INTERNATIONAL STANDARD

ISO 4308-1

Third edition
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Cranes and lifting appliances — Selection of wire ropes —

Part 1: **General**

Grues et appareils de levage — Choix des câbles —

Partie 1: Généralités

Reference number
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PDF disclaimer

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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.

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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 4308-1 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 4308-1:1986), which has been technically revised.

ISO 4308 consists of the following parts, under the general title *Cranes and lifting appliances — Selection of wire ropes*:

— *Part 1: General*

— *Part 2: Mobile cranes — Coefficient of utilization*

Cranes and lifting appliances — Selection of wire ropes —

Part 1:
General

1 Scope

This part of ISO 4308 specifies two methods for the selection of wire rope to be used on lifting appliances as designated in ISO 4306-1, one based on the value of the rope selection factor C and the other based on the value of the coefficient of utilization Z_p

This part of ISO 4308 establishes the minimum requirements for acceptable strength and performance levels of wire ropes with respect to the design, application and maintenance of the lifting appliance.

This part of ISO 4308-1 establishes the minimum requirements for the diameters of drums and sheaves that are to be associated with the selected wire rope.

A non-exhaustive list of types of lifting appliance to which this part of ISO 4308 is applicable is given in Annex A.

Annex B provides some examples of rope selection.

Annex C gives factors, additional to those mentioned above, which may need consideration when selecting the wire rope.

Annex D specifies the selection method for the diameter of the compensating sheave when used in relation to hoists.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 2408:1985, *Steel wire ropes for general purposes — Characteristics*

ISO 4301-1:1986, *Cranes and lifting appliances — Classification — Part 1: General*

ISO 4306-1:1990, *Cranes — Vocabulary — Part 1: General*

ISO 4309, *Cranes — Wire ropes — Care, maintenance (including installation), inspection*

3 Terms and definitions

For the purposes of this part of ISO 4308, the following terms and definitions apply.

3.1
parallel-closed rope
stranded rope consisting of at least two layers of strand laid helically in one closing operation around a strand or fibre centre

3.2
rotation-resistant rope
multi-strand rope
non-rotating 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.

3.3
single-layer rope
stranded rope consisting of one layer of strands laid helically around a core

3.4
stranded rope
assembly of several strands, laid helically in one or more layers around a core (single-layer rope) or centre (rotation-resistant or parallel-closed rope)

NOTE Single-layer ropes consisting of three and four strands may or may not have a core.

4 Type of rope

Where possible, the wire rope selected shall be in accordance with ISO 2408.

Selection of wire rope not specified by ISO 2408 is permitted, but in such cases the supplier of the wire rope shall show, to the user, documentation which is supported by the rope-maker’s technical file for the product, that clearly demonstrates that the product has acceptable strength and performance levels with respect to the design of mechanisms, application and maintenance of the appliance.

5 Duty conditions

The mechanisms of lifting appliances shall be classified according to the duty conditions laid down in ISO 4301-1.

6 Selection procedure

6.1 Calculation of C values

The value of the rope selection factor, C, is a function of the coefficient of utilization, Z_p, and is given by Equation (1):

$$C = \sqrt{\frac{Z_p}{K' \cdot R_o}} \quad (1)$$

where

C is the rope selection factor (minimum);

K' is the empirical factor for minimum breaking load of a given rope construction (see Table 3 of ISO 2408:1985 or as otherwise provided by the rope supplier);

R_o is the minimum tensile strength of the wire used in the rope, in newtons per square millimetre[1)];

Z_p is the minimum practical coefficient of utilization.

6.2 Z_p values

Table 1 gives the values of Z_p which shall be used for each classification group of mechanism in order to meet the minimum requirements of this part of ISO 4308. It also gives the calculated values of C corresponding to the rope type (6 × 36 WS - IWRC) with R_o = 1 770 N/mm^2 and with an empirical factor K' = 0,356.

Table 1 — Z_p values and C values (for R_o = 1 770 N/mm^2 and K' = 0,356)

Classification of mechanism	Z_p value	C value
M1	3,15	0,071
M2	3,35	0,073
M3	3,55	0,075
M4	4,0	0,080
M5	4,5	0,085
M6	5,6	0,094
M7	7,1	0,106
M8	9,0	0,120

NOTE Whilst Equation (1) shows the exact relationship between C and Z_p, the values shown in Table 1 have been corrected by rounding to three decimal places.

For ropes having a tensile strength R_o and an empirical factor K' different from those shown above, different values of C may be calculated using Equation (1) and substituted in Equation (2) indicated in 6.3.

1) 1 N/mm^2 = 10^6 N/m^2 = 1 MPa

6.3 Calculation of minimum rope diameter

The minimum diameter of the rope, d_{min}, in millimetres, is given by Equation (2):

$$d_{\text{min}} = C\sqrt{S} \quad (2)$$

where

d_{min} is the calculated minimum diameter of the rope, and is the value used in the selection process for calculating the drum and sheave diameters;

C is the rope selection factor;

S is the maximum rope tension, in newtons, obtained by taking into account the following factors:

- rated working load of the appliance;
- mass of the pulley block and/or other lifting attachments;
- mechanical advantage of reeving;
- efficiency of the rope reeving;
- the increase in force in the rope caused by the rope inclination at the upper extreme position of the hook, if the rope inclination with respect to the drum axis exceeds 22,5°.

The nominal diameter of the rope selected (d) shall be within the range: d_{min} to $d_{\text{min}} \times 1{,}25$.

6.4 Calculation of minimum breaking force

The minimum breaking force, F_{min}, in newtons, of the particular rope intended for use is given by Equation (3):

$$F_{\text{min}} = S \cdot Z_{\text{p}} \quad (3)$$

where

S is the maximum rope tension, in newtons, as established in 6.3;

Z_{p} is the minimum practical coefficient of utilization.

Examples of rope selection are given in Annex B.

7 Diameter of rope drums and sheaves

The minimum pitch circle diameter of the rope drums and rope sheaves shall be calculated using the minimum rope diameter established in 6.3 and by applying the respective values of h_1, h_2 as shown in Table 2 and the rope type factor t, as shown in Table 3, as applicable, and which relates to the classification of the mechanism, in Equations (4) and (5):

$$D_1 \geqslant h_1 \cdot t \cdot d_{\mathrm{min}} \tag{4}$$

or

$$D_2 \geqslant h_2 \cdot t \cdot d_{\mathrm{min}} \tag{5}$$

where

D_1 is the minimum pitch circle diameter of the drum;

D_2 is the minimum pitch circle diameter of the sheave;

d_{min} is the minimum diameter of the rope, calculated in accordance with 6.3;

h_1 is the selection factor for the drum (ratio of the pitch circle diameter of the drum to the calculated diameter of the rope);

h_2 is the selection factor for the sheave (ratio of the pitch circle diameter of the sheave to the calculated diameter of the rope);

t is the rope type factor in accordance with Table 3. The rope type factor takes into account the different bending fatigue performance of different types of rope.

Table 2 — Selection factors h_1 and h_2

Classification of mechanism	Drums h_1	Sheaves h_2
M1	11,2	12,5
M2	12,5	14,0
M3	14,0	16,0
M4	16,0	18,0
M5	18,0	20,0
M6	20,0	22,4
M7	22,4	25,0
M8	25,0	28,0

For hoists, the minimum pitch circle diameter of any compensating sheave shall be calculated in accordance with Annex D.

Table 3 — Rope type factor t for various rope types

Number of outer strands in the rope	Rope type factor t
3 to 5	1,25
6 to 10	1,00
8 to 10 plastic impregnation	0,95
10 and greater RR[a]	1,00

[a] Rotation-resistant rope

8 Stationary ropes

Stationary ropes are fixed at both ends and are not subject to coiling on a drum or over a sheave. Their selection is made in accordance with 6.4, with Z_p values modified as in Table 4, where the maximum rope tension, S, shall be established by the manufacturer of the mechanism who shall take account of both the static forces.

Table 4 — Z_p values for stationary ropes

Classification of mechanism	Z_p value
M1	2,5
M2	2,5
M3	3,0
M4	3,5
M5	4,0
M6	4,5
M7	5,0
M8	5,0

9 Dangerous conditions

For dangerous conditions, for example the handling of molten metal,

a) no classification group lower than M5 shall be used,

b) the Z_p value shall be increased by 25 % up to a maximum of 9,0 or, alternatively, the C value for the next higher classification group shall be adopted when selecting the rope.

10 Care, maintenance, examination and discard

The selection of the ropes, drums and sheaves according to this part of ISO 4308 does not alone ensure safe operation of the rope for indefinite periods.

The instructions on care, maintenance (including installation), examination and discard for wire ropes given in ISO 4309 shall be adopted.

Annex A
(normative)

Lifting appliances to which this part of ISO 4308 is applicable

This part of ISO 4308 is applicable to the following non-exhaustive list (extracted from ISO 4306-1) of cranes and lifting appliances:

a) overhead travelling cranes;

b) hoists-wire rope;

c) portal or semi-portal cranes;

d) portal or semi-portal bridge cranes;

e) cable and portal cable cranes (hoist and trolley mechanisms only);

f) mobile cranes;

g) tower cranes;

h) railway cranes;

i) floating cranes;

j) deck cranes;

k) derrick and guy derrick cranes;

l) derrick cranes with rigid bracing;

m) cantilever cranes (pillar, jib, wall or walking).

The cranes can be used for hook, grabbing, magnet, ladle, bucket or stacking duties, and can be operated manually, electrically or hydraulically.

Annex B
(informative)

Examples of wire rope selection

B.1 Example 1

A lifting appliance is intended to operate under duty conditions defined in the classification of mechanisms as M4. The maximum rope tension has been established as 79 kN.

The type and grade of the rope to be selected has a K' value of 0,356 and R_o value of 1 770 N/mm^2. From Table 1, the C value is 0,080.

From 6.3 using Equation (2):

d_{min} = 0,080 × (79 000)$^{1/2}$

= 22,486 mm

For practical purposes, the minimum diameter of the rope selected is not to be less than 22,5 mm or greater than 28,1 mm.

From 6.4 using Equation (3):

Minimum breaking force F_{min} = 79 × 4 = 316 kN

For practical purposes, the minimum breaking force of the rope selected shall not be less than 316 kN.

B.2 Example 2

The parameters required are similar to those indicated in Example 1, but on this occasion the constructor of the appliance wishes to employ a smaller rope size to reduce equipment mass, and therefore selects a rope type and grade having a K' value of 0,497 and R_o value of 1 960 N/mm^2.

From 6.1 using Equation (1):

C = [4/(0,497 × 1 960)]$^{1/2}$

= 0,064 1

corrected to 0,065 (Renard number from R40 series)

d_{min} = 0,065 × (79 000)$^{1/2}$

= 18,270 mm

For practical purposes, the nominal diameter of the rope selected shall not be less than 19 mm or greater than 22 mm.

From 6.4, using Equation (3) as in Example 1:

Minimum breaking force F_{min} = 79 × 4 = 316 kN

Annex C
(informative)

Other selection aspects

C.1 General

In addition to the selection procedure (Clause 6) and the determination of the diameter of rope drums and sheaves (Clause 7), other factors may need consideration when selecting the rope class, construction and type. The final rope selection may have an influence on the design of the mechanism.

C.2 Types of drum and rope selection

C.2.1 Types of drum

C.2.1.1 General

Drums may be either smooth or grooved.

For maximum rope life, the drum should hold the rope in a single layer. In cases where this is not possible, due to space restrictions, two or more layers are required to accommodate all of the rope.

A grooved drum provides better rope coiling performance and less rope wear than a smooth drum where multi-layer coiling has to be used.

When multi-layer coiling must be used, it should be realized that after the first layer is coiled onto a drum, the rope has to cross the underlying rope in order to advance across the drum in the second layer. The points at which the turns in the upper layer cross those in the lower layer are known as the cross-over points, and the rope in those areas is susceptible to increased abrasion and crushing.

The drum flanges should project above the last layer of rope by a minimum of 1,5 times the rope diameter.

The direction of coiling of the rope on the drum is important. It should be related to the direction of lay of the rope (see Figure C.1) and applies to both smooth and grooved surfaces.

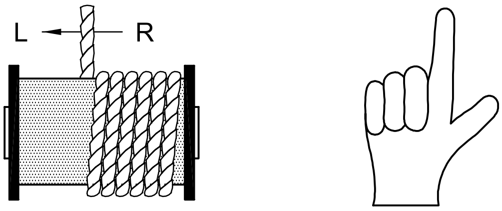
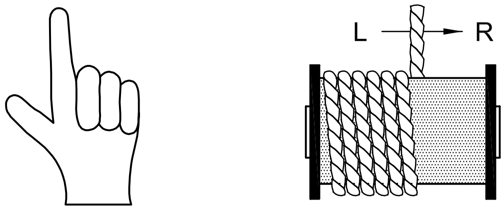
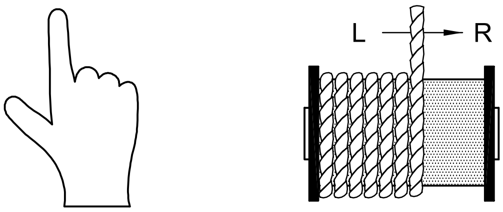
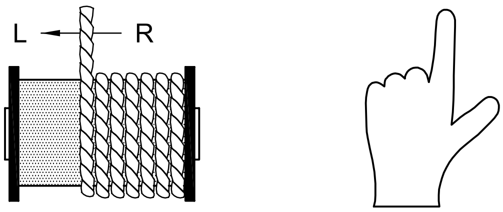
 Start rope at right-hand flange for right-hand-lay rope	**a) Right-hand-lay rope – underwind**
 Start rope at left-hand flange for left-hand-lay rope	**b) Left-hand-lay rope – underwind**
 Start rope at left-hand flange for right-hand-lay rope	**c) Right-hand-lay rope – overwind**
 Start rope at right-hand flange for left-hand-lay rope	**d) Left-hand-lay rope – overwind**
NOTE Thumb indicates the side of the rope anchorage.	

Figure C.1 — Correct method for locating the rope anchorage point on a drum

C.2.1.2 Smooth drums

Coiling of a wire rope on a smooth drum requires a great deal of care.

Any looseness or uneven coiling will result in excessive wear, crushing and distortion of the rope.

C.2.1.3 Grooved drums

With grooved drums, the bottom layer of rope will coil correctly and the grooves will give a degree of support to the rope, thereby reducing the unit contact pressure.

There are two forms of groove:

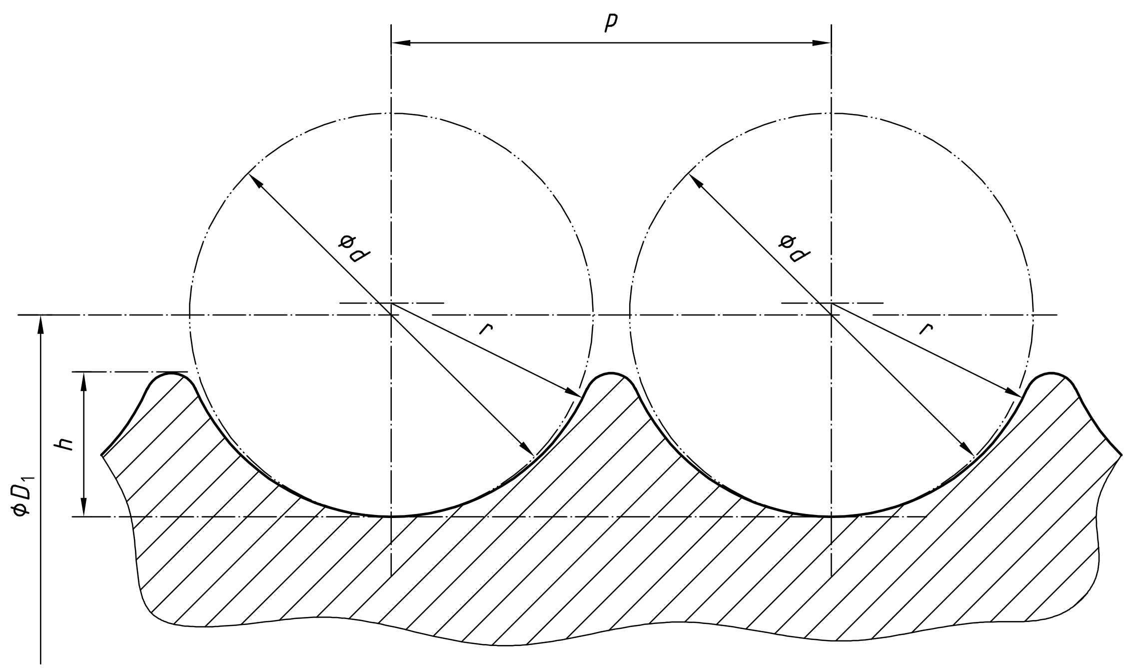
a) spiral groove, machined in a continuous spiral around the barrel, which ensures satisfactory coiling of the first layer of rope;

b) parallel groove, machined parallel to the drum flanges.

   A section of the drum barrel periphery is either plain or spiral-grooved to facilitate transfer of the rope from one parallel groove to the next. This form of grooving is used with multi-layer coiling to reduce rope damage at crossover points.

The relationship between the rope diameter and the diameter of the drum, pitch of the drum groove and type of groove system is important.

The contour at the bottom of the grooves should be circular, and it is recommended that the groove radius, r, should lie within the range 0,525 d to 0,550 d, with 0,537 5 d as the optimum (see Figure C.2).



d Nominal diameter of the rope

h Depth of the groove

p Pitch of the groove

r Radius of the groove

D_1 Pitch circle diameter of the rope drum

Figure C.2 — Drum groove design

C.2.2 Coiling aids

When using smooth drums or drums with parallel grooves and plain cross-over sections, rope wedges or starter strips may be used to guide the rope across the barrel into its correct position for coiling at the commencement of the second lap.

Similarly, side plates can be used to ensure satisfactory coiling of the second and subsequent layers.

If the use of any coiling aid is being considered, then the rope and/or drum manufacturers should be consulted.

C.2.3 Selection of rope

A rope with fibre core should generally be restricted for use on a drum with single layer coiling. Where multi-layer coiling is required, a rope with steel core is recommended.

Wire ropes with steel cores are less likely to distort than those with fibre cores, when used in multi-layer coiling.

Ropes manufactured with compacted outer strands have an even greater resistance to crushing and distortion.

Rope with plastic impregnation can be employed to restrict distortions and reduce the ingress of moisture resulting from environmental conditions.

The diameter of the rope selected should correctly relate to the drum groove dimensions, particularly the groove pitch.

C.3 Sheaves, rollers and rope selection

C.3.1 General

Sheaves are employed when it is necessary to change the direction of a rope within a machine or system. Sheaves should be free-running and designed to afford adequate support to the rope, avoiding excessive bending stresses, radial pressures and inertias. If reverse bending is employed, a time lapse (at least 0,25 s) is recommended to allow the rope to recover from one bend before coiling into the reverse bend.

Sheaves and rollers can have their groove surfaces damaged prematurely if ropes are selected which cause the design criteria of the materials involved to be exceeded.

Traditional sheaves are manufactured from ferrous materials, but the use of plastic sheaves and sheaves with plastic inserts is increasing. For many uses, plastic sheaves and inserts increase rope life, but the mode of deterioration of the rope can change. If there are no practical means for recognizing the mode of deterioration of the rope, it is recommended that at least one ferrous sheave be included in the reeving arrangement.

C.3.2 Sheave groove profile

For optimum rope life, the sheave groove profile should be correctly matched to the rope diameter.

If the groove is too small, the rope will be “pinched” as it is forced into the groove under the influence of load, thus damaging both the rope and sheave.

If the groove is too large, there could be insufficient support for the rope, which can become flattened and distorted under load, thus accelerating rope deterioration.

The groove radius, r , should lie within the range 0,525 d to 0,550 d, with 0,537 5 d as the optimum, where d is the nominal rope diameter.

Sheaves should have a smoothly finished groove, free from ridges, of depth not less than 1,5 times the nominal diameter of the rope. The profile at the bottom of the groove should be circular. The angle between the sides of the sheave, ω, (see Figure C.3) should be between 30° and 60° but should be greater if the fleet angle exceeds the values recommended in C.4.

NOTE For mobile cranes, the final sentence of this subclause might not apply, particularly in respect of the rope reeving through telescopic sheave assemblies.

C.3.3 Rope rollers

Rope rollers can be installed at appropriate intervals where it is necessary to support the rope over a long catenary to prevent contact with the machine structure. Rollers are not generally intended for deflecting or changing the direction of the rope, because their relatively small diameter can subject the rope to unacceptably high compressive and bending stresses, and can induce turn into the rope.

Surface embrittlement of rope can result from the use of steel sheaves and rollers over which a rope bends at high speed or high rates of velocity change and particularly where small-angle deflections occur. Consideration should be given to non-metallic materials.

Ropes having eight or more outer strands can provide improved performance compared with six strand ropes.

C.3.4 Selection of rope

If the classification of the mechanism for the duty is less than M4, the size of the outer wire of the outer strands should not be less than 0,05 × nominal rope diameter. The strand construction of ropes of less than 8 mm nominal diameter should be selected with particular care, to ensure that the wire sizes are appropriate to the duty.

If the classification of the mechanism for the duty equals or exceeds M4, the rope type selected should generally have optimum bend-fatigue characteristics.

If it is not possible to select a rope type having adequate bend-fatigue performance, consideration should be given to increasing the sheave selection factor (h_2) beyond that specified in Table 2.

See also C.4.

C.4 Fleet angle and rope selection

Figure C.4 a) shows a wide drum with a pitch angle α and a deflection sheave. If the rope is coiling towards the flanges of the drum, it will be deflected at the sheave by a fleet angle β_{left} or β_{right}. On the drum, it will be deflected by an angle ($\beta_{left} + \alpha$) or ($\beta_{right} - \alpha$).

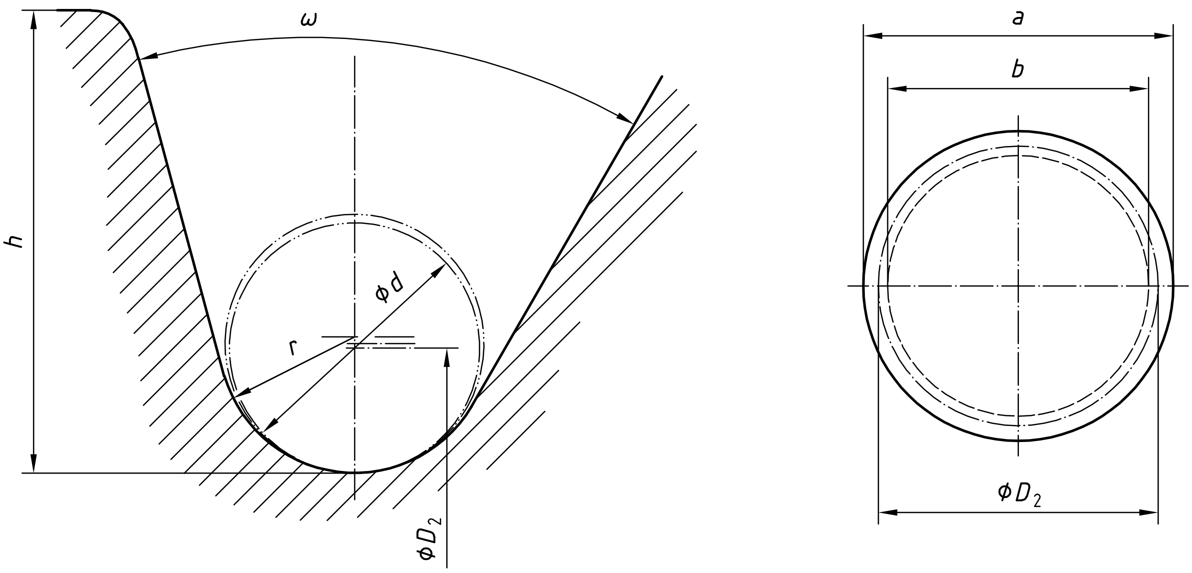
Rope which is coiling on and off a drum or running over sheaves under a fleet angle will be twisted by rolling down into the bottom of the drum or sheave groove along the flange (see Figure C.5). This action changes the lay length of the rope and results in poor fatigue performance of the rope and poor coiling. In the worst case, it leads to structural damage such as “birdcages”. The fleet angles in the reeving system therefore need to be kept to a minimum.

The fleet angles in the reeving system should be no greater than 4° for all ropes, and no greater than 2° for rotation-resistant rope. Fleet angles can be reduced by, for example:

a) decreasing the drum width and/or increasing the drum diameter (see Figure C.5);

b) increasing the distances between sheaves and drums.

When a rope is coiling in multiple layers on the drum, the fleet angle at the flanges should be greater than 0.5° to avoid rope pile-up.



a Overall diameter of the sheave

b Tread diameter of the sheave

h Depth of the sheave groove

ω Angle between sides of the sheave

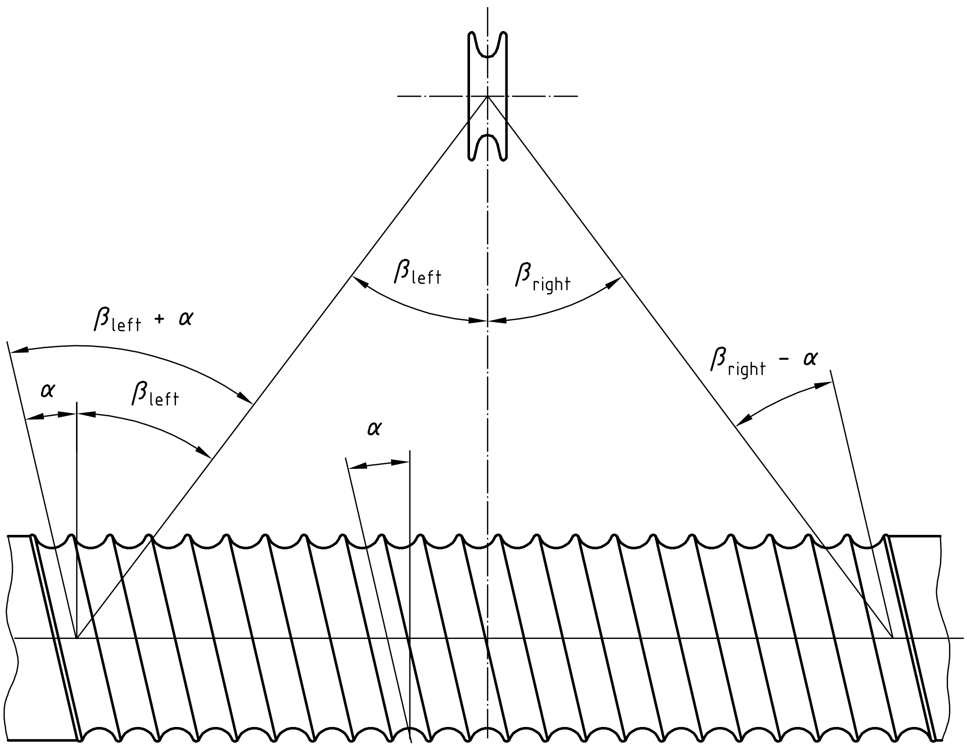
d Nominal diameter of the rope

r Radius of the groove in the sheave

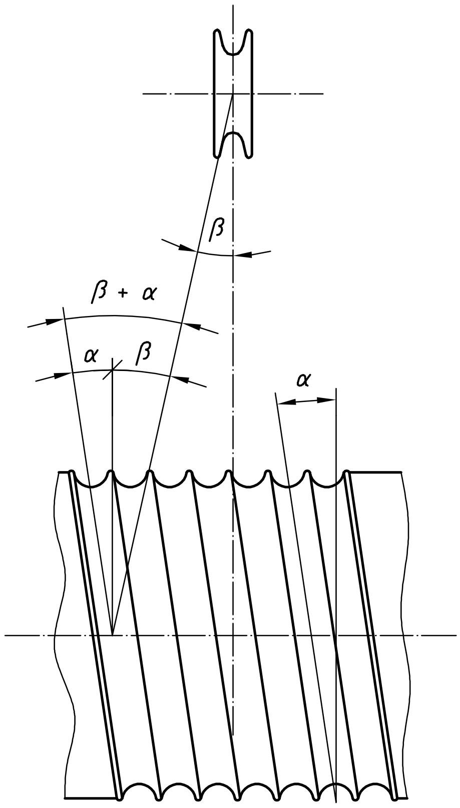
D_2 Pitch circle diameter of the rope sheave

NOTE This drawing shows the support provided in the sheave groove for wire rope, for different dimensions of the sheave and rope. It is not suggested that a sheave should be designed with differing angles between the sheave flanges.

Figure C.3 — Sheave groove



a) Fleet and groove angles



b) Reduction in fleet angle achieved by increasing the diameter of the drum and reducing the drum width

Figure C.4 — Fleet angle

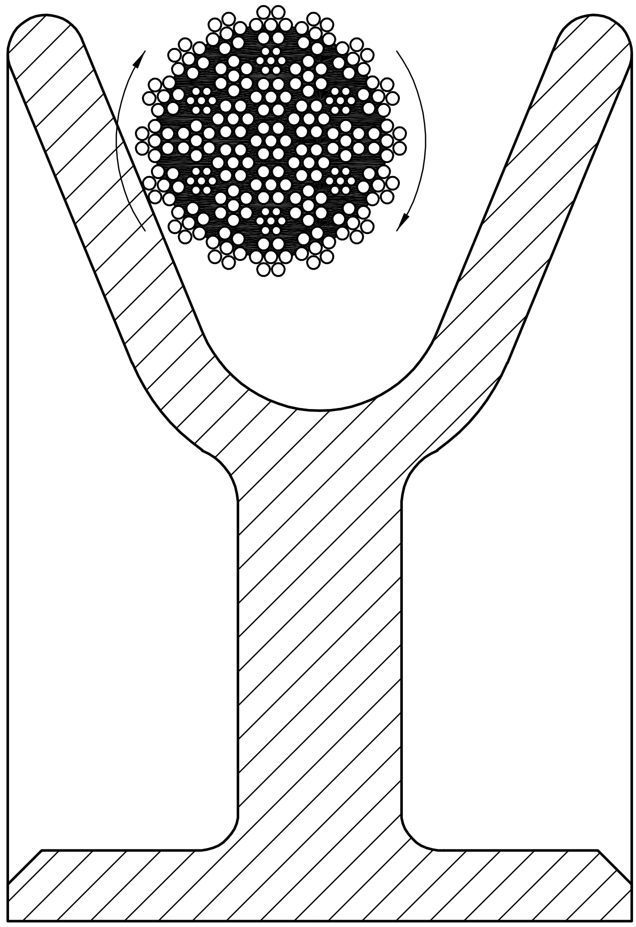


Figure C.5 — Twisting of a rope resulting from the fleet angle

C.5 Rope velocity

An increase in the drum and/or sheave diameters should be considered for applications where the rope velocity exceeds 4 m/s. If such an increase creates substantial added inertia (of ferrous sheaves), consideration should be given to the use of non-metallic sheaves.

If the rope velocity exceeds 4 m/s, special consideration should be given to the rope type. Ropes having eight or more strands can provide improved performance compared with ropes having a lesser number of outer strands.

C.6 Rotation and the use of swivels

C.6.1 General

Rotation is a factor which can affect the efficient operation of a rope and in some circumstances can cause premature deterioration. All ropes are liable to some degree of rotation in service, and in single-fall lifts with unguided loads, rotation-resistant rope should be considered for use.

C.6.2 Swivels

To limit the hazard of a rotating load during a lifting operation and to ensure the safety of personnel within the lifting zone, it is preferable to select a rotation-resistant rope that will only rotate a small amount when loaded, see a) below. With such ropes, the purpose of a swivel is to relieve the rope of any induced rotation resulting from angular deflections at a sheave or drum.

Other rotation-resistant ropes, having less resistance to rotation when loaded [see b) below], are likely to require the assistance of a swivel to minimize the hazard. In such cases, however, it should be recognized that excessive rope rotation can have an adverse affect on rope performance and can also result in a reduction in breaking force of the rope, the magnitude of which will depend on the rotational properties of the selected rope and the magnitude of the load being lifted.

Each such lifting operation should be assessed by a competent person, and the crane manual should reference the approval for use of a swivel based on a maximum lift condition and examination of the rope at specified periods.

The following is a summary of general guidance on the use of a swivel based on the rotational property of the rope:

a) rotational property less than or equal to 1 turn/1 000 d and lifting a load equivalent to 20 % F_{min}: a swivel can be used;

b) rotational property greater than 1 turn but no greater than 4 turns/1 000 d and lifting a load equivalent to 20 % F_{min}: a swivel may be used subject to the recommendations of the rope manufacturer and/or approval of a competent person;

c) rotational property greater than 4 turns/1 000 d and lifting a load equivalent to 20 % F_{min}: a swivel should not be used,

where

1 turn = 360°;

d is the nominal rope diameter;

F_{min} is the minimum breaking force of rope.

C.7 Height of lift and multi-part reeving

The selection of the rope should recognize the rotational characteristics of the rope type. If one end of the rope is free to rotate (single-part reeving), some rope types cannot be used and other rope types can be used only to a specified height of lift.

If both ends of the rope are fixed (stationary rope and rope used in multi-part reeving), the torsional value should be considered. The torsional value has the effect of causing angular displacement of the pulley block in multi-part reeving arrangements, and adequate rope spacing related to the height of lift should be achieved so that excessive angular displacement (cabling of the reeving) is prevented.

The stability of the reeving system:

a) decreases with decreasing spacing between the rope parts;

b) decreases with an uneven number of parts;

c) decreases with increasing height of lift;

d) decreases with increasing torsional value (torque factor) of the rope type.

The rotational characteristics (turn and torsional values) of the rope types considered for selection should be provided by the rope manufacturer. If necessary, the rope manufacturer should also be asked for assistance.

C.8 Causes of rope deterioration

C.8.1 General

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

One or more of these causes can be present, or dominant, depending on the duty. It is essential to select the rope most suitable for each particular duty, and the rope manufacturer or supplier is generally the best source of advice.

C.8.2 Fatigue

Fatigue in wire ropes is normally caused by repeated bending of ropes under tensile loading, e.g. when ropes operate over sheaves and around drums.

The main factors affecting fatigue are, therefore, the load on the rope, the ratios of sheave and drum diameters to rope diameter, the rope performance in bending and the number of operating cycles.

In general, rope performance will increase as the tensile load decreases, assuming the dimensions of the mechanism remain unchanged. Rope performance usually increases significantly with an increase in the selection factors h_1 and h_2.

The comparative fatigue life of round-strand Lang-lay ropes tends to be greater than for ordinary-lay ropes of the same strand construction. However, single-layer and parallel-closed ropes in Lang-lay may only be selected if both ends of the rope are fixed so as to prevent rotation.

C.8.3 Corrosion

Corrosion, often in combination with fatigue, is a main cause of wire rope deterioration in service. Except under very dry conditions, there is always some corrosion of unprotected (bright) steel wires.

In some respects, the requirements for corrosion resistance and fatigue resistance are contradictory. For the former, a small number of large wires is an advantage, whereas for the latter a large number of small wires is preferred. Choice of construction is, therefore, nearly always a compromise. To inhibit the onset of corrosion, ropes should be given frequent applications of suitable dressings during their working life. If there is a risk of severe corrosion, it is preferable to use a rope with galvanized wires.

C.8.4 Abrasion

Abrasion occurs primarily in the outer wires. Ropes with fewer large outer wires, e.g. 6 × 19 Seale, exhibit a longer rope life under abrasive conditions than those with many smaller outer wires, e.g. 6 × 36 Warrington-Seale. Ropes with compacted outer strands provide a longer rope life under abrasive conditions than those without compacted outer strands.

C.8.5 Relative fatigue and abrasion resistance

The requirements for fatigue resistance are almost opposite to those for abrasion resistance. Generally, as the number of outer wires increases, the resistance to fatigue increases, whereas the resistance to abrasion decreases.

C.8.6 Crushing

if crushing is a main deterioration factor, parallel-closed rope with steel cores and compacted outer strands are recommended.

C.9 Elongation and rope selection

Elongation of a wire rope can occur for a number of reasons :

a) due to the settling of its components (this is normally referred to as the permanent constructional extension and occurs relatively early in the service life of the rope);

b) elastic stretch due to tension in the rope;

c) temperature change;

d) rope rotation.

Rope with fibre core will have a much greater elongation than rope with steel core. If values of elongation are required for the rope types considered for selection, these should be made available by the rope manufacturer, based on the specific circumstances of the application.

C.10 Temperature and rope selection

The product safety instructions and warnings of the rope manufacturer should be considered and particular attention given to temperature limitations.

C.11 Termination selection for ropes

There are two forms of rope termination which permit the connection of wire ropes to other components. These are

a) by forming an eye (protected by a thimble) at the end of a rope,

b) by use of a fitting attached to the rope.

An eye is made either by conventional splicing of the rope, or by forming a Flemish eye and securing with a ferrule, or by “turning back” the end of the rope and securing with a ferrule.

A fitting attached directly to the end of a wire rope may be either a socket, wedge socket, swaged or pressed termination. A stationary rope should not be terminated with wedge sockets without a concomitant increase in the rope diameter to account for the efficiency loss of the termination, and a statement in the crane manual to refer to inspection of the termination, and where appropriate, re-assembly of the wedge socket at specified intervals of time.

Different types of rope termination have different performance levels and the performance level can be affected by the rope type selected, hence consideration should be given to International Standards listed in the Bibliography.

C.12 Lubrication by the manufacturer

The manufacturer generally lubricates the rope during the production of the strands and at the time of core production.

Lubrication by the manufacturer at final closing can be required for applications and for duties where operational and/environmental conditions are severe. Extreme temperature conditions can require the use of special lubricants. Discussion with the manufacturer of the rope at the enquiry stage is recommended.

The lubricant chosen to be applied to the rope in service is generally different from that used in manufacture, because of the methods of application during the production process. However, the former should be compatible with the latter and therefore advice from the manufacturer of the rope should be obtained.

If the environment requires that the rope not be lubricated, discussion with the manufacturer of the rope at the enquiry stage is recommended. There are special requirements for the frequency of rope inspection when a rope is not lubricated.

Annex D
(normative)

Hoists — Diameter of compensating sheaves

The minimum pitch circle diameter of the rope compensating sheaves shall be calculated using the minimum rope diameter established in 6.3 and by applying the respective value of h_3, as shown in Table D.1 below, and the rope type factor t as shown in Table 3, as applicable, and which relates to the classification of the mechanism in Equation (D.1):

$$D_3 \geqslant h_3 \times t \times d_{\text{min}} \tag{D.1}$$

where

D_3 is the minimum pitch circle diameter of the compensating sheave;

h_3 is the selection factor for the compensating sheeve (ratio of the pitch circle diameter of the compensating sheave to the calculated diameter of the rope, see Table D.1);

t is the rope type factor, in accordance with Table 3;

d_{min} is the minimum diameter of the rope, as established in 6.3.

Table D.1 — Selection factor h_3

Classification of mechanism	Compensating sheave selection factor h_3
M1	11,2
M2	12,5
M3	12,5
M4	14,0
M5	14,0
M6	16,0
M7	16,0
M8	18,0

Bibliography

[1] ISO 3189-1, *Sockets for wire ropes for general purposes — Part 1: General characteristics and conditions of acceptance*

[2] ISO 3189-2, *Sockets for wire ropes for general purposes — Part 2: Special requirements for sockets produced by forging or machined from the solid*

[3] ISO 3189-3, *Sockets for wire ropes for general purposes — Part 3: Special requirements for sockets produced by casting*

[4] ISO 7595, *Socketing procedures for wire ropes — Molten metal socketing*

[5] ISO/TR 7596, *Socketing procedures for wire ropes — Resin socketing*

[6] ISO 8793, *Steel wire ropes — Ferrule-secured eye terminations*

[7] ISO 8794, *Steel wire ropes — Spliced eye terminations for slings*

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