



**■ STEEL WIRE
ROPES**

1- Definition of steel wire ropes

Steel wire rope is a machine that consists of a number of moving parts that are designed and manufactured to be in constant interaction with each other. Steel ropes consist of wires, strands and a core. The main element is steel wire. Wire ropes are produced by careful processing and shaping of wires with predetermined physical properties and nominal strength. (Figure 1).

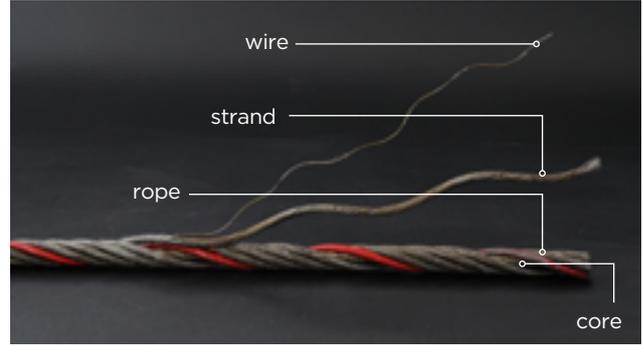


Figure 1: Components of a steel wire rope

2- Steel wire rope structure

Steel ropes are named according to the structures. Special ropes may have their own names (6x19 Seale, 6x36 Warrington Seale, X 53, HD 8 K etc.) extensions like Standard, Filler, Seale, Warrington Seale refers to the thinness, thickness and arrangement of the wires in a strand (Figure 2).

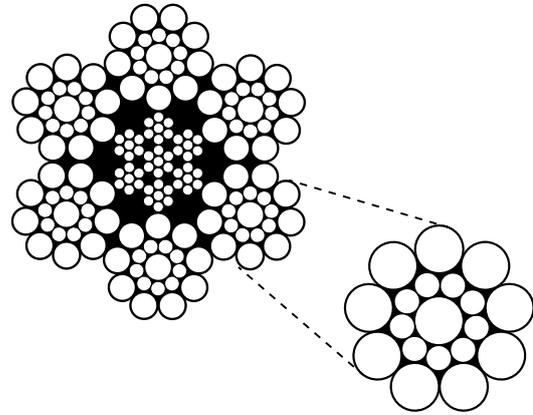


Figure 2: Example of steel wire rope structure

3- Surface finish

Steel ropes are normally made of bright wires that have not been coated. They are galvanized if protection is required due to rust, moisture and steam.

4- Nominal strength

It refers to the amount of load at which the mm² of the wires are broken. Some nominal strengths are as follows;

- 1770 N/mm² = 180 kgf.mm²
- 1960 N/mm² = 200 kgf.mm²
- 2160 N/mm² = 220 kgf.mm²

5- Direction of lay

During the production of rope, while the wires and the strands are helically shaped, the selected directions of lay indicates the direction of the rope if lay of the strands and the wires in the strand have the opposite direction, then it is called ordinary lay, if have the same direction, then called lang lay. The lay of the strand determines the lay of the rope. The basic lays are seen to Figure 3.

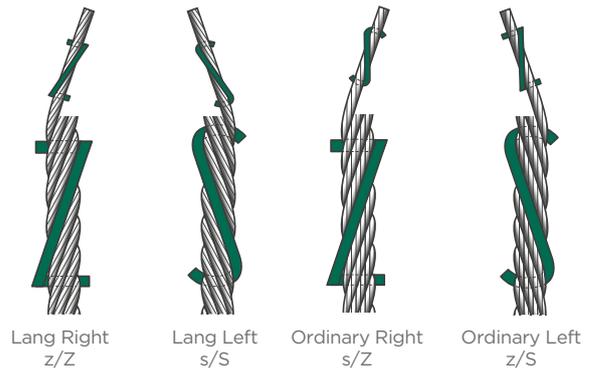


Figure 3: Lay types of steel wire ropes

6- Preforming

Preformed means that the wires and strands have been pre - set during manufacture into the permanent helical form they take in the completed rope.

7- Rope core

There are basically two types of core. There are basically two types of essence. These are called fiber core and steel core. Fiber cores are usually formed from fibers of synthetic products such as sisal and polypropylene. The steel core is again made of steel wires and there are two main types strand core and independent rope core.

8- Cutting of rope

Hand cutting tools up to 8 mm rope diameter can be used. But it is necessary to use mechanical or hydraulic cutters for diameters greater than 8 mm. The best method is cutting with grinding disc. If the rope is not scraped, it is not recommended to cut using flaming cutting tools.

The ropes should be cut with grinding discs by seizing with wire as in the figure 4. Wire should be seized to the right and left with 3 times the wire diameter. This process is important in order not to disturb the physical property of the rope.

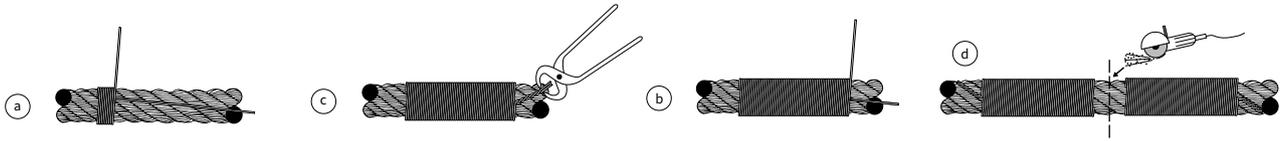
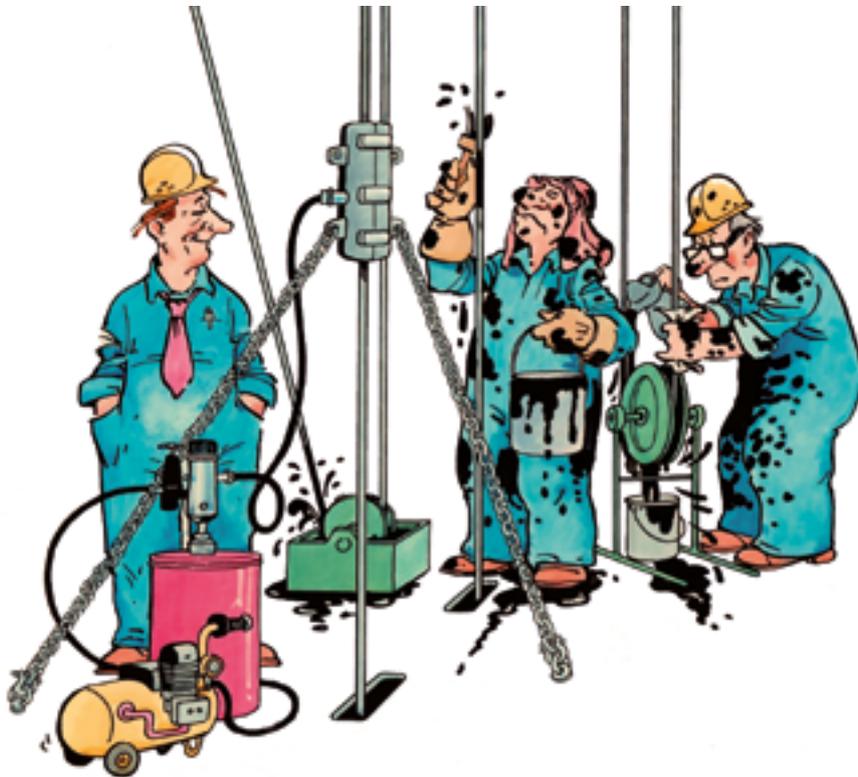


Figure 4: Cutting of rope

9- Rope lubrication

Lubricant applied to steel ropes during production; is used to prevent problems such as corrosion, dust and abrasion due to friction. Lubricants are generally asphalt based.



10- Abrasion flexibility relationship

There are two main features that influence the selection of rope; these are abrasion resistance caused by friction and fatigue resistance due to bending and twisting.

TECHNICAL INFORMATION / STEEL WIRE ROPES

Standart Rope Groups	Rope Constructions	Factors Effecting The Rope Selection				Relative Effects of Rope Constructions Against Wear, Crushing and Bending Fatigue	
		Metallic Cross - Section Approx	Percentage of The Total Reserve Strength	Approx diameter of Wires in Outer Strands of 25,4 mm Rope		MINIMUM RESISTANCE to Bending Fatigue	MAXIMUM RESISTANCE to Abrasion and Crushing
6x7	6x7 (6/1)	0.385	17,0	2,70	6		
	6x10 F.S (7/3)	0.440	23,0	2,69	7		
6x19	6x17 S. (8/8/1)	0.385	28,0	2,20	8		
	6x24 F.S. (9/12/3)	0.440	31,3	2,26	9		
6x19	6x19 S. (9/9/1)	0.395	32,0	2,03	9		
6x19	6x25 S. (9/9/6/1)	0.395	31,0	2,03	9		
	6x25 F.S. (10/12/3)	0.440	31,3	2,05	10		
6x19	6x21 F. (10/5 & 5/5/1)	0.395	37,0	1,87	10		
6x19	6x26 W.S. (10/5 & 5/5/1)	0.400	38,0	1,87	10		
	6x27 F.S (12/12/3)	0.400	34,0	1,77	12		
6x19	6x19 W. (6 & 6/1)	0.400	41,0	1,87/1,42	12		
	17 or 18x7 N.R. (6/1)	0.426	46,0	1,62/1,72	6		
6x19	6x19 (12/6/1)	0.395	40,4	1,62	12		
8x19	8x19 S. (9/9/1)	0.352	32,0	1,62	9		
6x19	6x25 F. (12/6 + 6/1)	0.405	45,0	1,62	12		
8x19	8x19 W. (6 & 6/6/1)	0.352	41,0	1,52/1,14	12		
6x37	6x31 S.W. (12/6 & 6/6/1)	0.405	42,0	1,62	12		
8x19	8x21 F. (10/5 + 5/1)	0.352	37,0	1,52	100		
	12x6/3 x 24 N.R.	0.370	50,0	1,44	6		
	6x30 F.S. (15/12/3)	0.440	37,5	1,34	15		
6x37	6x36 S.W. (14/7 & 7/7/1)	0.405	50,0	1,44	14		
6x24	6x24 (15/9 LÖ)	0.330	37,5	1,37	15		
6x19	6x26 W. (7 & 7/7/7/4/1)	0.400	48,0	1,67/1,16	14		
6x37	6x37 S. (15/15/6/1)	0.400	51,0	1,34	15		
	34x7 N.R. (6/1)	0.436	59,5	1,19/1,29	6		
	6x33 F.S. (18/12/3)	0.445	53,0	1,24	18		
8x19	6x25 F. (12/6 + 6/1)	0.352	45,0	1,32	12		
6x37	6x41 F. (16/8 & 8/8/1)	0.404	54,0	1,29	16		
6x37	6x41 S.W. (16/8 & 8/8/1)	0.404	55,0	1,29	16		
6x37	6x49 S.W. (16/8 & 8/8/1)	0.405	56,0	1,29	16		
6x37	6x37 (18/12/6/1)	0.388	56,0	1,16/1,34	18		
6x37	6x43 F. (18/9 + 9/6/4)	0.404	57,0	1,16	18	MINIMUM RESISTANCE to abrasion and crushing	MAXIMUM RESISTANCE to bending fatigue
6x37	6x46 F. (18/9 + 9/9/1)	0.405	59,0	1,16	18		

Abrasion flexibility table

11- Determination of equivalent rope

If you cannot supply the current rope you have used or if you need to use an equivalent rope for any reason, you must check the following rope characteristics.

- ★ The diameter of the rope should always be the same.
- ★ The minimum breaking load of the equivalent rope must be equal to or greater than the minimum breaking load of the previous rope.
- ★ Always replace with a rope with the same characteristic. For example, a non-rotating rope should be replaced with a non-rotating rope.

12- Measuring wire rope diameter

Rope diameters are determined by measuring the circle that just touches the extreme outer limits of the strands. In the measurement of the rope, it is necessary for the caliper's jaws to contact the two outerstrands (Figure 5), generally two measurements perpendicular to each other, at least 1 meter apart from two points in the distance. And the average of these four measurement is to be within tolerances. In case of dispute in standards, it is also foreseen to measure the rope diameter under a certain tension.

Nominal rope diameter Tolerance	Minus	Plus
Up to 3 mm	0%	8%
Between 3 mm and 5 mm	0%	7%
Between 5 mm and 8 mm	0%	6%
Greater than 8 mm	0%	5%

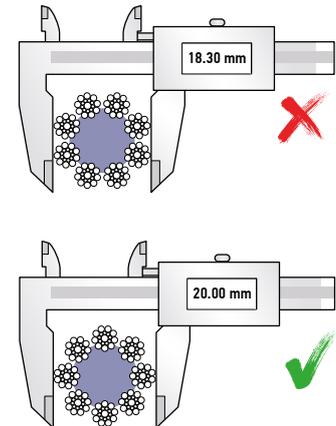


Figure 5: Correct and wrong diameter measurement

13- Groove and rope relation

The diameter of the pulley and drum and the diameter and other characteristics of the grooves on them have a great impact on the rope life. The groove gauges can be used for the diameter and width measurements of the grooves. Drum and pulley made of suitable material are useful for rope life. If the grooves are wider and the rope contact angle is higher, then the rope is ovalized. If grooves are narrower or less than necessary, the wire and strands will get stuck both cases there are inconvenient for the service life of the rope. Generally the rope and groove contact angle should be between 135 - 150 degrees (Figure 6).

- a. New rope - new groove
- b. New rope - worn groove
- c. Worn rope - worn groove

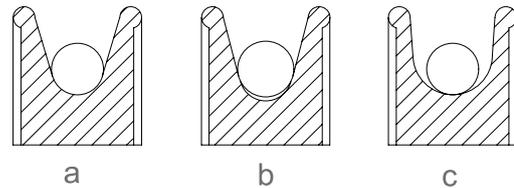


Figure 6: Groove and rope relation

14- Unwinding of ropes

The ropes must be delivered in coils or on reels, when using the rope for the purpose of use or taking into system, the precautions shown in Figure 8 must be complied. Waves occurred during the unwinding, cause permanent and undesired damages like kinks and birdcages that lead the rope to be unusable for further applications (Figure 7). It is not possible to repair the ropes that have the damages of kink or birdcage leading the discard of the ropes.

It cannot be the manufacturer's fault in the rope damage caused by such use errors. In order to avoid similar situations, winding machines should be used in the rope unwinding and cutting operations for certain lengths ropes should be rewind under a preload.

Ropes, are part of a working system, should be very carefully handled and stored before use. In all these activities, rope contact with external influences should be avoided. It should not be forgotten that the ropes are composed of a number of thin wires, as will be seen when they are examined closely, and this situation is very sensitive to external influences.

When the ropes are unwinded from the reels or coils during installation, service and rewinding to the reels, that care should be taken not to cause any damage to the rope and create stress on the ropes due to external factors. No matter what the method is unwinding, the sand, gravel and other hard objects should not be adhered to the rope. Otherwise, it can damage the system and rope when the rope passes through the pulleys during the use due to these hard objects.

It has been tested that it is not a practical and efficient method, even if the problem is not seen in the rope unwinding process by rounding the wooden reel on the ground face.



Figure 7: Damages due to wrong unwinding of rope

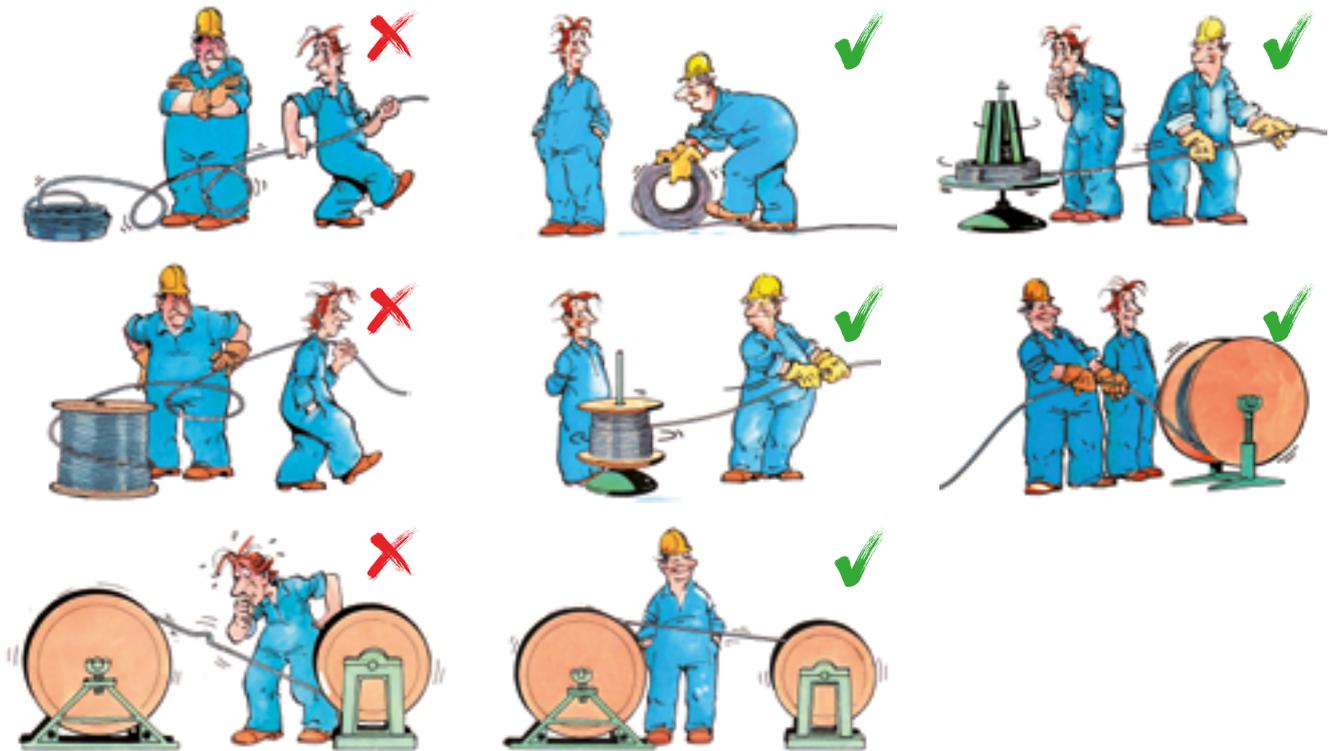


Figure 8: Correct and wrong examples of unwinding of rope

15- Rotation resistant ropes

It should be noted that especially the rotation resistant ropes are more sensitive than the other ropes during opening, transferring, end cutting and use. Therefore;

- ★ Both ends of the rotation resistant ropes must be firmly seized before cutting.
- ★ The winding, unwinding and length cutting operations must be carried out in accordance with the rules.
- ★ Before the rope is to be mounted on a crane, it should be laid on the ground if possible and should be allowed to rotate around its axis in such a way as to eliminate internal stresses.
- ★ The rope mounted to the crane must be operated for at least one hour without load, in order to remove any internal stresses that may occur, the wire and strands are to be allowed to move along the axis of the ropes, then ends of the ropes are cut and mounted to the crane again. If the rope is rotated for any reason during use, it is necessary to reapply the above - mentioned end cutting.
- ★ During use, the application of shock loads should be avoided and the rope should not pass through the small diameter pulleys and not to contact with the sharp corners.
- ★ No sudden discharge should be applied while the rotation resistant ropes are working.
- ★ The rotation resistant rope ends must be seized before use and during cutting.
- ★ Rotation resistant ropes should not be rotated under the influence of other external forces under load.

16- Considerations of rope selection

Rope constructions are selected according to the working conditions, the load to be exposed and the probability of life risk. It is useful to consider the following information regarding the selection of rope.

1. Wire grades

Of ropes are depended on;

- ★ Breaking load,
- ★ Resistance to crushing and impact,
- ★ Flexibility,
- ★ Resistance to bending fatigue.

2. Constructions

Of ropes should be taken into account according to following information;

- ★ Resistance to abrasion and impact,
- ★ Bending fatigue. These characteristics and operating conditions should also be considered for economic rope service life.

3. Rope safety factor and metallic cross sectional area

The purpose of the safety factor is to determine a satisfactory ratio between the sum of the different forces on the rope and the rope breaking load. In determining this ratio, followings should be noticed;

- ★ Rope weight “static weight”,
- ★ Impact load weights “Dynamic weight”,
- ★ Change of forces during acceleration and deceleration “accelerated weight”,
- ★ Stresses caused by bending “rope efficiency ratio”,
- ★ Stresses changes caused by vibration and winding,
- ★ Type of the load (Human, material etc.),
- ★ Usage conditions,
- ★ Difficulties in determination of rope service life,
- ★ Unpredictable changes due to misuse.

4. Lifting angle, lifting capacity and considerations in use

- ★ It should be noted that the lifting capacity of the rope is affected when lifting the sling with a certain angle. The amount of this effect is shown in the table below.

Lifting Angle	Reduction of Rope Capacity (%)
30	5
60	13
90	30
120	50

- ★ The ropes must not be used to touch the sharp corners to prevent wire breaks.
- ★ Fiber core ropes should not be used for lifting molten metals at high temperatures.
- ★ Important parameters like rope diameter, broken wire number, lubrication etc. should be checked continuously and recorded in use.
- ★ The ropes used as pairs must be fitted together, evaluated and take over.

17- Rope damages and examination methods

No matter how high quality the rope is, the rope life depends on;

- ★ The properties of the rope
- ★ Usage area
- ★ Equipment that is in contact or working together
- ★ Type of usage

In addition to the above factors, the factors that cause the ropes to be taken out of service or have an effect on the life of the rope are given below.

These are;

- ★ Unsuitable rope construction, wire breaking strength and diameter,
- ★ Unsuitable wire properties (galvanised - bright),
- ★ Operation on abrasive obstacles and lifting of sharp corner loads by direct contact to the rope,
- ★ Lubrication not suitable for use conditions,
- ★ Working on drums and pulleys of unsuitable sizes,
- ★ Multi-layered and cross winding on drum,
- ★ Operation on misaligned drums and pulleys,
- ★ Operation on unsuitable grooved drums and pulleys,
- ★ Jumping out of pulleys,
- ★ Contact with moisture and acidic environment,
- ★ Use of unsuitable fittings,
- ★ Permission to turn opposite sides,
- ★ Exposure of high temperatures,
- ★ Formation of kink,
- ★ Overloading of ropes in unsuitable conditions,
- ★ Damages due to the entrance of abrasive particles into wires and strands.

When examining a rope, the following points must be noted;

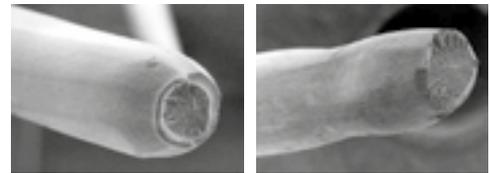
- ★ Reduction in rope diameter,
- ★ Abrasion in inner and outer wires,
- ★ Rope lay length,
- ★ Impact marks on wires and strands,
- ★ Scratch marks,
- ★ Corrosion,
- ★ Broken wires and the type of breaks.

The above considerations should be observed very well and experience should be given great importance. If possible, the route followed by the rope should be monitored until the end of the rope and the non-conforming issues should be eliminated one by one. A careful and conscious eye will not have trouble finding the cause of any errors.

18- Typical properties of broken ropes and wires

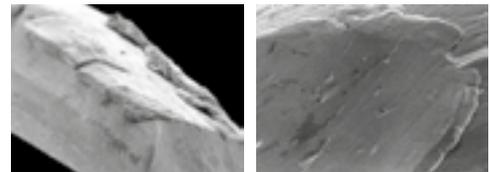
Strain Break

If one end of the broken wire is tapered and the other end is cup-shaped, it indicates that the wire is broken due to stretching. The downward movement of the broken wire ends is typical of such wire breaks. The reason is usually overloading.



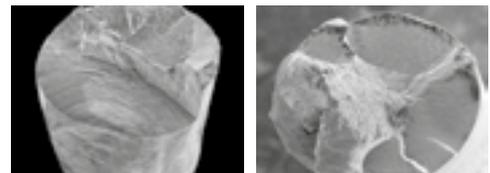
Abrasion break

Breaking wire ends are like knives. Abrasion breakage occurs in areas where the rope comes into contact with anything, in contact with the drum, pulley or grooves. An unexpected wear break; indicates an irregularity, wrong fleet angle, or local abrasive formation in the drum, grooves or sheaves.



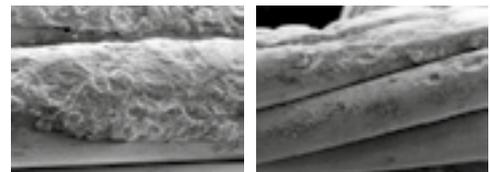
Fatigue break

The most important indication is the transverse or square fractures of a rough structure. When working with such fractures depending on the working environment of the rope, it will become shattered and rough. It is usually formed by repeated use of the rope around an object of very small diameter. Impact, vibration and torsional stress are also the cause of fatigue break. Abrasion and notching due to friction accelerates fatigue break.



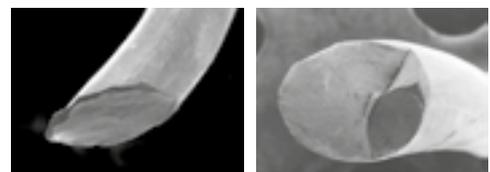
Corrosion break

The pits formed by the rust on the wire surface are indicative of such ruptures. Indicates that lubrication don't influence against corrosion. Very dangerous wire breaks may occur as the corrosion cannot be detected or detected in the inner areas of the rope.



Cut Break

It is caused by external factors. For example, a broken pulley flange may be the cause of such a break.



TECHNICAL INFORMATION / STEEL WIRE ROPES

19- How to order?

In order to prevent unnecessary time loss and misunderstanding, it is useful to give the order information as precisely and accurately as possible. For this purpose, when ordering;

- 1) Always notify the relevant standard,
- 2) If standard is not available, then provide the following information
- 3) Provide the certificate of present rope.

The following table provides information that should be provided when ordering simply.

Length	500 meter
Diameter	26 mm
Number of strands	6
Number of wires in a strand	36
Strand construction	Warrington seale
Lay of the rope	Right hand ordinary lay
Wire grade	1770 N/mm ²
Type of core	Steel
Wire surface finish	Bright
Type of lubricant	Nyrogen T55
Type of lubrication	A2

20- Handling, storage, packing

The ropes should be wound on wooden reel or steel reel (on special order) upon the customer demand according to the rope length and weight. Short ropes must be shipped in coils properly.

When transporting steel ropes, it should not touch hard, sharp, angular surfaces. Doing so could cause serious damage (Figure 9).



Steel wire ropes should be stored in closed, dry and cool environment. Direct contact with the ground must be cut. If open storage is to be done, suitable packaging should be made to prevent rusting due to wet, moisture and humidity.

When placing ropes in the stock area, they should be placed according to the first in first out principle. Thus, there will be no long waiting ropes in stocks.

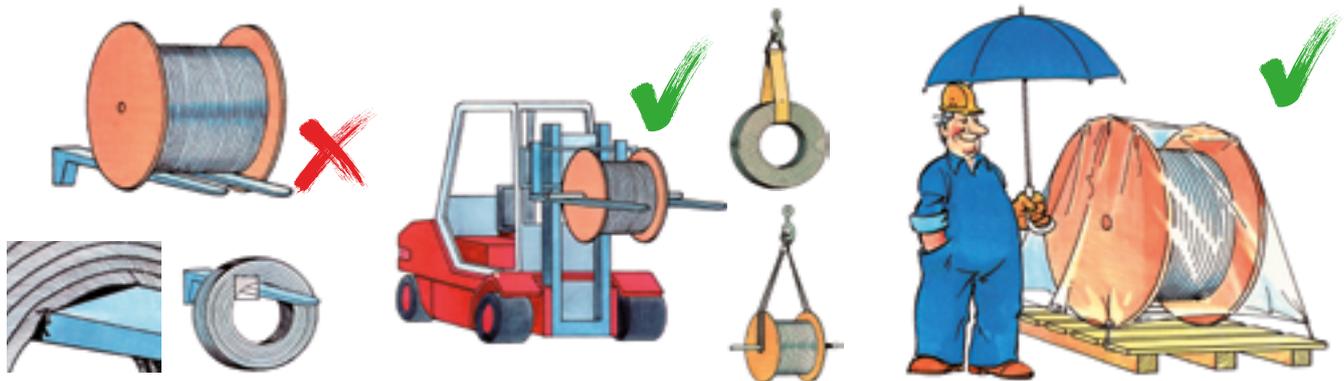


Figure 9: Examples of correct - wrong handling and correct storage

21- Compacted rope

Compacted rope is formed when the wires are compressed and shaped during production. This shape decreases the diameter of the strand, smooth the surface of the strand becomes (Figure 10). The contact between the strands and the wires increases according to the ropes with round strand.

Ropes with compacted strand have more breaking load than conventional stranded ropes. They are more flexible. Due to increases surface area, strands come contact with drums and grooves on larger surface (Figure 11); this reduces the load on the rope. They are also resistant to corrosion and abrasion.

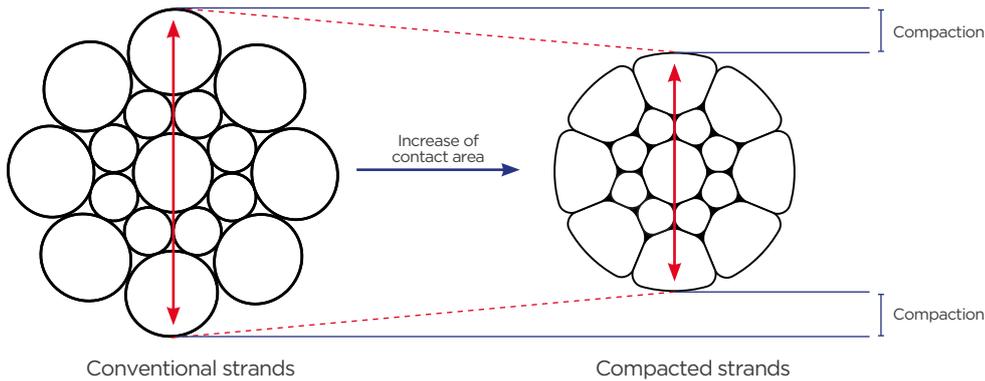


Figure 10: Compacted rope

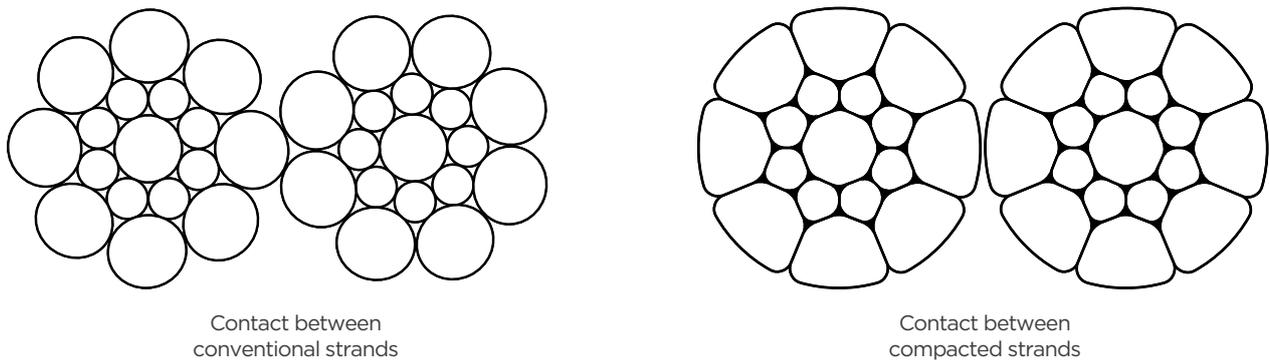


Figure 11: Contact in conventional and compact strands

22- Parallel Laid

All wires have different lengths in cross laid strands. At the same time, they had different lay lengths in the parallel laid strands. They apply pressure each other as a point and early damage occurs because of increased force at these points.

All wires have the same length in parallel laid strands. They also have the same lay length in the strands. Because of the parallel contact, load distribution becomes more homogeneous and thus prevents prior damage (Figure 12).

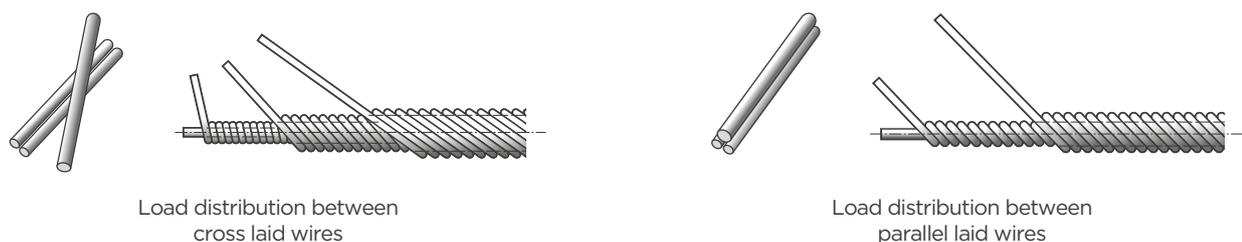


Figure 12: Types of wire rope lays

23- Drum diameter - rope diameter relation D/d

Drum and rollers are important elements in lifting systems. The relationship of the rope with the drum effects the service life of the rope in a positive or negative way. The table below gives the recommended ratio of the minimum drum/rope diameter (D/d) according to the rope constructions.

Rope Constructions	Recommended D/d Ratio	Minimum D/d Ratio
6x7	72	
6x19 S	51	34
19x7 - 18x7	51	34
6x25 B Flattened Strand	45	30
6x27 H Flattened Strand	45	30
6x30 C Flattened Strand	45	30
6x21 FW	45	30
6x26 WS	45	30
6x25 FW	39	26
6x31 WS	39	26
6x37 SFW	39	26
6x36 WS	35	23
6x43 FWS	35	23
6x41 WS	32	21
6x41 SWF	32	21
6x49 SWS	32	21
6x43 FW	28	18
6x46 SFW	28	18
6x46 WS	28	18
8x19 S	41	27
8x25 FW	32	21

24- Fleet angle

Fleet angle as shown in the figure 13 is the angle between the two lines drawn perpendicular from the drum flange and the drum core to the center of the groove. There are two types of fleet angles, right and left. If a rope enters the pulley with a high fleet angle, first the rope will touch the sides of the pulley (flanges) and then it will be rounded to the bottom of the groove. Thus, the rope will be rotated in this way. Increased fleet angle will increase in rotation.

For rotation resistant ropes, fleet angle should be less than 2° and the B/A ratio should be greater than 15. For non-rotation resistant ropes, the fleet angle must be less than 4° and the B/A ratio between them should be greater than 7.

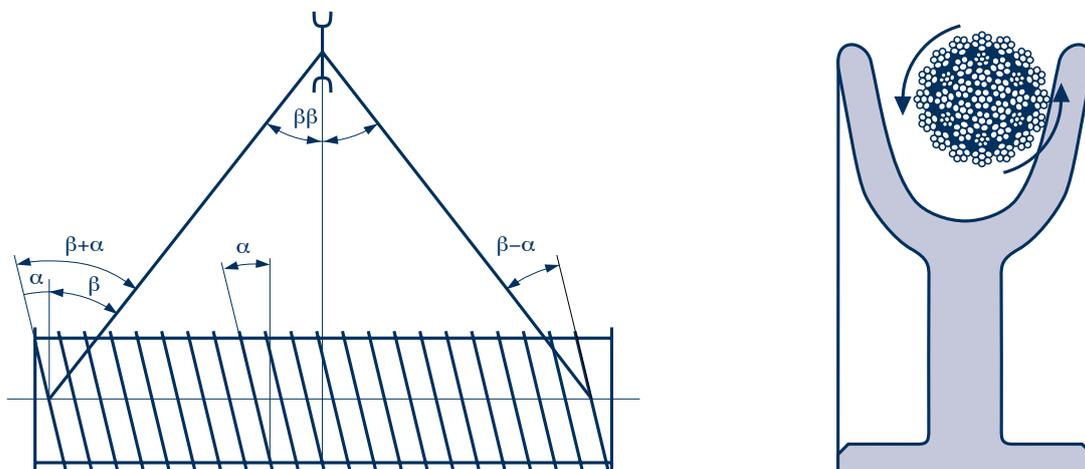


Figure 13: Fleet angle

25- Selection of drum and wire rope lay

Choosing the right rope is important for the proper service of the reeving system. Incorrectly selected rope direction leads to torque formation and causes structural damage to the rope (Figure 14).

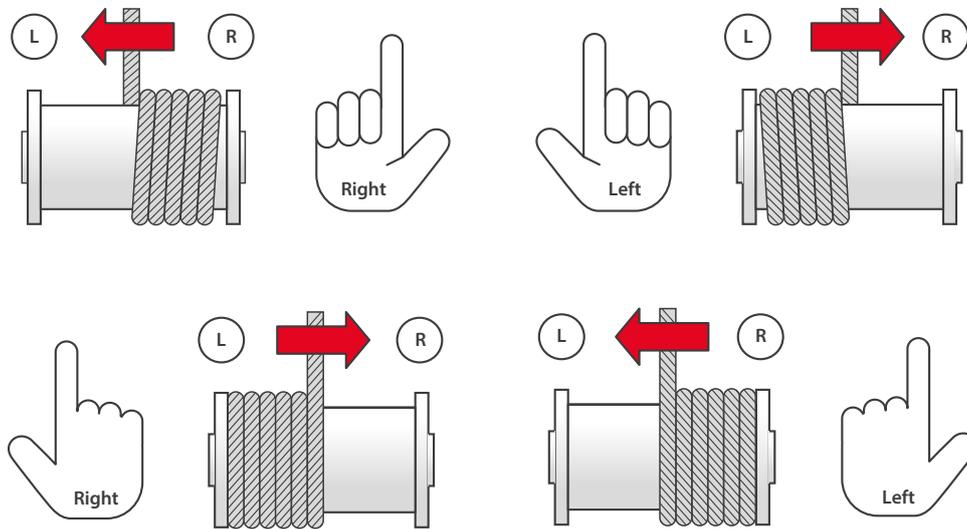


Figure 14: Selection of drum and wire rope lay

26- Installation

Appropriate methods to be applied during installation of the rope can vary from system to system. In any case, the aim should be to find a method that minimizes the damage caused by the contact of the rope with the external factors and at the same time the minimum possible torsion in the rope while assembling the rope.

Assembly under load; In order to achieve a perfect winding in multi - layer winding drums, it is important to apply pretension on the rope during installation. If the first few rows are not wrapped in a stretched state on the load, these windings may be wrapped very loosely. The subsequent windings will sink into the lower loose windings when they reach the load during use.

After the assembly of the ropes, it is needed to perform systematic movements which will be done several times in light load for a while before applying the rope to the real load. In this way, the new rope is adapted to the genuine working environment. Unfortunately, in practice, often the opposite of this advice is made. Usually the new rope is pulled with a thin rope or an old rope. In both cases, a secure connection should be provided between these two ropes (Figure 15). During the assembly of the rope, the old rope and the new rope should not be welded together in any way. Fasteners must be used to allow the rope to rotate.



Figure 15: Correct and incorrect installation

27- Maintenance and Lubrication

Steel wire ropes should be regularly maintained. The type of maintenance may vary depending on the machine, the type of use and the selected rope. The service life of a regularly maintained wire rope will increase significantly.

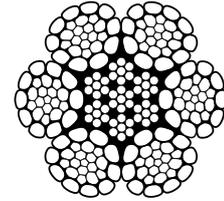
Removal of broken wires; if the ends of the broken wires are detected during the inspection, they must be removed. Because these broken wires can be crossed crosswise on other wires that are not broken and the rope can destroy other wires while passing through the sheaves in the service. For wires with a diameter that is too thick to be handled by a naked hand, the same procedure must be carried out using a tool.

During the production process, steel ropes are heavily lubricated. Thanks to this application made during the production in the factory, the ropes will be provided with adequate protection against corrosion and abrasion. In other words, the friction between wires forming the ropes will reduce the friction between the rope and the drum, pulley and so on. However, the initial lubrication at the factory remains limited for a limited period of time. Then periodic lubrication should be continued.

Steel wire ropes must be lubricated continuously at regular intervals. Depending on their use, they must be lubricated throughout their bending area. If lubrication is not possible for operational reasons, the service life of the rope must be shorter.

28- Swaged rope

Swaged ropes are produced for use in heavy industry in multi-layer drums. After the rope is made Swage process, the rope is made by the method of hammering of the rope is done. Swaging provides high friction resistance, high strength and smooth surface and high breaking strength. In addition, a complete coating method can be applied to protect the rope from mechanical effect.

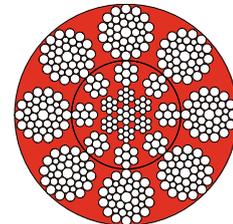
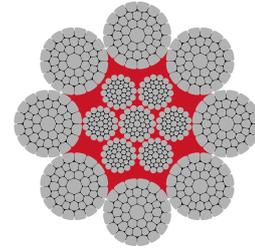


29- Coated and filled wire ropes

Closing the gaps in the rope, ropes designed to avoid the contact between the core and the outer strands. This can be done by spraying or coating. The advantages can be listed as follows.

Advantages listed as below:

- ★ Reduces or disappears completely risk of birdcage.
- ★ Keeps away water and abrasive substances.
- ★ Serves as a buffer between core and outer strands.
- ★ Prevents internal wire breaks due to abrasion.
- ★ Reduces the noise of the rope during operation.
- ★ Absorbs dynamic energy.
- ★ Strengthen the structure of the rope.
- ★ Keeps the lubricant in rope and helps to lubrication.
- ★ Prevents metal to metal contact.
- ★ Allows the rope to stand properly during assembly.



30- Inspection

1- General

If there is no demand from the crane manufacturer, the rope manufacturer and the rope supplier, the following steps related to the inspection should be followed

2- Daily visual inspection

On certain days, the working part of the rope must be observed in order to detect any mechanical damage to the ropes. The connection points of the rope must be included in this observation. Make sure that the rope is correctly positioned in the drum and pulleys. If there is a significant situation, it should be checked and examined by the authorized person. The rope must be visually inspected again when the crane is moved to a different location, reassembled or replaced.

3- Periodic control

a. General

Periodic inspections must be carried out by authorized persons. The data obtained in the periodic examination is used to decide whether or not to use the rope.

- It is decided whether it is proper for using or when is the next periodic inspection to be carried out.
- It can be decided to discard the wire rope immediately or in a period of time.

The following table presents the table of deformation types and measurement methods.

Mode of Deterioration	Assessment Method
Number of visible broken wires (including those which are randomly distributed, localized groupings, valley wire breaks and those that are at, or in the vicinity of, the termination)	By counting
Decrease in rope diameter (resulting from external wear/abrasion, internal wear and core deterioration)	By measurement
Fracture of strand(s)	Visual
Deformations	Visual
Mechanical Damage	Visual
Heat damage (including electric arcing)	Visual and by measurement (wave only)

b. Frequency

The frequency of the periodic inspection shall be determined by the competent person, who shall take account of at least the following.

- ★ The statutory requirements covering the application in the country of use,
- ★ The type of crane and the environmental conditions in which it operates,
- ★ The classification group of the mechanism,
- ★ The results of previous inspection(s),
- ★ Experience gained from inspecting ropes on comparable cranes,
- ★ The length of time the rope has been in service,
- ★ The frequency of use.

c. Extent of inspection

Each rope shall be inspected along its entire length. However, in the case of a long length, and at the discretion of the competent person, the working length plus at least five wraps on the drum may be inspected. In such a case, and where a greater working length is subsequently foreseen after the previous inspection and prior to the next one, that additional length should also be inspected before the additional length of rope is used. Particular care, however, shall be taken at the following critical areas and locations.

- ★ Drum anchorage
- ★ Any section at, and in the vicinity of, a rope termination,
- ★ Any section that travels through one or more sheaves,
- ★ Any section that travels through the hook block,
- ★ Any part of rope that is exposed to heat,
- ★ Any section that is subjected to abrasion by external features,
- ★ That part of the rope which lies over a compensating sheave,
- ★ In the case of cranes performing a repetitive operation, any part of the rope that lies over a sheave while the crane is in a loaded condition,
- ★ Any section that travels through a spooling device,
- ★ Those sections that spool on the drum, particularly cross - over zones that are associated with multi - layer spooling.

d. Inspection at a termination

The rope shall be inspected in the vicinity of the termination, particularly where it enters the termination, as this location is vulnerable to the onset of wire breaks due to vibration and other dynamic effects and, depending on the state of the environment, corrosion. Some probing with a spike may be carried out to establish if there is any looseness in any of the wires, suggesting the existence of a broken wire within the termination. The termination itself should also be inspected for any excessive amounts of distortion and wear.

e. Inspection reports

After each periodic inspection, the competent person shall provide a rope inspection record, and state a maximum time interval that shall not be exceeded before the next periodic inspection takes place.

4- Inspection following an incident

If an incident has occurred that might have caused damage to a rope and/or its termination, the rope and/or its termination shall be inspected as described for a periodic inspection, prior to re-commencement of work or as required by the competent person.

5- Inspection following period with crane out of operation

If the crane has been out of operation for more than three months, the rope(s) shall undergo a periodic inspection, prior to re - commencement of work.

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6- Non - destructive testing

Non - destructive testing (NDT) by electro - magnetic means may be used as an aid to visual inspection to determine the location of those sections of rope which could be suffering deterioration. If it is the intention to carry out NDT by electro-magnetic means at some point during the life of the rope, it should be subjected to an initial examination as soon as possible/practicable in the lifetime of the rope (which might be at rope manufacture, during installation of the rope or, preferably, after the rope has been installed) to serve as a reference point (sometimes referred to as “rope signature”) for future comparison.

31 - Discard criteria (According to ISO 4309)

1- General

In the absence of any instructions provided by the manufacturer of the crane in his manual or any provided by the supplier or manufacturer of the rope, the individual discard criteria shall apply. As deterioration often results from a combination of different modes at the same position in the rope, the competent person shall assess the “combined effect”. If, for whatever reason, there is a noticeable change in the rate of deterioration of the rope, the reason for this shall be investigated and, wherever possible, corrective action taken. In extreme cases, the competent person may decide to discard the rope or amend the discard criteria, for example by reducing the allowable number of visible broken wires.

2- Visible broken wires

a. Criteria for visible broken wires

The discard criteria for the various natures of visible broken wire shall be as specified in table

	Nature of Visible Broken Wire	Discard Criteria
1	Wire breaks occurring randomly in sections of rope	See related tables For single - layer and parallel - closed ropes and rotation - resistant ropes
2	Localized grouping of wire breaks in sections of rope which do not spool on and off the drum	If grouping is concentrated in one or two neighbouring strands it might be necessary to discard the rope, even if the number is lower than the values over a length of 6d
3	Valley wire breaks	Two or more wire breaks in a rope lay length
4	Wire breaks at a termination	Two or more wire breaks

b. Rope Category Number (RCN)

If the rope is a single - layer or parallel - closed rope, then can look at to Table 2. If the rope is a rotation - resistant rope, then refer to Table 1.

c. Wire breaks other than those resulting from service

As a consequence of shipping, storage, handling, installation and manufacturing, an individual wire can be broken. They would not normally be counted when inspecting the rope for broken wires. Their existence, however, if discovered, should be recorded, as this can assist future inspections.

d. Rotation - resistant ropes

Category Number	Total Number of Load - Bearing Wires in The Outer Layer of Strands in The Rope	Number of visible broken outer wires			
		Sections of Rope Working in Steel Sheaves and/or Spooling on a Single - Layer Drum (Wire breaks randomly distributed)		Sections of Rope Spooling on a Multi - Layer Drum	
		Over a Length of 6d	Over a Length of 30d	Over a Length of 6d	Over a Length of 30d
21	4 strands $n \leq 100$	2	4	2	4
22	3 or 4 strands $n \leq 100$	2	4	4	8
23-1	At least 11 outer strands $71 \leq n \leq 100$	2	4	4	8
23-2	$101 \leq n \leq 120$	3	5	5	10
23-3	$121 \leq n \leq 140$	3	5	6	11
24	$141 \leq n \leq 160$	3	6	6	13
25	$161 \leq n \leq 180$	4	7	7	14
26	$181 \leq n \leq 200$	4	8	8	16
27	$201 \leq n \leq 220$	4	9	9	18
28	$221 \leq n \leq 240$	5	10	10	19
29	$241 \leq n \leq 260$	5	10	10	21
30	$261 \leq n \leq 280$	6	11	11	22
31	$281 \leq n \leq 300$	6	12	12	24
-	$n > 300$	6	12	12	24

Table 1: Allowed number of broken outer wires for rotation - resistant ropes (d= Rope diameter, n= Number of wire rope outer wires)

e. Single - layer and parallel - closed ropes

Category Number	Total Number of Load - Bearing Wires in The Outer Layer of Strands in The Rope	Number of Visible Broken Outer Wires					
		Sections of Rope Working in Steel Sheaves and/or Spooling on a Single - Layer Drum (Wire breaks randomly distributed)				Sections of Rope Spooling on a Multi - Layer Drum	
		Classes M1 to M4 or Class Unknown				All Classes	
		Ordinary Lay		Lang Lay		Ordinary and Lang Lay	
		Over a Length of 6d	Over a Length of 30d	Over a Length of 6d	Over a Length of 30d	Over a Length of 6d	Over a Length of 30d
01	$n \leq 50$	2	4	1	2	4	8
02	$51 \leq n \leq 75$	3	6	2	3	6	12
03	$76 \leq n \leq 100$	4	8	2	4	8	16
04	$101 \leq n \leq 120$	5	10	2	5	10	20
05	$121 \leq n \leq 140$	6	11	3	6	12	22
06	$141 \leq n \leq 160$	6	13	3	6	12	26
07	$161 \leq n \leq 180$	7	14	4	7	14	28
08	$181 \leq n \leq 200$	8	16	4	8	16	32
09	$201 \leq n \leq 220$	9	18	4	9	18	36
10	$221 \leq n \leq 240$	10	19	5	10	20	38
11	$24 \leq n \leq 260$	10	21	5	10	20	42
12	$261 \leq n \leq 280$	11	22	6	11	22	44
13	$281 \leq n \leq 300$	12	24	6	12	24	48
	$n > 300$	$0,04 \times n$	$0,08 \times n$	$0,02 \times n$	$0,04 \times n$	$0,08 \times n$	$0,16 \times n$

Table 2: Allowed number of broken outer wires for single - layer and parallel - closed ropes (d= Rope diameter, n= Number of wire rope outer wires)

3- Decrease in rope diameter

a. Uniform decrease in diameter

Table below is used to determine the decrease in rope diameter.

Rope type	Uniform decrease in diameter (expressed as % of nominal diameter)	Description	Severity rating %
Fiber core	Less than 6%	-	0
	6% and over but less than 7%	Slight	20
	7% and over but less than 8%	Medium	40
	8% and over but less than 9%	Very high	60
	9% and over but less than 10%	Very high	80
	10% and over	Discard	100
Steel core or parallel - closed rope	Less than 3,5%	-	0
	3,5% and over but less than 4,5%	Slight	20
	4,5% and over but less than 5,5%		40
	5,5% and over but less than 6,5%	Medium	60
	6,5% and over but less than 7,5%	Very high	80
	7,5% and over	Very high	100
Rotation - resistant rope	Less than 1%	Discard	0
	1% and over but less than 2%	-	20
	2% and over but less than 3%	Slight	40
	3% and over but less than 4%	Medium	60
	4% and over but less than 5%	Very high	80
	5% and over	Very high	100

b. Calculation to determine actual uniform decrease in diameter

$$[\frac{(d_{ref} - d_m)}{d} * 100\%]$$

d_{ref} : Reference diameter

d_m : Measured diameter

d : Nominal diameter

c. Local decrease

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

$$[\frac{(d_{ref} - d_m)}{d} * 100\%]$$



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

4- Corrosion

When assessing the extent of corrosion, it is important to recognize the difference between corrosion of the wires and any corrosion on the rope surface that is associated with the oxidation of foreign particles. Therefore, before making an assessment, the rope sections undergoing inspection shall be wiped or brushed clean. The use of solvents for cleaning should be avoided



a. Beginning of surface oxidation, can be wiped clean, Superficial — rating: 0% towards discard



b. Wires rough to touch, general surface oxidation — rating: 20% towards discard



c. Surface of wire now greatly affected by oxidation - rating: 60% towards discard



d. Surface heavily pitted and wires quite slack, gaps between wires — discard immediately

5- Deformation and damage

RCN numbers of several types of ropes are shown below.

ROPE	Category Number (RCN)
6x7-FC Single layer rope	RCN.01
6x19S-IWRC Single layer rope	RCN.02
6x19M-WSC Single layer rope	RCN.04
6x25F-IWRC Single layer rope	RCN.04
6x25TS-IWRC Single layer rope	RCN.04
6x36WS-IWRC Single layer rope	RCN.09
6x41WS-IWRC Single layer rope	RCN.11
6x37M-IWRC Single layer rope	RCN.10
8x19S-IWRC Single layer rope	RCN.04
8x25F-IWRC Single layer rope	RCN.06
8x19S-PWRC Parallel closed rope	RCN.04
8xK26WS-IWRC Single layer rope with compacted strands	RCN.09
4xK26WS Single layer rope / rotation resistant rope with compacted strands	RCN.22
6xK26WS-IWRC Single layer rope with compacted strands	RCN.06
6xK36WS-IWRC Single layer rope with compacted strands	RCN.09
8xK26WS-PWRC Parallel closed rope with compacted strands	RCN.09
18xK19S-WSC or 19xK19S Rotation resistant rope with compacted strands	RCN.26
4x29F Single layer / rotation resistant rope	RCN.21
K3x40 Single layer compacted (swaged) rope / rotation resistant compacted (swaged) rope	RCN.22
Kx40 Single layer compacted (swaged) rope / rotation resistant compacted (swaged) rope	RCN.22
K3x48 Single layer compacted (swaged) rope / rotation resistant compacted (swaged) rope	RCN.22
Kx48 Single layer compacted (swaged) rope / rotation resistant compacted (swaged) rope	RCN.22
17x7-FC Rotation resistant rope	RCN.23-1
18x7-WSC or 19x7 Rotation resistant rope	RCN.23-1
12xP6:3x02 Rotation resistant rope (Paragon)	RCN.23-1
34(W)x7-WSC or 3(W)x7 Rotation resistant rope	RCN.23-2
39(W)x7-WSC Rotation resistant rope	RCN.23-3
34(W)xK7-WSC Rotation resistant rope with compacted strands	RCN.23-2
39(W)xK7-KWSC Rotation resistant rope with compacted strands	RCN.23-3



6- Typical modes of deterioration

Rope damage types are shown in the following pictures.



a. Strand protrusion or distortion



b. Flattened portion



c. Kink (positive)



d. Kink (negative)



e. Waviness



f. Basket deformation



g. External wear



h. External corrosion



i. Enlargement of External corrosion



i. Crown wire breaks



j. Valley wire breaks



k. Protrusion of inner rope of rotation-resistant rope



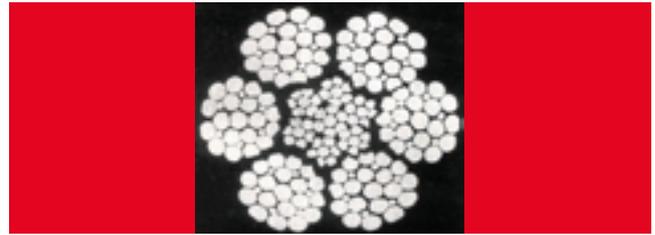
l. Local increase in rope diameter due to core distortion



m. Kink



n. Flattened portion



o. Internal corrosion

7- Combined effect assessment

Example	Severity Rating of Individual Modes of Deterioration			Combined Severity Rating %	Comment
	Wire Breaks	Decrease in Diameter	External Corrosion		
1	0	20	20	40	Safe to continue
2	20	20	0	40	Safe to continue
3	20	20	20	60	Safe to continue
4	40	20	20	80	Inspect more frequently
5	40	40	0	80	Inspect more frequently
6	0	80	0	80	Consider discard if reduction in diameter is mainly attributed to external wear
7	60	0	0	60	Inspect (particularly for broken wires) more frequently
8	60	20	0	80	Inspect more frequently (particularly for broken wires) and prepare for replacement

The table is an example and may vary.