SLOVENSKI STANDARD
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Žerjavi - Konstrukcija, splošno - 3-1. del: Mejna stanja in dokaz varnosti jeklene nosilne konstrukcije

Cranes - General design - Part 3-1: Limit states and proof competence of steel structure

Krane - Konstruktion allgemein - Teil 3-1: Grenzzustände und Sicherheitsnachweis von Stahltragwerken

Appareils de levage à charge suspendue - Conception générale - Partie 3-1 : Etats limites et vérification d'aptitude des charpentes en acier

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This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee CEN/TC 147.

If this draft becomes a European Standard, CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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

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European foreword

This document (prEN 13001-3-1:2022) has been prepared by Technical Committee CEN/TC 147 “Cranes - Safety”, the secretariat of which is held by DIN.

This document is currently submitted to the CEN Enquiry.

This document will supersede EN 13001-3-1:2012+A2:2018.

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 13001-3-1:2012+A2:2018 to adapt the document to technical progress. The main changes are:

— Design values for bolt materials were changed (Table 5);

— Limit design values for welded connection were changed (5.2.5);

— Static proof of welded connections was changed (5.3.4 and Annex C);

— Proof of fatigue strength was revised to include additional modern methods (6.1);

— Fatigue strength specific resistance factors were modified (Table 9);

— The geometric stress (Hot Spot) method was added (6.2.4 and Annex I);

— The effective notch method was added (6.2.5);

— Lateral torsional stability of beams was added (8.4 and 8.5.3 and Annex J);

— Recommended tightening torques for preloaded bolts were modified (Annex B);

— Characteristic fatigue strengths for plates in shear were modified (Table D.1);

— Annex L with a list of hazards was inserted;

— Annex ZA was significantly revised.

This European Standard is one part of the EN 13001 series of standards. The other parts are:

— Part 1: General principles and requirements;

— Part 2: Load actions;

— 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;

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

— Part 3-6: Limit states and proof of competence of hydraulic cylinders.

This European Standard is intended to be used together with EN 13001-2:2021 as well as pertinent crane type product EN standards, see Annex K.

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 Machinery Directive, as amended.

This document is a type-C standard as stated in EN ISO 12100:2010.

This document is of relevance, in particular, for the following stakeholder groups representing the market players with regard to machinery safety:

— machine manufacturers (small, medium and large enterprises);

— health and safety bodies (regulators, accident prevention organizations, market surveillance, etc.).

Others can be affected by the level of machinery safety achieved with the means of the document by the above-mentioned stakeholder groups:

— machine users/employers (small, medium and large enterprises);

— machine users/employees (e.g. trade unions, organizations for people with special needs);

— service providers, e.g. for maintenance (small, medium and large enterprises);

— consumers (in case of machinery intended for use by consumers).

The above-mentioned stakeholder groups have been given the possibility to participate in the drafting process of this document.

The machinery concerned and the extent to which hazards, hazardous situations or hazardous events 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 limit states, requirements and methods to prevent mechanical hazards in steel structures of cranes by design and theoretical proof of competence.

The significant hazardous situations and hazardous events that could result in risks to persons during intended use are identified in Annex L. Clauses 4 to 8 of this document provide requirements and methods to reduce or eliminate these risks:

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

b) exceeding temperature limits of material or components;

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

This document is not applicable to cranes which are designed before the date of its publication as EN and serves as reference base for the European Standards for particular crane types (see Annex K).

NOTE This document deals only with the limit state method in accordance with EN 13001-1:2015.

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.

EN 1993-1-8:2005, *Eurocode 3: Design of steel structures - Part 1-8: Design of joints*

EN 10025-2:2019, *Hot rolled products of structural steels - Part 2: Technical delivery conditions for non-alloy structural steels*

EN 10025-3:2019, *Hot rolled products of structural steels - Part 3: Technical delivery conditions for normalized/normalized rolled weldable fine grain structural steels*

EN 10025-4:2019, *Hot rolled products of structural steels - Part 4: Technical delivery conditions for thermomechanical rolled weldable fine grain structural steels*

EN 10025-6:2019, *Hot rolled products of structural steels - Part 6: Technical delivery conditions for flat products of high yield strength structural steels in the quenched and tempered condition*

EN 10029:2010, *Hot-rolled steel plates 3 mm thick or above - Tolerances on dimensions and shape*

EN 10088-2:2014, *Stainless steels - Part 2: Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for general purposes*

EN 10149-2:2013, *Hot rolled flat products made of high yield strength steels for cold forming - Part 2: Technical delivery conditions for thermomechanically rolled steels*

EN 10149-3:2013, *Hot rolled flat products made of high yield strength steels for cold forming - Part 3: Technical delivery conditions for normalized or normalized rolled steels*

EN 10160:1999, *Ultrasonic testing of steel flat product of thickness equal or greater than 6 mm (reflection method)*

EN 10163-1:2004, *Delivery requirements for surface condition of hot-rolled steel plates, wide flats and sections - Part 1: General requirements*

EN 10163-2:2004, *Delivery requirements for surface condition of hot-rolled steel plates, wide flats and sections - Part 2: Plate and wide flats*

EN 10163-3:2004, *Delivery requirements for surface condition of hot-rolled steel plates, wide flats and sections - Part 3: Sections*

EN 10164:2018, *Steel products with improved deformation properties perpendicular to the surface of the product - Technical delivery conditions*

EN 13001-1:2015, *Cranes - General design - Part 1: General principles and requirements*

EN 13001-2:2021, *Crane safety - General design - Part 2: Load actions*

EN 20273:1991, *Fasteners - Clearance holes for bolts and screws (ISO 273:1979)*

EN ISO 148-1:2016, *Metallic materials - Charpy pendulum impact test - Part 1: Test method (ISO 148-1:2016)*

EN ISO 286-2:2010, *Geometrical product specifications (GPS) - ISO code system for tolerances on linear sizes - Part 2: Tables of standard tolerance classes and limit deviations for holes and shafts (ISO 286-2:2010)*

EN ISO 898-1:2013, *Mechanical properties of fasteners made of carbon steel and alloy steel - Part 1: Bolts, screws and studs with specified property classes - Coarse thread and fine pitch thread (ISO 898-1:2013)*

EN ISO 5817:2014, *Welding - Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) - Quality levels for imperfections (ISO 5817:2014)*

EN ISO 9013:2017, *Thermal cutting - Classification of thermal cuts - Geometrical product specification and quality tolerances (ISO 9013:2017)*

EN ISO 12100:2010, *Safety of machinery - General principles for design - Risk assessment and risk reduction (ISO 12100:2010)*

EN ISO 17659:2004, *Welding - Multilingual terms for welded joints with illustrations (ISO 17659:2002)*

ISO 4306-1:2007, *Cranes - Vocabulary - Part 1: General*

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 12100:2010 apply. For the definitions of loads, Clause 6 of ISO 4306-1:2007 applies.

ISO and IEC maintain terminological 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/

3.2 Symbols and abbreviations

The symbols and abbreviations used in this document are given in Table 1.

Table 1 — Symbols and abbreviations

Symbols, abbreviations	Description
A	cross section
A_n	net cross section
A_S	stress area of a bolt
A_S	shear area of the tear-out section (pinned connections)
a	length of plate in buckling
a	throat thickness of fillet welds
a_r	effective weld thickness
b	width of plate
c	edge stress ratio factor (buckling)
D_o, D_i	outer, inner diameter of hollow pin
d	diameter (shank of bolt, pin)
d_o	diameter of hole
E	modulus of elasticity
F_b	tensile force in bolt
F_d	limit force
F_k	characteristic value (force)
F_p	preloading force in bolt
F_{Rd}	limit design force
$F_{e,t}$	external tensile force on bolted connection
$F_{b,\,Rd}$	limit design bearing force
$F_{b,\,Sd}$; $F_{bi,\,Sd}$	design bearing force
$F_{cs,\,Rd}$	limit design tensile force
$F_{p,\,d}$	design preloading force
F_{cr}	reduction in compression force due to external tension
$F_{t,\,Rd}$	limit design tensile force in bolt
$F_{t,Sd}$	external tensile force per bolt
$F_{v,\,Sd}$	design shear force per bolt and shear plane
$F_{vp,\,Rd}$	limit design shear force per pin and shear plane
$F_{vp,\,Sd}$	design shear force per pin and shear plane
$F_{s,Rd}$	limit design slip force per bolt and shear plane

Symbols, abbreviations	Description
$F_{vs,\,Rd}$	limit design shear force of the connected part
$F_{vd,\,Sd}$	design force in the connected part
$F_{vt,\,Rd}$	limit design tensile force of the connected part
$F_{\sigma,\tau}$	acting normal/shear force
f	maximum imperfection
f_d	limit stress
f_k	characteristic value (stress)
f_{Rd}	limit design stress
f_u	ultimate strength of material
f_{ub}	ultimate strength of bolts
$f_{w,\,Rd}$	limit design weld stress
$f_{w,\,Rd,1}$	limit design weld stress with respect to the weld material
$f_{w,\,Rd,2}$	limit design weld stress with respect to the material of the connected members
f_y	yield stress of material, specified or measured
f_{yb}	yield stress of bolts
f_{yp}	yield stress of pins, specified or measured
h_d	distance between weld and contact level of acting load
I, I_i	moments of inertia of members
k	stress concentration factor (pinned connections)
K_b	stiffness of bolt
K_c	stiffness of connected parts
k^*	specific spectrum ratio factor
k_m	stress spectrum factor based on m of the detail under consideration
k_3	stress spectrum factor based on m = 3
$k_{\sigma x}$, $k_{\sigma y}$, k_τ	buckling factors
L	element length (buckling)
l_m	gauge length
l_r	relevant weld length
l_W	weld length
M_{Rd}	limit design bending moment
M_{Sd}	design bending moment
m	slope constant of log Δσ/log N-curve
N	compressive force (buckling)

Symbols, abbreviations	Description
NC	notch class
N_k	critical buckling load
N_{ref}	reference number of cycles
$min\ \sigma$, $max\ \sigma$	extreme values of stresses
P_S	probability of survival
p	penetration of weld
Q	shear (evaluation of stress cycles)
q_i	impact toughness parameter
α	cross section parameter (lateral buckling)
α_b	characteristic factor for bearing connection
α_L	load introduction factor (bolted connection)
α_w	characteristic factor for limit weld stress
γ_m	general resistance factor
γ_{mf}	fatigue strength specific resistance factor
γ_p	partial safety factor
γ_R	resulting resistance factor
γ_S	specific resistance factor
γ_{Rb}	resulting resistance factor of bolt
γ_{sbb}, γ_{sbs}, γ_{sbt}	specific resistance factors of bolted connections
γ_{Rm}	resulting resistance factor of members
γ_{sm}	specific resistance factor of members
γ_{Rp}	resulting resistance factor of pins
γ_{spm}, γ_{sps}, γ_{spb}, γ_{spt}	specific resistance factors of pins
γ_{Rs}	resulting resistance factor of slip-resistance connection
γ_{ss}	specific resistance factor of slip-resistance connection
γ_{Rc}	resulting resistance factor for tension on section with holes
γ_{st}	specific resistance factor for tension on section with holes
γ_{Rw}	resulting resistance factor of welding connection
γ_{sw}	specific resistance factor of welding connection
δ_p	elongation from preloading
ϕ_2	dynamic factor
κ	dispersion angle (wheel pressure)
κ, κ_x, κ_y, κ_τ	reduction factors (buckling)

Symbols, abbreviations	Description
λ	width of contact area in weld direction
$\lambda_x, \lambda_y, \lambda_\tau$	non-dimensional plate slenderness (buckling)
Ψ	edge stress ratio (buckling)
ΔF_b	additional force
$\Delta \delta_t$	additional elongation
μ	slip factor
ν	relative total number of stress cycles
ν_D	ratio of diameters
$\Delta\sigma_c$	characteristic value of stress range (normal stress)
$\Delta\tau_c$	characteristic value of stress range (shear stress)
σ_e	reference stress (buckling)
σ_b	lower extreme value of stress range
σ_u	upper extreme value of stress range
σ_{Sd}	design stress (normal)
τ_{Sd}	design stress (shear)
$\sigma_{w,Sd}$	design weld stress (normal)
$\tau_{w,Sd}$	design weld stress (shear)
$\Delta\sigma_{Rd}$	limit design stress range (normal)
$\Delta\sigma_{Rd,1}$	limit design stress range for k* = 1
$\Delta\tau_{Rd}$	limit design stress range (shear)
$\Delta\sigma_{Sd}$	design stress range (normal)
$\Delta\tau_{Sd}$	design stress range (shear)

4 General

4.1 Documentation

The documentation of the proof of competence shall include:

— design assumptions including calculation models,

— applicable loads and load combinations,

— material grades and qualities,

— weld quality levels, in accordance with EN ISO 5817:2014,

— materials of connecting elements,

— relevant limit states,

— results of the proof of competence calculation and tests when applicable.

4.2 Materials for structural members

4.2.1 Grades and qualities

For structural members, steels in accordance with the following European Standards shall be used:

a) Non-alloy structural steels EN 10025-2:2019;

b) Weldable fine grain structural steels in conditions:

1) normalized (N) EN 10025-3:2019;

2) thermomechanical (M) EN 10025-4:2019;

c) High yield strength structural steels in the quenched and tempered condition EN 10025-6:2019;

d) High yield strength steels for cold forming in conditions:

1) thermomechanical (M) EN 10149-2:2013;

2) normalized (N) EN 10149-3:2013.

e) Austenitic stainless steels EN 10088-2:2014.

Alternatively, grades and qualities other than those mentioned in the above standards and in Table 2 may be used, if the mechanical properties and the chemical composition are specified in a manner corresponding to relevant European standard, and the following conditions are fulfilled:

— the design value of f_y is limited to $f_u/1{,}05$ for materials with $f_u/f_y < 1{,}05$;

— the percentage elongation at fracture $A \geq 7\ \%$ on a gauge length $L_0 = 5{,}65 \times \sqrt{s_0}$ (where S_0 is the original cross-sectional area);

— the weldability or non-weldability of the material is specified and, if intended for welding, weldability is demonstrated;

— if the material is intended for cold forming, the pertinent parameters are specified.

Where stainless steels are welded, special attention should be given to the welding process and corrosion effects. Only austenitic stainless steels are covered by this standard.

Table 2 shows specific values for the nominal value of strength f_u, f_y. For limit design stresses f_{Rd} see 5.2. The values given are applicable for temperatures up to 100 °C for stainless steels and up to 150 °C for all other steels. For more information see the specific European Standard.

To allow the use of nominal values of plate thicknesses in the proof calculations, the minus tolerance of the plate shall be equal or better than that of class A of EN 10029:2010. Otherwise, the actual minimum value of plate thickness shall be used. Nominal dimensions for other steel products than plates may be used, provided those products comply with their standardized minus tolerances.

Where it is deemed necessary to check for internal defects, classes of EN 10160:1999 should be specified.