SLOVENSKI STANDARD

SIST EN 13001-2:2005+A3:2009

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Varnost dvigala (ġerjava) - Konstrukcija, sploġno - 2. del: Bremenski uļ inki

Crane safety - General design - Part 2: Load effects

Kransicherheit - Konstruktion allgemein - Teil 2: Lasteinwirkungen

Sécurité des appareils de levage à charge suspendue - Conception générale - Partie 2: Effets de charge

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EUROPEAN STANDARD

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English Version

Crane safety - General design - Part 2: Load effects

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This European Standard was approved by CEN on 2 March 2004 and includes Corrigendum 1 issued by CEN on 5 July 2006, Amendment 1 approved by CEN on 18 September 2006, Amendment 2 approved by CEN on 5 January 2009 and Amendment 3 approved by CEN on 16 May 2009.

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Contents

Foreword

This document (EN 13001-2:2004+A3:2009) has been prepared by Technical Committee CEN/TC 147 “Cranes — Safety”, the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by December 2009, and conflicting national standards shall be withdrawn at the latest by December 2009.

This European Standard was approved by CEN on 2 March 2004 and includes Corrigendum 1 issued by CEN on 5 July 2006, Amendment 1 approved by CEN on 18 September 2006, Amendment 2 approved by CEN on 5 January 2009 and Amendment 3 approved by CEN on 16 May 2009.

This document supersedes [A3⟩ EN 13001-2:2004+A2:2009 ⟨A3].

The start and finish of text introduced or altered by amendment is indicated in the text by tags [A1⟩ ⟨A1], [A2⟩ ⟨A2] and [A3⟩ ⟨A3].

The modifications of the related CEN Corrigendum have been implemented at the appropriate places in the text and are indicated by the tags [AC⟩ ⟨AC].

[A2⟩ This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EC Directive(s).

For relationship with EC Directive(s), see informative Annexes ZA and ZB, which are integral parts of this document. ⟨A2]

Annex A is normative, Annex B is informative.

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

Part 1: General principles and requirements

Part 2: Load actions

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

Part 3.2: Limit states and proof of competence of rope reeving components

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

Part 3.4: Limit states and proof of competence of machinery

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: 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 United Kingdom.

Introduction

This European Standard has been prepared to be a harmonised 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 European Standard is a type C standard as stated in the [AC) EN ISO 12100-1 (AC].

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

When provisions of this type C standard are different from those, which are stated in type A or B standards, the provisions of this type C standard take precedence over the provisions of the other standards, for machines that have been designed and built according to the provisions of this type C standard.

1 Scope

This European Standard is to be used together with Part 1 and Part 3 and as such they specify general conditions, requirements and methods to prevent hazards of cranes by design and theoretical verification. Part 3 is only at pre-drafting stage; the use of Parts 1 and 2 is not conditional to the publication of Part 3.

NOTE Specific requirements for particular types of crane are given in the appropriate European Standard 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. Clause 4 of this standard is necessary to reduce or eliminate the risks associated with the following hazards:

a) Rigid body instability of the crane or its parts (tilting and shifting).

b) Exceeding the limits of strength (yield, ultimate, fatigue).

c) Elastic instability of the crane or its parts (buckling, bulging).

d) Exceeding temperature limits of material or components.

e) Exceeding the deformation limits.

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

2 Normative references

This European Standard 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 European Standard only when incorporated in it by amendment or revision. For undated references the latest editions of the publication referred to applies (including amendments).

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

EN ISO 12100-2:2003, *Safety of machinery — Basic concepts, general principles for design — Part 2: Technical principles and specifications (ISO 12100-2:2003).*

[AC) *deleted text* (AC]

[AC) EN 1990:2002, *Eurocode — Basic of structural design* (AC].

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

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

3 Terms, definitions, symbols and abbreviations

3.1 Terms and definitions

For the purposes of this European Standard, the terms and definitions given in [AC) *deleted text* (AC], [AC) EN 1990:2002 (AC] and clause 6 of ISO 4306-1:1990 apply.

3.2 Symbols and abbreviations

For the purposes of this European Standard, the symbols and abbreviations given in Table 1 apply.

Table 1 — Symbols and abbreviations

Symbols, abbreviations	Description
A1 to A4	Load combinations including regular loads
A	Characteristic area of a crane member
A_g	Projection of the gross load on a plane normal to the direction of the wind velocity
A_c	Area enclosed by the boundary of a lattice work member in the plane of its characteristic height d
A_j	Area of an individual crane member projected to the plane of the characteristic height *d*
b_h	Width of the rail head
b	Characteristic width of a crane member
*B*1 to *B*5	Load combinations including regular and occasional loads
c	Spring constant
c_a, c_{oy}, c_{oz}	Aerodynamic coefficients
c_o	[AC> Aerodynamic coefficient <AC]
*C*1 to *C*9	Load combinations including regular, occasional and exceptional loads
CFF, *CFM*	Coupled wheel pairs of system F/F or F/M
d	Characteristic dimension of a crane member

Table 1 *(continued)*

Symbols, abbreviations	Description
d_i, d_n	Distance between wheel pair i or n and the guide means
e_G	Width of the gap of a rail
f	Friction coefficient
f_i	Loads
f_q	natural frequency
f_{rec}	Term used in calculating v(z)
F	Force
F, F_y, F_z	Wind loads
F_b	Buffer force
$\hat{F}$	Maximum buffer force
F_i, F_f	Initial and final drive force
ΔF	Change of drive force
F_{x1i}, F_{x2i}	Tangential wheel forces
F_{y1i}, F_{y2i}	
F_y	Guide force
F_{z1i}, F_{z2i}	Vertical wheel forces
F/F, *F/M*	Abbreviations for Fixed/Fixed and Fixed/Moveable, characterizing the possibility of lateral movements of the crane wheels
g	Gravity constant
h	Distance between instantaneous slide pole and guide means of a skewing crane
$h(t)$	Time-dependent unevenness function
h_s	Height of the step of a rail
$H1$, $H2$	Lateral wheel forces induced by drive forces acting on a crane or trolley with asymmetrical mass distribution
HC1 to HC4	Hoisting classes
*HD*1 to *HD*5	Classes of the type of hoist drive and its operation method
i	Serial number
IFF, IFM	Independent wheel pairs of system F/F or F/M
j	Serial number
k	Serial number
K	Drag-coefficient of terrain
$K1$, $K2$	Roughness factors
l	Span of a crane
l_a	Aerodynamic length of a crane member
l_o	Geometric length of a crane member
m_H	Mass of the gross or hoist load

Table 1 *(continued)*

Symbols, abbreviations	Description
m	Mass of the crane and the hoist load
Δm_H	Released or dropped part of the hoist load
$MDC1$, $MDC2$	Mass distribution classes
n	Number of wheels at each side of the crane runway
n_r	Exponent used in calculating γ_n
n_m	Exponent used in calculating the shielding factor η
p	Number of pairs of coupled wheels
q	Equivalent static wind pressure
$\overline{q}$	Mean wind pressure
$q(z)$	Equivalent static storm wind pressure
$q(3)$	Wind pressure at v (3)
r	Wheel radius
R	Stormwind recurrence interval
Re	Reynold number
s_g	Slack of the guide
s_y	Lateral slip at the guide means
s_{yi}	Lateral slip at wheel pair i
S	Load effect
$\hat{S}$	Maximum load effect
$S1$, $S2$	Stability classes
S_i, S_f	Initial and final load effects
ΔS	Change of load effect
t	Time
u	Buffer stroke
$\hat{u}$	Maximum buffer stroke
v	Travelling speed of the crane
$\overline{v}$	Constant mean wind velocity
$\overline{v}^*$	Constant mean wind velocity if the wind direction is not normal to the longitudinal axis of the crane member under consideration
$v(z)$	Equivalent static storm wind velocity
$v(z)^*$	Equivalent static storm wind velocity if the wind direction is not normal to the longitudinal axis of the crane member under consideration
$v(3)$	Gust wind velocity averaged of a period of 3 seconds
v_g	Three seconds gust amplitude
v_h	Hoisting speed
$v_{h,max}$	Maximum steady hoisting speed
$v_{h,CS}$	Steady hoisting creep speed

Table 1 *(continued)*

Symbols, abbreviations	Description
$v_m(z)$	Ten minutes mean storm wind velocity in the height z
v_{ref}	Reference storm wind velocity
w_b	Distance between the guide means
z	Height above ground level
$z(t)$	Time-dependent coordinate of the mass centre
α_r	Relative aerodynamic length
α_w	Angle between the direction of the wind velocity $\overline{v}$ or $v(z)$ and the longitudinal axis of the crane member under consideration
α	Skewing angle
α_g	Part of the skewing angle α due to the slack of the guide
α_G	Term used in calculating ϕ_4
α_s	Term used in calculating ϕ_4
α_t	Part of the skewing angle α due to tolerances
α_w	Part of the skewing angle α due to wear
β	Angle between horizontal plane and non-horizontal wind direction
β_2	Term used in calculating ϕ_2
β_3	Term used in calculating ϕ_3
γ_f	Overall safety factor
γ_m	Resistance coefficient
γ_n	Risk coefficient
γ_p	Partial safety factor
δ	Term used in calculating ϕ_1
ε_S	Conventional start force factor
ε_M	Conventional mean drive force factor
η	Shielding factor
η_W	Factor for remaining hoist load in out of service condition
λ	Aerodynamic slenderness ratio
μ, μ'	Parts of the span l
F	Term used in calculating the guide force F_y
F_{1i}, F_{2i}	Terms used in calculating F_{y1i} and F_{y2i}
ξ	Term used in calculating ϕ_7
ξ_{1i}, ξ_{2i}	Term used in calculating F_{x1i} and F_{x2i}
$\xi_G(\alpha_G)$, $\xi_s(\alpha_s)$	Curve factors
ρ	Density of the air
φ	Solidity ratio
ϕ_i	Dynamic factors

Table 1 *(concluded)*

Symbols, abbreviations	Description
ϕ_1	Dynamic factor for hoisting and gravity effects acting on the mass of the crane
ϕ_2	Dynamic factor for inertial and gravity effects by hoisting an unrestrained grounded load
ϕ_{2min}	Term used in calculating ϕ_2
ϕ_3	Dynamic factor for inertial and gravity effects by sudden release of a part of the hoist load
ϕ_4	Dynamic factor for loads caused by travelling on uneven surface
ϕ_5	Dynamic factor for loads caused by acceleration of all crane drives
ϕ_6	Dynamic factor for test loads
ϕ_7	Dynamic factor for loads due to buffer forces
ϕ_8	Gust response factor
ψ	Reduction factor used in calculating aerodynamic coefficients

4 Safety requirements and/or measures

4.1 General

Machinery shall conform to the safety requirements and/or measures of this clause. In addition, the machine shall be designed according to the principles of EN ISO 12100-1:2003 and EN ISO 12100-2:2003 for hazards relevant but not significant which are not dealt with by this document (e. g. sharp edges).

4.2 Loads

4.2.1 General

4.2.1.1 Introduction

The loads acting on a crane are divided into the categories of regular, occasional and exceptional as given in 4.2.1.2, 4.2.1.3 and 4.2.1.4. For the proof calculation of means of access loads only acting locally are given in [AC) 4.2.5 (AC].

These loads shall be considered in proof against failure by uncontrolled movement, yielding, elastic instability and, where applicable, against fatigue.

4.2.1.2 Regular loads

a) hoisting and gravity effects acting on the mass of the crane;

b) inertial and gravity effects acting vertically on the hoist load;

c) loads caused by travelling on uneven surface;

d) loads caused by acceleration of all crane drives;

e) loads induced by displacements.

Regular loads occur frequently under normal operation.

4.2.1.3 Occasional loads

a) loads due to in-service wind;

b) snow and ice loads;

c) loads due to temperature variation;

d) loads caused by skewing.

NOTE Occasional loads occur infrequently. They are usually neglected in fatigue assessment.

4.2.1.4 Exceptional loads

a) loads caused by hoisting a grounded load under exceptional circumstances;

b) loads due to out-of-service wind;

c) test loads;

d) loads due to buffer forces;

e) loads due to tilting forces;

f) loads caused by emergency cut-out;

g) loads caused by failure of mechanism or components;

h) loads due to external excitation of crane foundation;

i) loads caused by erection and dismantling.

NOTE Exceptional loads are also infrequent and are likewise usually excluded from fatigue assessment.

4.2.2 Regular loads

4.2.2.1 [A1⟩ Hoisting and gravity effects acting on the mass of the crane

When lifting the load off the ground or when releasing the load or parts of the load vibrational excitation of the crane structure shall be taken into account. The gravitational force induced by the mass of the crane or crane parts shall be multiplied by the factor ϕ_1. The masses of cranes or crane parts in class MDC1 (see 4.3.3) shall be multiplied by

$$\phi_1 = 1 + \delta, \quad 0 \le \delta \le 0{,}1 \qquad (1)$$

The value of δ depends on the crane structure and shall be specified.

The divisions of masses of crane parts in class MDC2 (see 4.3.3) shall be multiplied by

$$\phi_1 = 1 \pm \delta, \quad 0 \le \delta \le 0{,}05 \qquad (2)$$

depending on whether their gravitational acting is partly increasing (+δ) or decreasing (-δ) the resulting load effects in the critical points selected for the proof calculation.

The mass of the crane includes those components which are always in place during operation except for the net load itself. For some cranes or applications, it may be necessary to add mass to account for accumulation of debris. ⟨A1⟩

4.2.2.2 Inertial and gravity effects acting vertically on the hoist load

4.2.2.2.1 Hoisting an unrestrained grounded load

In the case of hoisting an unrestrained grounded load, the hereby induced vibrational effects shall be taken into account by multiplying the gravitational force due to the mass of the hoist load by a factor ϕ_2 (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 or chains etc.

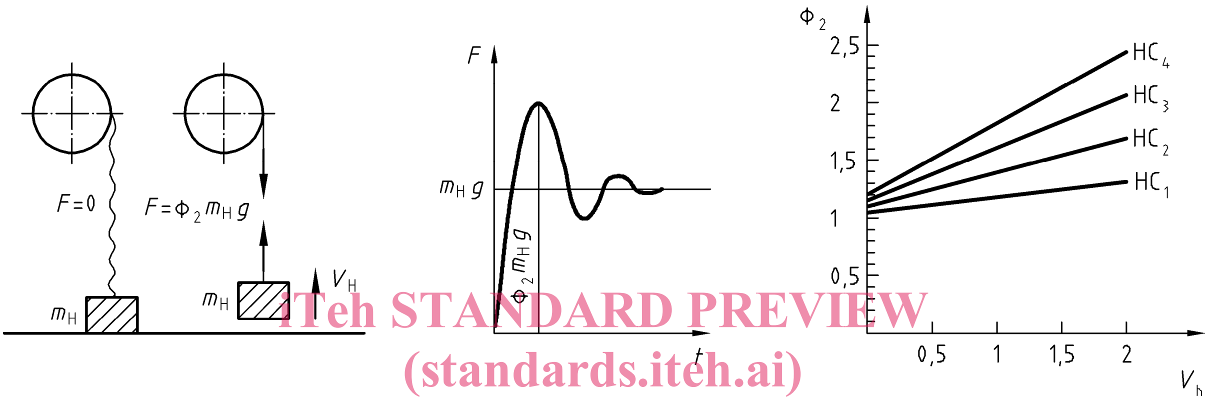

Figure 1 — Factor ϕ_2

The factor ϕ_2 shall be taken as follows:

$$\phi_2 = \Phi_{2,\min} + \beta_2 v_h \quad (3)$$

$\phi_{2,\min}$ and β_2 are given in Table 2 for the appropriate hoisting class. For the purposes of this standard, cranes are assigned to hoisting classes ranging from HC1 to HC4 according to their dynamic and elastic characteristics. HC1 requires a flexible structure and a drive system with smooth dynamic characteristics, whereas a rigid structure and a drive system with sudden speed changes imply HC4. The selection of hoisting classes depends on the particular type of cranes and is dealt with in the European Standards for specific crane types, see annex B. Equally, values of ϕ_2 can be determined by experiments or analysis without reference to hoisting class.

v_h is the steady hoisting speed, in meters per second, related to the lifting attachment. Values of v_h are given in Table 3.

Table 2 — Values of β_2 and ϕ_2,min

Hoisting class of appliance	β_2	$\phi_{2,\min}$
HC1	0,17	1,05
HC2	0,34	1,10
HC3	0,51	1,15
HC4	0,68	1,20

Table 3 — Values of v_h for estimation of ϕ_2

Load combination (see 4.3.6)	Type of hoist drive and its operation method				
	HD1	HD2	HD3	HD4	HD5
A1, B1	$v_{h,max}$	$v_{h,CS}$	$v_{h,CS}$	$0,5 \cdot v_{h,max}$	$v_h = 0$
C1	–	$v_{h,max}$	–	$v_{h,max}$	$0,5 \times v_{h,max}$

A3⟩ Where

HD 1: Creep speed is not available, or the start of the lift without creep speed is possible

HD 2: Start of the lift is only possible at creep speed

HD 3: Hoist drive control maintains a steady creep speed until the load is lifted off the ground

HD 4: Start of the lift is performed with continuously increasing speed

HD 5: Hoist drive control is automatic and ensures that the speed influence on the dynamic force is negligible ⟨A3

$v_{h,max}$ is the maximum steady hoisting speed;

$v_{h,CS}$ is the steady hoisting creep speed.

4.2.2.2.2 Sudden release of a part of the hoist load

For cranes that release a part of the hoist load as a normal working procedure, the peak dynamic action on the crane can be taken into account by multiplying the hoist load by the factor ϕ_3 (see Figure 2).

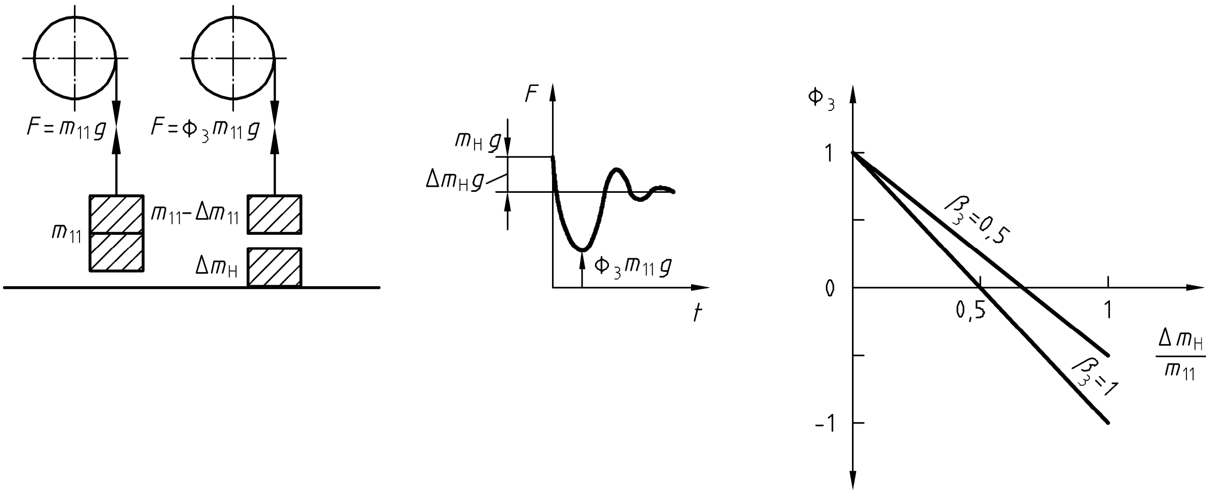

Figure 2 — Factor ϕ_3

The factor ϕ_3 shall be taken as follows:

$$\phi_3 = 1 - \frac{\Delta m_H}{m_H}(1 + \beta_3) \qquad (4)$$

where:

Δm_H is the released part of the hoist load;