INTERNATIONAL STANDARD

ISO 4309

Third edition
2004-08-01

Cranes — Wire ropes — Care, maintenance, installation, examination and discard

Appareils de levage à charge suspendue — Câbles — Entretien, maintenance, installation, examen et dépose

Reference number
ISO 4309:2004(E)

PDF disclaimer

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 4309 was prepared by Technical Committee ISO/TC 96, *Cranes*, Subcommittee SC 3, *Selection of wire ropes*.

This third edition cancels and replaces the second edition (ISO 4309:1990), which has been technically revised.

Introduction

The rope on a crane is regarded as an expendable component, requiring replacement when examination shows its strength to have diminished to the point where its further use would be unwise.

The working life of the rope varies in relation to the particular characteristics of the crane, its conditions and use. Where long rope life is essential, a high coefficient of utilization and high bending ratio (D/d) are adopted. Where lightness and compactness of design are essential, these values can be reduced, provided that a smaller number of operating cycles is acceptable.

In all cases the safe handling of loads by a correctly operated crane depends upon regular examination of the rope, so that the rope can be removed from service before problems arise.

Certain cranes function in conditions where the ropes are exposed to accidental damage, and the original rope selection would have taken this into account. In such circumstances, examination of the rope needs to be carried out with care to ensure that any critical condition of damage can be recognized and the rope can be immediately removed from service.

In all conditions of use, the discard criteria relating to wire breaks, wear, corrosion and deformation can be applied immediately. These different factors are considered in this International Standard, which is intended to provide guidance for competent persons involved in the maintenance and examination of cranes.

The criteria outlined are aimed at retaining, until the rope is discarded, an adequate safety margin for the handling of loads by cranes. Failure to recognize these criteria is dangerous.

This International Standard now includes recommendations in respect of the care and maintenance, including fitting, of the rope. These additions have been made to ensure that the user and competent persons responsible for the crane have one single guidance document covering all aspects, from receipt of the new rope through to the discard of the rope from service on the crane.

The classification groups of the mechanisms referred to in this International Standard are in accordance with ISO 4301-1.

Cranes — Wire ropes — Care, maintenance, installation, examination and discard

1 Scope

This International Standard details guidelines for the care, installation, maintenance and examination of wire rope in service on a crane, and enumerates the discard criteria to be applied to promote the safe use of the crane.

This International Standard is applicable to the following types of crane, as defined in ISO 4306-1:

a) cable and portal cable cranes;

b) cantilever cranes (pillar jib, wall or walking);

c) deck cranes;

d) derrick and guy derrick cranes;

e) derrick cranes with rigid bracing;

f) floating cranes;

g) mobile cranes;

h) overhead travelling cranes;

i) portal or semi-portal bridge cranes;

j) portal or semi-portal cranes;

k) railway cranes;

l) tower cranes.

This International Standard is applicable to cranes used for hook, grabbing, magnet, ladle, excavator or stacking duties, whether operated manually, mechanically, electrically or hydraulically.

This International Standard is also applicable to hoists and hoist blocks which use wire rope.

2 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

2.1
actual rope diameter
average of two measurements of the diameter of the rope, made normal to each other

NOTE It is expressed in millimetres.

2.2
clearance
space between individual wires in any layer in a wire rope strand or between any strands in the same layer

2.3
cross-over
⟨of rope on a drum⟩ portion of wire rope which changes from its normal path as it moves from one lap or layer to another lap or layer, due to the effect of either the type of drum grooving or the configuration of the underlying rope layer

2.4
Lang lay
lay in which the direction of lay of the wires in the outer strands is in the same direction as that of the outer strands in the rope

2.5
wrap
one revolution of rope around a drum

2.6
lay length
distance, measured parallel to the longitudinal rope axis, required for the outer wire of a spiral rope and the outer strands of a stranded rope to make one complete turn (or helix) about the axis of the rope

2.7
nominal rope diameter
designated diameter of the rope

NOTE It is expressed in millimetres.

2.8
ordinary lay
regular lay
lay in which the direction of lay in the outer wires in the outer strands is in the opposite direction to that of the outer strands in the rope

2.9
reel
flanged spool on which rope is wound for shipment or storage

NOTE A reel can be of wooden or steel construction, depending on the mass of rope involved.

2.10
rope core
central element of the rope that supports outer strands

2.11
rope examination record
record of the history and condition of the rope following an examination

2.12
single-layer rope
stranded rope consisting of one layer of strands laid helically over a core

2.13
parallel-closed rope
stranded rope consisting of at least two layers of strands laid helically in one closing operation around a strand or fibre centre

2.14
rotation-resistant rope
stranded rope designed to generate reduced levels of torque and rotation when loaded

NOTE 1 Rotation-resistant ropes generally comprise an assembly of two or more layers of strands laid helically around a centre, the direction of lay of the outer strands being opposite to that of the underlying layer.

NOTE 2 Ropes having three or four strands can also be designed to exhibit rotation-resistant properties.

NOTE 3 Rotation-resistant ropes have previously been referred to as contra-laid, multi-strand and non-rotating ropes.

2.15
stranded rope
assembly of several strands laid helically in one or more layers usually around a core or centre

NOTE Stranded ropes consisting of three or four outer strands may not have a core.

3 Wire rope

3.1 Condition before installation

3.1.1 Rope replacement

Only a rope of the correct length, diameter, construction and breaking force as specified by the crane manufacturer shall be installed on the crane, unless an alternative rope has been approved by the crane designer, rope manufacturer or other competent person.

Only rope terminations specified by the crane manufacturer, or alternatives similarly approved, shall be used to attach a rope to a drum, hook block or crane structure.

3.1.2 Rope length

The length of rope used shall be sufficient for the application for which the crane is to be used, and shall be such that in the extreme positions there are at least two wraps of rope left on the drum.

When the length of rope required for use is to be cut from a longer length, servings shall be made on both sides of the cutting point, or a suitable technique shall be used to prevent the rope from untwisting when the cut is made (see Figure 1).

3.1.3 Instructions from the crane manufacturer and the rope manufacturer

The instructions in the crane manual and those given by the rope manufacturer shall be followed.

Before re-equipping the crane, all grooves in drums and sheaves shall be checked to ensure that they will correctly accept the replacement rope (see Clause 5).

3.1.4 Offloading and storage

To avoid accidents, ropes shall be offloaded with care. The rope reels or coils shall not be dropped, neither shall the rope be struck by a metal hook or fork of a fork-lift truck.

Ropes shall be stored in a cool, dry building and shall not be in contact with the floor. Ropes shall never be stored where they are liable to be affected by chemical fumes, steam or other corrosive agents. Ropes in storage shall be examined periodically and if necessary, a rope dressing applied. If outdoor storage cannot be avoided, the ropes should be covered so that moisture cannot induce corrosion.

Ropes removed from a crane for future use shall be thoroughly cleaned and a rope dressing applied before being stored.

Ropes having a length in excess of 30 m should be stored on reels.

3.2 Installation

3.2.1 Uncoiling and installing

When uncoiling the wire rope from a reel or coil, every precaution shall be taken to avoid the inducement of turn into, or loss of turn out of, the rope. Allowing such a condition can result in formation of loops, kinks or bends in the rope. To prevent this condition, the rope shall be paid out without slack and in a straight line (see Figure 2).

A revolving reel of rope can have a high inertia, in which case it needs to be controlled in order to slowly pay out the rope.

Rope in coil should be paid out from a turntable. Alternatively, where a coil is of short length, the outer end of the coil may be made free and the remainder rolled along the ground (see Figure 3). For ease of handling, the inside end shall first be secured to an adjacent wrap. A rope shall never be paid out by throwing off wraps with the coil or reel flat on the ground (see Figure 4).

The rope shall be kept as clean as possible during uncoiling. When any rope is cut, the manufacturer's instructions shall be followed (see Figure 1).

Particular care shall be taken with rotation-resistant ropes to ensure that they are installed without inducing or losing turn, and that any cut is secure and prevented from unlaying.

NOTE 1 If the strands are disturbed, deformation of the rope is likely to occur during subsequent use and the service life of the rope may be reduced.

NOTE 2 Introducing or losing turn during installation can result in additional twisting of the hook block.

The lay of the rope shall not be disturbed during installation, i.e. turn should not be put in nor taken out of the rope. During installation, the rope shall always bend in the same direction: i.e. pay out from the top of the reel to the top of the drum, or from the bottom of the reel to the bottom of the drum (see Figure 2).

Care shall be taken to ensure that termination anchorages are made and secured in accordance with the instructions in the crane manual.

If the rope rubs against any part of the crane during installation, then the points of contact shall be suitably protected.

3.2.2 Running in

Before bringing the rope into operation on the crane, the user shall ensure that all the devices associated with the wire rope operation are functioning correctly. A number of operational cycles of the mechanism shall be carried out at reduced speed and load, up to approximately 10 % of the Working Load Limit (WLL) to allow the component parts of the rope to adjust to the actual operating conditions.

3.3 Maintenance

Maintenance of the wire rope shall be carried out relative to the crane, its use, the environment and the type of rope involved. Unless otherwise indicated by the manufacturer of either the crane or the rope, a rope dressing of grease or oil shall be applied during installation. Subsequently the wire rope shall be cleaned where necessary, and the rope dressing re-applied at regular intervals and before the rope shows signs of dryness or corrosion, particularly on the lengths which pass over sheaves.

The rope dressing shall be compatible with the original lubricant used by the wire rope manufacturer, and shall have penetrating characteristics. If the rope dressing is not identified in the crane manual, the user shall seek advice from the rope manufacturer.

A shorter working life of the rope will result from lack of maintenance, particularly if the crane is used in a corrosive environment and, in certain cases for reasons connected with the operation, if no rope dressing can be used. In such cases the period between rope examinations shall be reduced accordingly.

3.4 Examination

3.4.1 Frequency

3.4.1.1 Daily visual inspection

As far as possible, all visible parts of any rope shall be observed each working day with the objective of detecting general deterioration and deformation. Particular attention shall be paid to the rope at points of attachment to the crane (see Figure A.1). Any appreciable change suspected in the rope condition shall be reported, and the rope examined by a competent person in accordance with 3.4.2.

3.4.1.2 Periodic examination

Periodic examination shall be carried out by competent persons in accordance with 3.4.2.

In order to determine the frequency of a periodic examination, consideration shall be given to

a) the statutory requirements covering the application in the country of use,

b) the type of crane and the environmental conditions in which it operates,

c) the classification group of the crane,

d) the results of previous examination,

e) the length of time the rope has been in service.

Mobile crane ropes and tower crane ropes should be examined at least once per month or more often, in accordance with the instructions of the competent person.

NOTE Depending on the condition of the rope, the competent person may deem it necessary to reduce the time interval between examinations.

3.4.1.3 Special examination

Special examination shall be carried out in accordance with 3.4.2.

The rope shall be examined if an incident has occurred which could have caused damage to the rope and/or its termination, or if a rope has been brought back into operation after dismantling followed by re-assembly.

If the crane has been out of operation for three months or more, the ropes should be examined prior to recommencement of work.

NOTE Depending on the condition of the rope, the competent person may deem it necessary to reduce the time interval between examinations.

3.4.1.4 Inspection of ropes operating on synthetic sheaves or metal sheaves having synthetic lining

If a rope operates either solely or partially over synthetic sheaves or over metal sheaves having a synthetic lining, wire breaks can occur internally in large numbers before there is any external visible evidence of wire breaks or of substantial wear on the periphery of the rope. In these conditions, consideration shall be given to the establishment of a specific inspection schedule period based on past rope performance data, taking into account the results from regular inspection in service and information gained from detailed examination of ropes following retirement from service.

Particular attention shall be paid to any localized area which exhibits a dryness or denaturing of the lubricant.

Information for the criteria for discard of wire rope for specific lifting appliances shall be based on an exchange of information between the crane manufacturer and the wire rope manufacturer.

NOTE Depending on the condition of the rope, the competent person may deem it necessary to reduce the time interval between examinations.

3.4.2 Points to be covered by examination

3.4.2.1 General

Although the wire rope shall be examined throughout its length, particular care shall be taken at the following locations:

a) the termination points of both moving and stationary ropes;

b) that part of the rope which passes through the block or over sheaves;

c) in the case of cranes performing a repetitive operation, any part of the rope which lies over sheave(s) while the crane is in a loaded condition (see Annex A);

d) that part of the rope which lies over a compensating sheave;

e) any part of the rope which may be subject to abrasion by external features (e.g. hatch coamings);

f) internals of the rope, for corrosion and fatigue (see Annex C);

g) any part of the rope exposed to heat.

The results of the examination shall be recorded in the examination record for the crane (see Clause 6 and Annex B for a typical example).

3.4.2.2 Terminations, excluding slings

The rope shall be examined in the area where it passes out from the termination, as this position is critical for the onset of fatigue (wire breaks) and corrosion. The terminal fittings themselves shall also be examined for signs of distortion or wear.

Terminations involving pressed or swaged ferrules shall be similarly examined, and the ferrule checked for cracks in the material and possible slippage between the ferrule and the rope.

Detachable terminations (e.g. wedge sockets, grips) shall be examined for broken wires within and under the termination, and for tightness of wedges and screwed grips. The examination should also include an assessment that the standards and codes of practice specified for the termination of the rope have been met.

Eye splices made by hand shall be examined to check that they are served only over the tail of the splice (so as to protect the hands from protruding wire), while at all times allowing the remainder of the splice to be visually inspected for wire breaks.

When broken wires are evident close to, or within, the termination, it may be possible to shorten the rope and re-fit the terminal fittings. However, the resulting length of the wire rope shall be sufficient to allow for the minimum required number of rope wraps on the drum.

3.4.3 Non-destructive testing

Non-destructive testing by electromagnetic techniques may be used as an aid to visual inspection to determine areas and levels of rope deterioration.

When it is the intention to use electromagnetic means of NDT as an aid to visual examination, the rope should be subject to an initial electromagnetic NDT examination as soon as possible after the rope has been installed.

3.5 Discard criteria

3.5.1 General

The safe use of wire rope is qualified by the following criteria (see 3.5.2 to 3.5.12):

a) the nature and number of broken wires;

b) broken wires at the termination;

c) localized grouping of wire breaks;

d) the rate of increase of wire breaks;

e) the fracture of strands;

f) reduction of rope diameter, including that resulting from core deterioration;

g) decreased elasticity;

h) external and internal wear;

i) external and internal corrosion;

j) deformation;

k) damage due to heat or electric arcing;

l) rate of increase of permanent elongation.

All examinations shall take into account these individual factors, recognizing the particular criteria. However, deterioration frequently results from a combination of factors, giving a cumulative effect which should be recognized by the competent person, and which reflects the decision to discard the rope or to allow it to remain in service.

In all cases, the examiner shall investigate whether the deterioration has been caused by an abnormality in the crane; if so, he should recommend action to overcome that abnormality before installing a new rope.

The individual degrees of deterioration should be assessed, and expressed as a percentage of the particular discard criteria. The cumulative degree of deterioration at any given position is determined by adding together the individual values that are recorded at that position in the rope. When the cumulative value at any position reaches 100 %, the rope should be discarded.

3.5.2 Nature and number of broken wires

The overall design of a crane is such that it does not permit indefinite rope life. In the case of 6- and 8-strand ropes, broken wires usually occur at the external surface. In the case of rotation-resistant ropes, there is a probability that the majority of broken wires will occur internally and are “non-visible” fractures. Tables 1 and 2 take these factors into account when considered in conjunction with the factors given in 3.5.3 to 3.5.12.

One valley break may indicate internal rope deterioration, requiring closer inspection of this section of rope. When two or more valley breaks are found in one lay length, the rope should be considered for discard.

When establishing rejection criteria for rotation-resistant ropes, consideration shall be given to the rope construction, length of service and the way in which the rope is being used. Guidance relating the number of visible broken wires and their rejection is given in Table 2.

Particular attention shall be paid to any localized area which exhibits a dryness or denaturing of the lubrication.

Table 1 — Number, reached or exceeded, of visible broken wires in single-layer and parallel-closed ropes working in steel sheaves, signalling mandatory discard of rope (see 3.5.2)

Rope category number RCN (see Annex E)	**Number of load-bearing wires in all outer strands of the rope** [a] n	**Number of visible broken wires** [c, d]	
		in rope over a length of 6 d [b]	**in rope over a length of 30 d** [b]
01	$n \leqslant 50$	2	4
02	$51 \leqslant n \leqslant 75$	3	6
03	$76 \leqslant n \leqslant 100$	4	8
04	$101 \leqslant n \leqslant 120$	5	10
05	$121 \leqslant n \leqslant 140$	6	11
06	$141 \leqslant n \leqslant 160$	6	13
07	$161 \leqslant n \leqslant 180$	7	14
08	$181 \leqslant n \leqslant 200$	8	16
09	$201 \leqslant n \leqslant 220$	9	18
10	$221 \leqslant n \leqslant 240$	10	19
11	$241 \leqslant n \leqslant 260$	10	21
12	$261 \leqslant n \leqslant 280$	11	22
13	$281 \leqslant n \leqslant 300$	12	24

For ropes having outer wires that are larger than the norm, the particular construction is downgraded in the table. In the case of Seale (S) construction, where the number of wires in each outer strand is 19 or less, the rope shall be placed in the table two rows above that row in which the construction would normally be placed.

NOTE Above values may also apply to ropes working in sheaves that are exclusively made of a polymer in combination with multi-layer coiling. They do NOT apply to ropes working in sheaves that are exclusively made of a polymer material in combination with single-layer coiling.

[a] For the purposes of this International Standard, filler wires are not regarded as load-bearing wires and are not included in the value of n. In ropes having a number of layers of strands, only the visible outer layer is considered in the value of n. In ropes having a steel core, this is regarded as an internal strand and is not considered in the value of n.

[b] d = nominal diameter of rope.

[c] A broken wire will have two ends.

[d] The numbers of visible broken wires above apply to ropes operating on mechanisms whose classification is not known or known to be M1, M2, M3 or M4. Higher numbers, not exceeding twice those above, may be applied to ropes operating on mechanisms whose classification is known to be M5, M6, M7 or M8.

3.5.3 Broken wires at termination

Broken wires at, or adjacent to, the termination, even if few in number, are indicative of high stresses at this position and can be caused by incorrect fitting of the termination. The cause of this deterioration shall be investigated and, where possible, the termination shall be remade, shortening the rope if sufficient length remains for further use, otherwise the rope shall be discarded.

3.5.4 Localized grouping of broken wires

Where broken wires are very close together, constituting a localized grouping of such breaks, the rope shall be discarded. If the grouping of such breaks occurs in a length less than 6d or is concentrated in any one strand, it may be necessary to discard the rope even if the number of wire breaks is smaller than the maximum number shown in Tables 1 and 2.

Table 2 — Number, reached or exceeded, of visible broken wires in rotation-resistant ropes working in steel sheaves, signalling mandatory discard of rope (see 3.5.2)

Rope category number RCN (see Annex E)	**Rope construction or total number *n* of load-bearing wires in all outer strands of the rope** [a]	**Number of visible broken wires** [c, d]	
		in rope over a length of 6 *d* [b]	**in rope over a length of 30 *d*** [b]
21	4-strand ropes $n \leqslant 100$ total wires	2	4
22	3-strand ropes 4-strand ropes $n \geqslant 100$ total wires	2	4
23	At least 10 outer strands	2	4

NOTE The above values may also apply to ropes working in sheaves that are exclusively made of a polymer in combination with multi-layer coiling. They do NOT apply to ropes working in sheaves that are exclusively made of a polymer material in combination with single-layer coiling.

[a] For the purposes of this International standard, filler wires are not regarded as load-bearing wires and are not included in the value of *n*. For three- and four-strand ropes, only the wires in the outer strands are taken into account in the value of *n*.

[b] *d* = nominal diameter of rope.

[c] A broken wire will have two ends.

[d] The numbers of visible broken wires above apply to ropes operating on mechanisms whose classification is not known or known to be M1, M2, M3 or M4. Higher numbers, not exceeding twice those above, may be applied to ropes operating on mechanisms whose classification is known to be M5, M6, M7 or M8.

3.5.5 Rate of increase of broken wires

In applications where the predominant cause of rope deterioration is fatigue, broken wires will appear after a certain period of use, and the number of breaks will progressively increase over time.

In these cases, it is recommended that careful periodic examination and recording of the number of broken wires be undertaken, with a view to establishing the rate of increase in the number of breaks. This premise may be used to propose a future date for rope discard.

3.5.6 Fracture of strands

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

3.5.7 Reduction of rope diameter resulting from core deterioration

Reduction of rope diameter resulting from deterioration of the core can be caused by

a) internal wear and wire indentation,

b) internal wear caused by friction between individual strands and wires in the rope, particularly when it is subject to bending,

c) deterioration of a fibre core,

d) fracture of a steel core,

e) fracture of internal layers in a rotation-resistant rope.

If these factors cause the actual rope diameter to decrease by 3 % of the nominal rope diameter for rotation-resistant ropes, or by 10 % for other ropes, the rope shall be discarded even if no broken wires are visible.

NOTE New ropes will normally have an actual diameter greater than the nominal diameter.

Low values of deterioration might not be so apparent from normal examination, particularly if the rope stresses are well balanced throughout the individual strands. However, the condition can result in a high loss of rope strength, so any suggestion of such internal deterioration shall be verified by internal examination procedures (see Annex C or apply non-destructive testing). If such deterioration is confirmed, the rope shall be discarded.

3.5.8 External wear

Abrasion of the crown wires of outer strands in the rope results from rubbing contact, under pressure, with the grooves in the sheaves and drums. The condition is particularly evident on moving ropes at points of sheave contact when the load is being accelerated or decelerated, and is revealed by flat surfaces on the outer wires.

Wear is promoted by lack of lubrication, or incorrect lubrication, and also by the presence of dust and grit.

Wear reduces the strength of ropes by reducing the cross-sectional area of the steel strands.

If, due to external wear, the actual rope diameter has decreased by 7 % or more of the nominal rope diameter, the rope shall be discarded even if no wire breaks are visible.

3.5.9 Decreased elasticity

Under certain circumstances usually associated with the working environment, a rope can sustain a substantial decrease in elasticity and is thus unsafe for further use.

Decreased elasticity is difficult to detect. If the examiner has any doubt, advice shall be obtained from a specialist in wire ropes. However, it is usually associated with the following:

a) reduction in rope diameter;

b) elongation of the rope lay length;

c) lack of clearance between individual wires and between strands, caused by the compression of the component parts against each other;

d) appearance of fine, brown powder between or within the strands;

e) increased stiffness.

While no wire breaks may be visible, the wire rope will be noticeably stiffer to handle and will certainly have a reduction in diameter greater than that related purely to wear of individual wires. This condition can lead to abrupt failure under dynamic loading and is sufficient justification for immediate discard.

3.5.10 External and internal corrosion

3.5.10.1 General

Corrosion occurs particularly in marine and polluted industrial atmospheres. It will diminish the breaking strength of the rope by reducing the metallic cross-sectional area, and it will accelerate fatigue by causing surface irregularities which lead to stress cracking. Severe corrosion can cause decreased elasticity of the rope.

3.5.10.2 External corrosion

Corrosion of the outer wires can often be detected visually.

Wire slackness due to corrosion attack/steel loss is justification for immediate rope discard.

3.5.10.3 Internal corrosion

This condition is more difficult to detect than the external corrosion which frequently accompanies it, but the following indications can be recognized (see Annex D):

a) variation in rope diameter;

   In locations where the rope bends around sheaves, a reduction in diameter usually occurs. However, in stationary ropes it is not uncommon for an increase in diameter to occur due to the build-up of rust under the outer layer of strands.

b) loss of clearance between the strands in the outer layer of the rope, frequently combined with wire breaks between or within the strands.

If there is any indication of internal corrosion, the rope should be subjected to internal examination as indicated in Annex C. This shall be carried out by a competent person.

Confirmation of severe internal corrosion is justification for immediate rope discard.

3.5.11 Deformation

3.5.11.1 General

Visible distortion of the rope from its normal shape is termed “deformation” and can create a change at the deformation position which results in an uneven stress distribution in the rope.

3.5.11.2 Waviness

Waviness is a deformation in which the longitudinal axis of the wire rope takes the shape of a helix under either a loaded or unloaded condition. While not necessarily resulting in any loss of strength, such a deformation, if severe, can transmit a pulsation resulting in irregular rope drive. After prolonged working, this will give rise to wear and wire breaks.

In the case of waviness (see Figure 5), the wire rope shall be discarded if, under any load condition on a straight portion of rope that does not bend around a sheave or drum, the following condition is met:

$$d_1 > 4d/3$$

or, on a portion of rope that bends around a sheave or drum, the following condition is met:

$$d_1 > 1{,}1d$$

where

d is the nominal diameter of the rope;

d_1 is the diameter corresponding to the envelope of the deformed rope.

3.5.11.3 Basket or lantern deformation

Basket or lantern deformation, also called “birdcage”, is a result of a difference in length between the rope core and the outer layer of strands. Different mechanisms can produce this deformation.

If, for example, a rope is running over a sheave or onto the drum under a great fleet angle, it will touch the flange of the sheave or the drum groove first and then roll down into the bottom of the groove. This characteristic will unlay the outer layer of strands to a greater extent than the rope core, producing a difference in length between these rope elements.

When running over a “tight sheave”, i.e. a sheave with a groove radius that is too small, the wire rope will be compressed. This reduction in diameter will at the same time result in an increase in rope length. As the outer layer of strands will be compressed and lengthened to a greater extent than the rope core, this mechanism again will produce a difference in length between these rope elements.

In both cases, the sheaves and the drum will then be able to displace the loose outer strands and bring the length difference to one location in the reeving system where it will appear as a basket or lantern deformation.

Ropes with a basket or lantern deformation shall be immediately discarded.

3.5.11.4 Core or strand protrusion/distortion

This feature is a special type of basket or lantern deformation in which the rope imbalance is indicated by protrusion of the core (or centre of the rope, in the case of a rotation-resistant rope) between the outer strands, or protrusion of an outer strand of the rope or strand from the core.

Rope with core or strand protrusion/distortion shall be immediately discarded.

3.5.11.5 Wire protrusion

In wire protrusion, certain wires or groups of wires rise up, on the side of the rope opposite to the sheave groove, in the form of loops.

Rope with wire protrusion shall be immediatly discarded.

3.5.11.6 Local increase in diameter of rope

A local increase in rope diameter can occur and might affect a relatively long length of the rope. This condition usually relates to a deformation of the core (in particular environments, a fibre core can swell up owing to the effect of moisture) and consequently creates imbalance in the outer strands, which become incorrectly oriented.

If this condition causes the actual rope diameter to increase by 5 % or more, the rope shall be immediately discarded.

3.5.11.7 Flattened portions

Flattened portions of rope which pass through a sheave will quickly deteriorate, exhibiting broken wires and may damage the sheave. In such cases the rope shall be discarded immediately.

Flattened portions of rope in standing rigging can be exposed to accelerated corrosion, and shall be subject to inspection at a prescribed shortened frequency if retained in service.

3.5.11.8 Kinks or tightened loops

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 will cause excessive wear, and in severe cases the rope will be so distorted that it will have only a small proportion of its strength remaining.

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

3.5.11.9 Bends

Bends are angular deformations of the rope caused by external influence.

Rope with a severe bend will suffer similarly to flattened portions of rope and should be treated as in clause 3.5.11.7.

3.5.12 Damage due to heat or electric arcing

Ropes that have been subjected to exceptional thermal effects, externally recognized by the colours produced in the rope, shall be immediately discarded.

4 Operating performance of wire rope

Accurate recording of information by the examiner can be used to predict the performance of a particular type of rope on a crane. Such information is useful in regulating maintenance procedures and also control of replacement rope stock. If such forecasting is used, it shall not have the effect of relaxing examinations or prolonging the operating period beyond that indicated by the criteria specified in the preceding clauses of this International Standard.

5 Condition of equipment related to rope

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

Stiff or jammed sheaves or rollers wear heavily and unevenly, causing severe abrasion of the rope. Ineffective compensating of sheaves can give rise to unequal loading in the rope reeving.

The radius at the bottom of the groove in all sheaves shall be appropriate to the nominal diameter of the rope supplied (see ISO 4308-1 for further information). If the radius has become too large or too small, the groove should be remachined or the sheave replaced.

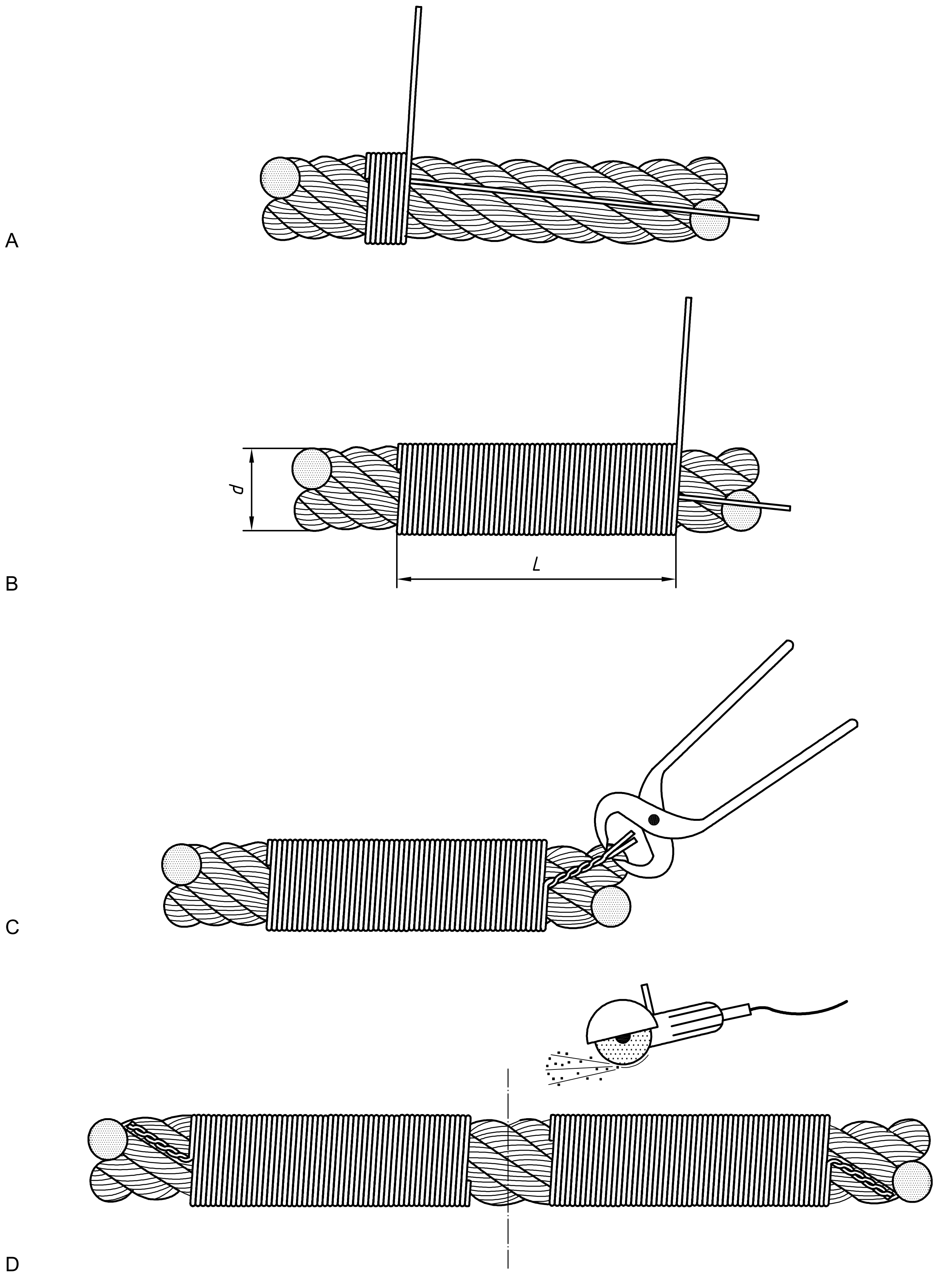
6 Rope examination record

For each periodic or special examination, the examiner shall provide a record containing information relating to the examination. See Annex B for typical examples of examination records.

7 Rope storage and identification

Clean, dry and non-polluted storage shall be provided to prevent deterioration of rope not in use.

Means shall be provided to enable ropes to be clearly identified with respect to their examination records.



$L \geqslant 2d$

Figure 1 — Application of serving prior to cutting

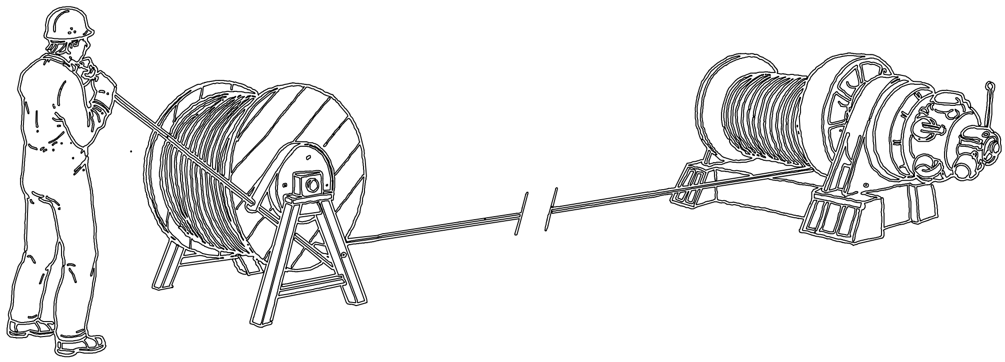
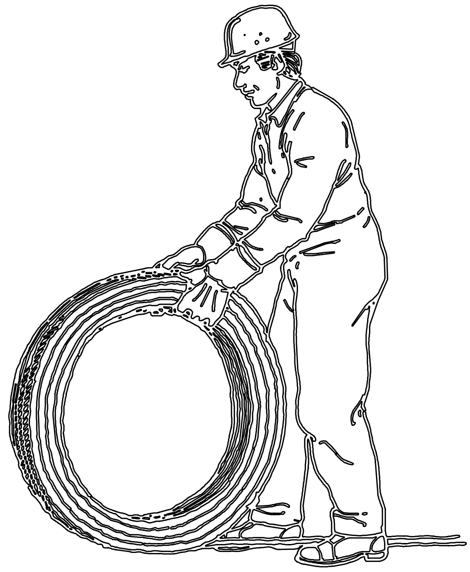
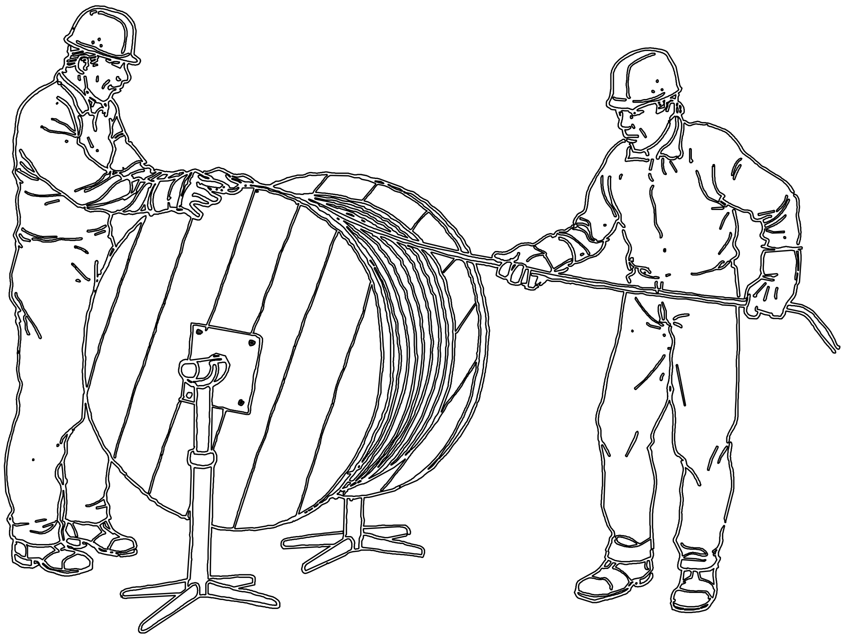


Figure 2 — Example of transfer of wire rope from bottom of reel to bottom of drum with control of rope tension

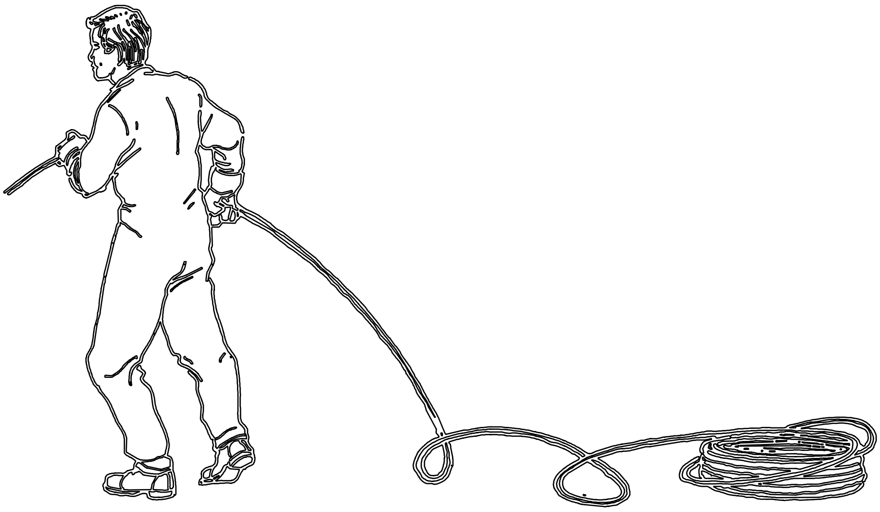


a) From a coil

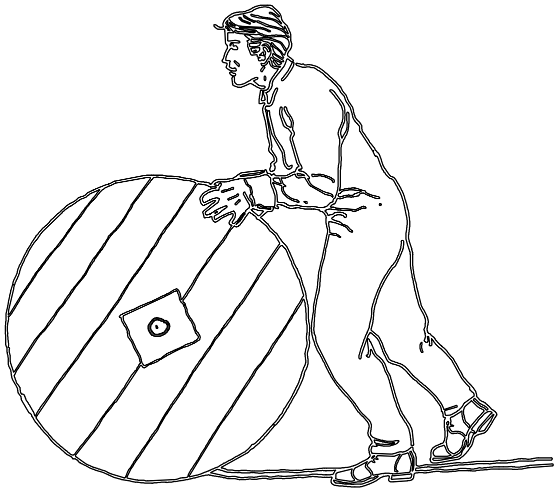


b) From a reel

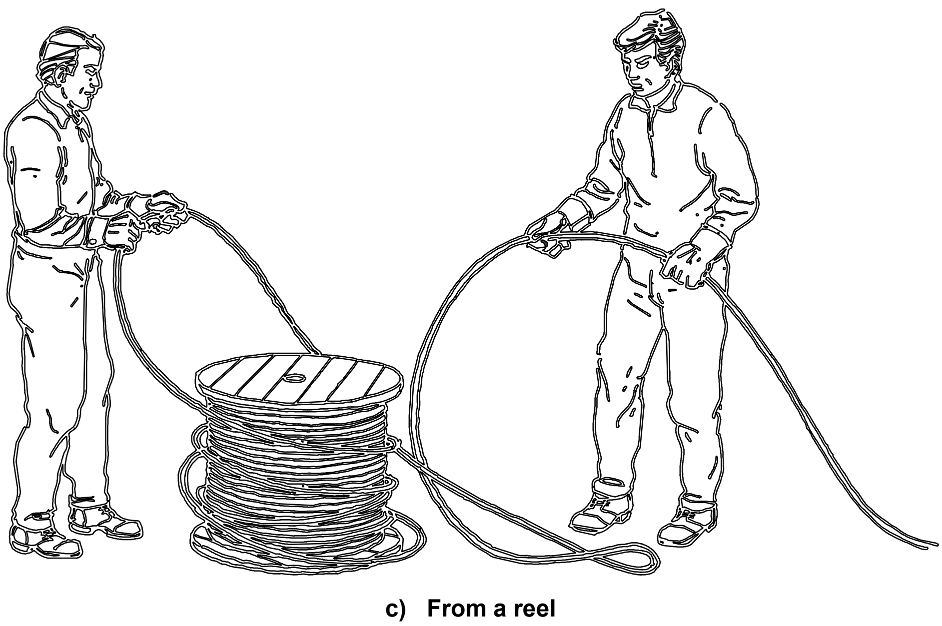
Figure 3 — Correct procedures for uncoiling a wire rope



a) From a coil



b) From a reel



c) From a reel

Figure 4 — Incorrect procedures for uncoiling a wire rope

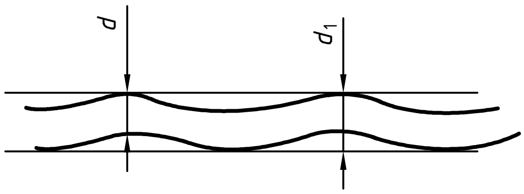
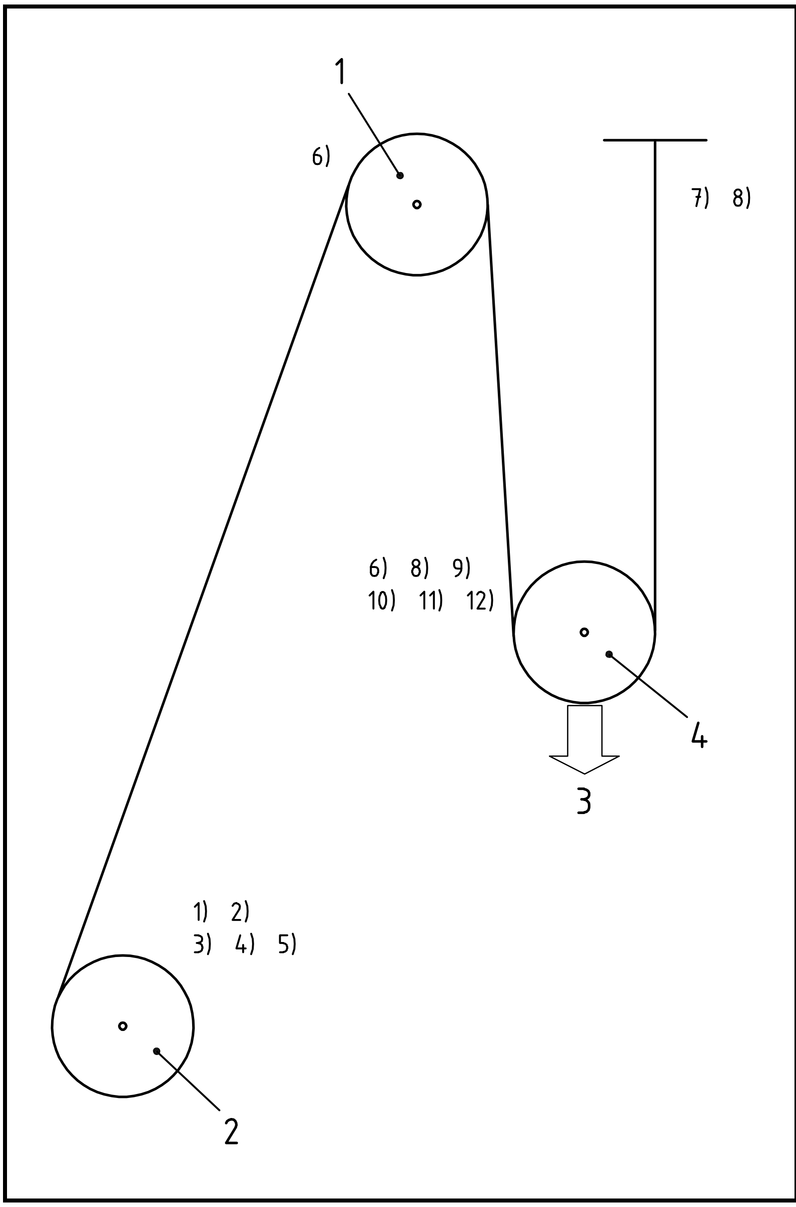


Figure 5 — Waviness

Annex A
(informative)

Critical areas for examination, and associated defects



Location on Figure	Type of examination
1)	Examine termination of rope at drum
2)	Examine for defective coiling, which causes deformations (flattened portions) and wear, which can be severe at cross-over positions
3)	Examine for wire breaks
4)	Examine for corrosion
5)	Look for deformations caused by snatch loading
6)	Examine portion which winds over sheave for wire breaks and wear
7)	Points of attachment: check for wire breaks and corrosion; similarly, check section of rope which lies on or adjacent to compensating sheaves.
8)	Look for deformation
9)	Check rope diameter
10)	Examine carefully length which runs through sheave block, particularly that length which lies on the sheave when the appliance is in a loaded condition
11)	Examine for wire breaks and surface wear
12)	Examine for corrosion

Key

1 sheave
2 drum
3 load
4 sheave block

Figure A.1 — Example of a rope system illustrating the critical areas for examination, and associated defects

Annex B
(informative)

Typical examples of rope examination record

B.1 Single record

Crane reference: ....
....

Rope application: ....
....

Rope details: ....
Brand name (if known) ....
Nominal diameter .... mm
Construction ....
Core [a]: IWRC FC WSC
Wire finish [a]: Uncoated Zinc/Gal.
Direction and type of lay [a]: Right: sZ zZ Z Left: zS sS S
Permissible number of visible broken wires: .... in 6*d* and .... in 30*d*
Allowable reduction of diameter: 10 % or 3 %

Date installed (yy/mm/dd): .... Date discarded (yy/mm/dd): ....

Visible broken wires		Reduction of diameter		Abrasion of outer wires	Corrosion	Damage and deformations	Positions in rope	Overall assessment
Number in length 6 *d*	30 *d*	Actual dia.	% below nominal	Degree [b]	Degree [b]	Degree [b] and nature		Degree [b]

Other observations/comments:

Performance to date (cycles/hours/days/months/etc.): ....

Date of examination (yy/mm/dd) .... Name (print) .... Signature ....

[a] Tick as applicable.

[b] Describe degree of deterioration as: slight; medium; high; very high; or discard.

B.2 Running record

Crane reference ………………………	Date rope installed yy/mm/dd …………	Rope details (see ISO 17893 for rope designation)					
		RCN[a] ………	Nominal diameter mm ………	Brand name ……………………………… Construction ………………………………	Core[b] IWRC FC WSC	Wire finish[b] Uncoated Zinc/Gal.	Direction and type of lay[b] Right: sZ zZ Z Left: zS sS S
Rope duty: ……………………… Rope termination(s): ………………………	Date rope discarded yy/mm/dd …………	Number of permissible broken outer wires …………….. in 6d and …………….. in 30d					Permissible reduction in diameter 10 % or 3 %

Date of examina-tion	Visible broken outer wires				Reduction of diameter				Corrosion		Damage and deformations		Cumulative degree[c] of deterioration (and any comments)
	Number in length		Position in rope	Degree[c]	Actual dia.	Reduction below nominal	Position in rope	Degree[c]	Position in rope	Degree[c]	Position in rope	Degree[c]	
yy/mm/dd	6d	30d				%							

Name (print) **and signature of examiner** ………..

[a] RCN is Rope Category Number (see Tables 1 and 2 and Annex E).

[b] Tick as applicable.

[c] Describe degree of deterioration as: 20 % = slight; 40 % = medium; 60 % = high; 80 % = very high; or 100% = discard.

Annex C
(informative)

Internal examination of rope

C.1 Introduction

Experience gained from examining wire rope and discarding it from service shows that internal deterioration, mainly as a result of corrosion and the normal progress of fatigue, is the prime cause of many rope failures. Normal external examination might not reveal the extent of internal deterioration, even to the point when fracture is imminent.

Internal examination should always be carried out by a competent person.

All types of stranded wire rope can be opened up sufficiently to permit assessment of their internal condition. It is difficult for large rope sizes. However, the majority of ropes fitted to cranes can be examined internally provided that they are at zero tension.

Visual examination of the wire rope, as recommended in this annex, can only be carried out on limited portions of the rope; consideration should be given to carrying out full-length inspections using approved non-destructive testing.

C.2 Procedure

C.2.1 General examination

Attach firmly to the rope two clamping jaws of suitable size and distance apart [see Figure C.1 a)].

Apply a force to the clamping jaws in the opposite direction to the rope lay. The outer strands will separate and move away from the core.

Care should be taken during the opening process to ensure that the clamping jaws do not slip about the periphery of the rope. The strands should not be displaced excessively.

When the rope opens a little, a small probe, such as a screwdriver, may be used to remove grease or debris which could hinder observation of the interior of the rope.

Observe the following:

a) the state of the internal lubrication;

b) the degree of corrosion;

c) any indentation of wires caused by pressure or wear;

d) presence of any broken wires (these are not necessarily easily visible).

After examination, insert a service dressing into the opened part and effect rotation of the clamping jaws with moderate force to ensure correct replacement of the strands around the core.

Remove the jaws and grease the surface of the rope.

C.2.2 Examination of rope portion adjacent to a termination

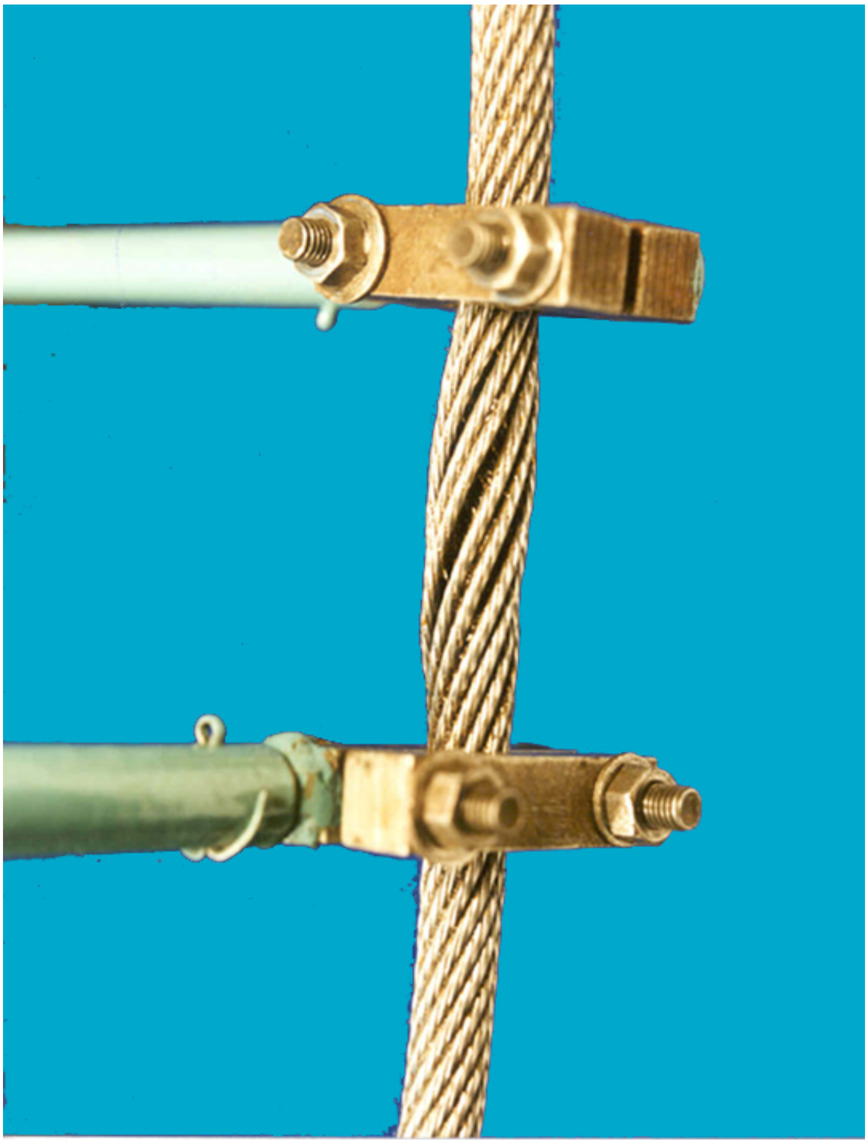
In examining these portions of rope, it is sufficient to use a single jaw, since the end anchorage system, or a bar suitably located through the end portion of the termination, will ensure the necessary immobilization of the outer end [see Figure C.1 b)]. Carry out the examination as in C.2.1.

C.3 Portions which should be examined

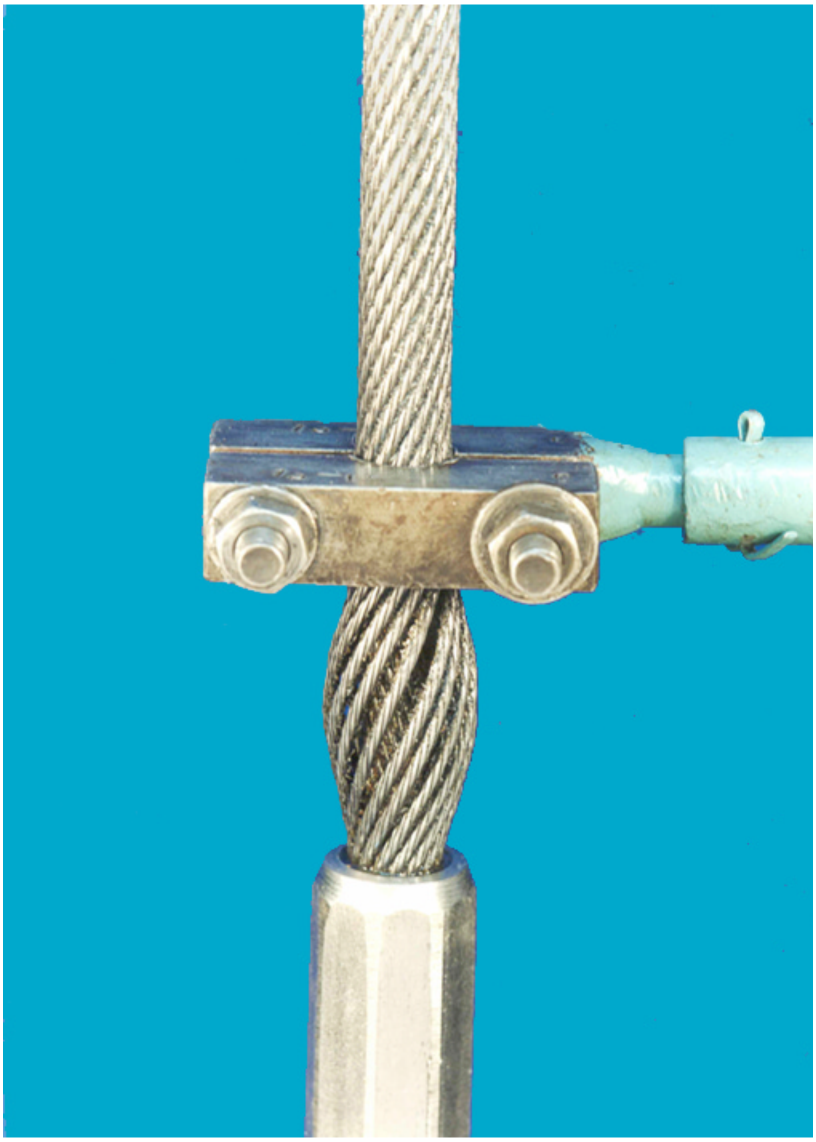
Since it is impracticable to examine the interior of the wire rope over the whole of its length, suitable sections should be selected.

In the case of wire ropes which wind onto a drum, or pass over sheaves or rollers, it is recommended that the lengths which engage the sheave grooves when the crane is in a loaded condition be examined. Those localized areas in which shock forces are arrested (i.e. adjacent to drum and jib lead sheaves) and those lengths which are particularly exposed to the weather for long periods should be examined.

Attention should be given to the area of rope close to its termination. This is particularly important in the case of fixed ropes, such as stays or pendants.



a) of a continuous portion of rope (zero tension)



b) **at the end of a rope, close to the terminal fitting** (zero tension)

Figure C.1 — Internal examination

Annex D
(informative)

Defects that can occur in wire rope

Table D.1 shows the defects that can occur, and the corresponding discard criteria. Figures D.1 to D.20 show a typical example of each defect.

Table D.1 — Defects that occur in wire rope

Photograph number	Defect	Reference in this International Standard
D.1	Wire protrusion	3.5.11.5
D.2	Core protrusion — single-layer rope	3.5.11.4
D.3	Local reduction in rope diameter (sunken strand)	3.5.7
D.4	Strand protrusion/distortion	3.5.11.4
D.5	Flattened portion	3.5.11.7
D.6	Kink (positive)	3.5.11.8
D.7	Kink (negative)	3.5.11.8
D.8	Waviness	3.5.11.2
D.9	Basket deformation	3.5.11.3
D.10	External wear	3.5.8
D.11	Enlargement of Figure D.10	3.5.8
D.12	External corrosion	3.5.10.2
D.13	Enlargement of Figure D.12	3.5.10.2
D.14	Crown wire breaks	3.5.2
D.15	Valley wire breaks	3.5.2
D.16	Protrusion of inner rope of rotation-resistant rope	3.5.11.4
D.17	Local increase in rope diameter due to core distortion	3.5.11.6
D.18	Kink	3.5.11.8
D.19	Flattened portion	3.5.11.7
D.20	Internal corrosion	3.5.10.3

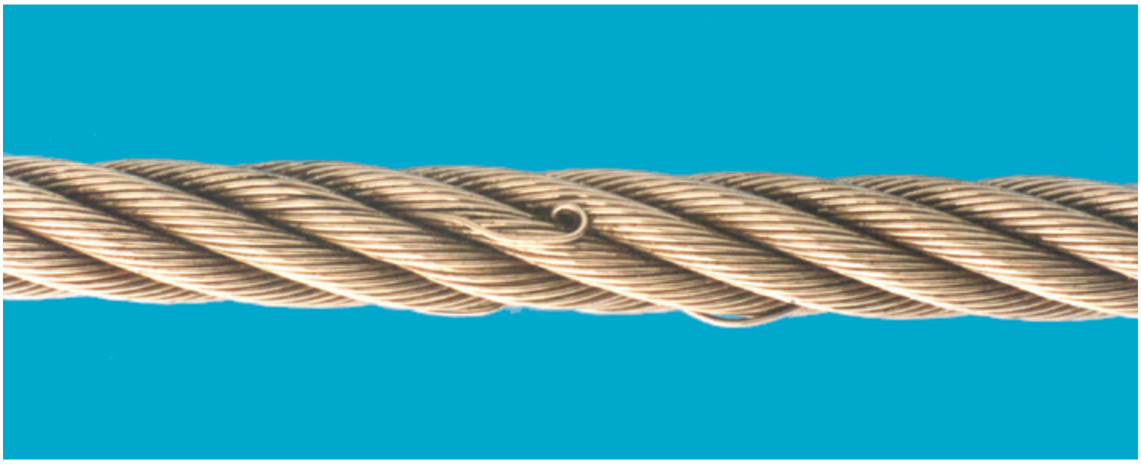


Figure D.1 — Wire protrusion

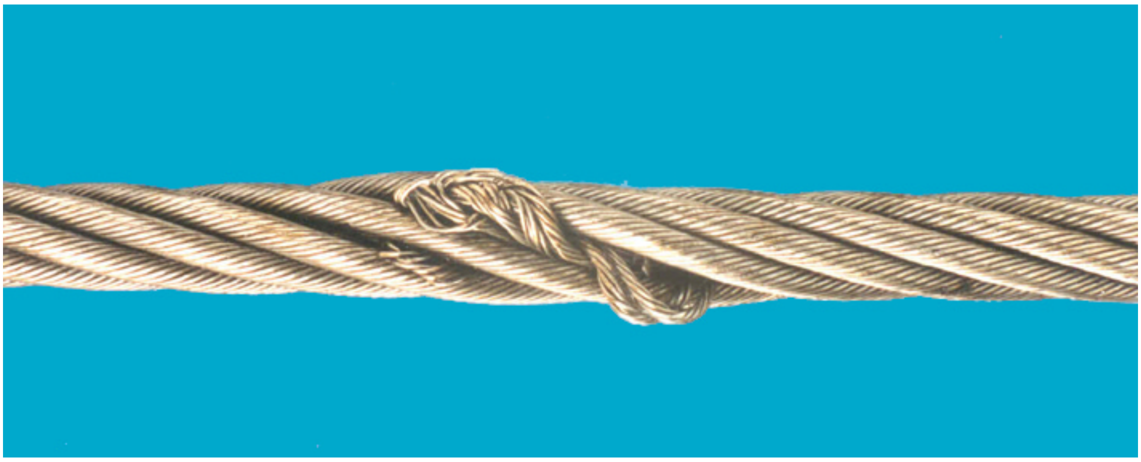


Figure D.2 — Core protrusion — Single-layer rope

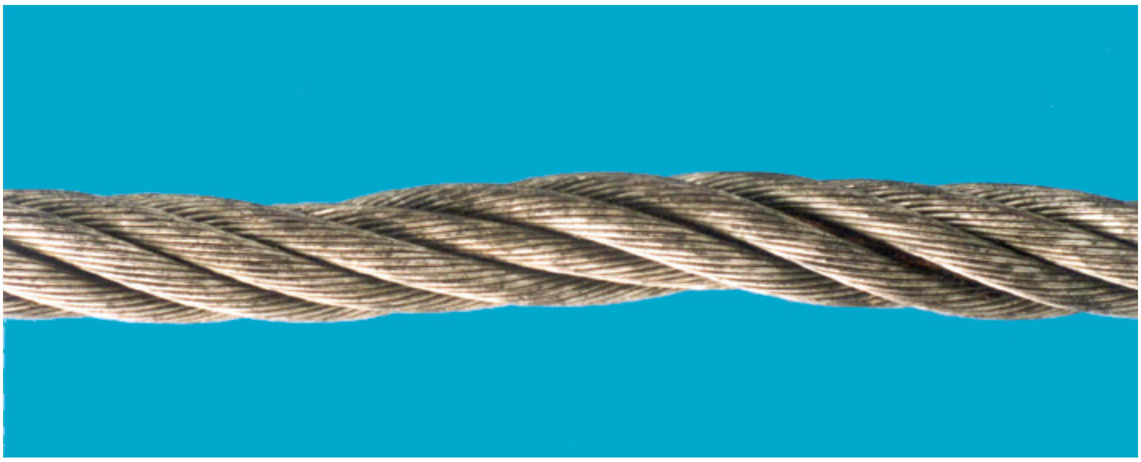


Figure D.3 — Local reduction in rope diameter (sunken strand)

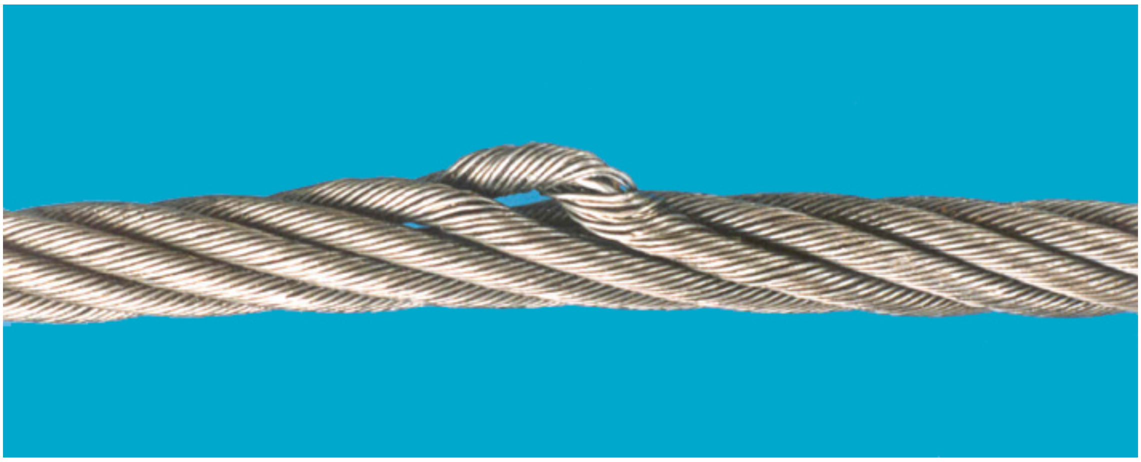


Figure D.4 — Strand protrusion/distortion

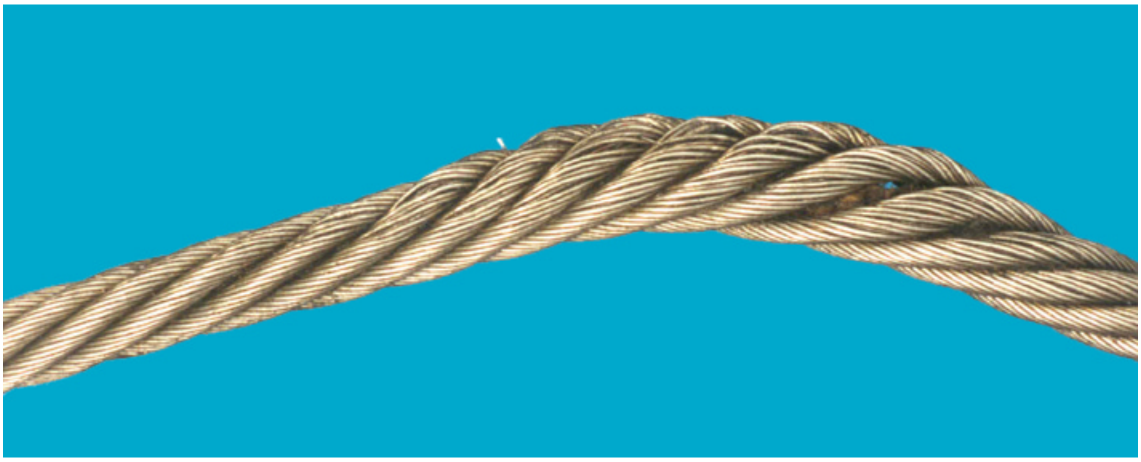


Figure D.5 — Flattened portion

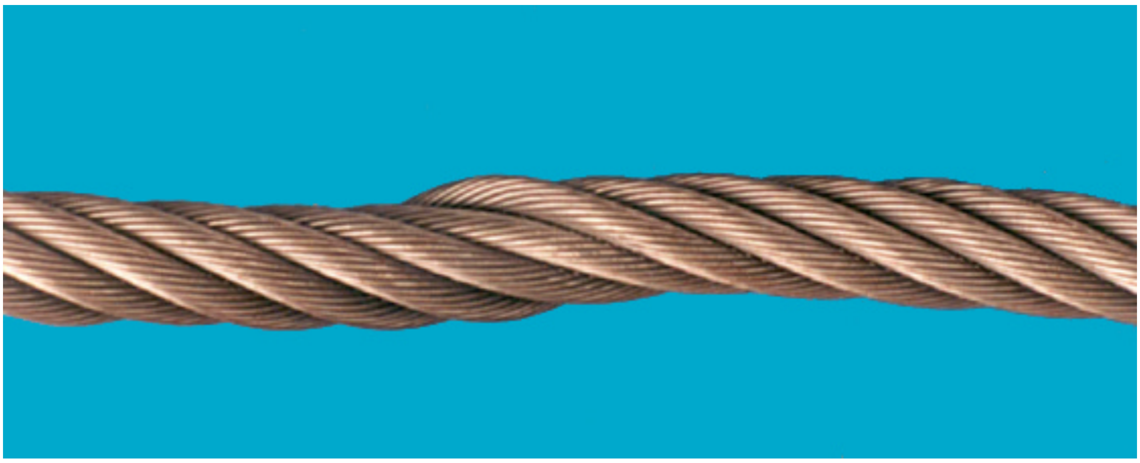


Figure D.6 — Kink (positive)

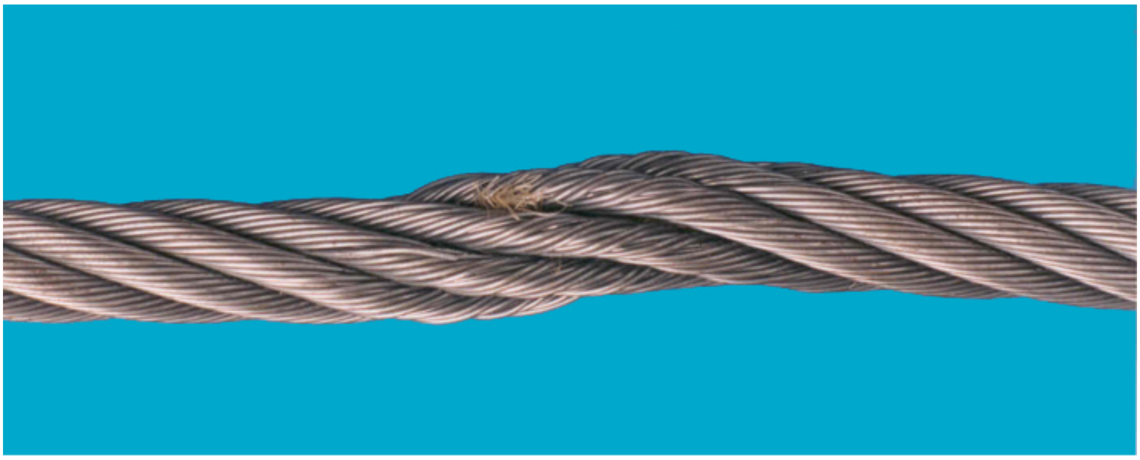


Figure D.7 — Kink (negative)

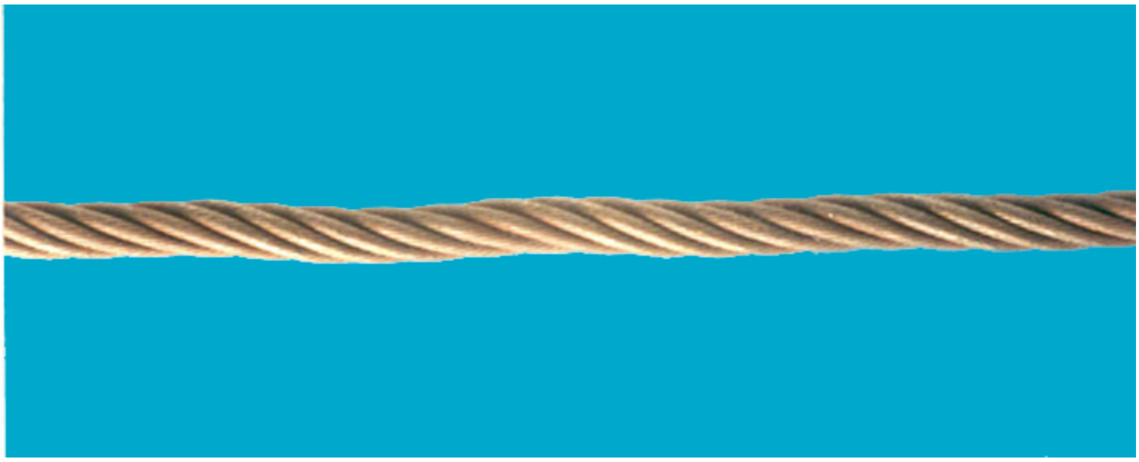


Figure D.8 — Waviness

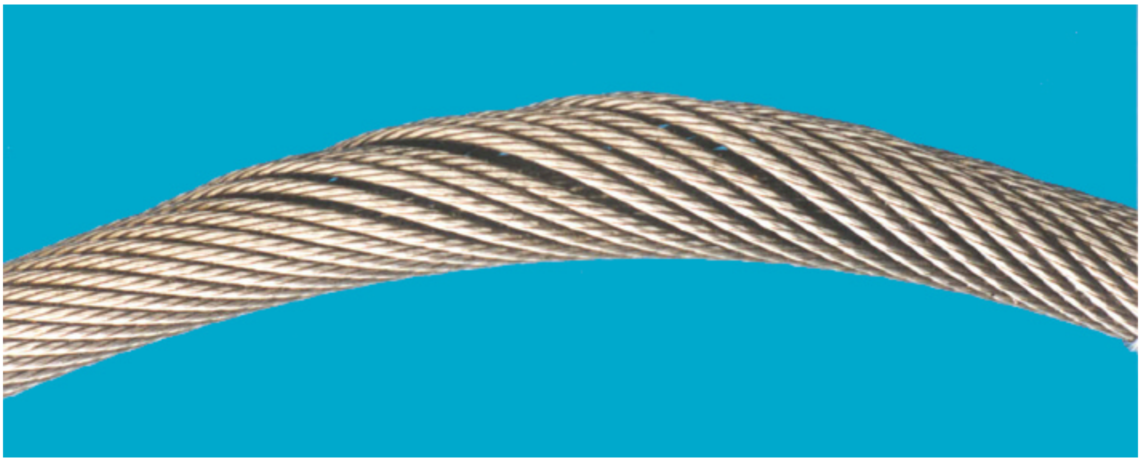


Figure D.9 — Basket deformation

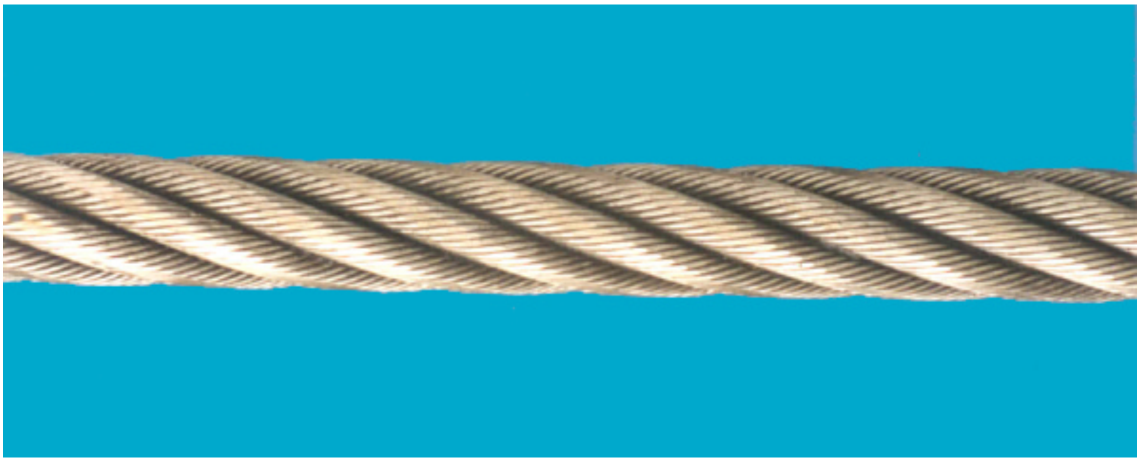


Figure D.10 — External wear

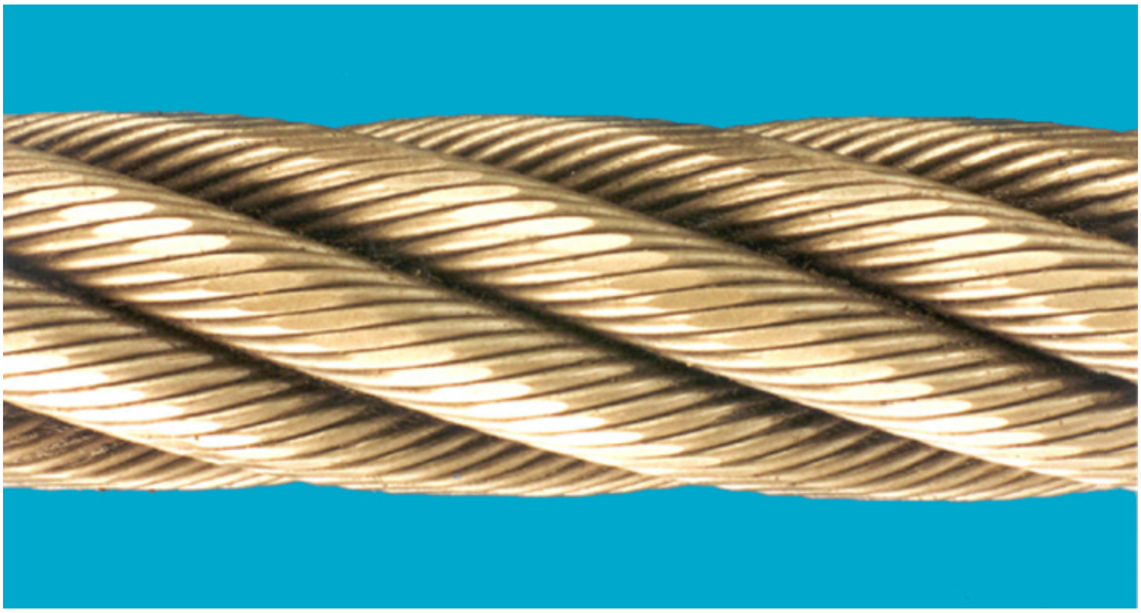


Figure D.11 — Enlargement of Figure D.10

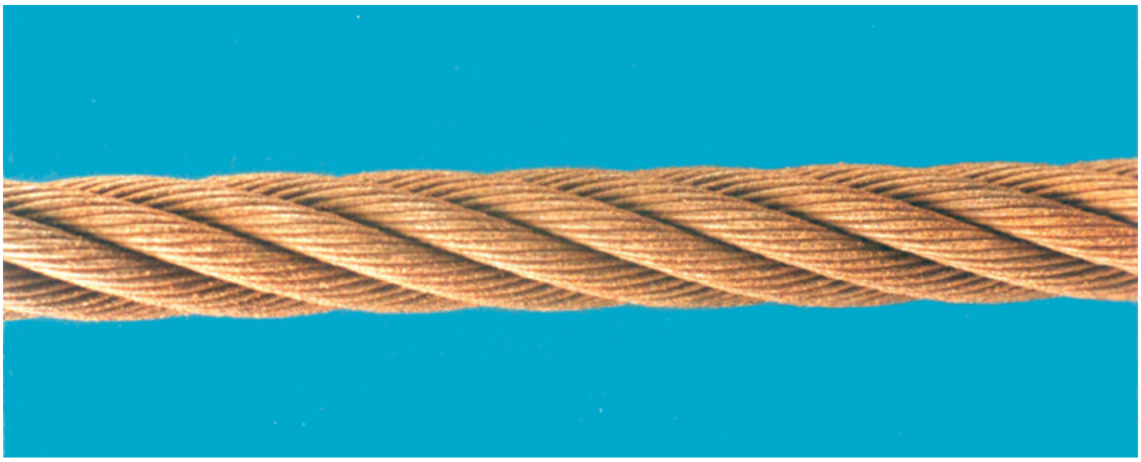


Figure D.12 — External corrosion

Figure D.13 — Enlargement of Figure D.12

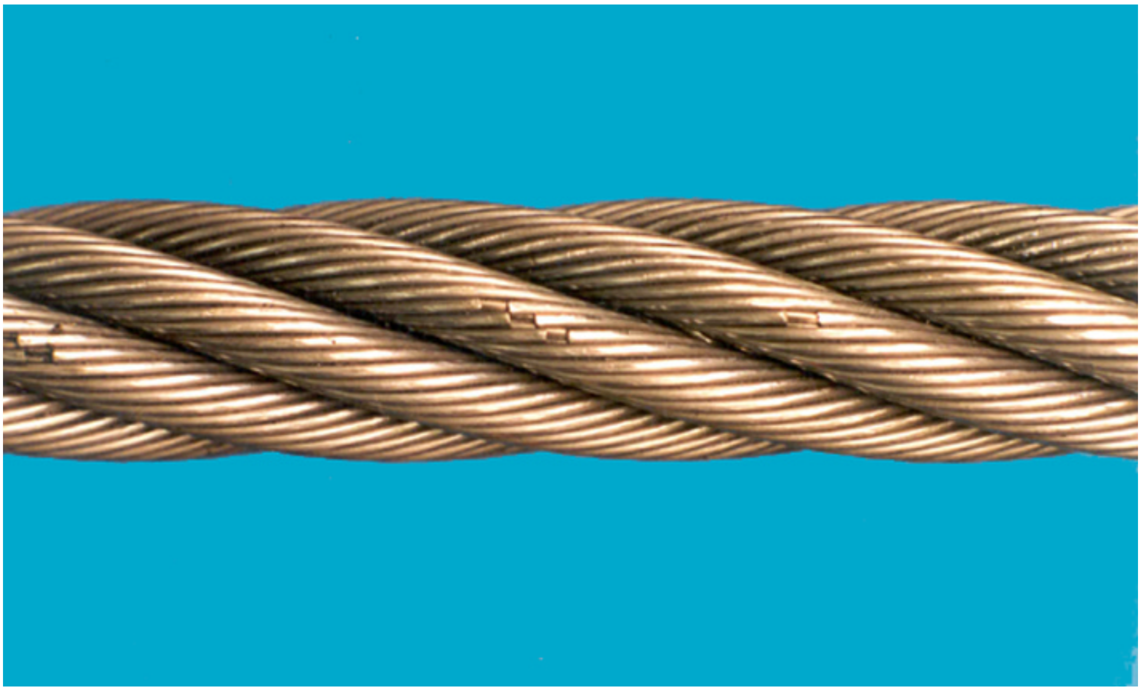


Figure D.14 — Crown wire breaks

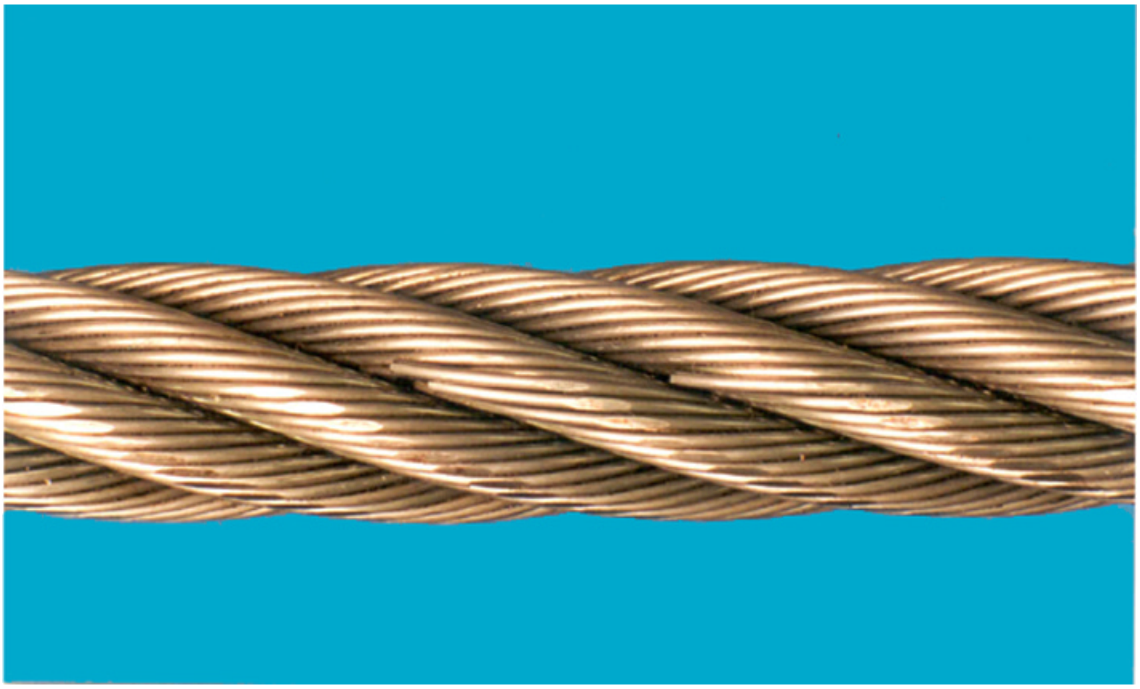


Figure D.15 — Valley wire breaks

Figure D.16 — Protrusion of inner rope of rotation-resistant rope

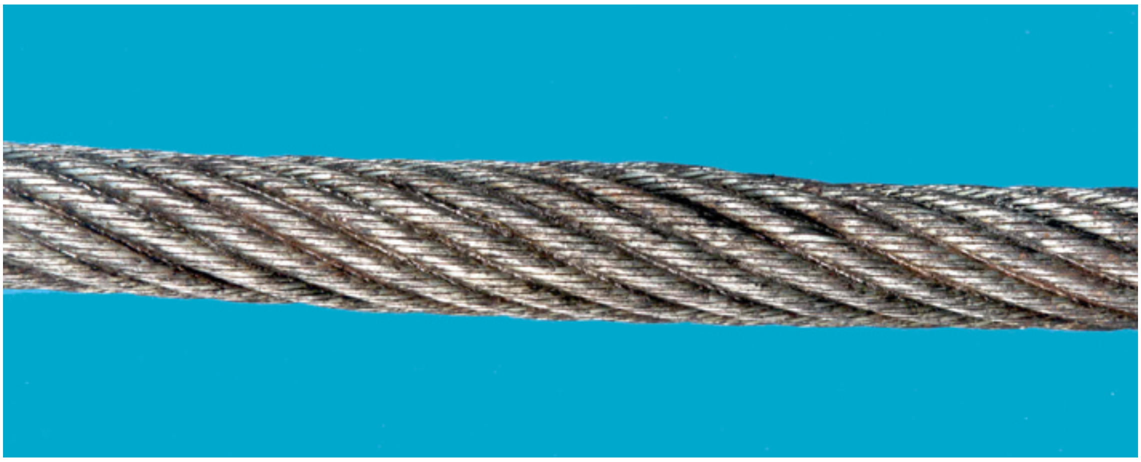


Figure D.17 — Local increase in rope diameter due to core distortion

Figure D.18 — Kink

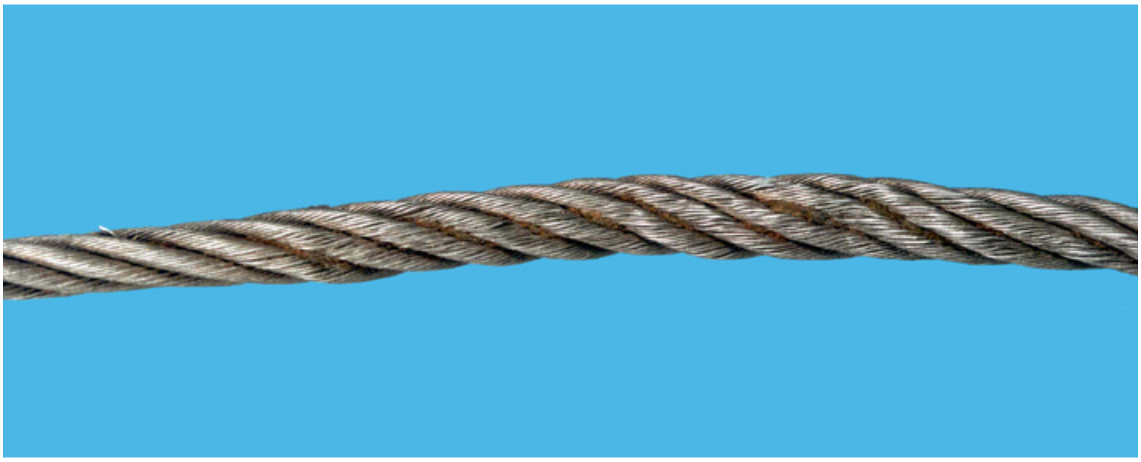


Figure D.19 — Flattened portion

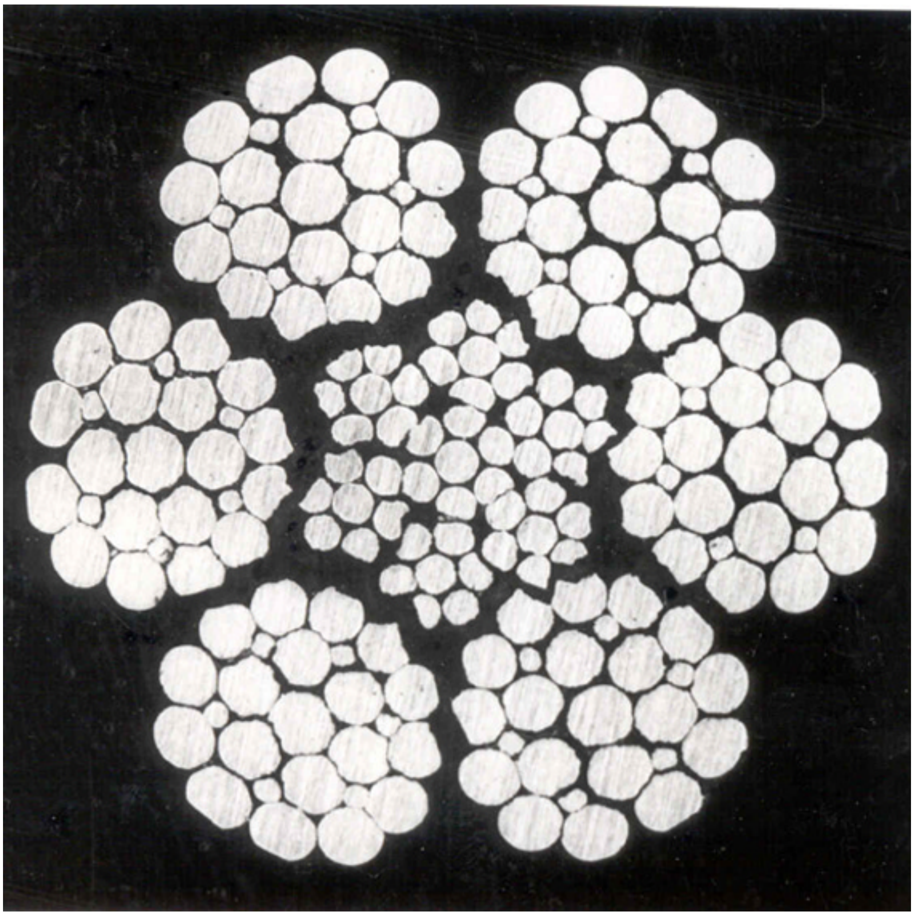
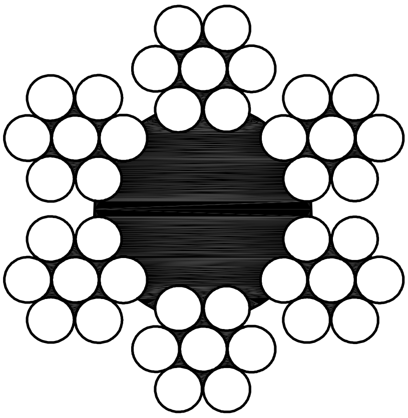


Figure D.20 — Internal corrosion

Annex E
(informative)

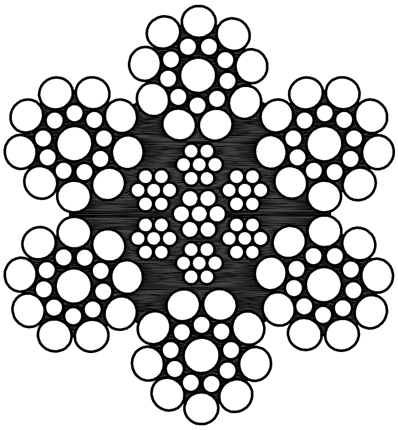
Examples of cross sections of ropes and corresponding rope category numbers (RCN)

Construction: 6 × 7-FC Single-layer rope



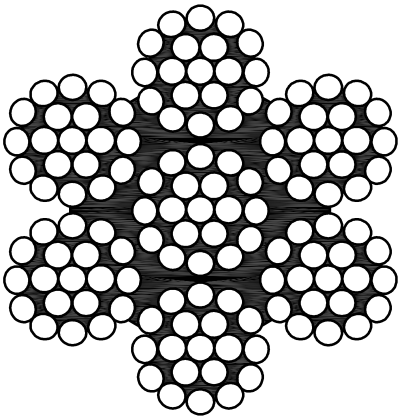
RCN.01

Construction: 6 × 19S-IWRC Single-layer rope



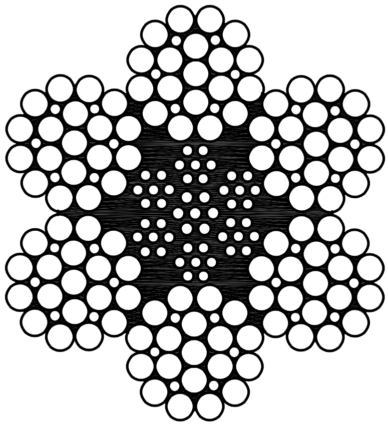
RCN.02

Construction: 6 × 19M-WSC Single-layer rope



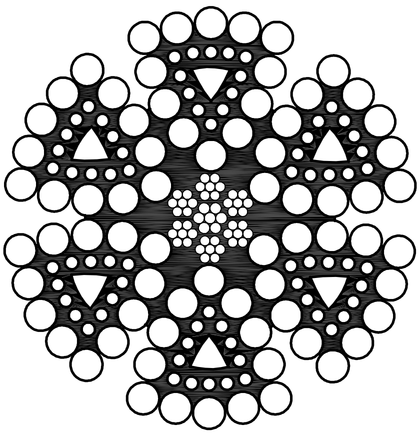
RCN.04

Construction: 6 × 25F-IWRC Single-layer rope



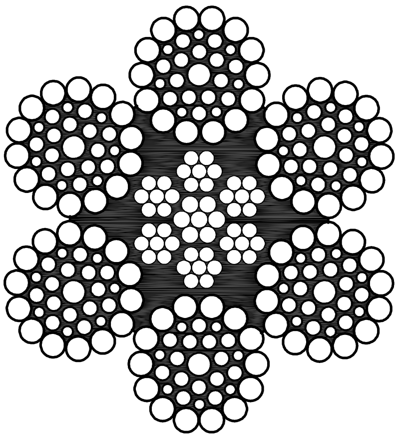
RCN.04

Construction: 6 × 25TS-IWRC Single-layer rope

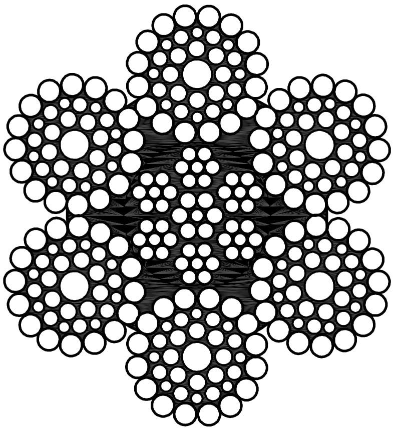
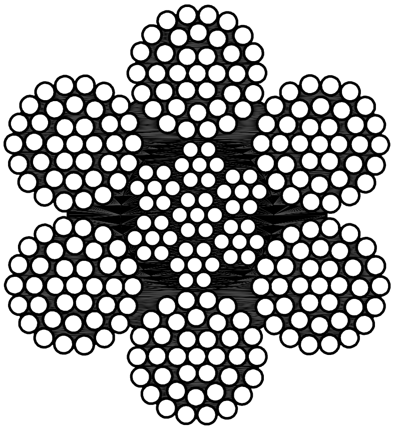
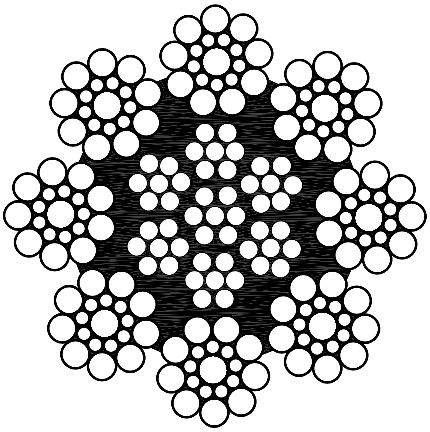
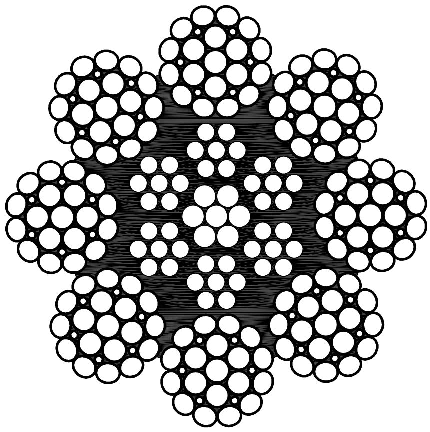
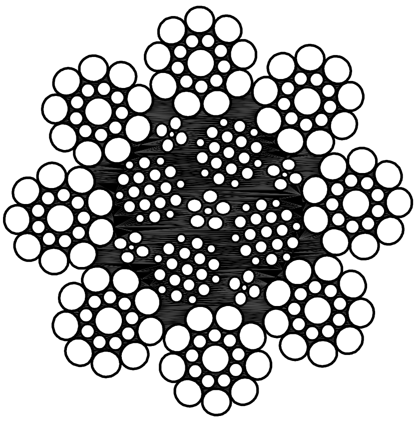
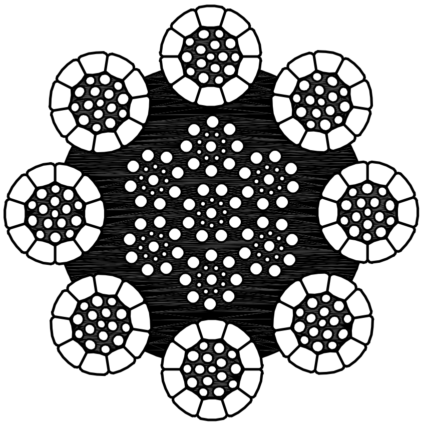


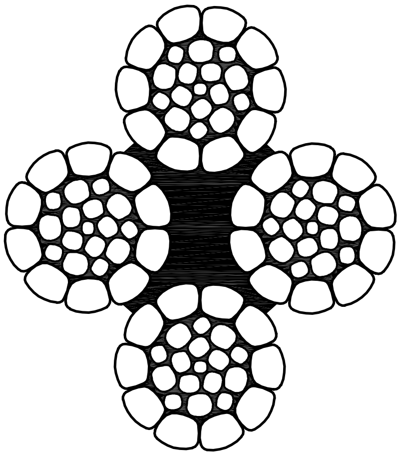
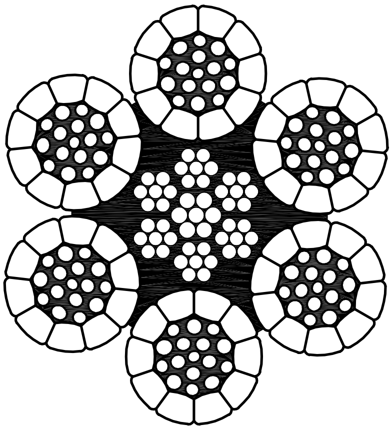
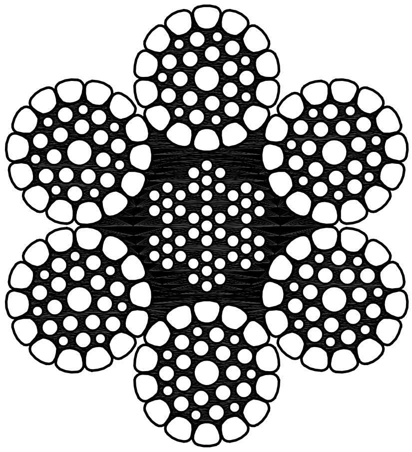
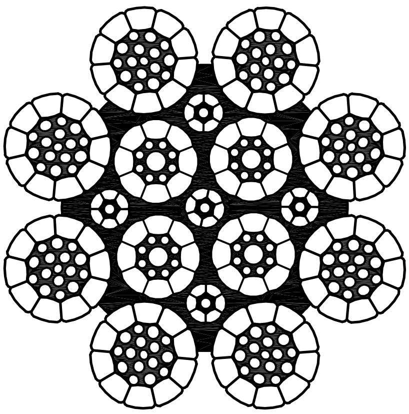
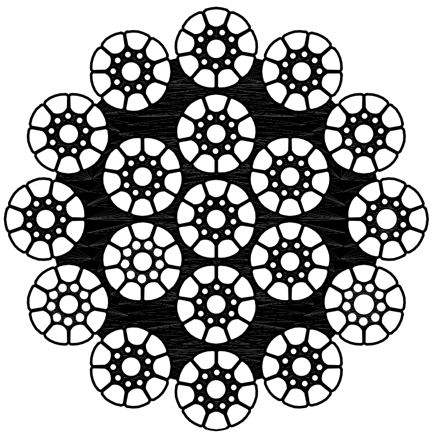
RCN.04

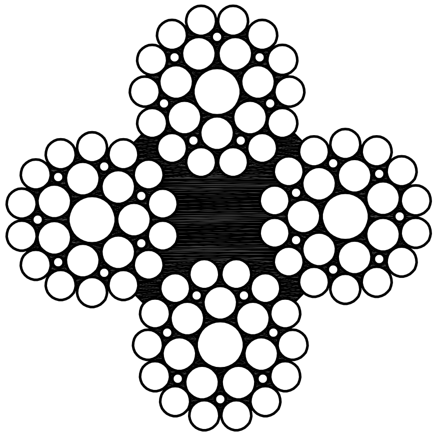
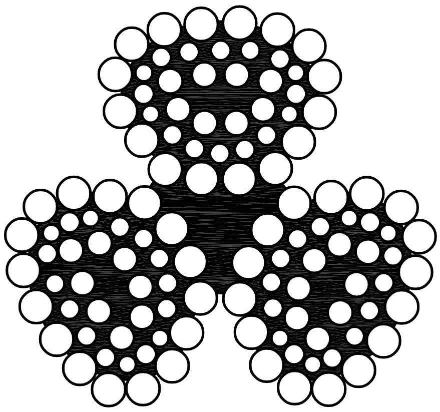
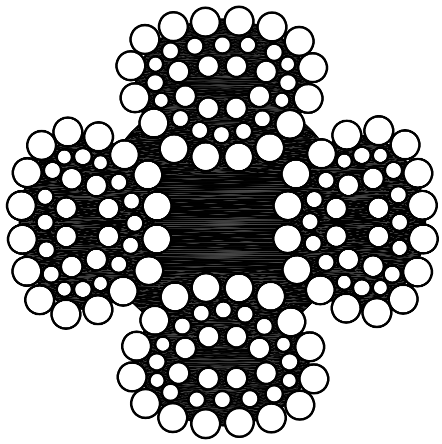
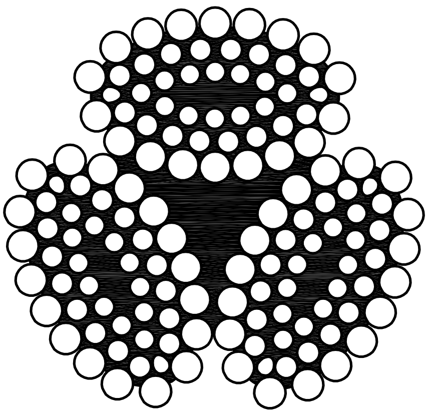
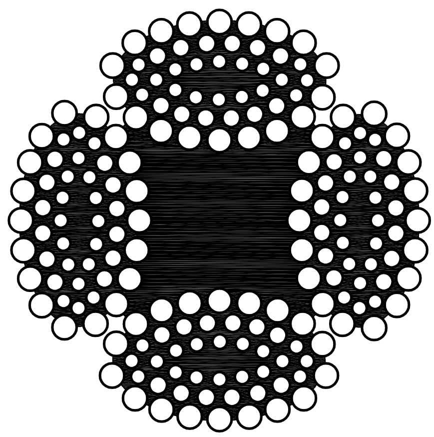
Construction: 6 × 36WS-IWRC Single-layer rope



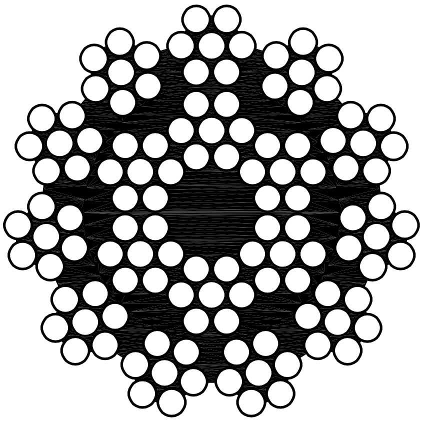
RCN.09

Construction: 6 × 41WS-IWRC Single-layer rope  RCN.11	Construction: 6 × 37M-IWRC Single-layer rope  RCN.10
Construction: 8 × 19S-IWRC Single-layer rope  RCN.04	Construction: 8 × 25F-IWRC Single-layer rope  RCN.06
Construction: 8 × 19S-PWRC Parallel-closed rope  RCN.04	Construction: 8 × K26WS-IWRC Single-layer rope with compacted strands  RCN.09

	Construction: 4 × K26WS Single-layer/rotation-resistant rope with compacted strands  RCN.22
Construction: 6 × K26WS-IWRC Single-layer rope with compacted strands  RCN.06	Construction: 6 × K36WS-IWRC Single-layer rope with compacted strands  RCN.09
Construction: 8 × K26WS-PWRC Parallel-closed rope with compacted strands  RCN.09	Construction: 18 × K19S-WSC or 19 × K19S Rotation-resistant rope with compacted strands  RCN.23

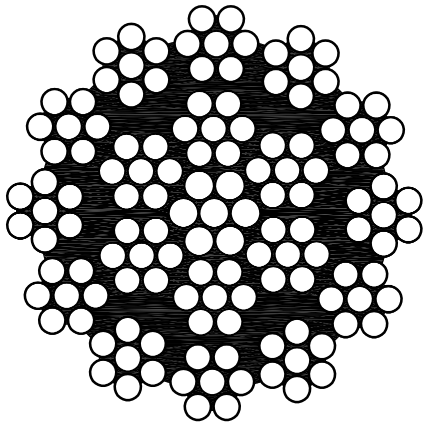
	Construction: 4 × 29F Single-layer rope/rotation-resistant rope 4 × 29F  RCN.21
Construction: K3 × 40 Single-layer compacted (swaged) rope/rotation-resistant compacted (swaged) rope  RCN.22	Construction: K4 × 40 Single-layer compacted (swaged) rope/rotation-resistant compacted (swaged) rope  RCN.22
Construction: K3 × 48 Single-layer compacted (swaged) rope/rotation-resistant compacted (swaged) rope  RCN.22	Construction: K4 × 48 Single-layer compacted (swaged) rope/rotation-resistant compacted (swaged) rope  RCN.22

Construction: 17 × 7-FC
Rotation-resistant rope



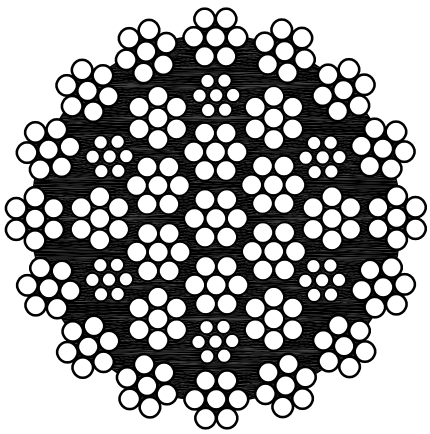
RCN.23

Construction: 18 × 7-WSC or 19 × 7
Rotation-resistant rope



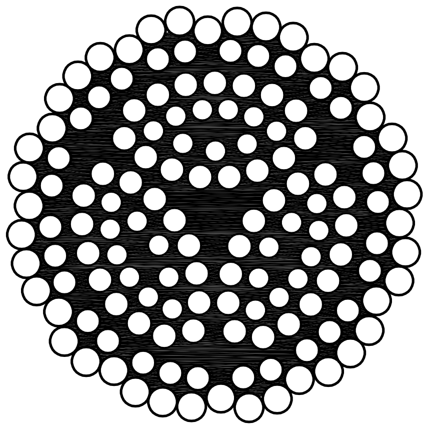
RCN.23

Construction: 34(W) × 7-WSC or 35(W) × 7
Rotation-resistant rope



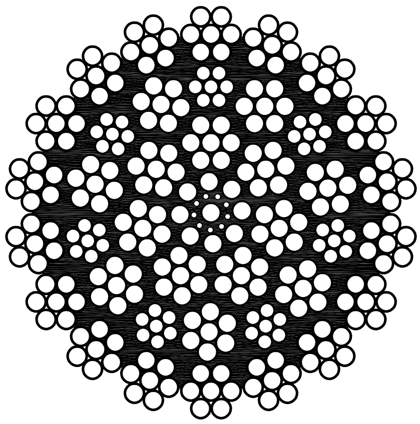
RCN.23

Construction: 12 × P6:3 × Q24
Rotation-resistant rope (Paragon)



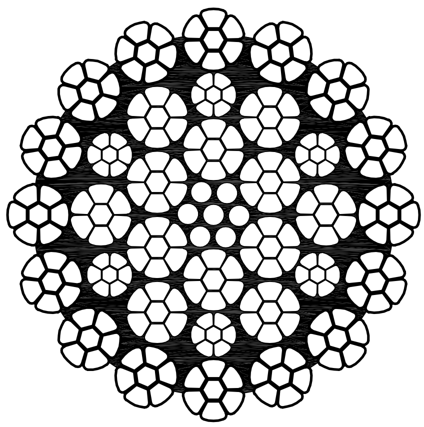
RCN.23

Construction: 39(W) × 7-WSC
Rotation-resistant rope

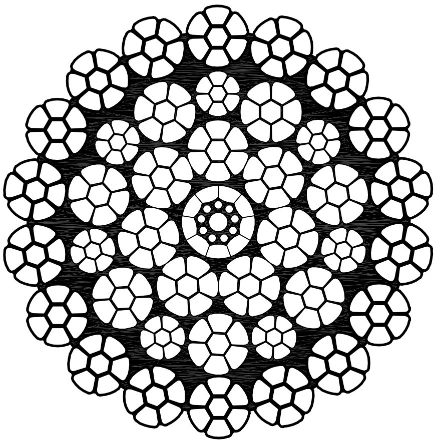


RCN.23

Construction: 34(W) × K7-WSC
Rotation-resistant rope with compacted strands
Compacted



RCN.23

Construction: 39(W) × K7-KWSC Rotation-resistant rope with compacted strands  RCN.23	

Bibliography

[1] ISO 4301-1, *Cranes and lifting appliances — Classification — Part 1: General*

[2] ISO 4306-1, *Cranes — Vocabulary — Part 1: General*

[3] ISO 4308-1, *Cranes and lifting appliances — Selection of wire ropes — Part 1: General*

[4] ISO 4308-2, *Cranes and lifting appliances — Selection of wire ropes — Part 2: Mobile cranes — Coefficient of utilization*

[5] ISO 17893, *Steel wire ropes — Vocabulary, designation and classification*

ICS 53.020.30

Price based on 40 pages