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Varnost žerjava - Konstrukcija, splošno - 2. del: Učinki obremenitev

Crane safety - General design - Part 2: Load actions

Kransicherheit - Konstruktion allgemein - Teil 2: Lasteinwirkungen

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

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Crane safety - General design - Part 2: Load actions

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

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This European Standard was corrected and reissued by the CEN-CENELEC Management Centre on 21 April 2021.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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European foreword

This document (EN 13001-2:2021) has been prepared by Technical Committee CEN/TC 147 “Cranes — Safety”, the secretariat of which is held by DIN.

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of an identical text or by endorsement, at the latest by September 2021, and conflicting national standards shall be withdrawn at the latest by September 2021.

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

This document supersedes EN 13001-2:2014.

This document has been prepared under a standardization request given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this document.

CEN/TC 147 WG 2 has reviewed EN 13001-2:2014 to adapt the document to the technical progress, new requirements and changes in the document referred. The main topics and changes include:

— Cranes on vessels which are within the scope of the Directive 2016/1629/EU (Inland Waterway Vessels) and “European Standard laying down Technical Requirements for Inland Navigation vessels” (ES-TRIN:2019/1);

— Loads relevant to cranes on vessels were added;

— The clause on favourable/unfavourable masses and the clause on high risk applications including Annex D were modified;

— A new 4.3.6 for measured load effects was added;

— 4.3.8 on rigid body stability was modified;

— A new 4.2.1.5 added, on internal loads inside mechanisms;

— Requirements for loads on access ways were replaced by a reference to EN 13586:2004+A1:2008;

— Annex ZA has been revised.

This document is Part 2 of the EN 13001 series. The other parts are as follows:

— *Part 1: General principles and requirements*

— *Part 3-1: Limit states and proof of competence of steel structures*

— *Part 3-2: Limit states and proof of competence of wire ropes in reeving systems*

— *Part 3-3: Limit states and proof of competence of wheel/rail contacts*

— *Part 3-4: Limit states and proof of competence of machinery — Bearings*

— *Part 3-5: Limit states and proof of competence of forged hooks and cast hooks*

— *Part 3-6: Limit states and proof of competence of machinery — Hydraulic cylinders*

For the relationship with other European Standards for cranes, see Annex E.

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

This document 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 EU Directive 2006/42/EC (Machinery), as amended. This document also establishes interfaces between the user (purchaser) of the crane 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 document is a type C standard as stated in the EN ISO 12100.

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

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 document specifies load actions and load combinations for the calculation of load effects as basis for the proof of competence of a crane and its main components. It will be used together with the other generic parts of the EN 13001 series of standards, see Annex E. As such they specify conditions and requirements on design to prevent mechanical hazards of cranes and provide a method of verification of those requirements.

NOTE Specific requirements for particular types of crane are given in the appropriate European product standards for the particular crane type, see Annex E.

The following is a list of significant hazardous situations and hazardous events that could result in risks to persons during normal use and reasonably foreseeable misuse. Clause 4 of this document provides means to reduce or eliminate the risks of mechanical failures due to the following:

a) rigid body instability of the crane or its parts (tilting);

b) exceeding the limits of strength (yield, ultimate, fatigue);

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

The hazards covered by this document are identified by Annex G.

This document is not applicable to cranes that are manufactured before the date of its publication as EN.

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.

<std>EN 13001-1:2015, *Cranes — General design — Part 1: General principles and requirements*</std>

<std>EN 13586:2004+A1:2008, *Cranes — Access*</std>

<std>ISO 4306-1:2007, *Cranes — Vocabulary — Part 1: General*</std>

3 Terms and definitions, symbols and abbreviations

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 4306-1:2007, Clause 6 and the following apply.

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

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

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

3.1.1
hoist load
sum of the masses suspended from the crane, taken as the sum of payload, the fixed and non-fixed load lifting attachments and the suspended portion of the hoist medium

Note 1 to entry: “hoist load” is equivalent to “gross load” as defined in ISO 4306-1:2007.

3.1.2
single failure proof system
force carrying arrangement of several components, arranged so that in case of a failure of any single component in the arrangement, the capability to carry the force is not lost

3.1.3
vessel
floating installation the crane is mounted on

Note 1 to entry: The above definition is limited to vessels which are within the scope of the EU Directive 2016/1629 EU (Inland Waterway Vessels).

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
A1 to A4	Load combinations including regular loads
A	Characteristic area of a crane member
A_g	Projection of the hoist 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
B1 to B5	Load combinations including regular and occasional loads
c	Spring constant
c_o, c_a, c_{oy}, c_{oz}	Aerodynamic coefficients
C1 to C11	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
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 in general

Symbols, abbreviations	Description
F, F_y, F_z	Wind loads
$\hat{F}$	Maximum buffer force
F_i, F_f	Initial and final drive force
ΔF	Change of drive force
$F_{x1i}, F_{x2i}, F_{y1i}, F_{y2i}$	Tangential wheel forces
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	Acceleration due to gravity
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
H_1, H_2	Lateral wheel forces induced by drive forces acting on a crane or trolley with asymmetrical mass distribution
HC1 to HC4	Stiffness classes
HD1 to HD5	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
K_1, K_2	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 hoist load
m	Mass of the crane and the hoist load
Δm_H	Released or dropped part of the hoist load
n	Number of wheels at each side of the crane runway
n_m	Exponent used in calculating the shielding factor η
p	Number of pairs of coupled wheels

Symbols, abbreviations	Description
q	Equivalent static wind pressure
$\bar{q}$	Mean wind pressure
$q(z)$	Equivalent static storm wind pressure
$q(3)$	Wind pressure at $v(3)$
r	Wheel radius
R	Out-of-service wind 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
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
$\bar{v}$	Constant mean wind velocity
$\bar{v}^*$	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
$v_m(z)$	Ten minutes mean storm wind velocity in the height z
v_{ref}	Reference storm wind velocity
w_b	Distance between the guide means

Symbols, abbreviations	Description
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 $\bar{v}$ 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, α_s	Terms 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
γ_s	Additional safety factor for stability
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

Symbols, abbreviations	Description
φ	Solidity ratio
ϕ_i	Dynamic factors
ϕ_1	Dynamic factor acting on the mass of the crane
ϕ_2	Dynamic factor on hoist load when hoisting an unrestrained grounded load in regular operation
ϕ_{2C}	Dynamic factor on hoist load when hoisting an unrestrained grounded load under exceptional conditions
$\phi_{2,min}$	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
ϕ_L, ϕ_{ML}	Factors for calculation of force in case the load or moment limiter is activated
ψ	Reduction factor used in calculating aerodynamic coefficients

4 Safety requirements and/or measures

4.1 General

Loads and load combinations, as given in 4.2 and 4.3, shall only be applied as relevant for specified configurations and operational conditions of the crane.

The load actions shall be taken into account in proofs against failure by uncontrolled movement, yielding, elastic instability and, where applicable, against fatigue.

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. Combinations of regular, occasional and exceptional loads into load combinations A, B and C are given in 4.3.

Internal loads inside mechanisms are mentioned in 4.2.1.5 and should be considered where relevant.

4.2.1.2 Regular loads

Regular loads are those loads that occur frequently under normal operation.

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;

f) loads due to vessel inclinations and motions.

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.

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 due to dynamic cut-off by lifting force limiting device;

h) loads due to dynamic cut-off by lifting moment limiting device;

i) loads due to unintentional loss of hoist load;

j) loads caused by failure of mechanism or components;

k) loads due to external excitation of crane support;

l) loads caused by erection and dismantling;

m) loads due to vessel inclinations and motions while the crane is in stowage position.

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

4.2.1.5 Internal loads inside mechanisms

Load effects in drive mechanisms shall be derived both from the global, external load actions on the crane and from the internal loads inside the mechanisms. The latter depend on one hand on the arrangement of the mechanism and on the other hand on the physical quantities determining the internal load effects, e.g.:

— brake torques;

— inertia of rotating components;

— friction in driving contacts.

Special consideration shall be given to internal load effects in mechanisms due to exceptional loads given in 4.2.4, such as:

— 4.2.4.4, buffer forces;

— 4.2.4.7, emergency cut-out;

— 4.2.4.8, dynamic cut-off by lifting force limiter;

— 4.2.4.9, dynamic cut-off by lifting moment limiter;

— 4.2.4.11, apprehended failure of duplicated mechanism.

Special consideration should be given to rotating components that might be subjected to fatigue from this internal loading.

4.2.2 Regular loads

4.2.2.1 Mass of the crane

When lifting the load off the ground or when releasing the load or parts of the load, the crane structure is under effect of vibration excitation, which shall be taken into account as a load effect. The gravitational force induced by the mass of the crane or crane part shall be multiplied by the factor ϕ_1. Dependent upon the gravitational load effect of the mass and load combination in question, the factor ϕ_1 is calculated in accordance with either Formula (1) or (2). For definitions of unfavourable and favourable load effects see 4.3.3.

The gravitational load effect of the mass is unfavourable, Formula (1) applies:

$$\phi_1 = 1 + \delta \text{ with } 0 \leq \delta \leq 0{,}1 \quad (1)$$

The gravitational load effect of the mass is favourable, Formula (2) applies:

$$\phi_1 = 1 - \delta \text{ with } 0 \leq \delta \leq 0{,}05 \quad (2)$$

The maximum values of δ from the Formulae (1) and (2) shall be used unless other values are justified by measurements, calculations or obtained from the appropriate European Standard for the particular type of crane.

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 is necessary to add mass to account for accumulation of debris.