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Cranes and hoists — Selection of wire ropes, drums and sheaves

Appareils de levage à charge suspendue — Choix des câbles, tambours et poulies

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2. www.iso.org/directives

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The committee responsible for this document is ISO/TC 96, *Cranes*, Subcommittee SC 3, *Selection of wire ropes*.

This first edition of ISO 16625 cancels and replaces ISO 4308-1:2003, ISO 4308-2:1988 and ISO 8087:1985, of which it constitutes a technical revision.

Cranes and hoists — Selection of wire ropes, drums and sheaves

1 Scope

This International Standard specifies the minimum practical design factors, Z_p, for the various classifications of mechanism, rope types, rope duties and types of spooling and demonstrates how these are used in the determination of the minimum breaking force of the wire rope.

It specifies the selection factors for drums and sheaves for the various classifications of mechanisms, rope types and rope duties and how these are used in the determination of the minimum practical diameters of drums and sheaves that work in association with the selected wire rope.

A list of types of cranes and hoists to which this standard applies is given in Annex A.

Annex B gives factors, additional to those mentioned above, which might need consideration when selecting the wire rope and associated equipment.

2 Normative references

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

ISO 2408, *Steel wire ropes for general purposes — Minimum requirements*

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

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

ISO 4309, *Cranes — Wire ropes — Care and maintenance, inspection and discard*

ISO 10425, *Steel wire ropes for the petroleum and natural gas industries — Minimum requirements and terms of acceptance*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 4306-1 and ISO 17893 apply.

NOTE 1 In this document, "single-layer ropes" and "parallel-closed ropes", as defined in ISO 17893, are referred to as "standard ropes" to distinguish them from "rotation-resistant ropes".

NOTE 2 Single-layer ropes and parallel-closed ropes are also sometimes referred to as "*non*-rotation-resistant ropes".

4 Group classification of the mechanism as a whole

The resulting classification of mechanism (M4, M5, etc.) shall be taken into account when establishing the minimum design factor and the minimum drum and sheave sizes.

The group classification of the mechanism as a whole takes account of the state of loading (light, moderate, heavy, etc.) and the class of utilization of the mechanism (based on total duration of use) as a whole, as detailed in ISO 4301-1.

NOTE Other parts of ISO 4301 (such as ISO 4301-2, covering mobile cranes) specify the classification of a particular type of crane and related crane mechanisms taking account of the rope duty (hoisting, luffing, etc.) and crane operating conditions.

5 Selection of rope

5.1 Type and construction

The wire rope selected shall conform to either ISO 2408 or ISO 10425, according to the application and/or duty.

5.2 Design factor, Z_p

The minimum design factor shall be specified in accordance with Tables 1, 2 or 3, as applicable, taking into account the classification of mechanism and the rope duty or rope hoist and, in the case of stationary ropes, the crane classification.

NOTE The design factors listed in the tables are based on long experience in the field.

Table 1 — Minimum design factors for all cranes and hoists except mobile cranes

Group classification of mechanism in accordance with ISO 4301-1:1986	Hoisting				Boom hoisting or luffing	
	Single-layer spooling		Multi-layer spooling			
	Standard rope	Rotation-resistant rope	Standard rope	Rotation-resistant rope	Standard rope	Rotation-resistant rope
M1	3,15	3,15	3,55	3,55	3,55	4,5
M2	3,35	3,35	3,55	3,55	3,55	4,5
M3	3,55	3,55	3,55	3,55	3,55	4,5
M4	4,0	4,0	4,0	4,0	4,0	4,5
M5	4,5	4,5	4,5	4,5	4,5	4,5
M6	5,6	5,6	5,6	5,6	5,6	5,6
M7	7,1	7,1	—	—	7,1	—
M8	9,0	9,0	—	—	9,0	—

Table 2 — Minimum design factors for mobile cranes

Group classification of mechanism in accordance with ISO 4301-1:1986	Running rope						
	Hoisting		Boom hoisting				Telescoping
			Working		Erecting		
	Standard rope	Rotation-resistant rope	Standard rope	Rotation-resistant rope	Standard rope	Rotation-resistant rope	
M1	3,55	4,5	3,35	4,5	3,05	4,5	3,15
M2	3,55	4,5	3,35	4,5	3,05	4,5	3,35
M3	3,55	4,5	3,35	4,5	3,05	4,5	3,35
M4	4,0	4,5	3,35	4,5	3,05	4,5	3,35
M5	4,5	4,5	3,35	4,5	—	—	—
M6	5,6	5,6	3,35	5,6	—	—	—

Table 3 — Stationary working rope and erecting rope

Crane classification	All cranes	
	Stationary ropes	Erection ropes
A1	3,0	2,73
A2	3,0	2,73
A3	3,0	2,73
A4	3,5	2,73
A5	4,0	2,73
A6	4,5	—
A7	5,0	—
A8	5,0	—

5.3 Minimum breaking force

The minimum breaking force of the rope, F_{min}, shall be calculated using Formula (1):

$$F_{min} \geq S \times Z_p \quad (1)$$

where, for hoisting ropes, S is the maximum rope tension, in kN, obtained by taking into account

— rated working load of the appliance,

— mass of the sheave block and/or other lifting attachments,

— mechanical advantage of reeving,

— efficiency of reeving (e.g. bearing efficiency), and

— the increase in force in the rope caused by the rope inclination at the upper extreme position of the hook, if the inclination with respect to the drum axis exceeds 22,5°;

or, for stationary ropes, S is the maximum rope tension, in kN, obtained by taking account of both the static and dynamic forces;

and where Z_p is the minimum design factor.

For values of Z_p, see 5.2. Alternatively, in circumstances when rotation-resistant ropes are used for hoisting and the mass of the sheave block and other lifting attachments and the efficiency of the reeving are not required to be taken into account, the design factor shall be at least 5.

In the case of appliances with grabs, where the mass of the load is not always equally distributed between the closing ropes and the holding ropes during the whole of cycle, the value of S to be applied shall be determined as follows.

a) If the hoist mechanism automatically ensures an equal division of the hoisted load between the closing and holding ropes, and any difference between the loads carried by the ropes is limited to a short period at the end of the closing or the beginning of the opening:

   1) for closing ropes, S = 66 % of the mass of the loaded grab divided by the number of *closing* ropes;

   2) for holding ropes, S = 66 % of the mass of the loaded grab divided by the number of *holding* ropes.

b) If the hoist mechanism does *not* automatically ensure an equal division of load between the closing ropes and the holding ropes during the hoisting motion and, in practice, almost all the load is applied to the closing ropes:

   1) for closing ropes, S = total mass of the loaded grab divided by the number of closing ropes;

   2) for holding ropes, S = 66 % of the total mass of the loaded grab divided by the number of holding ropes.

NOTE For the more common wire rope classes and constructions and, where applicable, rope grade, minimum breaking force factors given in ISO 2408 and ISO 10425 enable the minimum breaking force value to be calculated for a given nominal rope diameter. It should be noted, however, that the minimum breaking force factor used by the rope manufacturer can be greater than that given in the above-mentioned International Standards, resulting in higher minimum breaking force values being specified.

5.4 Diameter

In the process of selecting a wire rope to satisfy the minimum breaking force requirement as given in 5.3, the situation can arise where, for practical reasons (e.g. availability, preferred sizes), the minimum breaking force exceeds the required minimum value, leading to a higher design factor than the minimum quoted in 5.2. In such cases, the selected nominal wire rope diameter, d, is to be used when calculating the diameter of sheaves and drums; see 6.2.

NOTE The nominal diameter of a given rope type, construction or class, minimum breaking force and, where applicable, grade, is established by the rope manufacturer.

6 Drums and sheaves

6.1 Sheave material

The manufacturer shall take account of the type of spooling when selecting the sheave material or sheave groove lining material.

Single-layer spooling

Where spooling at the drum is single-layer, the choice of sheave material can be critical, as deterioration of the wire rope is most likely to be through bending fatigue — particularly if the fleet angle is not excessive.

If all of the sheaves are made of a polymer material or have a polymer groove lining, there is a possibility of internal fatigue damage going largely unnoticed in service unless discard criteria and/or the frequency between inspections is/are significantly modified from that given in ISO 4309 and closely followed. Such an arrangement should generally be avoided; see B.3.1 for recommendation.

If the fleet angle is higher than recommended, then the most severe deterioration experienced in the reeving system can be in the form of increased wear/abrasion and scrubbing damage occurring between wraps on the drum as a result of higher-than-normal transverse loading at the extremity of travel.

Multi-layer spooling

Where spooling at the drum is multi-layer, it can be expected that deterioration of the wire rope will be at its greatest at those sections that coincide with the crossover zones at the drum rather than at those sections that simply run through sheaves. In such cases, polymer sheaves or sheaves having a polymer groove lining, as well as steel sheaves, may be used, provided other properties, such as limiting radial pressures, are not exceeded for the selected material.

6.2 Calculation of minimum drum and sheave diameters

The minimum pitch circle diameter of drums and sheaves for "hoisting" ropes shall be calculated using Formulae (2) or (3).

NOTE Any increase in pitch circle diameter from the calculated values will enhance the bending fatigue resistance of the rope.

$$D_1 \geq h_1 \times t \times d \tag{2}$$

or

$$D_2 \geq h_2 \times t \times d \tag{3}$$

where

D_1 is the minimum pitch circle diameter of the drum;

D_2 is the minimum pitch circle diameter of the sheave;

d is the nominal diameter of the selected rope;

h_1 is the selection factor for the drum (ratio of the pitch circle diameter of the drum to the nominal diameter of the rope) in accordance with Tables 4 and 5;

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

t is the rope type factor in accordance with Table 6.

Table 4 — Selection factors h_1, h_2 and h_3 — Hoisting and boom hoisting/luffing ropes — Cranes and hoists other than mobile cranes

Group classification of mechanism in accordance with ISO 4301-1:1986	Drums, h_1	Sheaves, h_2	Compensating sheaves, h_3	
	min.	min.	min.	preferred min.[a]
M1	11,2	12,5	11,2	12,5
M2	12,5	14,0	12,5	14,0
M3	14,0	16,0	14	16,0
M4	16,0	18,0	16,0	18,0
M5	18,0	20,0	18,0	20,0
M6	20,0	22,4	20,0	22,4
M7	22,4	25,0	22,4	25,0
M8	25,0	28,0	25,0	28,0

[a] These factors are particularly recommended to limit radial pressure at rope entry/exit zones when single-layer spooling where bending fatigue is usually the principal mode of deterioration.

Table 5 — Selection factors h_1, h_2 and h_3 — Mobile cranes

Rope duty and classification of mechanism in accordance with ISO 4301-1:1986		Drums, h_1			Sheaves, h_2			Compensating sheaves, h_3		
		Std. rope	R-R rope		Std. rope	R-R rope		Std. rope	R-R rope	
		min.	min.	preferred min.[a]	min.	min.	preferred min.[b]	min.	min.	preferred min.[c]
Hoisting	M1 to M6	16,0	18	20	18	18	20	14	18	20
Boom hoisting/ luffing	M1 to M6	14	16	20	16	16	20	12,5	16	20
Telescoping	M1 to M4	—	—	—	14	—	—	10	—	—

[a] These factors are particularly recommended for limiting radial pressure and attendant rope distortion effects at cross-over zones associated with multi-layer spooling.

[b] These factors are particularly recommended for limiting radial pressure and enhance bending fatigue performance on single-layer spooling mechanisms.

[c] These factors are particularly recommended for limiting radial pressure at rope entry/exit zones when single-layer spooling where bending fatigue is usually the principal mode of rope deterioration.

Table 6 — Rope type factor t for various rope types

Number of outer strands in rope	Rope type factor t
3	1,25
4 to 5	1,15
6 to 10	1,00
8 to 10 – plastic impregnation	0,95
10 and greater — rotation-resistant	1,00

7 Exceptional conditions

For exceptional conditions, such as the handling of molten metal, extremely dirty and/or corrosive environment,

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

b) the Z_p value shall be increased by 25 % up to a maximum of 9,0.

8 Care and maintenance, inspection and discard

The selection of ropes, drums and sheaves according to this International Standard cannot alone ensure safe operation of the rope for indefinite periods.

For drums and sheaves, the instructions provided by the manufacturer on care and maintenance, inspection and discard shall be followed.

For wire ropes, ISO 4309 applies.