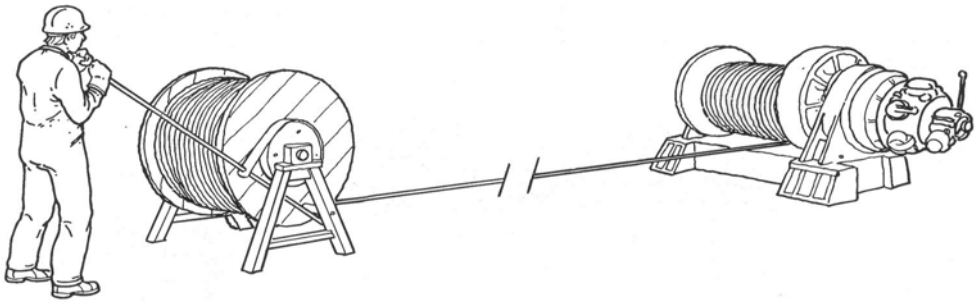
The complete procedure to put a new rope in a tackle will not be described, because this procedure depends on the design of the installation machine, such as traction winch, drum, etc.

One aspect of installing a new wire rope is that one should pay attention to the fact that the wire is tightly spooled on a drum before applying the full load to the crane. This can be reached by applying sufficient tension on the drum. Especially the bottom (1st) layer of a drum is important.

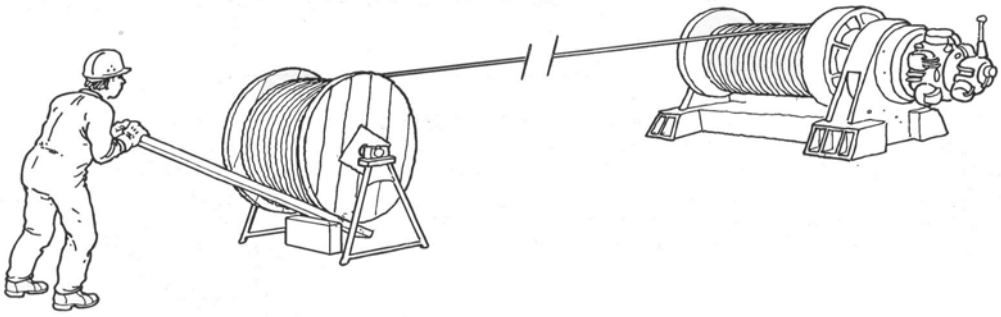
Another aspect is that the wire should not be twisted during installation, this goes especially for rotation resistant wire. When fitting a wire rope, the wire rope shall be spooled in the same direction from the drum as the first bend in the reeving.

WARNING

Large side lead angles on sheave causes twisted ropes! This must be prevented during the installation of wire ropes.



a) Bottom of reel to bottom of drum



b) top of reel to top of drum

Figure 5-9: Correct way of installing wire rope

5.5.4 INSTALLING UNDER LOAD

To achieve perfect multiple layer spooling of the rope on the drum it is very important - particularly with the so-called Lebus spooling - to apply a pretensioning load to the wire ropes during installation.

CAUTION

Under no circumstances should one attempt to generate the pretensioning load by jamming the rope, for instance between two boards. Structural changes would deform the rope beyond repair.

If the first layers are not under tension, they will be too loose, so that the top layers will get wedged into the lower layers under load. This could seriously damage the rope. the unwinding rope might even be clamped, so that the direction of spooling could suddenly be reversed during the course of unwinding. The result could be the abrupt lifting of the load that was actually traveling downwards.

The tensioning load should be 10% of the minimum SWL of the wire ropes. In many cases it might suffice to wind the rope quite normally in order to unwind it and rewind it with the help of an outer load.

CAUTION

Make sure that the line pull can be achieved.

5.5.5 ROPE TRAINING

Training is crucial to stabilize rope dimensions and to optimize the lifetime and performance of the wire rope. Rope training can be performed by lifting an adequate load for at least three times using the full rope length, excluding the safety wraps which must be always remain on the drum. The load automatically develops proper back tension, diameter stabilization, and torque factor reduction.

Winding and Unwinding the Drum

Before fully operating the new wire rope, the user needs to do winding and unwinding of the drum first. It is recommended to fully unwind the drum and wind it again with a lower load first since the rope has never been used before. It is suggested to lower and hoist the block several times with a smaller load, for instance 10% of the drum SWL. After this, increasing the load to 25% and repeat the hoisting and lowering procedure. This process can be repeated several times until rope diameter is stabilized.

5.5.6 INSTALLATION RECORDS

It is important that full records should be kept for each wire rope from its first installation to discard. At installation, details of the installed wire rope should include:

- date and name of manufacturer;
- rope certificate;
- measured diameter, construction, wire grade and surface treatment as delivered;
- NDE trace where practicable;
- usage log or operational history
- date and length installed.

6 TROUBLESHOOTING

The following is a simplified guide to common wire rope problems. In the event of no other standard being applicable, Huisman recommends that ropes are inspected/examined in accordance with ISO 4309.

Problem	Cause/Action
Mechanical damage	- Generally results from incidents. - Check sheave guards and support/guide sheaves to ensure that the rope has not “jumped out” of the intended reeving system. - Review operating conditions
Multiple layer spooling and spooling problems	- The first layers must be installed under tension. - Spooling is not done properly (Rope entrance on drums must be checked). - Sufficient line-pull on 1st layer must be applied.
Opening of strands in rotation-resistant ropes - in extreme circumstances the rope may develop a “birdcage distortion” or protrusion of inner strands. NOTE: Rotation-resistant ropes are designed with a specific strand gap which may be apparent on delivery in an off tension condition. These gaps will close under load and will have no effect on the operational performance of the rope.	- Check sheave and drum groove radii using sheave gauge to ensure that they are no smaller than nominal rope radius +2.5%. Supplier recommends that the sheave and drum groove radii are checked prior to any rope installation. - Repair or replace drum/sheaves if necessary. - Check fleet angles in the reeving system -a fleet angle in excess of 1.5° may cause distortion. - Check installation method - turn induced during installation can cause excessive rope rotation resulting in distortion. - Check if the rope has been cut on site prior to installation or cut to remove a damaged portion from the end of the rope. If so, was the correct cutting procedure used? Incorrect cutting of rotation-resistant, low-rotation and parallel closed ropes can cause distortion in operation. - Rope may have experienced a shock load.
Corrosion (general)	- Lack of lubrication - Environmental damage, e.g. acidic fume - exposure - Improper storage
External corrosion.	- Consider selection of galvanized rope. - Review level and type of service dressing.

Internal corrosion.	- Consider selection of galvanized rope. - Review frequency amount and type of service dressing.
Drum crushing	- Not installed under tension - Loose structure while installing - Loose first layer / wraps on drum. - Drum has to be applied with tension.
Wires looping from strands.	- Check that the sheave and drum diameter is large enough. Supplier recommends a minimum ratio of the drum/sheave to nominal rope diameter of 18:1. - Indicates that the rope has run over a small radius or sharp edge. - Check to see if the rope has “jumped off” a sheave and has run over a shaft.
“Pigtail” or severe spiralling in rope.	- Check that the sheave and drum diameter is large enough. Supplier recommends a minimum ratio of the drum/sheave to nominal rope diameter of 18:1. - Indicates that the rope has run over a small radius or sharp edge. - Check to see if the rope has “jumped off” a sheave and has run over a shaft.
Wave or corkscrew deformations normally associated with rotation-resistant ropes.	- Check sheave and drum groove radii using sheave gauge to ensure that they are no smaller than nominal rope radius +2.5%. Supplier recommends that the sheave/drum groove radii are checked prior to any rope installation. - Repair or replace drum/sheaves if necessary. - Check fleet angles in the reeving system - a fleet angle in excess of 1.5° may cause distortion - Check that rope end has been secured in accordance with manufacturer's instructions. - Check operating conditions for induced turn.
Short rope life induced by excessive wear and abrasion.	- Check fleet angle to drum. - Check general alignment of sheaves in the reeving system. - Check that all sheaves are free to rotate. - Review rope selection.

APPENDIX A: ROPE CONSTRUCTION

A.1 INTRODUCTION

A.1.1 GENERAL

A steel wire rope (see Figure 7-1) is a complex machine part and consists of a great number of wires and strands of different dimensions. It is subjected to a wide spectrum of mechanical loads.

A.1.2 WIRES

Wires are the basic building blocks of a wire rope. They often lay around a “center” (see Figure 7-2) in a specified pattern in one or more layers to form a strand.

A.1.3 STRANDS

The strands (see Figure 7-2) lay around a core to form a wire rope. The strands provide all the tensile strength over 90% of the strength of a typical 6-strand wire rope with an independent wire rope core.

Characteristics like fatigue resistance and resistance to abrasion are directly affected by the design of strands. The basic strand constructions are illustrated as follows:

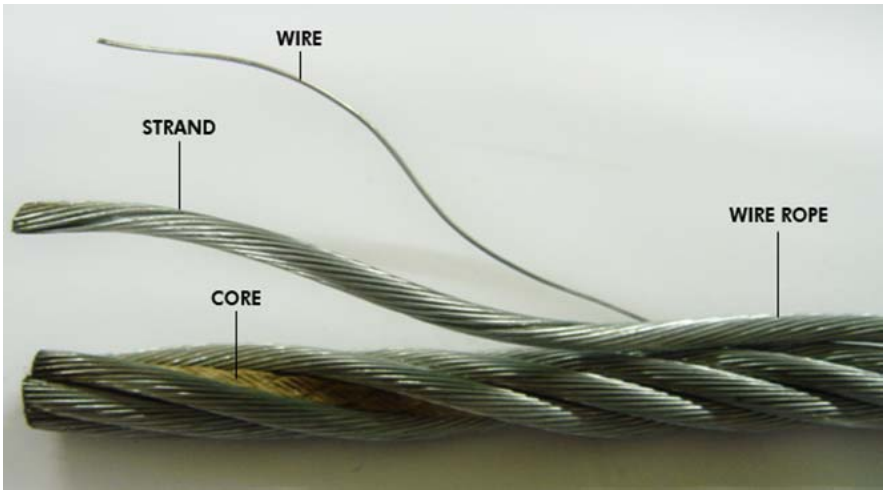


Figure 7-1: Wire rope composition (typical)

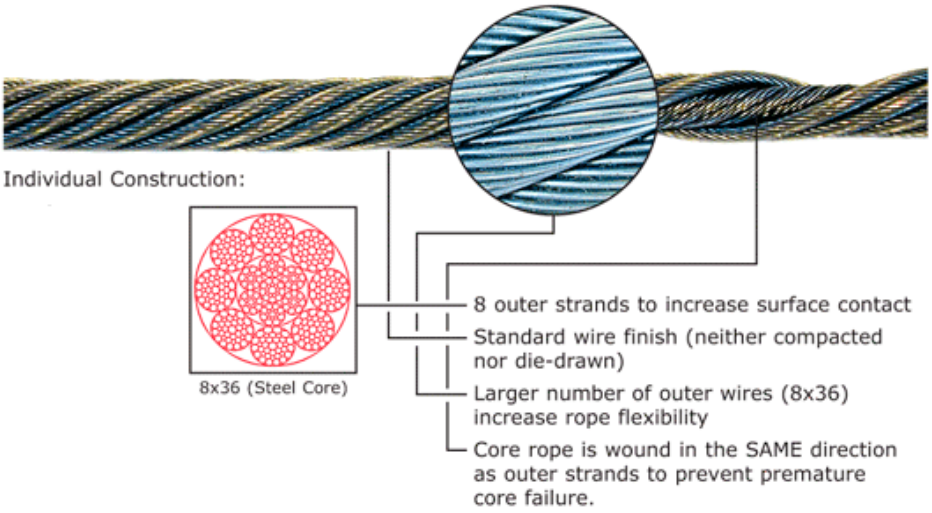


Figure 7-2: Wire rope (typical 8 x 36)

SINGLE LAYER

The most common example of the single layer construction is a 7-wire strand. It has a single-wire center with six wires of the same diameter around it.

SEALE

This construction has two layers of wires around a center with the same number of wires in each layer. All wires in each layer are the same diameter. The strand is designed so that the large outer wires rest in the valleys between the smaller inner wires.
Example: 19 Seale (1-9-9) strand.

FILLER WIRE

This construction has two layers of uniform-size wire around a center with the inner layer having half the number of wires as the outer layer.
Small filler wires, equal in number to the inner layer, are laid in valleys of the inner layer.
Example: 25 Filler wire (1-6-6f -12) strand.

WARRINGTON

This construction has two layers of wires around a center with one diameter of wire in the inner layer, and two diameters of wire alternating large and small in the outer layer.
The larger outer layer wires rest in the valleys, and the smaller ones on the crowns, of the inner layer.
Example: 19 Warrington [1-6-(6+6)].

A.1.4 COMPACTED STRANDS

A compacted strand (see Figure 7-3) is a strand of regular round wires with a diameter that is reduced – compacted – by passing the strand through a die or roller, or by swaging it. Before being compacted the strand has a larger diameter, requiring the use of thicker wires. Therefore, size for size, a compacted strand has a higher fill factor, and hence, a higher breaking force than a conventional strand of round wires.

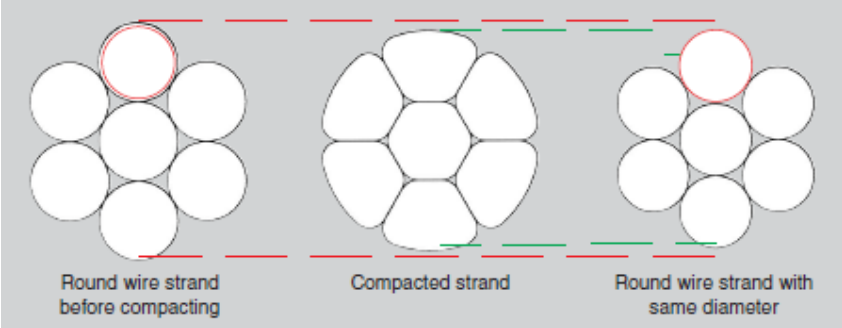


Figure 7-3: Compacted strands

Especially in a multi-layer coiling system, the outer strands of a rope with conventional strands will interface with those of a neighboring layer (figure 19) and suffer high abrasion of the surface. The smooth cylindrical surface of a compacted strand offers greater resistance to abrasion and crushing forces than a conventional strand (see Figure 7-4).

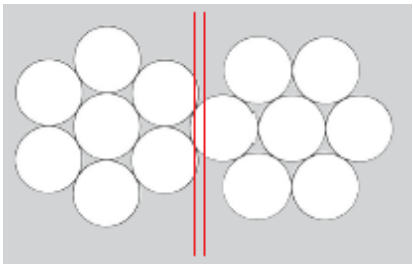


Figure 7-4: Interference of round wire strands

A.1.5 COMPACTED ROPES

Compacted ropes (see Figure 7-5) are made of either regular strands of round wires or of compacted strands. After the rope is closed, its diameter is reduced – compacted – by passing the rope through a die or a roller, or by swaging it. Such ropes have a particularly smooth, cylindrical surface and are designed and produced to perform especially well under the extreme radial pressures to which a rope is subjected in a multi-layer coiling system.

A compacted rope has a larger metallic cross-sectional area than a conventional rope, resulting in a particularly high breaking force.

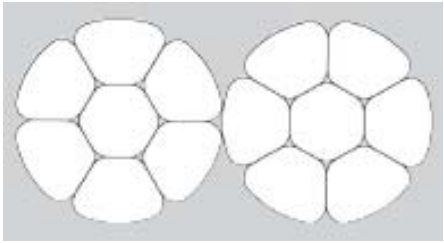


Figure 7-5: Contact between compacted strands

A.1.6 CORE

The purpose of the core is to provide support and maintain the position of the outer strands during operation. The core provides an elastic bed to enable movement or relative displacement and allow deformation of the wire strands when the rope is flexed round a sheave.

Independent Wire-Rope Core (IWRC)

The primary function of the core is to provide adequate support for the strands. As the name implies, an IWRC is a separate small-diameter wire rope that is used as the core for a larger wire rope (See Figure 7-6).

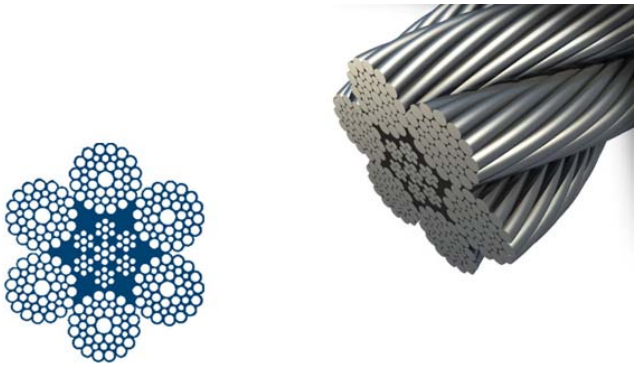


Figure 7-6: Independent wire rope core

Parallel lay

In a cross (**non-parallel**) lay strand **all wires** have different lay lengths, and in a cross (non-parallel) lay rope **all strands** have different lay lengths. The high stress concentration at the cross-over points leads to an early internal failure (see Figure 7-7).

In a **parallel** lay strand **all wires** have the same lay length, and in a parallel lay rope **all strands** have the same lay length. The linear contact leads to an optimal stress distribution.

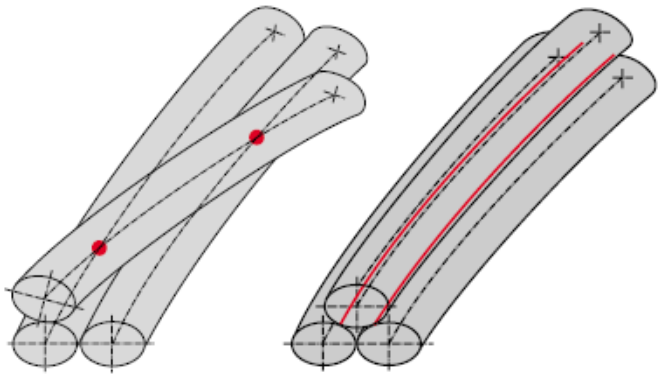


Figure 7-7: Cross (non-parallel) lay and parallel lay stress concentration and stress distribution

Spinning and non-spinning ropes

- In a conventional wire rope, an external tension load invokes a moment which tries to untwist the wire rope and causes the load to rotate. This is called: “Spinning”.
- The spinning effect is prevented by twisting the separate layers of strands in a different direction which results in a “Non-spin” wire rope (see Figure 7-8).

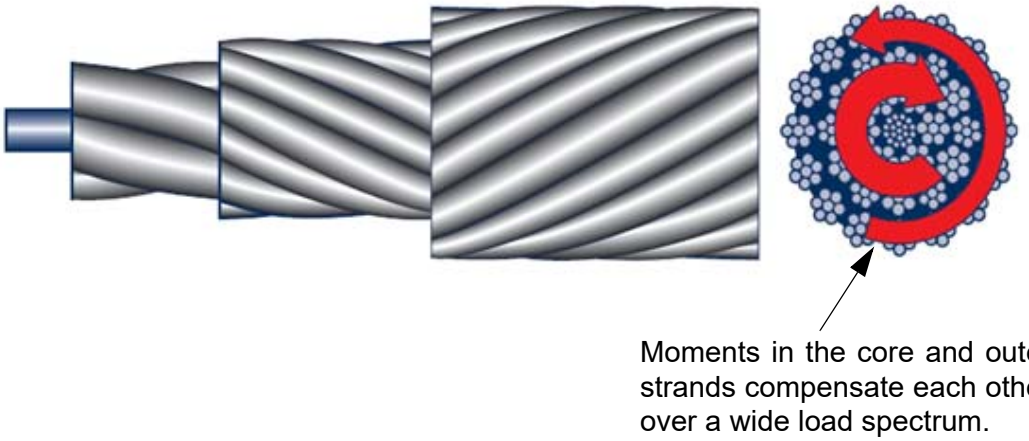


Figure 7-8: Non-spin wire rope

Strand core

This type of core has a single strand used as the core. This type is generally confined to the smaller ropes as a substitute for IWRC. The strand core may or may not have the same cross section as the surrounding strands.

A.1.7 DIAMETER

The diameter of rope is the diameter of its circumference, circumscribed to its normal section. This diameter is given in millimeters.

A.1.1.8 How to determine the practical diameter

You should make the measurement carefully with special calipers (see Figure 7-9). We recommend using calipers with wide jaws for measuring the actual diameter in order to get proper exact results.

NOTE *The right way to measure the diameter of a rope is to obtain the diameter of the circumscribed circle (see Figure 7-9).*

Measurements are taken at two points (Dx and Dy) at least one meter apart and two diameters are measured at 90° one from the other. The diameter measurement should be repeated 3 times to exclude measuring errors. Be aware of the fact that the rope diameter is directly dependent on the applied line pull. Therefore, the applied line pull should always be noted together with the measured rope diameter. Furthermore, during operation of the wire rope the diameter will become smaller due to compacting of the section, wear of the wires and bending around drums and sheaves.

The correct diameter (d) is the greatest diameter of the rope or strand (see Figure 7-9).

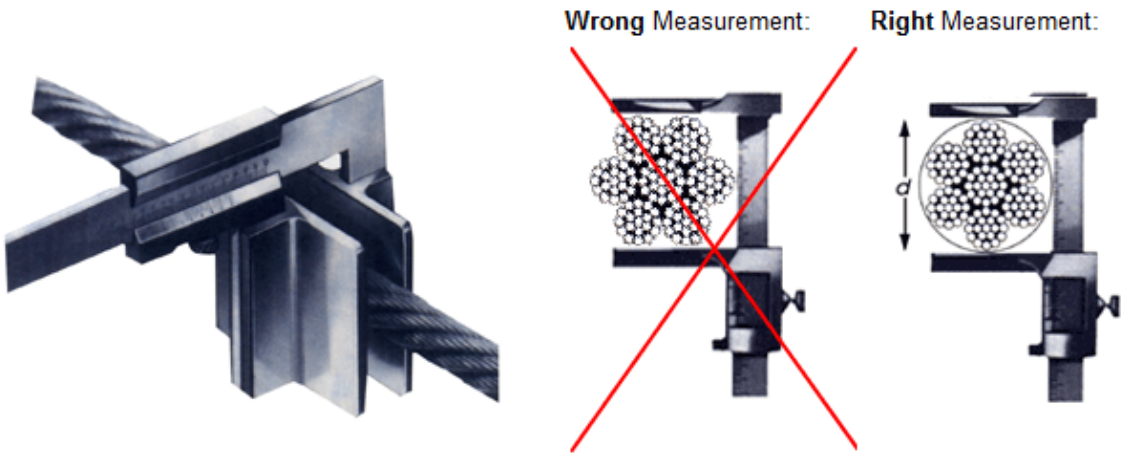


Figure 7-9: Diameter measurement

The measured diameter has to be recorded in specific table. The table below can be taken as an example.

	Dx [mm]	Dy [mm]	Davg = (Dx + Dy) / 2) [mm]
Measurement 1:			
Measurement 2:			
Measurement 3:			
Line pull [kN]:		Actual rope diameter [mm]:	

A.2 WIRE LAY

A.2.1 GENERAL

The term lay refers to the direction of the twist of the wires in a strand and to the direction that the strands are laid in the rope. In some instances, both the wires in the strand and the strands in the rope are laid in the same direction; and in other instances, the wires are laid in one direction and the strands are laid in the opposite direction, depending on the intended use of the rope.

1. The direction strands lay in the rope – right or left. In right regular lay rope, the wires in the strands are laid to the left, while the strands are laid to the right to form the wire rope. In left regular lay rope, the wires in the strands are laid to the right, while the strands are laid to the left to form the wire rope. In this lay, each step of fabrication is exactly opposite from the right regular lay.
2. The relationship between the direction strands lay in the rope and the direction wires lay in the strands. In appearance, wires in regular lay appear to run straight down the length of the rope, and in lang lay, they appear to angle across the rope.
   In regular lay, wires are laid in the strand opposite the direction the strands lay in the rope. In lang lay, the wires are laid the same direction in the strand as the strands lay in the rope.In right lang lay rope, the wires in the strands and the strands in the rope are laid in the same direction; in this instance, the lay is to the right.In left lang lay rope, the wires in the strands and the strands in the rope are also laid in the same direction; in this instance, the lay is to the left (rather than to the right as in the right lang lay).
3. The length along the rope that a strand makes one complete spiral around the rope core. This is a measurement frequently used in wire rope inspection. Standards and regulations require removal when a certain number of broken wires per rope lay are found.

A.2.2 LEFT OR RIGHT LAY

The lay of a rope (see Figure 7-10) is crucial for the performance and the lifetime of a wire rope. The correct lay can also be found in the product specification document. If you are not sure which lay is needed, you can also contact our wire rope experts.

A.2.3 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 must be specified in the crane specification document. Ropes in Lang's lay can reach a longer service life under certain circumstances. Lang's lay ropes must not be used in single layer spooling and/or just on plastic sheaves (where fitted).

Figure 7-10: Lay

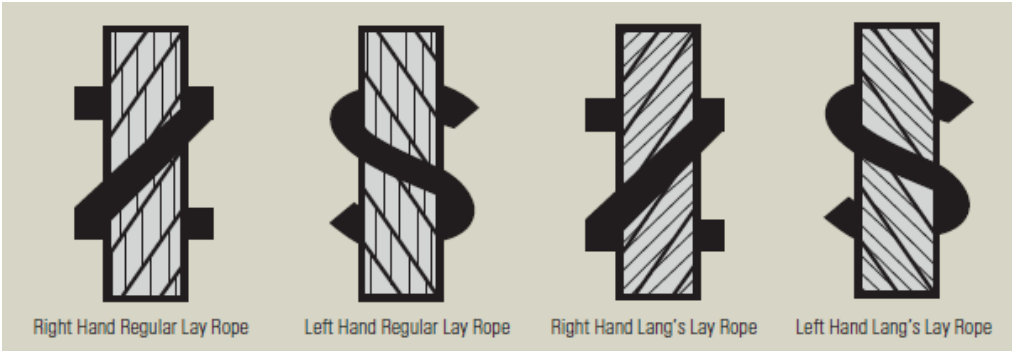


Figure 7-11: Regular and Lang's lay

A.2.4 LAY LENGTH

The lay length of a wire rope is defined as the distance of which a strand returns at the original position over a wrap (see Figure 7-12). The lay length depends on the wire rope construction - usually between 6 or 8 times the diameter of the wire rope.

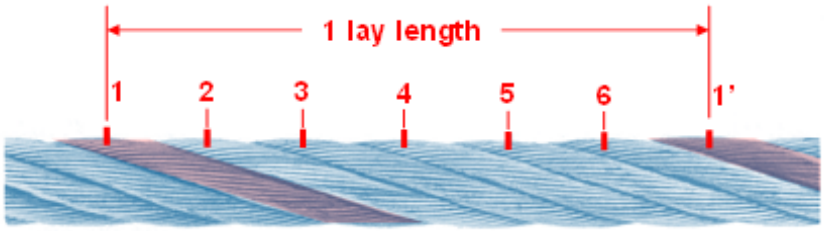


Figure 7-12: Lay length

APPENDIX B: END CONNECTIONS

B.1 WIRE ROPE END CONNECTIONS

B.1.1 GENERAL

A wire rope is a highly stressed machine element. The load is introduced into the wire rope by means of its end connection. The requirements for the end fitting are demanding:

- The connection must be able to transfer great static and dynamic forces
- The connection must be able to withstand high temperatures
- It must be able to rotate freely in one or two planes around its anchor point
- It must be easily attachable and detachable, particularly for reeving and inspection purposes.

The end connection can have two functions:

- Form the dead end of the rope
- Connect the rope to the drum.

The dead connection can be formed with an open wedge socket, an open spelter socket, a closed spelter socket or a fast reeving socket. The connection to the drum can be performed with a standard clamp block (welded eye needed) or with a weak link (peeled off end needed).

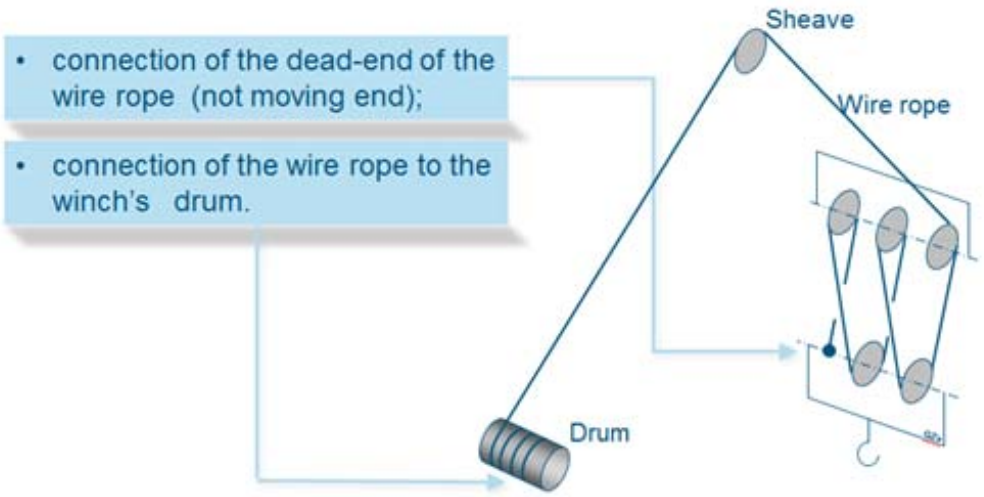


Figure 8-13: End connections

B.1.2 DEAD END CONNECTION

B.1.2.1 Open wedge, open spelter and closed spelter sockets

Open wedge, open spelter and closed spelter sockets are the most frequently used end connections (see Figure 8-14) in Huisman applications. These end connections are preferred and are listed in the European Standard (NEN-EN13411-4 Terminations for steel wire ropes - Safety - Part 4: Metal and resin socketing).

Open spelter Closed spelter Open wedge spelter

Figure 8-14: Spelter sockets

B.1.2.2 Fast reeving sockets

Three types of fast reeving sockets are available:

- Hexagon fast reeving socket
- Smooth fast reeving socket
- Fast reeving socket (supplied by Ropeblock).

Each of the fast reeving sockets can be locked against rotation and uplift. Advantage of the Huisman Design hexagon fast reeving socket is the variation in installation possibilities. The button can be installed in a socket or with a locking ring (Figure 3 4). The smooth fast reeving socket is an easy design and has advantages during reeving in of the wire due to its geometry (Figure 3 5).

The fast reeving socket supplied by Ropeblock contains a button cover with thread, which might come loose during reeving in of the wire. Therefore this fast reeving socket is not preferred. Furthermore, the Ropeblock fast reeving socket is currently only available for wire diameter 49-54mm.

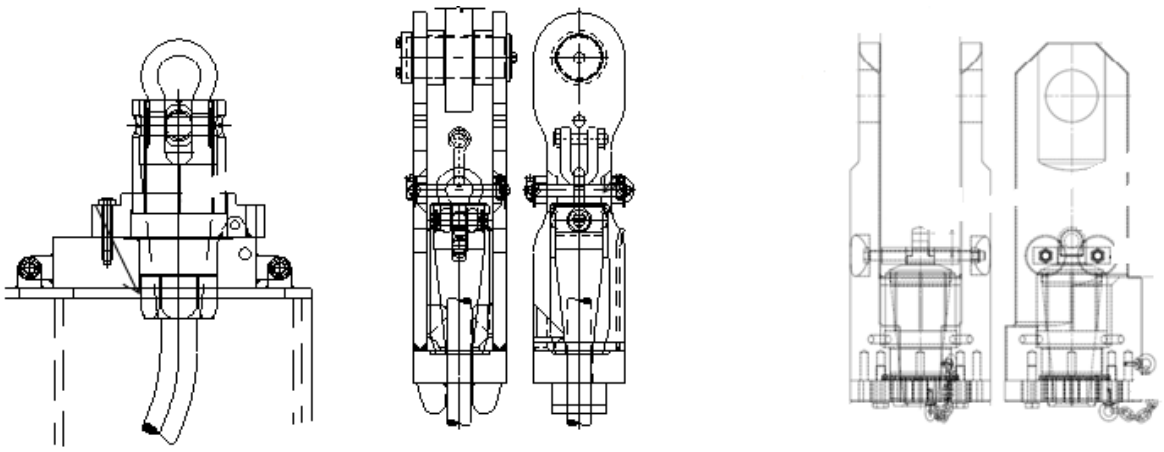


Figure 8-15: Fast reeving socket

B.1.3 DRUM CONNECTION

The choice of the end connection is dependent upon the application of the winch. In general an end connection which should be applied must be at least as strong as the wire itself. For the connection to the drum a clamp block or a weak link can be used.

When using a clamp block (see Figure 8-16), the wire rope is guided through the flange and fixed with a clamp block on the outside of the flange or on the extended drum.

When applying a weak link (see Figure 8-17), the peeled off rope core is attached on the inside of the flange. In both cases a welded eye needs to be attached to the wire rope for reeving purposes.

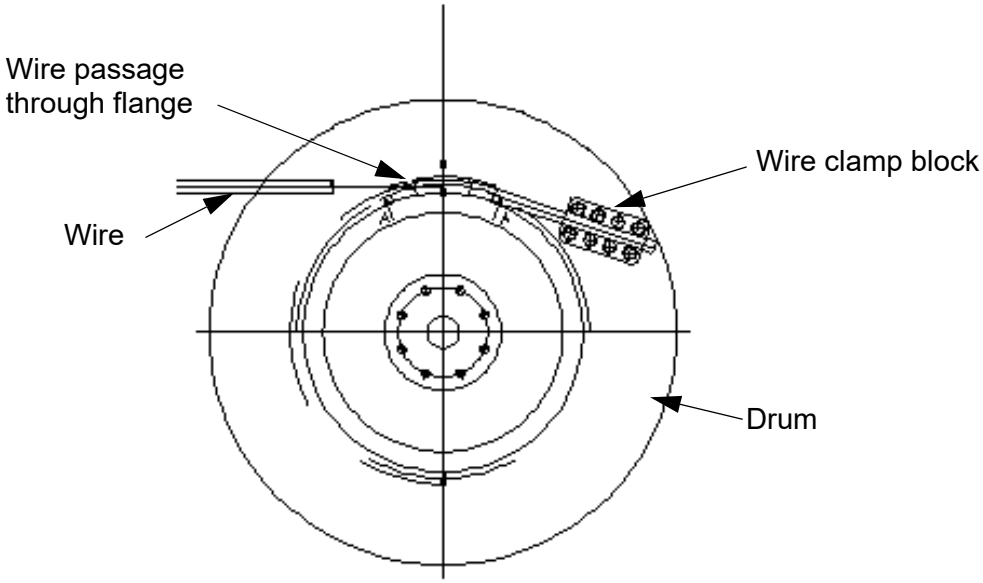


Figure 8-16: Clamp block

B.1.3.1 Bolted to inside of flange

Connecting the wire on the inside of the flanges can be done by clamping the wire between a standing strip and socket cap screws (see Figure 8-18). An advantage of this way of connecting the wire is that no big hole is needed in the flange to pass the wire through.

However for this case the outer strands of the wire need to be peeled over a certain distance. This way only the core strand will be clamped and the diameter will be reduced. A disadvantage of a wire connection on the inside of the drum is that it is impossible to inspect the connection.

When this method is chosen five safety windings are required.

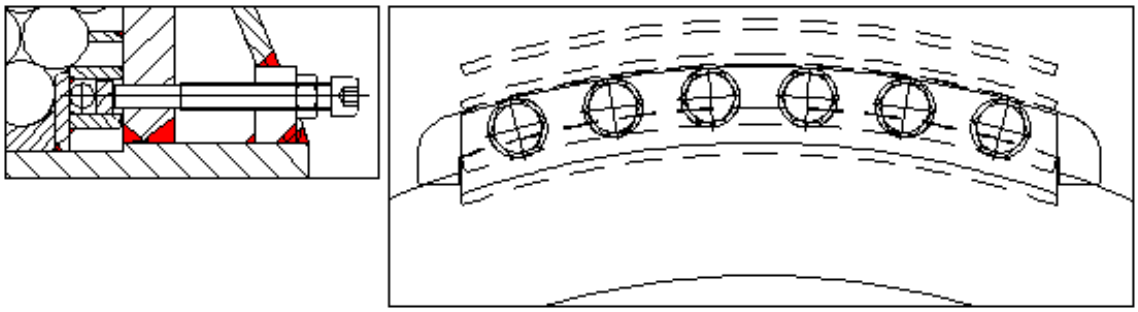


Figure 8-17: Week link (bolted to inside of flange)

8.3.1.1 Bolted to outside flange

The other solution for the end connection of the wire rope is to clamp it on the outside of the flange. An advantage of this connection is that the wire doesn't need to be peeled and no standing strip has to be welded onto the drum shells. However for this method a large hole has to be made in the flange to pass the wire through, which has consequences for the strength.

The clamp is normally made on a grooved block which will be screwed into the flange by 4 or 6 pre-tension bolts (see Figure 8-17).

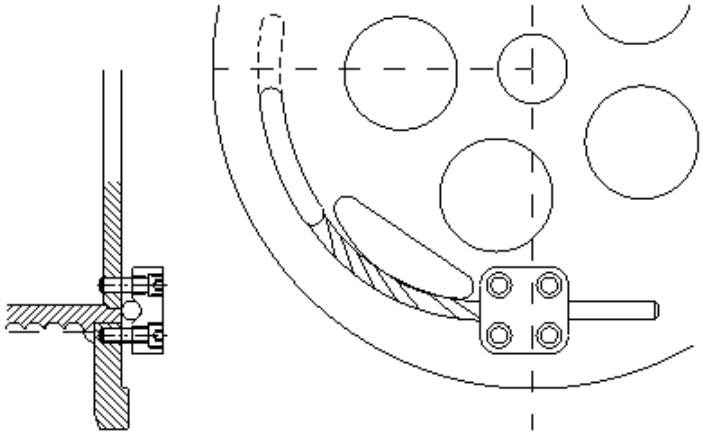


Figure 8-18: Week link (bolted to outside of flange)

B.1.4 EMPTY DRUM SWITCH

To reduce the risk that the omission of resetting the gear cam switch after rope exchange which will lead to unwind the drum completely and loosen the rope from the drum.

An empty drum warning placard is available, which states the following:

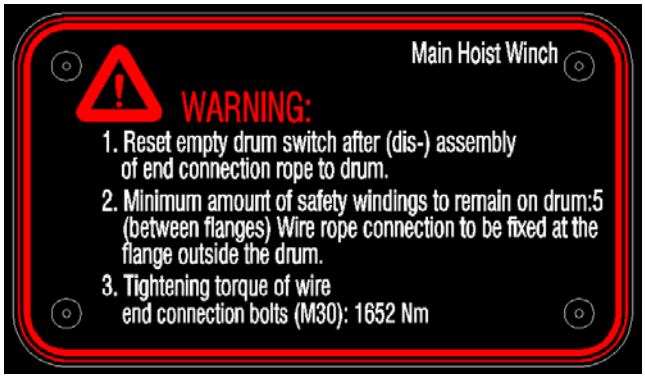


Figure 8-19: Empty drum warning placard (typical)

Carefully follow the instructions as given on the warning placard.

B.1.5 DIRECTION OF THE WINDING

To determine the direction of the winding of the drum or reeving system:

Place yourself at a fix point (⊗) of the rope on the drum (at the reeving system) and follow the turns of the rope with your finger (see Figure 8-20).

Right handed drum - left hand lay rope

Left handed drum - right hand lay rope

Figure 8-20: Direction of lay

Left hand illustration (see Figure 8-20)

If you move your finger clockwise, the drum (reeving system) is right hand, and needs a left hand lay rope.

Right hand illustration (see Figure 8-20)

If you move your finger counterclockwise, the drum (reeving system) is left hand, and needs a right hand lay rope.

APPENDIX C: GENERAL WEAR AND POSSIBLE ROPE DAMAGE

C.1 GENERAL

Life expectancy of a wire rope can vary significantly depending on its use.

The life expectancy of a wire rope might be based on:

- The number of cycles that it performs
- A period of time, or because of some particular noticeable factor detected during thorough examination/inspection
- At termination; for example the point at which a wire's protective galvanized coating starts to show signs of wear
- Signs of deterioration considered critical and may affect the relevant factor of safety.

The international standard ISO 4309 contains useful guidance on the causes of wire rope deterioration and clearly explains when discard if necessary.

The main types of deterioration of a wire rope in service are fatigue, corrosion, abrasion and mechanical damage.

One or more of these effects may be present and all should be taken into consideration when selecting a wire rope for a particular service. Incorrect spooling of a wire rope on a drum, badly aligned or inappropriate sheaves can cause serious damage.

C.2 CAUSES

Several causes of wire rope damage are explained in this section.

C.2.1 FATIGUE

Fatigue in a wire rope is normally caused by repeated bending of wire ropes under tensile loading, for example, when wire ropes operate over sheaves and rollers, around drums and through heave compensation systems.

Generally, wire rope constructions with a greater number of smaller wires will have a greater resistance to bending fatigue.

Given correctly operating equipment in good condition, the main factors causing fatigue are, therefore:

- The number and degree of load during operating cycles
- A small ratio of sheave to wire rope diameter (D/d)
- A small drum to wire rope diameter
- Incorrect fleet angles.

Fatigue breaks may not be visible in some forms of wire rope construction. In certain circumstances these breaks occur only in the internal wires and the wire rope may fail before there is any external indication of wire breaks.

Careful periodic thorough examination and inspection should be recorded and studied as part of the maintenance process, to determine the current and projected health status of the wire rope.

C.2.2 BROKEN WIRES

Wire breaks in a wire rope are one of the most obvious indicators of degradation. However, these wire breaks may not be so evident on rotation-resistant wire ropes as the majority of wire breaks are likely to occur internally, thus highlighting the requirement for periodic internal examination and/or non-destructive examination. The rate of breakage increases with use and age.

C.2.3 PROTRUDING WIRES IN LOOPS

Ropes with protruding wires, usually occurring in groups on the opposite side of the rope which is in contact with a sheave groove, shall be immediately discarded (see Figure 9-21).

Figure 9-21: Wire protrusion

NOTE	*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.*

C.2.4 CORROSION

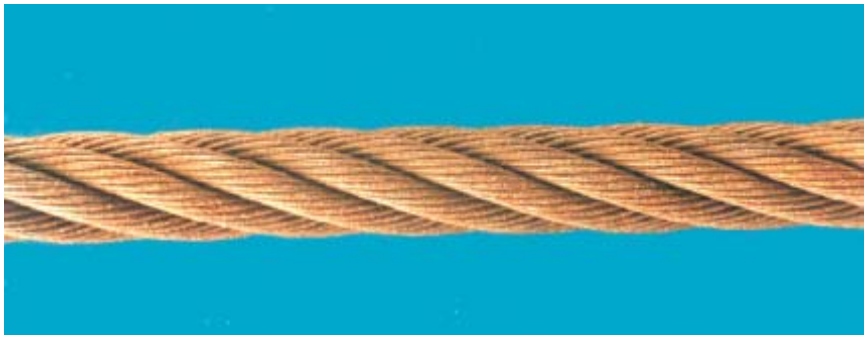


Figure 9-22: External corrosion

Corrosion is a main cause of wire rope deterioration and failure in service. Even in very dry condition there is always some corrosion of unprotected steel wires. Corrosion will reduce the strength of a wire rope by reducing its metallic cross-sectional area. Fatigue will also be accelerated by corrosion creating surface irregularities which lead to stress cracking. Severe corrosion can result in a loss of elasticity of the wire rope.

In some respects, requirements for corrosion resistance and fatigue resistance are contradictory. For the former, a small number of large wires are an advantage, whereas for the latter a large number of small wires are to be preferred.

Subsea wire ropes are highly prone to corrosion. There is an increased risk of internal corrosion in wire ropes of dense construction, where lubrication may not be penetrating to the center, especially when such wire ropes are used subsea.

Corrosion of outer wires can be seen more readily (see Figure 9-22), but internal inspection, including Non-Destructive Examination (NDE), may be required to detect internal corrosion.

C.2.5 ABRASION

Abrasion occurs primarily in the outer wires. Wire ropes pulled across abrasives will wear more quickly. Wire ropes with fewer but larger outer wires give a longer working life under abrasive conditions than those with many smaller outer wires.

Langs lay has superior wear resistance and better performance in multi-layer spooling due to better contact against wires of the adjacent wrap.

The cross-sectional area of the wire rope will be reduced by abrasive wear and if the diameter decreases more than 7% of the nominal wire rope diameter, the wire rope should be discarded and the information recorded, even if no wire breaks are visible (see ISO 4309).

C.2.6 CRUSHING AND CROSSOVER DAMAGE

The type of drum (e.g. plain or grooved), type of grooving (e.g. helical, parallel, or counterbalanced) and the condition of the grooves will influence the amount of damage to the rope when multi-layer spooling, particularly at the cross-over zones.

If correct back tension is not achieved when spooling a wire rope on to a drum, severe crushing damage can be caused to underlying layers when the wire rope comes under sufficient load.

A wire rope that “cuts in” to a lower layer on a drum due to poor spooling can become wedged, and if the drum continues to rotate, the shock loading can damage or even break the wire rope.

When paying out a wire rope that is trapped by a crossover, it is possible that the direction of wire rope movement is reversed, that is, that the same direction of drum rotation actually starts to heave the rope in, creating a high potential for a lifting incident and probable significant damage to the wire rope.

The result of crushing or crossover can be severe including multiple broken wires, deformation and subsequent requirement to discard.

In systems that use multi-layer winding on to the winch drum, there is the possibility that local damage can be caused to the wire rope in the regions where the wire rope crosses from one layer to the next, or where the wire rope crosses over the turns in the layer beneath.

This can be mitigated by slipping and cutting a length sufficient to move all the layer crossover regions on the wire rope, and the groove crossovers, where this type of winding is used. This cut-and-slip does not eliminate the crossover damage but distributes it along the length of the wire rope. Such damage and cut and slip operations should be recorded.

C.2.7 BASKET/LANTERN/BIRDCAGE DEFORMATION

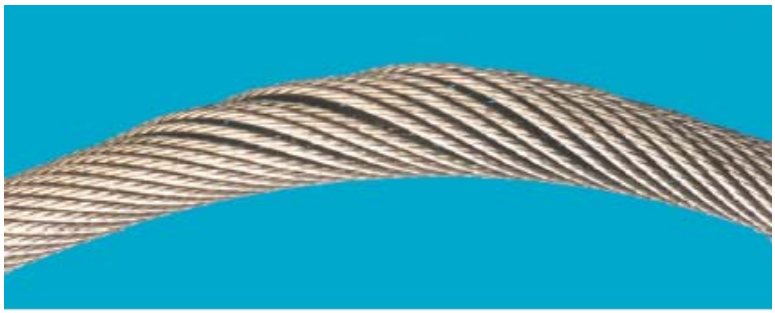


Figure 9-23: Basket deformation

This form of deformation (see Figure 9-23) can occur as a result of a difference in length between the wire rope core and the outer layer of strands, for example, when wire ropes with high rotation characteristics are used between blocks that are free to rotate.

Care needs to be taken in block and swivel connections as incorrect application can lead to premature deterioration.

C.2.8 UN-LAYING

Un-laying can occur if wire ropes of different types and lay are joined in series. Un-laying could lead to catastrophic failure. If joining two ropes of different types is unavoidable, specialist advice should be sought and information recorded.

When lack of a swivel has caused a wire rope to un-lay under load, the outer wires may not show the damage done to the interior of the wire rope when off load.

C.2.9 DIAMETER REDUCTION AS A RESULT OF CORE DETERIORATION

Figure 9-24: Local reduction of rope diameter

The core of a wire rope can deteriorate for a number of reasons. Even if the core cannot be accessed for internal examination, evidence of this can be indicated by a reduction in wire rope diameter (see Figure 9-24). This can result in a significant loss of strength.

Any indicators of such deterioration should be supplemented by internal visual examination where practicable. In circumstances where this cannot be done, the wire rope should be thoroughly examined by a competent person and the results recorded.

ISO 4309 states that if these factors cause the actual wire rope diameter to decrease by 3% of the nominal wire rope diameter for rotation-resistant wire ropes, or by 10% for other wire ropes, the wire rope shall be discarded even if no broken wires are visible. Note: New wire ropes will normally have an actual diameter greater than the nominal diameter.

C.2.10 LOCAL INCREASE IN WIRE ROPE DIAMETER

Figure 9-25: Local increase in wire diameter

An increase in the diameter of a low rotational wire rope is normally, as a result of internal corrosion (this is caused by a build-up of rust). Where this is suspected, the wire rope should be thoroughly examined by a competent person.

Increase in wire rope diameter can also be the result of deformation of the core. The remainder of the wire rope would then become misshapen. If this condition results in the wire rope diameter increasing by 5% or more, then the wire rope should be immediately discarded (see section 3).

C.2.11 WAVINESS

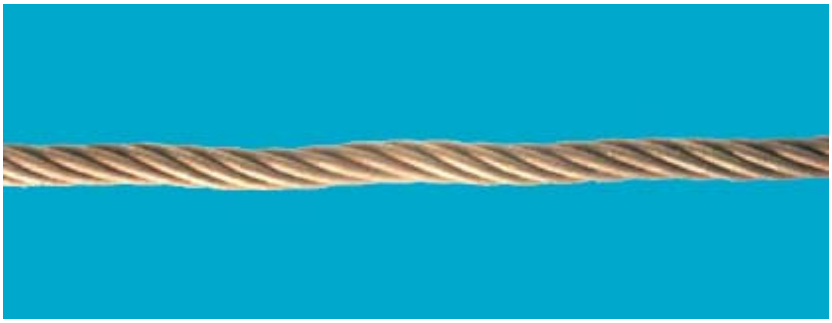


Figure 9-26: Waviness

Waviness is the deformation that results in a wave pattern forming in the wire rope (see Figure 9-26) when in either a loaded or unloaded condition and should be recorded when detected.

While not necessarily resulting in any loss of strength, such a deformation will result in an imbalance in turn leading to wear and wire breaks.

C.2.12 FLATTENED PORTION

Flattened portions (see Figure 9-27) of rope which run through a sheave are likely to deteriorate more quickly and show 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.

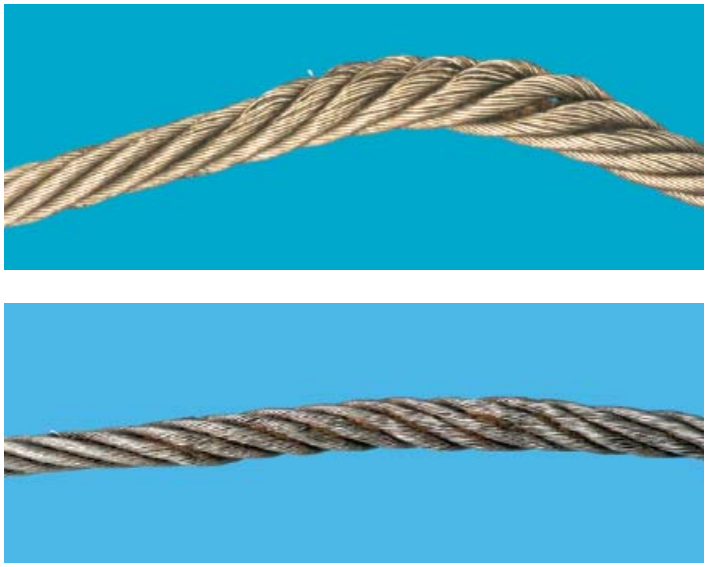


Figure 9-27: Flattened portions

C.2.13 KINK OR TIGHTENED LOOP

Ropes with a kink or tightened loop shall be immediately discarded (see Figure 9-28).

NOTE	*A kink or tightened loop is a deformation created by a loop in the rope, which has been tightened without allowing for rotation about its axis. Imbalance of lay length occurs which causes excessive wear and, in severe cases, the rope becomes so distorted that it only has a small proportion of its strength remaining.*

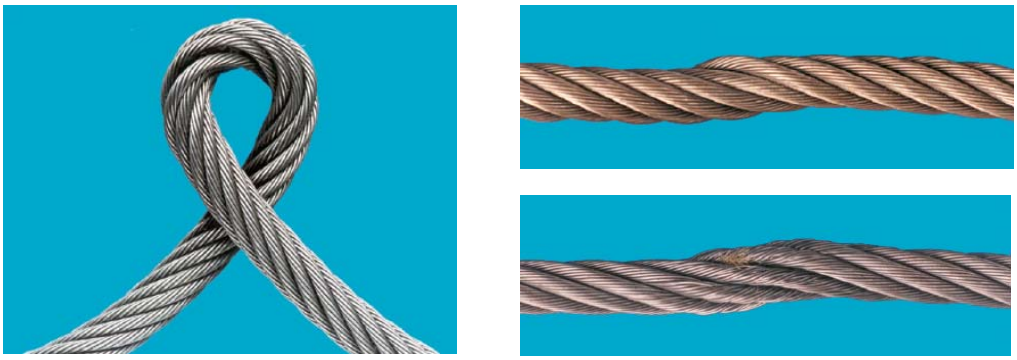


Figure 9-28: Kinks

C.2.14 OTHER DEFORMATIONS AND DAMAGE

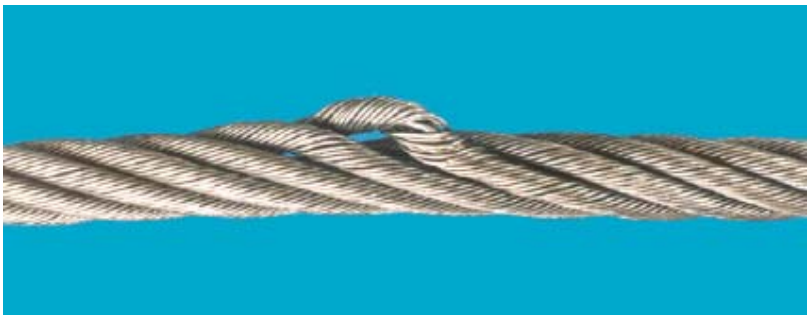


Figure 9-29: Distortion

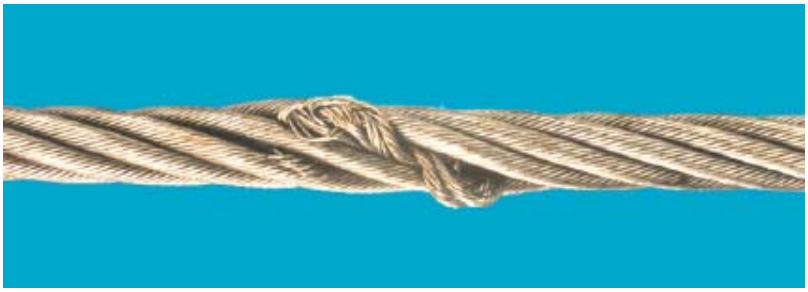


Figure 9-30: Strand protrusion

The types of deformation and damage noted below are fully described in ISO 4309.2:

- Core or strand protrusion/distortion (see Figure 9-29)
- Kinks/tightened loops (see Figure 9-28)
- Flattened portions (see Figure 9-27).

Other types of damage and deformation which are seen only infrequently should be referred to the company competent person responsible for thorough examination for advice. These include, but are not limited to:

- Weld spatter, exposure to strong heat, funnel exhaust, chemical spill or chemical fumes;
- Wire ropes that have been subjected to exceptional thermal effects, externally recognised by the colours produced in the wire rope.

All damage detected should be recorded.

C.2.15 COMBINED EFFECT

An examiner should be aware of, and note, the cumulative effect of any combination of these factors in assessing a wire rope for continued service or discard. Care should also be taken to seek out and record the cause of deterioration wherever possible, especially if the mechanical components of the lifting system or faults in that system have been the cause of the deterioration.

In circumstances where there is a combined effect of two or more of the above factors at a location in the wire rope the personnel responsible for inspection should refer to the company's appointed competent person.

LIST OF FIGURES

LIST OF TABLES