SLOVENSKI STANDARD
oSIST prEN 13001-3-8:2022

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Žerjavi - Konstrukcija, splošno - Mejna stanja in dokaz varnosti mehanizma - 3-8. del: Gredi

Cranes - General design - Limit states and proof competence of machinery - Part 3-8: Shafts

Krane - Konstruktion allgemein - Teil 3-8: Grenzzustände und Sicherheitsnachweise für Maschinenbauteile - Wellen

Appareils de levage à charge suspendue - Conception générale - Partie 3-8 : États limites et vérification d'aptitude des éléments de mécanismes - Arbres

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ICS:

21.120.10	Gredi	Shafts
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Cranes - General design - Limit states and proof competence of machinery - Part 3-8: Shafts

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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 13001-3-8:2021) 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 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.

This European Standard is one part of the EN 13001 series. 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 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*

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

— *Part 3-7: Limit states and proof of competence of machinery — Gears*

1 Scope

This document is intended to be used together with the other generic parts of the EN 13001 series of standards, see Annex C, and as such, they specify general conditions, requirements and methods to prevent mechanical hazards of cranes by design and theoretical verification.

Specific requirements for particular types of cranes are given in the appropriate European standard for the particular crane type.

This document covers specific shafts and rotating or non-rotating axles as an integrated part of cranes, that are not dealt with by other EN 13001 standards (e.g. pinned connections in EN 13001-3-1). It is not applicable to shafts or axles being part of standard equipment (e.g. gearboxes, motors).

The significant hazardous situations and hazardous events that could result in risks to persons during intended use and reasonably foreseeable misuse are identified by Annex D. Clauses 4 to 7 of this document are necessary to reduce or eliminate these risks.

Clauses 4 to 7 of this document are necessary to reduce or eliminate these risks associated with the following hazards:

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

— exceeding temperature limits of material or components.

This standard does not deal with the proofs of strength of welded and cast shafts.

This document is not applicable to cranes that are manufactured before the date of its publication as EN and serves as reference base for the European standards for particular crane types (see Annex C).

NOTE prEN 13001-3-8:2021 deals only with 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 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 10088-3:2014, *Stainless steels - Part 3: Technical delivery conditions for semi-finished products, bars, rods, wire, sections and bright products of corrosion resisting steels for general purposes*

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 13001-3-1:2012+A2:2018, *Cranes - General Design - Part 3-1: Limit States and proof competence of steel structure*

EN 13001-3-4:2018, *Cranes - General design - Part 3-4: Limit states and proof of competence of machinery - Bearings*

EN ISO 683-1:2018, *Heat-treatable steels, alloy steels and free-cutting steels - Part 1: Non-alloy steels for quenching and tempering (ISO 683-1:2016)*

EN ISO 683-2:2018, *Heat-treatable steels, alloy steels and free-cutting steels - Part 2: Alloy steels for quenching and tempering (ISO 683-2:2016)*

EN ISO 683-3:2019, *Heat-treatable steels, alloy steels and free-cutting steels - Part 3: Case-hardening steels (ISO 683-3:2019)*

EN ISO 683-5:2021, *Heat treatable steels, alloy steels and free-cutting steels - Part 5: Nitriding steels (ISO 683-5:2017)*

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

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

3 Terms and 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 and the following apply. For the definitions of loads, ISO 4306-1:2007, Clause 6 applies.

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

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

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

3.1.1
shaft
cylindrical rotating rod for the transmission of motion or power and on which are fixed parts for the transmission of motion or power

3.1.2
axle
spindle on which a component (e.g. wheel, sheave) revolves or which rotates with a component (or components) attached to it

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_v	Minimum impact toughness
b	Fatigue strength exponent, for a material (ε-N method)
bp	Fatigue strength exponent, for a component (ε-N method)
c	Fatigue ductility exponent, for a material (ε-N method)
C	Total number of working cycles (see EN 13001-1:2015)
cp	Fatigue ductility exponent, for a component (ε-N method)
D_{Sd}	Design fatigue damage
D_{Rd}	Limit design fatigue damage
d	Diameter
d_{equ}	Equivalent diameter
E	Modulus of elasticity
$f_{Rd,\sigma}$	Limit design normal stress
$f_{Rd,\tau}$	Limit design shear stress
f_u	Ultimate strength of material
f_y	Yield strength of material
f_1	Notch factor
f_2	Size factor
f_3	Surface roughness factor
f_4	Surface treatment factor
K'	Factor of cyclic resistance (ε-N method)
K_t	Stress concentration factor
k_m	Stress spectrum factor (see EN 13001-1:2015)
k_s	Shaft stress spectrum factor
l_s	Design number of shaft sets
m_σ	Inverse slope of σ/N-curve (or S-N curve) for normal stresses
m_τ	Inverse slope of σ/N-curve (or S-N curve) for shear stresses
m'	Second inverse slope of σ/N-curve
n_i	Number of stress cycles, of range i
n'	Cyclic strain-hardening exponent (ε-N method)
$\hat{n}$	Total number of stress cycles (see EN 13001-1:2015)
N_{fi}	Number of stress cycles to failure, for stress of range i

Symbols, abbreviations	Description
N; N_f	Number of stress cycles to failure
N_{Ref}	Reference number of stress cycles
r	Notch radius
R	Stress ratio
R_d	Design resistance
R_a	Average depth of surface profile according to EN ISO 4287:1998
S_d	Design stress or design force
s_s	Shaft stress history parameter
T	Operation temperature
z	Adaptation factor
$\varepsilon_f^{'}$	Fatigue ductility factor (ε-N method)
ε_a	Total strain amplitude (ε-N method)
ε_{ae}	Elastic strain amplitude (ε-N method)
ε_{ap}	Plastic strain amplitude (ε-N method)
$\varepsilon_{e,a}$	Amplitude of elastic strain (ε-N method)
$\varepsilon_{e,loc}$	Elastic local strain value (ε-N method)
ε_r	Real strain value (ε-N method)
$\varepsilon_{r,a}$	Amplitude of strain value (ε-N method)
$\varepsilon_{r,i}$	Amplitude of strain value, of range i (ε-N method)
$\varepsilon_{r,loc}$	Real local strain value (ε-N method)
γ_{ff}	Safety factor for fatigue
γ_m	General resistance factor
γ_{Mf}	Fatigue strength specific resistance factor
γ_p	Partial safety factor (see EN 13001-2:2021)
γ_{Rm}	Resulting resistance factor
γ_{sm}	Specific resistance factor
υ_s	Relative total number of stress cycles
$\sigma_{a,i}$	Design stress amplitude
$\hat{\sigma}_{a,i}$	Maximal design stress amplitude
$\sigma_{d,ref}$	Material fatigue strength (normal stress)
σ_d	Component fatigue strength (normal stress)

Symbols, abbreviations	Description
σ_{dtr}	Alternating fatigue strength (normal stress)
$\sigma_{e,loc}$	Elastic local stress (ε-N method)
$\sigma_{e,nom}$	Nominal elastic stress (ε-N method)
$\sigma_{eq,e,loc,m}$	Mean equivalent elastic local stress (ε-N method)
$\sigma_{eq,e,loc,a}$	Amplitude of equivalent elastic local stress (ε-N method)
$\sigma_{eq,e,loc,max}$	Maximal equivalent elastic local stress (ε-N method)
$\sigma_{eq,e,loc,min}$	Minimal equivalent elastic local stress (ε-N method)
σ_{eq}	Equivalent normal stress
$\sigma_{eq,a}$	Amplitude of equivalent normal stress
$\sigma_{f}^{'}$	Fatigue resistance factor (ε-N method)
σ_{m}	Mean stress
$\sigma_{r,a}$	Amplitude of real local stress (ε-N method)
$\sigma_{r,loc}$	Real local stress (ε-N method)
$\sigma_{r,m}$	Mean real local stress (ε-N method)
$\sigma_{Rd,f}$	Limit design normal stress for fatigue
σ_{Sd}	Design normal stress
$\sigma_{Sd,f}$	Design normal stress for fatigue
$\sigma_{Sd,eq}$	Equivalent design normal stress
$\tau_{Rd,f}$	Limit design shear stress for fatigue
τ_{Sd}	Design shear stress

4 General

4.1 Documentation

The documentation of the proof of competence shall include:

— design assumptions;

— applicable loads and load combinations;

— material grades and qualities;

— relevant limit states;

— results of the proof of competence calculations and, when applicable, tests.

4.2 Materials

4.2.1 Grades and qualities for shafts

European and International Standards specify materials and specific values. This document gives a preferred selection of materials with their mechanical properties.

For shafts, steel in accordance with following European Standards shall be used, alternatively grades and qualities other than those mentioned in the above standards may be used if the mechanical properties and the chemical composition are specified in a manner corresponding to relevant European standards:

— steels for quenching and tempering (see Table 2):

  — non alloy steels: EN ISO 683-1:2018;

  — alloy steels: EN ISO 683-2:2018;

— structural steels (see Table 2);

  — non-alloy structural steels: EN 10025-2:2019;

  — weldable fine grain structural steels in conditions:

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

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

— stainless steels (see Table 2);

  — semi-finished (bars, rods …): EN 10088-3:2014;

— steels with heat treatment;

  — case hardening: EN ISO 683-3:2019;

  — nitriding (see Table 2): EN ISO 683-5:2021.

Table 2 shows specific values for the nominal value of strength f_u, f_y. For more information see the specific European standards listed above.

Table 2 — Specific values of a selection of steels

Steels for quenching and tempering, in the quenched and tempered condition (+QT)				
Steel	**Standard**	**Diameter d/Thickness t** mm	**Nominal strength**	
			f_y **Yield** N/mm²	f_u **Ultimate** N/mm²
C22E	EN ISO 683-1:2018	$d \leq 16$ or $t \leq 8$	340	500
C22R		$16 < d \leq 40$ or $8 < t \leq 20$	290	470
C35E		$d \leq 16$ or $t \leq 8$	430	630
C35R		$16 < d \leq 40$ or $8 < t \leq 20$	380	600
C35		$40 < d \leq 100$ or $20 < t \leq 60$	320	550
C40E		$d \leq 16$ or $t \leq 8$	460	650
C40R		$16 < d \leq 40$ or $8 < t \leq 20$	400	630
C40		$40 < d \leq 100$ or $20 < t \leq 60$	350	600
C45E		$d \leq 16$ or $t \leq 8$	490	700
C45R		$16 < d \leq 40$ or $8 < t \leq 20$	430	650
C45		$40 < d \leq 100$ or $20 < t \leq 60$	370	630
C50E		$d \leq 16$ ou $t \leq 8$	520	750
C50R		$16 < d \leq 40$ or $8 < t \leq 20$	460	700
		$40 < d \leq 100$ or $20 < t \leq 60$	400	650
C55E		$d \leq 16$ or $t \leq 8$	550	800
C55R		$16 < d \leq 40$ or $8 < t \leq 20$	490	750
C55		$40 < d \leq 100$ or $20 < t \leq 60$	420	700
C60E		$d \leq 16$ or $t \leq 8$	580	850
C60R		$16 < d \leq 40$ or $8 < t \leq 20$	520	800
C60		$40 < d \leq 100$ or $20 < t \leq 60$	450	750
28Mn6		$d \leq 16$ or $t \leq 8$	590	800
		$16 < d \leq 40$ or $8 < t \leq 20$	490	700
		$40 < d \leq 100$ or $20 < t \leq 60$	440	650

Steels for quenching and tempering, in the quenched and tempered condition (+QT)				
Steel	**Standard**	**Diameter d/Thickness t** mm	**Nominal strength**	
			f_y **Yield** N/mm^2	f_u **Ultimate** N/mm^2
38Cr2	EN ISO 683-2:2018	$d \leq 16$ or $t \leq 8$	550	800
		$16 < d \leq 40$ or $8 < t \leq 20$	450	700
		$40 < d \leq 100$ or $20 < t \leq 60$	350	600
46Cr2		$d \leq 16$ or $t \leq 8$	650	900
		$16 < d \leq 40$ or $8 < t \leq 20$	550	800
		$40 < d \leq 100$ or $20 < t \leq 60$	400	650
34Cr4 34CrS4		$d \leq 16$ or $t \leq 8$	700	900
		$16 < d \leq 40$ or $8 < t \leq 20$	590	800
		$40 < d \leq 100$ or $20 < t \leq 60$	460	700
37Cr4 37CrS4		$d \leq 16$ or $t \leq 8$	750	950
		$16 < d \leq 40$ or $8 < t \leq 20$	630	850
		$40 < d \leq 100$ or $20 < t \leq 60$	510	750
41Cr4 41CrS4		$d \leq 16$ or $t \leq 8$	800	1000
		$16 < d \leq 40$ or $8 < t \leq 20$	660	900
		$40 < d \leq 100$ or $20 < t \leq 60$	560	800
25CrMo4 25CrMoS4		$d \leq 16$ or $t \leq 8$	700	900
		$16 < d \leq 40$ or $8 < t \leq 20$	600	800
		$40 < d \leq 100$ or $20 < t \leq 60$	450	700
		$100 < d \leq 160$ or $60 < t \leq 100$	400	650
34CrMo4 34CrMoS4		$d \leq 16$ or $t \leq 8$	800	1000
		$16 < d \leq 40$ or $8 < t \leq 20$	650	900
		$40 < d \leq 100$ or $20 < t \leq 60$	550	800
		$100 < d \leq 160$ or $60 < t \leq 100$	500	750
		$160 < d \leq 250$ or $100 < t \leq 160$	450	700
42CrMo4 42CrMoS4	EN ISO 683-2:2018	$d \leq 16$ or $t \leq 8$	900	1100
		$16 < d \leq 40$ or $8 < t \leq 20$	750	1000
		$40 < d \leq 100$ or $20 < t \leq 60$	650	900
		$100 < d \leq 160$ or $60 < t \leq 100$	550	800
		$160 < d \leq 250$ or $100 < t \leq 160$	500	750

Steels for quenching and tempering, in the quenched and tempered condition (+QT)				
Steel	**Standard**	**Diameter d/Thickness t** mm	**Nominal strength**	
			f_y **Yield** N/mm^2	f_u **Ultimate** N/mm^2
50CrMo4	EN ISO 683-2:2018	$d \leq 16$ or $t \leq 8$	900	1100
		$16 < d \leq 40$ or $8 < t \leq 20$	780	1000
		$40 < d \leq 100$ or $20 < t \leq 60$	700	900
		$100 < d \leq 160$ or $60 < t \leq 100$	650	850
		$160 < d \leq 250$ or $100 < t \leq 160$	550	800
34CrNiMo6		$d \leq 16$ or $t \leq 8$	1000	1200
		$16 < d \leq 40$ or $8 < t \leq 20$	900	1100
		$40 < d \leq 100$ or $20 < t \leq 60$	800	1000
		$100 < d \leq 160$ or $60 < t \leq 100$	700	900
		$160 < d \leq 250$ or $100 < t \leq 160$	600	800
30CrNiMo8		$d \leq 16$ or $t \leq 8$	1050	1250
		$16 < d \leq 40$ or $8 < t \leq 20$	1050	1250
		$40 < d \leq 100$ or $20 < t \leq 60$	900	1000
		$100 < d \leq 160$ or $60 < t \leq 100$	800	1000
		$160 < d \leq 250$ or $100 < t \leq 160$	700	900
35NiCr6		$d \leq 16$ or $t \leq 8$	740	880
		$16 < d \leq 40$ or $8 < t \leq 20$	740	880
		$40 < d \leq 100$ or $20 < t \leq 60$	640	780
36NiCrMo16		$d \leq 16$ or $t \leq 8$	1050	1250
		$16 < d \leq 40$ or $8 < t \leq 20$	1050	1250
		$40 < d \leq 100$ or $20 < t \leq 60$	900	1100
		$100 < d \leq 160$ or $60 < t \leq 100$	800	1000
		$160 < d \leq 250$ or $100 < t \leq 160$	800	1000