# SLOVENSKI STANDARD
# SIST-TS CEN/TS 13001-3-2:2008

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**SIST-TS CEN/TS 13001-3-2:2005**
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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 à charge suspendue - Conception générale - Partie 3-2: Etats limites et vérification d'aptitude des systèmes de mouflage

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53.020.20 Dvigala Cranes

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**CEN/TS 13001-3-2**

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Supersedes CEN/TS 13001-3-2:2004

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: Etats 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 5 February 2008 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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EUROPEAN COMMITTEE FOR STANDARDIZATION
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EUROPÄISCHES KOMITEE FÜR NORMUNG

**Management Centre: rue de Stassart, 36 B-1050 Brussels**



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# Contents

Page



Figures

**Tables**

## Foreword

This document (CEN/TS 13001-3.2:2008) has been prepared by Technical Committee CEN/TC 147 “Cranes — Safety”, the secretariat of which is held by BSI.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document will supersede CEN/TS 13001-3-2:2004.

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

This European Technical Specification is one part of EN 13001 and CEN/TS 13001, *Cranes — General design*. The other parts are:

*Part 1: General principles and requirements;*

*Part 2: Load actions;*

*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 3-5: Limit states and proof of competence of forged hooks*.



The following has been changed:

— 6.4.8, Rope type – the last paragraph has been changed and Table 8 has been added;

— Annex C has been updated.

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

# 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 to the essential health and safety requirements of the Machinery Directive, as amended. This Technical Specification 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 Technical Specification.

## 1 Scope

This Part 3-2 of the Technical Specification CEN/TS 13001 is 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.



Exceeding the limits of strength could result in risks to persons during normal use and foreseeable misuse. Clauses 5 to 6 of this Technical Specification are necessary to reduce or eliminate these risks.



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

NOTE 2 CEN/TS 13001-3-2 deals only with the limit state method in accordance with EN 13001-1.

## 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.

EN 1990:2002, *Eurocode: Basis of structural design*

EN 12385-2, *Steel wire ropes — Safety — Part 2: Definitions, designation and classification*

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 actions*

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 socket*

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 — Part 1: General*

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

## 3 Terms, definitions, symbols and abbreviations

### 3.1 Terms and definitions

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

### 3.2 Symbols and abbreviations

For the purposes of this document, 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 |
| $D_{\text{drum}}$ | Minimum pitch diameter of drum |
| $D_{\text{sheave}}$ | Minimum pitch diameter of sheave |
| $D_{\text{comp}}$ | Minimum pitch diameter of compensating sheave |
| $d$ | Rope diameter |
| $d_{\text{bearing}}$ | Diameter of bearing or shaft |
| $F_{\text{equ}}$ | Equivalent force |
| $F_{\text{gd}}$ | Part of $F_{equ}$ induced by gravity, exclusive of mass of payload, amplified by $\gamma_p$ |
| $F_{\text{gl}}$ | Part of $F_{equ}$ induced by gravity forces of mass of payload, amplified by $\gamma_p$ |
| $F_{\text{o}}$ | Part of $F_{equ}$ induced by any other forces, amplified by $\gamma_p$ |
| $F_{\text{Rd,s}}$ | Limit design rope force for the proof of static strength |
| $F_{\text{Rd,f}}$ | Limit design rope force for the proof of fatigue strength |
| $F_{\text{Sd,s}}$ | Design rope force for the proof of static strength |
| $F_r$ | Part of $F_{equ}$ induced by resistances, amplified by $\gamma_p$ |
| $F_{\text{Sd,f}}$ | Design rope force for the proof of fatigue strength |
| $F_{\text{t}}$ | Part of $F_{equ}$ induced by rope tightening forces, amplified by $\gamma_p$ |
| $F_{\text{u}}$ | Minimum rope breaking force |
| $F_{\text{w}}$ | Part of $F_{equ}$ induced by wind forces, amplified by $\gamma_p$ |
| $f_{\text{f}}$ | Factor of further influences |
| $f_{\text{f1}}$ | Factor of diameter ratio influence |
| $f_{\text{f2}}$ | Factor tensile strength of wire influence |
| $f_{\text{f3}}$ | Factor of fleet angle influence |
| $f_{\text{f4}}$ | Factor of lubrication influence |
| $f_{\text{f5}}$ | Factor of multilayer drum influence |

**Table 1** (*continued*)

| Symbols, abbreviations | Description |
|---|---|
| $f_{f6}$ | Factor of groove radius influence |
| $f_{f7}$ | Factor of rope type influence |
| $f_{S1}$ | 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 |
| $q$ | Normalized height distribution |
| $m_H$ | Mass of hoist load (see EN 13001-2) |
| $m_{Hr}$ | 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 |
| $R_r$ | Tensile strength level of wire |
| $r_g$ | Groove radius |
| $S_R$ | Class of rope force history |
| $s_r$ | Rope force history parameter |
| $t$ | Rope type factor |
| $t_{e,i}$ | Experimentally derived rope type factor for experiment $i$ |
| $t_e$ | Arithmetic mean of $t_{e,i}$ |
| $w$ | 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 |
| $z$, $z_i$, $z_{min}$, $z_{max}$, $z_{ref}$ | Height coordinates |
| $\alpha$ | Angle of slope |
| $\beta$, $\beta_{max}$ | Angles between falls and line of acting force |
| $\gamma$ | Angle between gravity and projected rope in plane of $F_h$ and $g$ |
| $\gamma_n$ | Risk coefficient |
| $\gamma_p$ | Partial safety factor |
| $\gamma_{rb}$ | Minimum rope resistance factor (static) |
| $\gamma_{rf}$ | Minimum rope resistance factor (fatigue) |
| $\delta$ | Design fleet angle |
| $\varepsilon$ | Angle between sheave planes |
| $\eta_s$ | Efficiency of single sheave |
| $\eta_{tot}$ | Total efficiency of rope drive |
| $\nu_r$ | Relative total number of bendings |
| $\phi$ | Dynamic factor for inertial or gravity effects |
| $\phi^*$ | Dynamic factor for inertial or gravity effects in fatigue |
| $\phi_2$ | Dynamic factor for hoisting an unrestrained grounded load |
| $\phi_5$ | Dynamic factor for loads caused by acceleration |
| $\phi_6$ | Dynamic factor for test load |
| $\omega$ | 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 Technical Specification 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 in accordance with 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 acceleration due to gravity (gravity constant);

$n_f$ is the number of falls carrying $m_{Hr}$;

$\phi$ 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;

$\gamma_p$ is the partial safety factor (see EN 13001-2):

$\gamma_p$ = 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);

$\gamma_n$ is the risk coefficient (see EN 13001-2), where applicable.

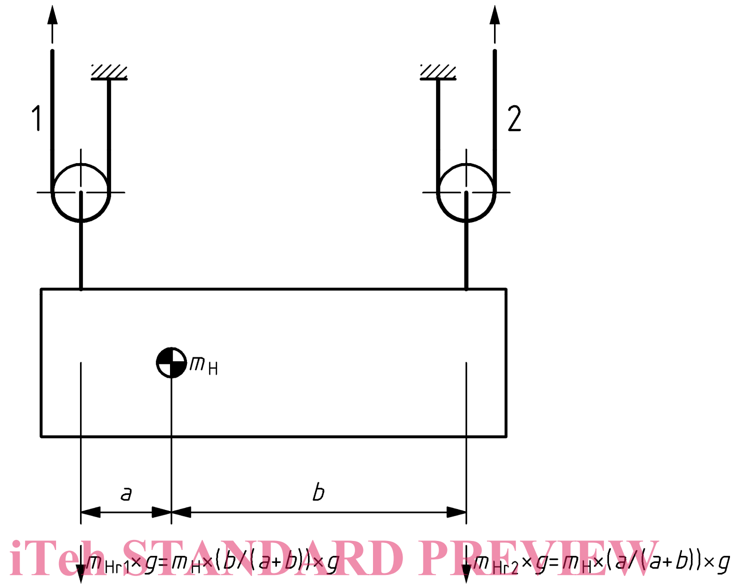




**Figure 1 — Example for the acting parts of hoist mass**



### 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 $\phi$., given in 5.2.2.2 to 5.2.2.4.

#### 5.2.2.2 Hoisting an unrestrained grounded load

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

where:

$\phi_2$ 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 hoist load

$$\phi = 1 + \phi_5 \cdot \frac{a}{g} \qquad (4)$$

where:

$\phi_5$ is the dynamic factor for loads caused by acceleration (see EN 13001-2);

$a$ is the vertical acceleration or deceleration;

$g$ is the acceleration due to gravity (gravity constant).

### 5.2.2.4 Test load

$$\phi = \phi_6 \qquad (5)$$

where:

$\phi_6$ is the dynamic factor for testload (see EN 13001-2).

### 5.2.3 Rope reeving efficiency

The rope force increasing factor from rope reeving efficiency $f_{S1}$ shall be calculated as follows:

$$f_{S1} = \frac{1}{\eta_{tot}} \qquad (6)$$

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

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



where:

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



NOTE Other values for ηS 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.

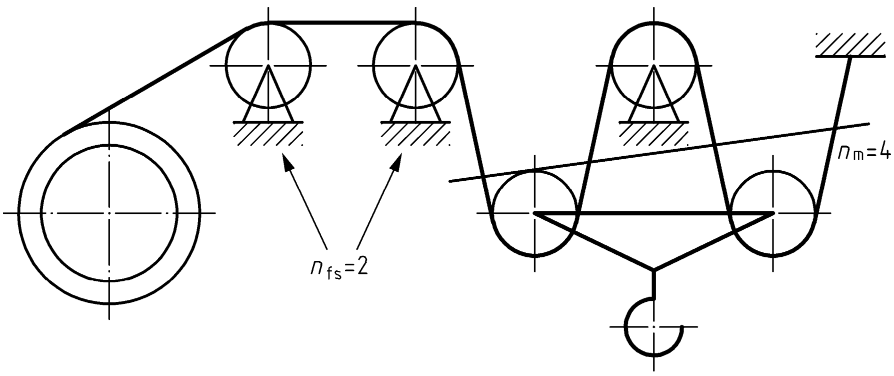


**Figure 2 — Example for Rope reeving efficiency**

### 5.2.4 Non parallel falls

When the rope falls are not parallel, the rope force is increased. The rope force increasing factor $f_{S2}$ shall be determined for the most unfavourable position. For simplification $f_{S2}$ may be calculated by