



SLOVENSKI STANDARD
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Cranes -- Wire ropes -- Code of practice for examination and discard

Appareils de levage à charge suspendue -- Câbles -- Critères d'examen et de dépose

Ta slovenski standard je istoveten z: ISO 4309:1990

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INTERNATIONAL STANDARD

ISO 4309

Second edition
1990-08-15

Cranes — Wire ropes — Code of practice for examination and discard

iTeh STANDARD PREVIEW
*Appareils de levage à charge suspendue — Câbles — Critères d'examen et de
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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.

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.

International Standard ISO 4309 was prepared by Technical Committee ISO/TC 96, *Cranes*.

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This second edition cancels and replaces the first edition (ISO 4309 : 1981), of which it constitutes a minor revision.

Annexes A to F of this International Standard are for information only.

Introduction

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

In all cases, however, the safe handling of loads by correctly operated equipment requires regular examination of the rope so that it is removed from service in adequate time.

Finally, certain cranes function in conditions where the ropes are particularly exposed to accidental damage and the original selection of the rope will have taken account of this factor. In such circumstances, examination of the rope must be particularly careful and its removal from service must be made immediately a critical condition of damage is recognized.

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 for the guidance of 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.

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Cranes — Wire ropes — Code of practice for examination and discard

1 Scope

This International Standard specifies the examination and discard criteria of wire rope.

It is applicable to

- 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

The cranes may be used for hook, grabbing, magnet, ladle, excavator or stacking duties and may be operated manually, mechanically, electrically or hydraulically.

The criteria contained in this International Standard also apply to hoist blocks.

ISO 4306-1 provides a vocabulary for cranes covered by this International Standard.

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

This International Standard details the essential guidelines for examination of wire rope in service on a crane and enumerates discard criteria which are to be applied to ensure the efficient and safe use of the equipment.

2 Definitions

For the purposes of this International Standard, the following definitions apply.

2.1 core of a rope: That portion which supports the outer strands of the rope. In a 6- and 8-strand construction, the core may comprise a natural fibre or synthetic rope, a steel strand or a number of strands spun helically to form an independent and smaller wire rope.

2.2 cross-over of a rope on a drum: That portion of a rope which changes from its normal path as it moves from one layer to another due to the effect of either the type of drum grooving or the configuration of the underlying rope layer.

2.3 rope examination record: Record which is held by the user of the lifting appliance and of which a typical example is shown in annex B.

2.4 gap: That space which exists between individual wires in any layer in a strand or between any strands in the same layer of a rope.

2.5 gusset: That area between individual outer strands. Wire breaks in the gusset positions may be indicative of lack of strand gap.

2.6 laps of rope on a drum: Turns around the drum which together make up a full layer. (The laps will be helically or parallel wound, and in the case of the latter, the cross-over from one layer to another will take place in line with the rope anchorage on the drum.)

2.7 Langs lay: Rope in which the direction of lay of the outer layer of wire in the strands is the same as the direction of lay of the strands in the rope.

2.8 lay length: Length of helix made by an individual strand.

2.9 multi-strand rope: Rope comprising a number of layers of strands. A rope may have reduced rotational characteristics if one or more layers are spun in the opposite direction to the outer strands; if all the strands are spun in the same direction, no such benefit occurs.

2.10 ordinary lay; regular lay: Rope in which the direction of lay of the outer layer of wires in the strand is opposite to the direction of lay of the strands in the rope.

2.11 reel: Transit package on which the rope is coiled. It may be of wooden or steel construction, depending on the mass of rope involved.

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2.12 actual rope diameter: Diameter of the circle, in millimetres, which circumscribes the rope.

2.13 rope nominal diameter: Value, in millimetres, by which the diameter of a rope is designated.

2.14 rotation-resistant rope: Construction of rope having eight or more strands in an outer layer which is spun helically in opposition to the direction of the layer beneath.

3 Wire rope**3.1 State before fitting**

The user shall ensure that the condition of the rope meets the requirements of this International Standard.

A rope of the same type as that initially fitted will normally be adopted for replacement purposes. If it is of a different type, the user shall ensure that it possesses properties at least equivalent to those of the rope being discarded.

When the length of rope required for the crane is to be taken from a longer length, a serving 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.

Before re-equipping the appliance, all grooves in drums and pulleys should be checked to ensure that they will correctly accept the replacement rope (see clause 5).

3.2 Fitting

When drawing the wire rope from a reel or coil, every precaution should be taken to avoid the inducement of loss of turn, because to allow such a condition may result in loops, kinks or bends forming in the rope.

If the rope rubs against any part of the appliance when it is not under tension, then the points of contact should be suitably protected.

Before bringing the rope into operation on the appliance, the user shall ensure that all the devices associated with the wire rope operation are set and functioning correctly.

A number of operations of the crane shall be carried out at approximately 10 % of the normal load to stabilize the wire rope.

3.3 Maintenance

The maintenance of the wire rope shall be carried out relative to the lifting appliance, its use, the environment and the type of rope involved. Unless otherwise indicated by the manufacturer either of the crane or of the rope, the wire rope should be cleaned, where possible, and covered with a service dressing of grease or oil, particularly on those lengths which bend when passing over pulleys.

The service dressing shall be compatible with the original lubricant used by the wire rope manufacturer.

A shorter working life of the rope will result from lack of maintenance, particularly when the crane works in a corrosive environment and, in certain cases, for reasons connected with the operation, where no service dressing can be used.

3.4 Examination**3.4.1 Frequency****3.4.1.1 Daily observation**

As far as possible, all visible parts of any rope should be observed each working day with the object of detecting general deterioration and deformation. Particular attention should be paid to the rope at points of attachment to the appliance. 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 carried out by competent persons (in accordance with 3.4.2)

In order to determine the frequency of such periodic examination, consideration shall be given to the following :

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

3.4.1.3 Special examination in accordance with 3.4.2

3.4.1.3.1 In all cases when an incident has occurred which may have caused damage to the rope and/or its termination, or on every occasion when a rope has been brought back into operation after dismantling followed by re-assembly, the rope shall be examined.

3.4.1.3.2 In every case where a lifting appliance has been out of operation for three months or more, the ropes shall be examined prior to recommencement of work.

3.4.1.4 Ropes operating with synthetic sheaves or metal sheaves having synthetic lining

Where a rope operates either solely or partially with synthetic sheaves, or metal sheaves having a synthetic lining, wire breaks may occur in large numbers internally before there is any visible evidence of wire breaks, or substantial wear on the periphery of the rope.

Under these conditions, consideration should be given to the establishment of a specific inspection schedule period based on past rope performance data and taking into account the results from both 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 discard criteria of wire rope for specific lifting appliances should be based on an exchange of information between the lifting appliance manufacturer and the wire rope manufacturer.

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 positions:

- the termination points at the end of both moving and stationary ropes;
- that part of a rope which passes through the block or over pulleys; particular attention shall be paid, in the case of appliances performing a repetitive operation, to any part of the rope which lies over the pulleys while the appliance is in a loaded condition (see annex A);
- that part of the rope which lies over a compensating pulley;
- any part of the rope which may be subject to abrasion by external features (for example hatch coamings);
- internal examination for corrosion and fatigue (see annex D);
- any part of the rope exposed to heat.

The results of the examination shall be recorded in the examination record for the appliance (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 (wedge sockets, grips) shall be examined for broken wires within and under the termination and to ensure the tightness of wedges and screwed grips. The examination shall also ensure that the requirements of the standards and codes of practice laid down for the termination of the rope have been met.

Eye splices made by hand shall be 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 become evident close to, or within, the termination, it may be possible to shorten the rope and re-fix the terminal fittings. However, the length of the wire rope shall be sufficient to allow for the minimum required number of rope turns on the drum.

3.5 Discard criteria

The safe use of rope is qualified by the following criteria (see 3.5.1 to 3.5.11) :

- a) the nature and number of broken wires;
- b) broken wires at the termination;
- c) the 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 account of these individual factors, recognizing the particular criteria. However, deterioration will frequently result from a combination of factors giving a cumulative effect which shall be recognized by the competent person, and which will reflect on the decision to discard the rope or to allow it to remain in service.

In all cases, the examiner should investigate whether the deterioration has been caused by a defect in the appliance; if so, he should recommend action to overcome the defect before fitting a new rope.

3.5.1 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 occur principally at the external surface. This does not apply to wire ropes having a number of layers of strands (typically multi-strand constructions), where the majority of breaks occur internally and are therefore "non-visible" fractures.

Tables 1 and 2 take these factors into consideration when considered in conjunction with the factors given in 3.5.2 to 3.5.11.

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 to the number of visible broken wires which shall give rise to 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 – Guidance for the number of broken wires in round strand ropes working in steel sheaves

Number of load-bearing wires in outer strands ¹⁾	Typical examples of rope constructions ²⁾	Number of visible broken wires ³⁾ related to the fatigue of the rope in a crane which gives rise to rejection							
		Classification groups for M1, M2, M3 and M4 mechanisms				Classification groups for M5, M6, M7 and M8 mechanisms			
		Ordinary over a length ⁴⁾ of		Langs over a length ⁴⁾ of		Ordinary over a length ⁴⁾ of		Langs over a length ⁴⁾ of	
n		$6d$	$30d$	$6d$	$30d$	$6d$	$30d$	$6d$	$30d$
$n < 50$	$6 \times 7 (6/1)$	2	4	1	2	4	8	2	4
$51 < n < 75$	$6 \times 19 (9/9/1)^*$	3	6	2	3	6	12	3	6
$76 < n < 100$		4	8	2	4	8	16	4	8
$101 < n < 120$	$8 \times 19 (9/9/1)^*$ $6 \times 19 (12/6/1)$ $6 \times 19 (12/6 + 6F/1)$ $6 \times 25FS (12/12/1)^*$	5	10	2	5	10	19	5	10
$121 < n < 140$		6	11	3	6	11	22	6	11
$141 < n < 160$	$8 \times 19 (12/6 + 6F/1)$	6	13	3	6	13	26	6	13
$161 < n < 180$	$6 \times 36 (14/7 + 7/7/1)^*$	7	14	4	7	14	29	7	14
$181 < n < 200$		8	16	4	8	16	32	8	16
$201 < n < 220$	$6 \times 41 (16/8 + 8/8/1)^*$	9	18	4	9	18	38	9	18
$221 < n < 240$	$6 \times 37 (18/12/6/1)$	10	19	5	10	19	38	10	19
$241 < n < 260$		10	21	5	10	21	42	10	21
$261 < n < 280$		11	22	6	11	22	45	11	22
$281 < n < 300$		12	24	6	12	24	48	12	24
$300 < n^2)$		$0,04n$	$0,08n$	$0,02n$	$0,04n$	$0,08n$	$0,16n$	$0,04n$	$0,08n$

1) Filler wires are not regarded as load-bearing wires and are therefore excluded from the examination. In ropes having a number of layers of strands, only the visible outer layer is considered. In ropes having a steel core, this is regarded as an internal strand and is not considered.

2) In the case of a calculation for numbers of visible broken wires, the value is rounded to a whole number. For ropes having outer wires in the external strands of larger size than the norm, the particular construction is down-graded in the table and indicated by an asterisk(*).

3) A broken wire may have two visible ends.

4) d = nominal diameter of the rope

Table 2 – Guidance for the number of broken wires in rotation-resistant ropes working in steel sheaves

Number of visible broken wires ¹⁾ related to the fatigue of the rope in a crane which gives rise to rejection			
Classification groups for M1, M2, M3 and M4 mechanisms		Classification groups for M5, M6, M7 and M8 mechanisms	
Over a length ²⁾ of		Over a length ²⁾ of	
$6d$	$30d$	$6d$	$30d$
2	4	4	8

1) A broken wire may have two visible ends.

2) d = nominal diameter of the rope

3.5.2 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 may be caused by incorrect fitting of the termination. Investigation of the cause of this deterioration shall be made, and, where possible, the termination should be remade, shortening the rope if sufficient length remains for further use.

3.5.3 Localized grouping of broken wires

Where broken wires are very close together, constituting local 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 will be prudent to discard the rope even if the number of wire breaks is smaller than the maximum number indicated in tables 1 and 2.

3.5.4 Rate of increase of broken wires

In applications where the predominant cause of rope deterioration is fatigue, the commencement of broken wires will begin after a certain period of usage, but the number of breaks will progressively increase at ever-shortening intervals.

In these cases, it is recommended that careful examination and recording of the increase of broken wires should be undertaken with a view to establishing the rate of increase of the breaks. An application of this "law" may be used in deciding the future date for rope discard.

3.5.5 Fracture of strands

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

3.5.6 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 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 multi-strand construction.

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

NOTE — New ropes may have an actual diameter greater than the nominal diameter so that the wear permissible will therefore be greater by the same amount.

Small deterioration may not be so apparent from normal examination, particularly if the rope stresses are well balanced throughout the individual strands. However, the condition may result in a high loss of rope strength, so that any suggestion of such internal deterioration shall be verified by internal examination procedures. Where such deterioration is confirmed, the wire rope shall be discarded (see annex D).

3.5.7 External wear

Abrasion of the crown wires of outer strands in the rope results from rubbing contact, under pressure, with the grooves in the pulleys and the drums. The condition is particularly evident on moving ropes at points of pulley contact when the load is being accelerated or decelerated, and shows itself as 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.

When owing 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.

3.5.8 Decreased elasticity

Under certain circumstances usually associated with the working environment, a rope may sustain a substantial decrease in elasticity and will be unsafe for further use.

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

- a) reduction of rope diameter;
- b) elongation of the rope lay length;
- c) lack of gap between individual wires and between strands, caused by the compression of the component parts against each other;
- d) the appearance of fine, brown powder within the strand gussets;
- e) 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 related purely to wear of individual wires. This condition can lead to abrupt failure under dynamic loading and is sufficient justification for immediate discard.

3.5.9 External and internal corrosion

Corrosion occurs particularly in marine and industrial polluted atmospheres, and will not only diminish the breaking strength by reducing the metallic area of the rope but will also accelerate fatigue by causing the irregular surface from which stress cracking will commence. Severe corrosion may cause decreased elasticity of the rope.

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a) External corrosion

Corrosion of the outer wires may be detected visually.

b) Internal corrosion (see annex E, plate 7)

This condition is more difficult to detect than the external corrosion which frequently accompanies it, but the following indications may be recognized :

- 1) Variation in rope diameter. In positions where the rope bends around pulleys, 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;
- 2) Loss of gap between the strands in the outer layer of the rope, frequently combined with wire breaks in the strand gussets.

If there is any suggestion of internal corrosion, the rope should be subjected to internal examination as indicated in annex D; this shall be carried out by a competent person.

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

3.5.10 Deformation

Visible distortion of the rope from its normal formation is termed "deformation" and may create a change at the deformation position which will result in an uneven stress distribution in the rope.

Distinction is made between the following main deformations of rope on the basis of their appearance (see 3.5.10.1 to 3.5.10.9) :

- a) waviness;
- b) basket or lantern distortion;
- c) strand extrusion;
- d) wire extrusion;
- e) local increase in the diameter of the rope;
- f) local decrease in the diameter of the rope;
- g) flattened portions;
- h) kinks or tightened loops;
- i) bends.

3.5.10.1 Waviness (see annex E, plate 8)

Waviness is a deformation where the longitudinal axis of the wire rope takes the shape of a helix. While not necessarily resulting in any loss of strength, such a deformation, if severe, may 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 1), the wire rope shall be discarded if

$$d_1 > \frac{4d}{3}$$

where d is the nominal diameter of the rope and d_1 is the diameter corresponding to the envelope of the deformed rope, and the length of the rope under consideration does not exceed $25d$.

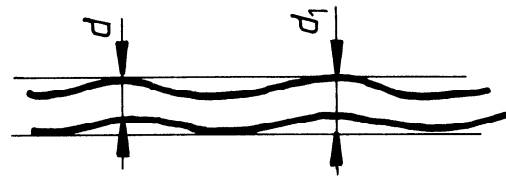


Figure 1 — Waviness

3.5.10.2 Basket or lantern distortion (see annex E, plate 9)

This condition occurs in ropes having a steel centre (or core) when the outer layer of strands has become dislocated, or when the outer layer becomes longer than the inner layer of strands. Such a condition may occur as a result of abrupt (snatch) loading of the rope from a slack condition.

A basket or lantern formation is justification for immediate discard.

3.5.10.3 Strand extrusion (see annex E, plate 10)

This feature is frequently associated with basket or lantern deformation where the rope imbalance is indicated in the extrusion of the core.

Strand extrusion is justification for immediate discard.

3.5.10.4 Wire extrusion (see annex E, plates 11 and 12)

In this condition, certain wires or groups of wires rise up, on the opposite side of the rope to the pulley groove, in the form of loops — this feature usually results from shock loading.

If the deformation is severe, there is justification for rope discard.

3.5.10.5 Local increase in diameter of rope (see annex E, plates 13 and 14)

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

A severe condition is justification for rope discard.