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Dvigala (žerjavi) - Konstrukcija, splošno – 3-2. del: Mejna stanja in dokaz varnosti jeklenih vrvi pri vrvnih pogonih

Cranes - General design - Part 3-2: Limit states and proof of competence of wire ropes in reeving systems

Krane - Konstruktion allgemein - Teil 3-2: Grenzzustände und Sicherheitsnachweis von Drahtseilen in Seiltrieben

Appareils de levage a charge suspendue - Conception générale - Partie 3-2 : États limites et vérification d'aptitude des systemes de mouflage

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TECHNICAL SPECIFICATION

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English version

Cranes - General design - Part 3-2: Limit states and proof of competence of wire ropes in reeving systems

Appareils de levage à charge suspendue - Conception générale - Partie 3-2 : États limites et vérification d'aptitude des systèmes de mouflage

Krane - Konstruktion allgemein - Teil 3-2: Grenzzustände und Sicherheitsnachweis von Drahtseilen in Seiltrieben

This Technical Specification (CEN/TS) was approved by CEN on 18 March 2004 for provisional application.

The period of validity of this CEN/TS is limited initially to three years. After two years the members of CEN will be requested to submit their comments, particularly on the question whether the CEN/TS can be converted into a European Standard.

CEN members are required to announce the existence of this CEN/TS in the same way as for an EN and to make the CEN/TS available promptly at national level in an appropriate form. It is permissible to keep conflicting national standards in force (in parallel to the CEN/TS) until the final decision about the possible conversion of the CEN/TS into an EN is reached.

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Foreword

This document (CEN/TS 13001-3.2:2004) has been prepared by Technical Committee CEN/TC 147 "Cranes — Safety", the secretariat of which is held by BSI.

The CEN/TC 147/WG 2 "Cranes — Design and Principles" is held by DIN.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to announce this Technical Specification: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

This European Technical Specification is one Part of EN 13001. The other parts are as follows:

Part 1: General principles and requirements;

Part 2: Load effects;

Part 3.1: Limit states and proof of competence of steel structures;

Part 3.3: Limit states and proof of competence of wheel/rail contacts;

Part 3.4: Limit states and proof of competence of machinery.

Annex A is normative, annexes B and C are informative.

Introduction

This Technical Specification has been prepared to be a harmonized standard to provide one means for the mechanical design and theoretical verification of cranes to conform with the essential health and safety requirements of the Machinery Directive, as amended. This standard also establishes interfaces between the user (purchaser) and the designer, as well as between the designer and the component manufacturer, in order to form a basis for selecting cranes and components.

This Technical Specification is a type C standard as stated in EN ISO 12100-1:2003.

The machinery concerned and the extent to which hazards are covered are indicated in the scope of this standard.

1 Scope

This Part 3-2 of the Technical Specification EN 13001 is to be used together with Part 1 and Part 2 and as such they specify general conditions, requirements and methods to prevent mechanical hazards of wire ropes in reeving systems of cranes by design and theoretical verification.

NOTE 1 Specific requirements for particular types of crane are given in the appropriate Technical Specification for the particular crane type.

The following is a list of significant hazardous situations and hazardous events that could result in risks to persons during normal use and foreseeable misuse. Clauses 5 to 6 of this standard are necessary to reduce or eliminate the risks associated with the following hazard:

Exceeding the limits of strength.

This Technical Specification is applicable to cranes which are manufactured after the date of approval by CEN of this standard and serves as reference base for the Technical Specifications for particular crane types.

NOTE 2 CEN/TS 13001-3-2 deals only with limit state method according to EN 13001-1.

2 Normative references

This Technical Specification incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this Technical Specification only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

ENV 1990-1:2002, *Eurocode : Basic of structural design.*

EN 12385-4, *Steel wire ropes — Safety — Part 4: Stranded ropes for general lifting applications.*

EN 13001-1, *Cranes — General Design — Part 1: General principles and requirements.*

EN 13001-2, *Cranes — General Design — Part 2: Load effects.*

CEN/TS 13001-3.2 *Cranes — General design — Part 3-2: Limit states and proof of competence of wire ropes in reeving systems.*

EN 13411-1, *Terminations for steel wire ropes — Safety — Part 1: Thimbles for steel wire rope slings.*

EN 13411-2, *Terminations for steel wire ropes — Safety — Part 2: Splicing of eyes for wire rope slings.*

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 ISO 12100-1:2003, *Safety of machinery — Basic concepts, general principles for design — Part 1:Basic terminology, methodology (ISO 12100-1:2003).*

ISO 4306-1:1990, *Cranes vocabulary.*

ISO 4309, *Cranes — Wire ropes — Code of practice for examination and discard*.

3 Terms, definitions, symbols and abbreviations

3.1 Terms and definitions

For the purposes of this Technical Specification, the terms and definitions given in EN ISO 12100-1:2003, EN 1990-1:2002 and clause 6 of ISO 4306-1:1990 apply.

3.2 Symbols and abbreviations

For the purposes of this Technical Specification, the symbols and abbreviations given in Table 1 apply.

Table 1 — Symbols and abbreviations

Symbols, abbreviations	Description
a	Acceleration
C	Total number of working cycles (see EN 13001-1) during useful life of crane
D	Relevant diameter
D_{drum}	Minimum pitch diameter of drum
D_{sheave}	Minimum pitch diameter of sheave
D_{comp}	Minimum pitch diameter of compensating sheave
d	Rope diameter
$d_{bearing}$	Diameter of bearing or shaft
F_{equ}	Equivalent force
F_{gd}	Part of F_{equ} induced by gravity, exclusive mass of payload, amplified by γ_p
F_{gl}	Part of F_{equ} induced by gravity forces of mass of payload, amplified by γ_p
F_o	Part of F_{equ} induced by any other forces, amplified by γ_p
$F_{Rd,s}$	Limit design rope force for the proof of static strength
$F_{Rd,f}$	Limit design rope force for the proof of fatigue strength
$F_{Sd,s}$	Design rope force for the proof of static strength
F_r	Part of F_{equ} induced by resistances, amplified by γ_p
$F_{Sd,f}$	Design rope force for the proof of fatigue strength
F_t	Part of F_{equ} induced by rope tightening forces, amplified by γ_p
F_u	Minimum rope breaking force
F_w	Part of F_{equ} induced by wind forces, amplified by γ_p
f_f	Factor of further influences
f_{f1}	Factor of diameter ratio influence
f_{f2}	Factor tensile strength of wire influence
f_{f3}	Factor of fleet angle influence
f_{f4}	Factor of lubrication influence
f_{f5}	Factor of multilayer drum influence
f_{f6}	Factor of groove radius influence
f_{f7}	Factor of rope type influence

Table 1 *(concluded)*

Symbols, abbreviations	Description
f_{S1}	Rope force increasing factor from rope reeving efficiency
f_{S2}	Rope force increasing factor from non parallel falls
f_{S3}	Rope force increasing factor from horizontal acceleration
f^*_{Si}	Rope force increasing factors in fatigue
g	Gravity constant
i	Index for cycles of lifting and lowering
k_r	Rope force spectrum factor
l_r	Number of ropes used during useful life of the crane
q	Height distribution
m_H	Mass of hoist load (see EN13001-2)
m_{Hr}	Mass of hoist load that is acting on the rope falls under consideration
m_{red}	Rotatory rope driven mass
m_{trans}	Translational rope driven mass
n	Number of contact points passed by rope
n_f	Number of falls or reeving lines
n_{fs}	Number of fixed sheave between drum and moving part
n_m	Mechanical advantage
R_0	Minimum tensile strength of the wire used in the rope
R_{Dd}	Reference ratio of rope bending diameter to rope diameter
r_g	Groove radius
S_R	Class of rope force history
s_r	Rope force history parameter
t	Rope type factor
w	Number of relevant bendings per lifting movement
w_c	Bending count
w_D	Number of bendings at reference point
w_{tot}	Total number of bendings
z, z_i, z_{min}, z_{max}	Height coordinates
α	Angle of slope
β, β_{max}	Angles between falls and line of acting force
γ	Angle between gravity and projected rope in plane of F_h and g
γ_n	Risk coefficient
γ_p	Partial safety factor
γ_{rb}	Minimum rope resistance factor (static)
γ_{rf}	Minimum rope resistance factor (fatigue)
δ	Design fleet angle
ε	Angle between sheave planes
η_s	Efficiency of single sheave
η_{tot}	Total efficiency of rope drive
ν_r	Relative total number of bendings
ϕ	Dynamic factor for inertial or gravity effects
ϕ^*	Dynamic factor for inertial or gravity effects in fatigue
ϕ_2	Dynamic factor for hoisting an unrestrained grounded load
ϕ_5	Dynamic factor for loads caused by acceleration
ϕ_6	Dynamic factor for testload
ω	Angle between the sheave groove sides

4 General

In all cranes running wire ropes are stressed by loads (described by a load spectrum) and by bendings. Both constitute the rope force history, classified in classes S_R (see 6.3.2). Classes S_R are used for the selection of the wire rope and diameters of drums and/or sheaves. They are independent of time.

The proof of competence for static strength and the proof of competence for fatigue strength shall be fulfilled for the selection of ropes and components. This standard is for design purposes only and should not be seen as a guarantee of actual performance.

To ensure safe use of the rope the discard criteria according to ISO 4309 shall be applied.

The wire rope should be in accordance with EN 12385-4. Rope terminations shall meet the requirements of EN 13411-1, EN 13411-2, EN 13411-3, EN 13411-4 and EN 13411-6.

5 Proof of static strength

5.1 General

For the proof of static strength it shall be proven that for all relevant load combinations of EN 13001-2

$$F_{Sd,s} \leq F_{Rd,s} \qquad (1)$$

where:

$F_{Sd,s}$ is the design rope force

$F_{Rd,s}$ is the limit design rope force.

5.2 Vertical hoisting

5.2.1 Design rope force

The design rope force $F_{Sd,s}$ in vertical hoisting shall be calculated as follows:

$$F_{Sd,s} = \frac{m_{Hr} \cdot g}{n_f} \cdot \phi \cdot f_{S1} \cdot f_{S2} \cdot f_{S3} \cdot \gamma_p \cdot \gamma_n \qquad (2)$$

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, 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 gravity constant

n_f is the number of falls carrying m_{Hr}

ϕ is the dynamic factor for inertial and gravity effects as shown in 5.2.2

f_{S1} to f_{S3} are the rope force increasing factors as shown in 5.2.3 to 5.2.5

γ_p is the partial safety factor (see EN 13001-2)

γ_p = 1,34 for regular loads (load combinations A)

γ_p = 1,22 for occasional loads (load combinations B)

γ_p = 1,10 or exceptional loads (load combinations C)

γ_n is the risk coefficient (see EN 13001-2)

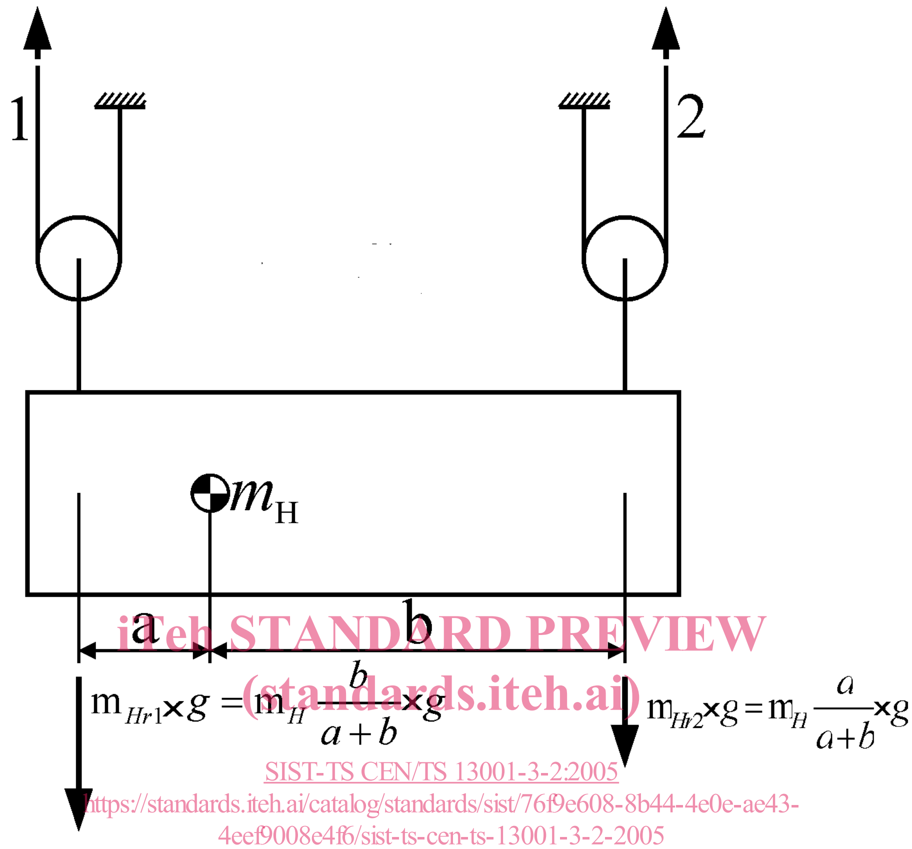

Figure 1— Example for the acting parts of hoist mass

5.2.2 Inertial and gravitational effects

5.2.2.1 Dynamic factors

For vertical hoisting the maximum inertial effects from either hoisting an unrestrained grounded load or from acceleration or deceleration shall be taken into account by the dynamic factor ϕ.

5.2.2.2 Hoisting an unrestrained grounded load

$$\phi = \phi_2 \tag{3}$$

where:

ϕ_2 is the dynamic factor for inertial and gravity effects when hoisting an unrestrained grounded load (see EN 13001-2)

5.2.2.3 Acceleration or deceleration of the hoistload

$$\phi = 1 + \phi_5 \cdot \frac{a}{g} \tag{4}$$

where:

ϕ_5 is the dynamic factor for loads caused by acceleration (see EN 13001-2)

a is the vertical acceleration or deceleration

g is the gravity constant

5.2.2.4 Testload

$$\phi = \phi_6 \tag{5}$$

where:

ϕ_6 is the dynamic factor for testload (see EN 13001-2)

5.2.3 Rope reeving efficiency

The increase of the design rope force by the rope reeving efficiency is given by

$$f_{S1} = \frac{1}{\eta_{tot}} \tag{6}$$

The total efficiency of the rope drive η_{tot} shall be calculated as follows:

$$\eta_{tot} = \frac{(\eta_S)^{n_{fs}}}{n_m} \cdot \frac{1-(\eta_S)^{n_m}}{1-\eta_S} \tag{7}$$

where:

η_S is the efficiency of a single sheave:
η_S = 0,985 for sheave with roller bearing
η_S = 0,985 × (1 - 0,15 × $d_{bearing} / D_{Sheave}$) for sheave with plain bearing

Other values for η_S may be used if verified by test results for the applied rope, sheave or bearing.

n_m is the mechanical advantage (see example in Figure 2)

n_{fs} is the number of fixed sheaves between drum and moving part

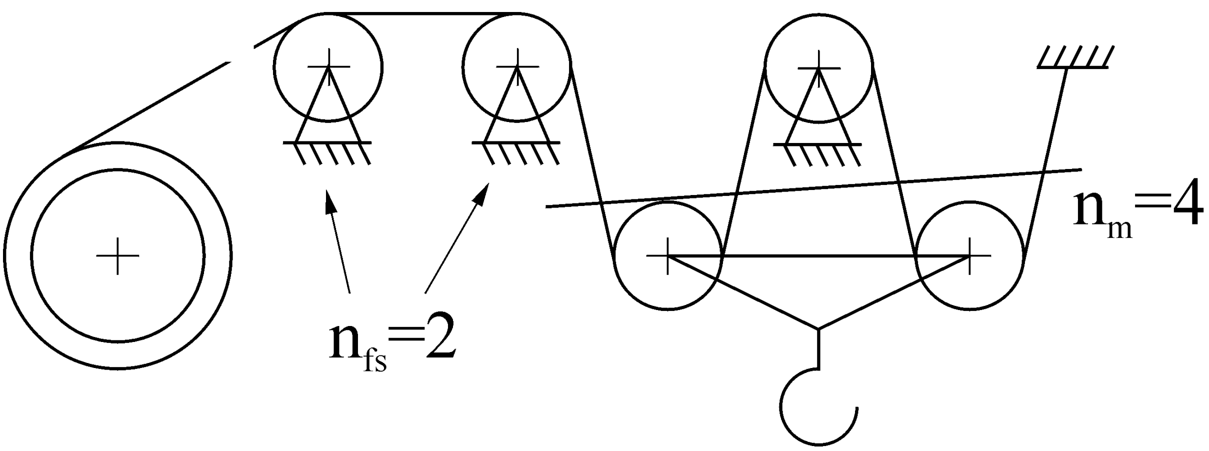

Figure 2 — Example for Rope Reeving Efficiency