International Standard ISO 4309

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Wire rope for lifting appliances — Code of practice for examination and discard

Câble pour appareils de levage — Critères d'examen et de dépose des câbles

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Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

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It has been approved by the member bodies of the following countries :

Australia	Italy	South Africa, Rep. of
Austria	Japan	Spain
Belgium	Korea, Rep. of	Switzerland
Czechoslovakia	Mexico	Turkey
Finland	Netherlands	United Kingdom
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Ireland	Poland	Yugoslavia
Israel	Romania	

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0 Introduction

In a lifting appliance, 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 appliance 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 appliances 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 recognised.

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 document, which is intended for the guidance of competent persons involved in the maintenance and examination of lifting appliances.

The criteria outlined in this document are aimed at retaining, until the rope is discarded, an adequate safety margin for the handling of loads by lifting appliances. Failure to recognise these criteria is dangerous.

1 Scope and field of application

This International Standard deals with the examination and discard criteria of wire rope for use on the lifting appliances which are listed in annex G of this International Standard.[1)]

The classification groups of the mechanisms referred to in this International Standard shall be in accordance with ISO 4301.

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

Relevant definitions are given in annex E.

2 Reference

ISO 4301, *Lifting appliances — Classification*.[2)]

3 Wire rope

3.1 State before fitting

The user should ensure that the condition of the rope meets the provisions 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 appliance 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.

1) An International Standard giving terminology relating to cranes is in preparation.

2) At present at the stage of draft.

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 should ensure that all the devices associated with the wire rope operation are set and functioning correctly.

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

3.3 Maintenance

The maintenance of the wire rope should 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 appliance 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 through pulleys.

The service dressing should 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 appliance works in a corrosive environment and, in certain cases, for reasons connected with the operation, where no service dressing can be used.

3.4 Examinations

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 should 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 should be made of the following :

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

b) the type of appliance and the environmental conditions in which it operates;

c) the classification group of the appliance;

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 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 should be examined.

3.4.1.3.2 In every case where a lifting appliance has been out of operation for a period, the ropes should be examined prior to recommencement of work.

3.4.2 Points to be covered by the examination

3.4.2.1 General

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

— the points of termination at the end of both moving and stationary ropes;

— that part of a rope which passes through the block or over pulleys; particular attention should 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 on 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.

The results of the examination should be recorded in the examination log 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 should also be examined for signs of distortion or wear.

Terminations involving pressed or swaged ferrules should 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) should be examined for broken wires within and under the termination and to ensure the tightness of wedges and screwed grips. The examination should 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 should 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 must 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 wire breaks;

b) wire breaks 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 breaking of the core;

g) decreased elasticity;

h) external and internal wear;

j) external and internal corrosion;

k) deformation;

m) damage due to heat or electric arcing;

n) rate of increase of permanent elongation.

All examinations should take account of these individual factors, recognising the particular criteria. However, deterioration will frequently result from a combination of factors giving a cumulative effect which should be recognised 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 wire breaks

The overall design of a lifting appliance is such that it does not permit an indefinite rope life.

In the case of 6- and 8-strand ropes, wire breaks 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 wire breaks occur internally and are therefore "non-visible" fractures.

The following table takes these factors into consideration and is therefore valid for all contructions of rope, when considered in conjunction with the factors included in clauses 3.5.2 to 3.5.11.

Table — Number of wire breaks

Number of load-bearing wires in outer strands[1] *n*	Typical examples of rope constructions[2]	Number of visible wire breaks related to the fatigue of the rope in a lifting appliance which give rise to compulsory rejection							
		Classification groups for M1 and M2 mechanisms				Classification groups for M3, M4, M5, M6, M7 and M8 mechanisms			
		Ordinary over a length of		Langs over a length of		Ordinary over a length of		Langs over a length of	
		6 *d*	30 *d*	6 *d*	30 *d*	6 *d*	30 *d*	6 *d*	30 *d*
50 and below	6 X 7 (6/1)	2	4	1	2	4	8	2	4
From 51 to 75	6 X 19 (9/9/1)* 12 X 6/3 X 24	3	6	2	3	6	12	3	6
From 76 to 100	–	–	–	–	–	–	–	–	–
From 101 to 120	8 X 19 (9/9/1)* 6 X 19 (12/6/1) 6 X 19 (12/6 + 6F/1) 6 X 25FS (12/12/1)* 34 X 7 (17 outer strands)	5	10	2	5	10	19	5	10
From 121 to 140		6	11	3	6	11	22	6	11
From 141 to 160	8 X 19 (12/6 + 6F/1)	6	13	3	6	13	26	6	13
From 161 to 180	6 X 36 (14/7 + 7/7/1)*	7	14	4	7	14	29	7	14
From 181 to 200		8	16	4	8	16	32	8	16
From 201 to 220	6 X 41 (16/8 + 8/8/1)*	8	18	4	9	18	38	9	18
From 221 to 240	6 X 37 (18/12/6/1)	10	19	5	10	19	38	10	19
From 241 to 260		10	21	5	10	21	42	10	21
From 261 to 280		11	22	6	11	22	45	11	22
From 281 to 300		12	24	6	12	24	48	12	24
Above 300[2]		0,04 *n*	0,08 *n*	0,02 *n*	0,04 *n*	0,08 *n*	0,16 *n*	0,04 *n*	0,08 *n*

d = the diameter of the rope.

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, the latter is regarded as an internal strand and is not considered.

2) In the case of a calculation for numbers of visible breaks in wire, 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 (*).

3.5.2 Wire breaks at the termination

Wire breaks 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 should 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 wire breaks

Where wire breaks are very close together, constituting local grouping of such breaks, the rope should be discarded. If the grouping of such breaks occurs in a length less than 6 *d* 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 the table.

3.5.4 Rate of increase of wire breaks

In applications where the predominant cause of rope deterioration is fatigue, the commencement of wire breaks 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 wire breaks should be undertaken with a view to establishing the rate of increase of wire breaks. An appreciation 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 should be discarded.

3.5.6 Reduction of rope diameter resulting from deterioration of the core

Where deterioration of a fibre core, or fracture of a steel core (or internal layers in a multi-strand construction) causes a noticeable reduction in rope diameter, the rope should be discarded.

Small deterioration may not be so apparent from normal examinations, 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 should be verified by internal examination procedures. Where such deterioration is confirmed, the wire rope should be discarded (see annex D).

3.5.7 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.

3.5.8 External and internal wear

Wear is produced in two ways :

a) Internal wear and indentation

This condition is caused by friction between individual strands and wires in the rope, particularly when it is subject to bending.

b) 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 the diameter of the rope has diminished by a value of 7 % or more compared to the nominal rope diameter, the rope should be discarded even if no wire breaks are visible.

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.

a) External corrosion

Corrosion of the outer wires may be detected visually.

b) Internal corrosion

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

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 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 subject to internal examination as indicated in annex D, which should be carried out by a competent person.

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

3.5.10 Deformation

Visual 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 distortion;

c) strand extrusion;

d) wire extrusion;

e) local increase in the diameter of rope;

f) local decrease in the diameter of rope;

g) flattened portions;

h) kinks;

j) bends.

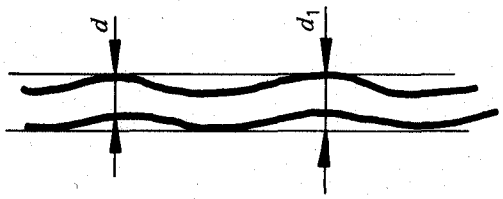
3.5.10.1 Waviness (see annex F, plate 8)

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, the wire rope should be discarded if

$$d_1 \geqslant \frac{4\,d}{3}$$

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 25 d.



3.5.10.2 Basket distortion (see annex F, 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 formation is justification for immediate discard.

3.5.10.3 Strand extrusion (see annex F, plate 10)

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

Strand extrusion is justification for immediate discard.

3.5.10.4 Wire extrusion (see annex F, 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—again, 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 F, 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 unbalance in the outer strands, which become incorrectly orientated.

A severe condition may be justification for rope discard.

3.5.10.6 Local decrease in diameter of rope (see annex F, plate 17)

A local decrease in the diameter of the rope is frequently associated with fracture of a core. Positions close to terminations should be carefully examined for such deformations.

A severe condition may be justification for rope discard.

3.5.10.7 Flattened portions (see annex F, plates 18 and 19)

Flattened portions occur as a result of mechanical damage; if severe, they are justification for rope discard.

3.5.10.8 Kinks (see annex F, plates 15 and 16)

A kink is a deformation created by a loop in the rope which has been tightened without allowing for rotation about its axis. Unbalance 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.

A kink is justification for immediate discard.

3.5.10.9 Bends (see annex F, plate 20)

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

The condition is justification for immediate discard.

3.5.11 Damage due to heat or electric arcing

Wire ropes which have been subjected to exceptional thermal effects, externally recognised by the colours produced, should be 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 lifting appliance. Such information is useful in regulating maintenance procedures and also stock control of replacement rope. If such forecasting is used, it should 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 the rope

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

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

The radius at the bottom of the groove in all pulleys should be appropriate to the nominal diameter of the cable. If the radius has become too great or too small, the groove should be remachined or the pulley replaced.

6 Rope examination log

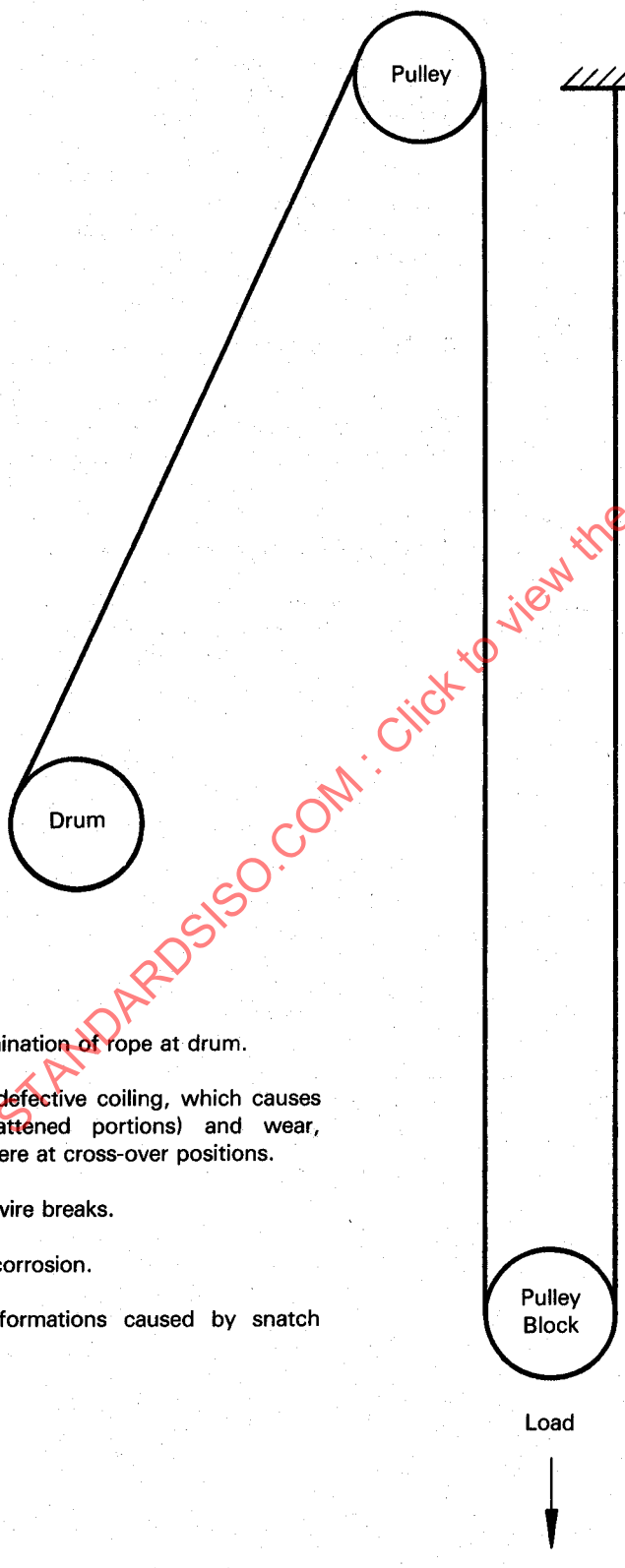
For each periodic examination users should provide a log in which should be recorded the information from each examination of the rope; see annex B for typical example of log.

7 Rope storage and identification

Clean and dry storage shall be provided to prevent deterioration of ropes not in use and means provided to enable ropes to be clearly identified with their examination logs.

Annex A

Diagrammatic illustration of possible defects to be considered during the examination, with reference to different areas



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 pulley 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 pulleys.

8) Look for deformation.

9) Check rope diameter.

10) Examine carefully length which runs through pulley block, particularly that length which lies on the pulley when the appliance is in a loaded condition.

11) Examine for wire breaks or surface wear.

12) Examine for corrosion.

Annex B

Typical example of examination log

Data-sheet for cable	Machine : Application :
Construction : Direction of rope lay : RH/LH Type of Lay : Ordinary/Langs Nominal diameter : Tensile grade : Quality : ungalvanized/galvanized Type of core : steel/fibre/synthetic Preformation : Length of rope : Type of termination :	Date fitted : Date discarded : Minimum breaking load : Working load : Diameter measured : Under a load of :

Visible wire breaks	**Abrasion of outer wires**	**Corrosion**	**Reduction of rope diameter**	**Positions measured**	**Overall assessment**	**Damage and deformations**
Number in length of 6 *d*	Degree of deterioration*	Degree of deterioration*	%		Degree of deterioration*	Nature

Date : Signature :

Rope supplier :	Number of working hours :
Other observations :	Reason for discard :

* In the column marked "degree of deterioration", describe the latter as : slight, medium, high, very high, discard.

Annex C

Frequency of examination of rope

C.1 Scope

This annex recommends the guidelines for frequency of examination.

C.2 Daily observations

As far as possible, and where visible, any wire rope should be observed each working day with the object of detecting general deterioration and deformation. Particular attention should be paid to the wire rope at points of attachment to the appliance.

C.3 Periodic examination

In order to determine the frequency of such examination, consideration is given to the following :

a) the statutory requirements covering the appliance in the country of use;

b) the type of appliance and the environmental conditions in which it operates;

c) the classification group of the appliance;

d) the results of previous examinations.

In all cases, an examination shall take place after any incident, and every time the rope is brought back into operation after a dismantling operation followed by a re-assembly.

C.3.1 General construction-site appliances

Mobile cranes and tower cranes : make provision for a minimum of one examination per week.

C.3.2 Appliances on which the ropes are expected to have an extended performance

In the case of these appliances, the periodic examination should take place at least once every month.

NOTE — When defects occur, it is prudent to reduce the time-interval between examinations.

Annex D

Internal examination of wire rope

D.0 Introduction

Experience of 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. A normal external examination may 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.

D.1 Scope

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

D.2 Method

The method consists in attaching firmly to the rope two clamping jaws of suitable size and distance apart.

By applying a force to the clamping jaws in the opposite direction to the rope lay, the outer strands separate and move away from the core.

Care is to 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 wire rope only opens slightly, 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.

The essential points which should be observed are :

a) the state of the internal lubrication;

b) the degree of corrosion;

c) indentation of wires caused by pressure or wear;

d) presence of wire breaks (these are not necessarily easily visible).

After examination, introduce 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. After removal of the jaws, the outer surface of the rope will normally be greased.

D.3 Rope portions adjacent to the termination

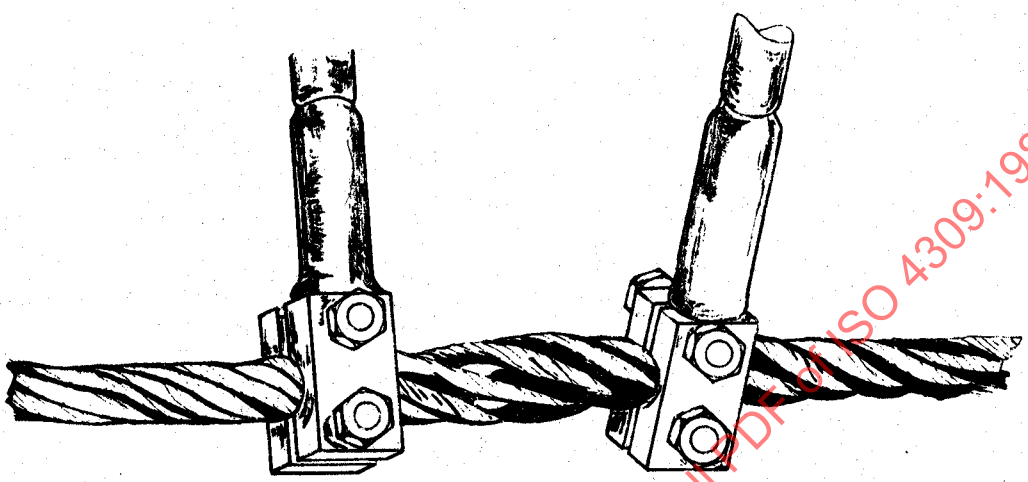
In examining these portions of rope, it is sufficient to use a single clamping jaw, since the end anchorage system, or a bar suitably located through the end portion of the termination, will ensure the necessary immobilization of the second end.

D.4 Portions which should be examined

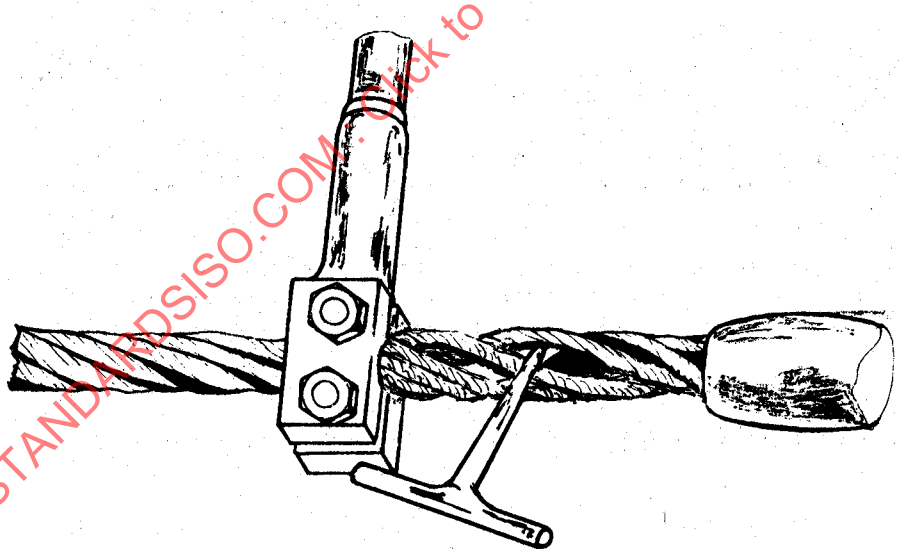
Since it is impossible to examine the interior of the wire rope over the whole of its length, suitable sections must be selected.

In the case of wire ropes which wind onto a drum, or pass over pulleys or rollers, it is recommended that the lengths which engage the pulley grooves when the appliance is in a loaded condition should be examined. Those localized areas in which shock forces are arrested (i.e. adjacent to drum and jib head pulleys) 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, and this is particularly important in the case of fixed ropes, such as stays or pendants.



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



Internal examination at the end of a rope, close to the terminal fitting (zero tension)

Annex E

Definitions

For the purpose of this International Standard, the following definitions apply :

E.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.

E.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.

E.3 **rope examination log** : A record which is held by the user of the lifting appliance and of which a typical example is shown in annex B.

E.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.

E.5 **gusset** : That area between individual outer strands. Wire breaks in the gusset positions may be indicative of lack of strand gap.

E.6 **laps of rope on a drum** : The 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.)

E.7 **Langs lay** : Rope in which the direction of lay of the outer layer of wires in the strands is the same as the direction of lay of the strands in the rope.

E.8 **lay length** : The length of helix made by an individual strand.

E.9 **multi-strand rope** : A 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.

E.10 **ordinary (or 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.

E.11 **reel** : The transit package on which the rope is coiled. It may be of wooden or steel construction, depending on the mass of rope involved.

E.12 **rope diameter** : The diameter of the circle which circumscribes the rope at any time during its life.

E.13 **rope nominal diameter** : The value, in millimetres, by which the diameter of a new rope is designated.

Annex F

Typical examples of defects that may occur in wire rope

(For emphasis many illustrations show exaggerated deterioration, and the ropes depicted should have been discarded at an earlier stage.)

Plate 1 — Wire breaks and wire displacement over two adjacent strands in an ordinary lay rope — *justification for discard*

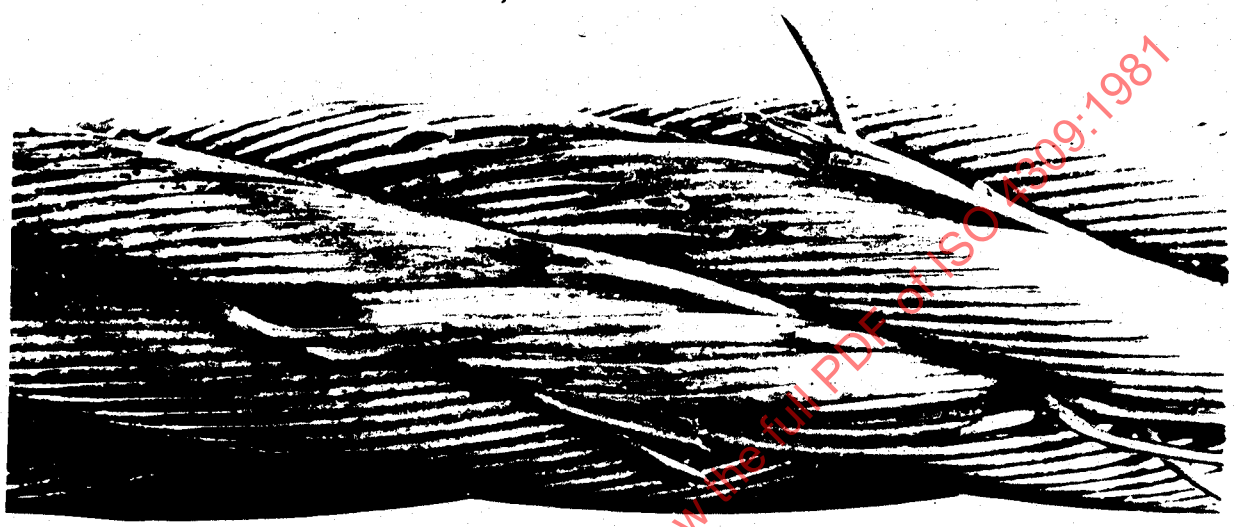


Plate 2 — A large number of wire breaks, associated with heavy wear in an ordinary lay rope — *justification for immediate discard*

Plate 3 — Wire breaks in one strand, associated with slight wear in a Langs lay rope — justification for further operation if this condition represents the worst condition (fractured wires should be broken out so that the end is at the strand gusset; this prevents further damage to the adjacent wires)

Plate 4 — Examples of the progression of wear and external corrosion in an ordinary lay rope

Wear		External corrosion	
	Slight flats on outer wires. Little reduction in rope diameter.	Beginning of surface oxidation	
	Increased length of flats on individual outer wires	Wires rough to touch. General surface oxidation.	
	Flats on individual wires longer, affecting all crown wires in each strand. Marked reduction in rope size (Other criteria should be noted carefully.)	Oxidation now more marked.	
	Flats on individual wires now almost continuous — strands appear slightly flattened and wires are noticeably thin (Could be justification for discard. Other criteria should be noted carefully; if the rope remains in service, the frequency of examination should be increased.)	Surface of wire now greatly affected by oxidation.	
	Flats touch each other, wires becoming slack with an estimated reduction in size of 40 % (*Discard immediately.*)	Surface heavily pitted and wire quite slack (*Discard immediately.*)	

Plate 5 — Wire breaks in several strands, local to a compensating pulley (and sometimes hidden by this pulley) — *justification for discard*

Plate 6 — Wire breaks in two strands, local to a compensating pulley and associated with local severe wear, caused by the jamming of the pulley — *justification for discard*

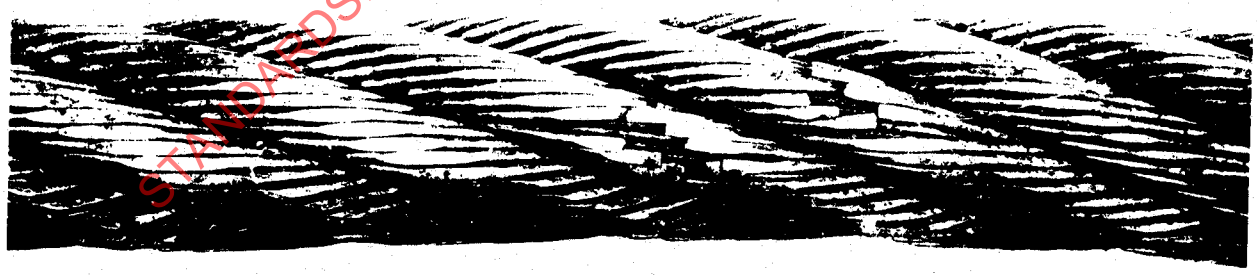


Plate 7 — An example of severe internal corrosion

The reduction of area of many outer wires in the strands where they are in contact with the core, the high degree of compression and loss of strand gap are all evident —*justification for immediate discard*

Plate 8 — Waviness : a deformation where the longitudinal axis of the rope takes the shape of a helix

If the deformation exceeds the value indicated in 3.5.10.1, the rope should be discarded

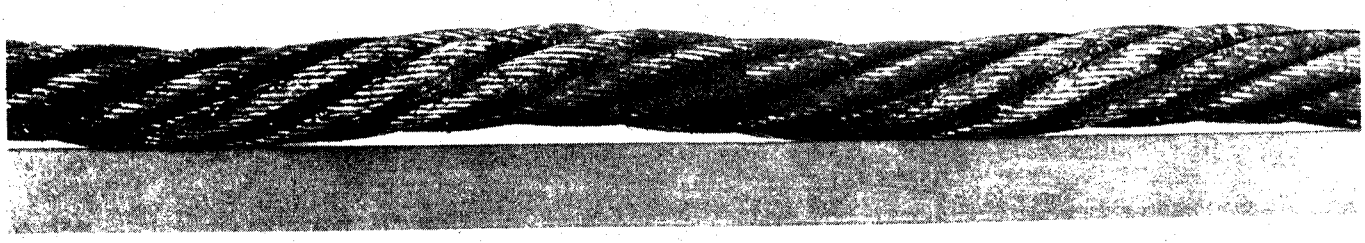


Plate 9 — Basket (bird cage) deformation of a multi-strand construction — *justification for immediate discard*

Plate 10 — Extrusion of a steel core, generally associated with a basket deformation in adjacent position — *justification for immediate discard*

Plate 11 — One strand only affected by wire extrusion, although examination over a length of rope shows that deformation is visible at regular intervals, normally of one lay length

Plate 12 — Aggravation of the previous fault to a degree of severity *justifying immediate discard of the rope*
(typical of a hoist rope on a piling machine)

Plate 13 — Local increase in diameter of a Langs lay wire rope caused by distortion of the steel core resulting from shock loading — *justification for immediate discard*