International Standard

ISO 16625

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

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

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Foreword

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

This second edition cancels and replaces the first edition (ISO 16625:2013), which has been technically revised.

The main changes are as follows:

— rope selection has been based on working cycles as opposed to the previous time-based concept;

— different proofs of competence for running ropes (static, fatigue, multilayer spooling) and stationary ropes (static, fatigue) have been incorporated;

— the substantial innovation of this document lies in a new mathematical approach for the proof of fatigue strength of running steel wire ropes. A new reference point has been introduced as a characteristic value for the fatigue strength, from which the S-N curves of the fatigue strength of steel wire ropes at different D/d-ratios are described;

— additional annexes have been introduced:

  — Annex A (normative) Number of relevant bending cycles;

  — Annex B (informative) Determination of the maximum tensile force in the ropes of multi-rope grabs (holding and closing);

  — Annex C (informative) Comparison of the minimum design factor according to ISO 16625:2013 and safety level according current version;

  — Annex D (informative) Selection of a rope by minimum design factor Z_p ;

  — Annex E (informative) Assumed number of hoist ropes l_r during life of a crane.

This document is intended to be used together with the ISO 4301-1 or other applicable part of the ISO 4301 series, ISO 4309, ISO 8686-1 or applicable part of the ISO 8686 series.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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

1 Scope

This document provides a proof of competence and criteria for the selection of steel wire ropes used in cranes as defined in ISO 4306-1.

The influence of the geometry of the rope drive, as well as drum and sheave geometry, are incorporated in the proof of competence.

This document does not apply to fibre ropes.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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, *Steel wire ropes — Requirements*

ISO 4301-1, *Cranes — Classification — Part 1: General*

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

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

ISO 8686-1:2012, *Cranes — Design principles for loads and load combinations — Part 1: General*

ISO 8686-2, *Cranes — Design principles for loads and load combinations — Part 2: Mobile cranes*

ISO 8686-3, *Cranes — Design principles for loads and load combinations — Part 3: Tower cranes*

ISO 8686-4, *Cranes — Design principles for loads and load combinations — Part 4: Jib cranes*

ISO 8686-5, *Cranes — Design principles for loads and load combinations — Part 5: Overhead travelling and portal bridge cranes*

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

ISO 17558, *Steel wire ropes — Socketing procedures — Molten metal and resin socketing*

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

ISO 20332, *Cranes — Proof of competence of steel structures*

EN 13411-3, *Terminations for steel wire ropes — Safety — Part 3: Ferrules and ferrule-securing*

EN 13411-4, *Terminations for steel wire ropes — Safety — Part 4: Metal and resin socketing*

EN 13411-6, *Terminations for steel wire ropes — Safety — Part 6: Asymmetric wedge sockets*

EN 13411-8, *Terminations for steel wire ropes — Safety — Part 8: Swage Terminals and Swaging*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 4301-1, ISO 4306-1, ISO 17893 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1.1
running rope
rope which is wound on and off a drum and bent over sheaves and/or drums, therefore stressed mainly by bending and secondly by tension

3.1.2
stationary rope
rope fixed at both ends, primarily under tensile load, and which is not subject on coiling (winding) on a drum or over a sheave

3.1.3
design life
estimation of the intended period of use for a crane, or component based on its original design specification and taking into consideration the load cycles and load spectrum expected during its intended usage

Note 1 to entry: According to ISO 4301-1, a rope is considered to be a component in this document.

[SOURCE: ISO 12482:2014, 3.2, modified]

3.1.4
work cycle
operating sequence starting from hoisting a load, transferring the load, lowering and grounding the load, detaching the load and moving the unloaded load lifting attachment back to a starting position ready to hoist another load

[SOURCE: ISO 12482:2014, 3.6]

3.1.5
rope bending diameter
diameter of the axis of the rope in the state when bent over a sheave or a drum

3.2 Symbols

The main symbols used in this document are given in ISO 4301-1, ISO 8686-1, ISO 20332 and Table 1.

Table 1 — Symbols

Symbols	Description
A	Classes for group classification of a crane or hoist (see ISO 4301-1)
A_C	Classes for group classification of a component (see ISO 4301-1)
a	Acceleration or deceleration
C	Total number of working cycles during design life of a crane (see ISO 4301-1)
C_r	Total number of working cycles during the design life of a rope
D	Rope bending diameter
D_1	Rope bending diameter of drum

Table 1 *(continued)*

Symbols	Description
D_2	Rope bending diameter of sheave
d	Nominal rope diameter
F, S	Rope tension force
F_h	Horizontal force acting on the hoist load
F_{min}	Minimum breaking force of the rope (see ISO 17893)
$F_{Rd,f}$	Limit design rope force for the proof of fatigue strength
$F_{Rd,m}$	Limit design rope force for multilayer spooling
$F_{Rd,s}$	Limit design rope force for the proof of static strength
F_{ref}	Reference value of rope tensile force to describe the reference point of the S-N curve (Wöhler-curve) at the proof of fatigue strength
F_{Sd}	Design rope force
$F_{Sd,f}$	Design rope force for the proof of fatigue strength
$F_{Sd,m}$	Design rope force for multilayer spooling
$F_{Sd,s}$	Design rope force for the proof of static strength
f_F	Factor of further influences to the rope tension force F_{ref}
f_{F1}	Factor of influence of wire tensile strength
f_{F2}	Factor of fleet angle influence
f_{F3}	Factor of lubrication influence
f_{F4}	Factor of groove radius influence
f_{S1}	Rope force increasing factor from rope reeving efficiency to be used at the proof of static strength
f_{S2}	Rope force increasing factor from non-parallel falls to be used at the proof of static strength
f_{S3}	Rope force increasing factor from horizontal forces to be used at the proof of static strength
f_{S4}	Rope force reduction factor due to the type of rope termination to be used at the proof of static strength
f_{S2}^*	Rope force increasing factor from non-parallel falls to be used at the proof of fatigue strength
f_{S3}^*	Rope force increasing factor from horizontal forces to be used at the proof of fatigue strength
f_w	Factor of further influences to the reference number of bending cycles w_{ref}
f_{w1}	Factor of rope type influence
f_{w2}	Factor of rope diameter influence
g	Acceleration due to gravity
K_p	Load spectrum factor (see ISO 4301-1)
k_r	Rope force spectrum factor
l_r	Number of ropes assumed to be used during the design life of the crane
m	Exponent, slope of the S-N curve (Wöhler-curve)
m_H	Mass of the hoist (gross) load (see ISO 8686-1)
m_{Hr}	Mass of the hoist load or that part of the mass of the hoist load that is acting on the rope falls
$m_{Hr,1}$	Portion of the total mass of the hoist load m_H that is acting on the closing ropes
$m_{Hr,2}$	Portion of the total mass of the hoist load m_H that is acting on the holding ropes
m_R	Mass of the portion of the suspended ropes of the hoist drive
N_{ref}	Number of tensile force cycles at reference point (see also ISO 20332)
N_t	Total number of tensile force cycles during the design life of a crane (see ISO 20332)
n	Number of contact points passed by a part of the rope that initiates a change of curvature in the rope
n	Number of tensile force cycles

Table 1 *(continued)*

Symbols	Description
n_m	Mechanical advantage
n_s	Number of fixed sheaves between drum and moving part
$p_{f,r}$	Proof of fatigue strength for running ropes
$p_{f,s}$	Proof of fatigue strength for stationary ropes
$p_{m,r}$	Proof of competence for multilayer spooling for running ropes
$p_{s,r}$	Proof of static strength for running ropes
$p_{s,s}$	Proof of static strength for stationary ropes
$q(z)$	Normalized position density
R_r	Rope grade (see ISO 2232)
r_g	Groove radius
S_k	Design load effect in rope drive k of ropes or rope falls, as an inner force, resulting from load combination F_j
S_r	Resulting design force in particular rope
S_{r1}	Design load effect in particular rope
S_{r2}	Design load effect in particular rope arising from local effects
s_r	Rope force history parameter
w	Number of bending cycles
w_c	Bending count of a particular type of bending
w_{Crane}	Assumed total number of bending cycles during the design life of a crane
w_{max}	Maximum number of bending cycles in the most unfavourable part of the reeving system
w_{ref}	Reference number of bending cycles of the S-N curve (Wöhler-curve) for the proof of fatigue strength
w_{tot}	Total number of bending cycles during the design life of a rope in the rope section
w^*	Assumed total number of bending cycles during the design life of a rope
Z_p	Minimum design factor
z, z_i, z_{min}, z_{max}, z_{ref}	Position coordinates
α	Deflection angle
β_{max}	Maximum angle between falls and line of action of force
$\beta(z)$	Angle between falls and line of action of force depending on coordinate z
γ	Angle between direction of gravity and rope projected in plane of F_h and g
γ_n	Risk coefficient (see ISO 8686-1)
γ_p	Partial safety factor (see ISO 8686-1)
γ_{rb}	Rope resistance factor to be used at the proof of static strength and multilayer spooling
γ_{ref}	Factor to adapt the minimum breaking force of the rope F_{min} to the reference rope tension force F_{ref} at the proof of fatigue strength
γ_{rf}	Rope resistance factor to be used at the proof of fatigue strength
γ_{rfD}	Minimum rope resistance factor to prevent from exceeding the Donandt-force
δ	Fleet angle
ε	Angle between sheave planes
η_s	Efficiency of applied rope, sheave and bearing
η_{tot}	Total rope reeving efficiency of the rope drive
ν_r	Relative total number of cycles
ϕ	Dynamic factor for inertial and gravity effects
ϕ^*	Dynamic factor for inertial effects at the proof of fatigue strength and multilayer spooling

Table 1 *(continued)*

Symbols	Description
ϕ_2	Dynamic factor for inertial and gravity effects when hoisting an unrestrained grounded load (see ISO 8686-1)
ϕ_5	Dynamic factor for inertial effect (see ISO 8686-1)
ϕ_6	Dynamic factor for inertial and gravity effects when hoisting an unrestrained grounded load under dynamic test load conditions (see ISO 8686-1)
ω	Groove opening angle

4 Running ropes and stationary ropes

4.1 General

Running ropes on cranes are stressed by tensile loads and by bending over sheaves and/or on drum. These cyclic load effects constitute a cumulative fatigue effect to the rope. Within this document this effect is expressed with the rope force history parameter s_r, which is independent of time. For the fatigue proof of competence, it is essential to select a proper number of ropes l_r, which are assumed to be used during the design life of the crane or hoist. Guidance for the choice of l_r is given in Annex E.

Stationary ropes are considered to be part of the cranes load bearing structure and are stressed primarily by tensile loads.

For both categories of wire ropes, running ropes and stationary ropes, several proofs of competence shall be performed.

For running ropes:

— static proof of competence, see 5.1;

— fatigue proof of competence, see 5.2;

— proof of competence for ropes in multilayer spooling, see 5.3, if applicable.

For stationary ropes:

— static proof of competence, see 6.1;

— fatigue proof of competence, see 6.2.

NOTE 1 Only in exceptional cases where some essential information regarding the crane or hoist is missing or some essential parameter values are unknown and cannot be obtained from the documentation of the crane or hoist, a selection of the wire rope according Annex D can be done in order to provide a minimum safety level.

NOTE 2 For the purposes of this document, ‘single-layer ropes’ and ‘parallel-closed ropes’, as defined in ISO 17893, are referred to as ‘standard ropes’ to distinguish themselves from ‘rotation-resistant ropes’.

NOTE 3 Single-layer ropes and parallel-closed ropes are sometimes referred to as ‘non-rotation-resistant ropes’.

4.2 Discard criteria

To ensure the safe use of the wire rope, the discard criteria of ISO 4309 shall apply.

If the intended number of ropes l_r to be used during the design life of the crane is greater than 1, then the design life of the specified rope shall be chosen to exceed the periodic inspection interval of the rope always.

When polymer sheaves are used exclusively in conjunction with single-layer spooling, the deterioration of the rope is likely to advance at a greater rate internally than externally.

Further information is given in Annex F, F.3.

4.3 Rope and rope terminations

The wire rope shall meet the requirements specified in ISO 2408.

Ropes selected shall be fit for the application and be made of suitable materials so that they withstand the design forces during the design life of the rope.

The operating environment shall be taken into account and, if necessary, greasing, galvanising or special rope materials shall be considered.

Rope terminations shall meet the requirements of one or more of the following standards: ISO 8793, ISO 17558, EN 13411-3, EN 13411-4, EN 13411-6, EN 13411-8.

Rope terminations shall be such that bending of the rope adjacent to the termination and other additional stresses on the rope are eliminated.

For non-rotation resistant ropes, the end termination shall be made in such a way that it is not possible for the rope to twist around the longitudinal axis. For rotation resistant ropes, a swivel can be integrated in the end termination to relieve any twist induced into the rope reeving system.

Further information is given in Annex F, F.10.2 and F.11.

5 Proof of competence of running ropes

5.1 Proof of static strength

5.1.1 General

The proof of static strength according to Formula (1) shall be provided for all relevant load combinations according to ISO 8686-1, or ISO 8686-2, ISO 8686-3, ISO 8686-4 or ISO 8686-5, as applicable, considering the rope specific effects described in this document.

$$p_{s,r} : F_{Sd,s} \leq F_{Rd,s} \quad (1)$$

where

$p_{s,r}$ is the proof of static strength for running ropes;

$F_{Sd,s}$ is the design rope force for the proof of static strength;

$F_{Rd,s}$ is the limit design rope force for the proof of static strength.

5.1.2 Vertical hoisting of loads

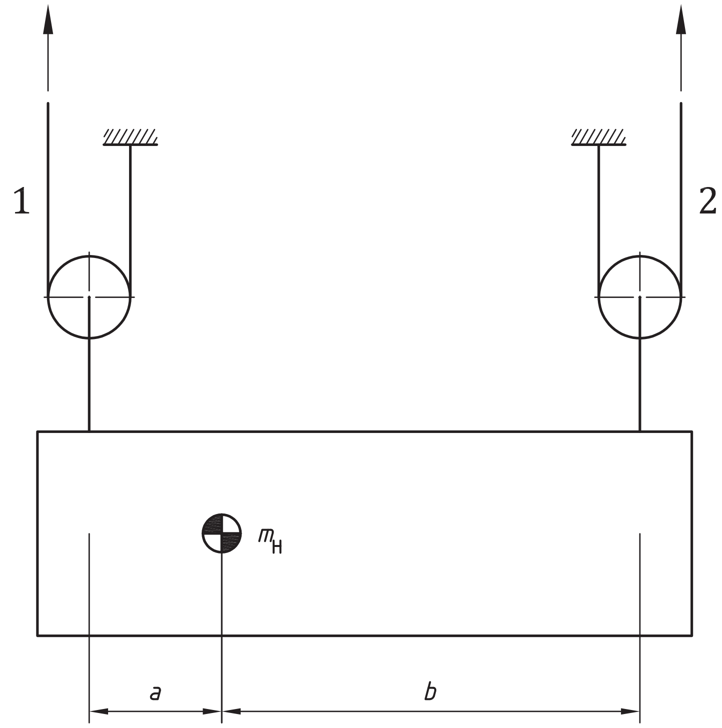
5.1.2.1 Design rope force

The design rope force $F_{Sd,s}$ in vertical hoisting of loads shall be calculated according to Formula (2):

$$F_{Sd,s} = \frac{m_{Hr} \times g}{n_m} \times \phi \times f_{S1} \times f_{S2} \times f_{S3} \times \gamma_p \times \gamma_n \quad (2)$$

where

m_{Hr}	is the mass of the hoist load (m_H) or that part of the mass of the hoist load that is acting on the rope falls under consideration (see Figure 1). The mass of the hoist load includes the masses of the payload, load-lifting attachments and a portion of the suspended hoist ropes. In statically undetermined systems, the unequal load distribution between ropes depends on elasticities and shall be taken into account;
g	is the acceleration due to gravity;
n_m	is the mechanical advantage of reeving;
ϕ	is the dynamic factor for inertial and gravity effects, see 5.1.2.2;
f_{S1} to f_{S3}	are the rope force increasing factors, see 5.1.2.3;
γ_p	is the partial safety factor (see ISO 8686-1):
$\gamma_p = 1{,}34$	for regular loads (load combinations A),
$\gamma_p = 1{,}22$	for occasional loads (load combinations B),
$\gamma_p = 1{,}10$	or exceptional loads (load combinations C);
γ_n	is the risk coefficient, where applicable (see ISO 8686-1, additionally ISO 12100 may be used for risk assessment).



Key

1 rope number 1

2 rope number 2

m_H mass of the hoist load

a distance between line of action of rope drive 1 to the centre of gravity of the hoist load

b distance between line of action of rope drive 2 to the centre of gravity of the hoist load

Figure 1 — Example for acting ropes on eccentric mass of hoist load

Further information regarding the determination of the maximum tensile force in the ropes of multi-rope grabs is given in Annex B.

5.1.2.2 Inertial and gravitational effects acting vertically on the load

5.1.2.2.1 General

For vertical hoisting of loads the maximum inertial effects from either hoisting an unrestrained grounded load or from acceleration or deceleration of same shall be taken into account by the dynamic factor ϕ, given in 5.1.2.2.2 to 5.1.2.2.4 according to ISO 8686-1.

5.1.2.2.2 Hoisting an unrestrained grounded load

The dynamic factor ϕ to consider hoisting of an unrestrained grounded load shall be calculated according to Formula (3):

$$\phi = \phi_2 \quad (3)$$

where ϕ_2 is the dynamic factor for inertial and gravity effects when hoisting an unrestrained grounded load (see ISO 8686-1).