SLOVENSKI STANDARD
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Žerjavi - Konstrukcija, splošno - 3-5. del: Mejna stanja in dokaz varnosti kovanih kavljev

Cranes - General design - Part 3-5: Limit states and proof of competence of forged hooks

Krane - Konstruktion allgemein - Teil 3-5: Grenzzustände und Sicherheitshinweise von geschmiedeten Haken

Appareils de levage à charge suspendue - Conception générale - Partie 3-5 : Etats limites et vérification d'aptitude des moufles à crochet

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English Version

Cranes - General design - Part 3-5: Limit states and proof of competence of forged hooks

Appareils de levage à charge suspendue - Conception générale - Partie 3-5 : Etats limites et vérification des crochets forgés

Krane - Konstruktion allgemein - Teil 3-5: Grenzzustände und Sicherheitsnachweise von geschmiedeten Haken

This European Standard was approved by CEN on 19 May 2016.

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This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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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 13001-3-5:2016) has been prepared by Technical Committee CEN/TC 147 “Crane — Safety”, the secretariat of which is held by BSI.

This document supersedes CEN/TS 13001-3-5:2010.

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of an identical text or by endorsement, at the latest by February 2017, and conflicting national standards shall be withdrawn at the latest by February 2017.

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 has been prepared under a mandate 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.

The major changes in this standard compared to CEN/TS 13001-3-5 are in 4.1, 4.2, 6.5, Clause 7 and Annex K (renumbered Annex J). A new Annex C has been added. Annexes E and F have been removed. New hook sizes were added to Annexes A and B.

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*[1]

— *Part 3-6: Limit states and proof of competence of machinery - Hydraulic cylinders*[2]

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

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, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

[1] Currently at Enquiry stage.

[2] Currently at Enquiry stage.

Introduction

This European Standard has been prepared to provide a means for the mechanical design and theoretical verification of cranes to conform to essential health and safety requirements. This European 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 EN ISO 12100.

The machinery concerned and the extent to which hazards, hazardous situations and events 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.

1 Scope

This European Standard is to be used together with EN 13001-1 and EN 13001-2 and, as such, they specify general conditions, requirements and methods to prevent by design and theoretical verification, mechanical hazards in crane hooks.

This European Standard covers the following parts of hooks and types of hooks:

— bodies of any type of hooks made of steel forgings;

— machined shanks of hooks with a thread/nut suspension.

Principles of this European Standard can be applied to machined shanks of hooks in general. However, stress concentration factors relevant to designs not given in this standard would have to be determined and applied.

NOTE 1 Cast hooks and plate hooks, which are those, assembled of one or several parallel parts of rolled steel plates, are not covered in this European Standard.

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. Clauses 4 to 8 of this document are necessary to reduce or eliminate the risks associated with the following hazards:

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

b) exceeding temperature limits of material.

The requirements of this European Standard are stated in the main body of the document and are applicable to forged hook designs in general.

The commonly used hook body and shank designs listed in Annexes A, B and F are only examples and should not be referred to as requirements of this European Standard. Annex I gives guidance for the selection of a hook size, where a hook body is in accordance with Annex A or B. The selection of hook form is not limited to those shown in Annexes A and B.

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

NOTE 2 This part of EN 13001 deals only with the limit state method in accordance with EN 13001–1.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

EN 10083-3, *Steels for quenching and tempering - Part 3: Technical delivery conditions for alloy steels*

EN 10204, *Metallic products - Types of inspection documents*

EN 10222-4, *Steel forgings for pressure purposes - Part 4: Weldable fine grain steels with high proof strength*

EN 10228-1, *Non-destructive testing of steel forgings - Part 1: Magnetic particle inspection*

EN 10228-2, *Non-destructive testing of steel forgings - Part 2: Penetrant testing*

EN 10228-3, *Non-destructive testing of steel forgings - Part 3: Ultrasonic testing of ferritic or martensitic steel forgings*

EN 10250-1, *Open die steel forgings for general engineering purposes - Part 1: General requirements*

EN 10250-2, *Open die steel forgings for general engineering purposes - Part 2: Non-alloy quality and special steels*

EN 10250-3, *Open die steel forgings for general engineering purposes - Part 3: Alloy special steels*

EN 10254, *Steel closed die forgings - General technical delivery conditions*

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

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

EN 13001-3-2, *Cranes - General design - Part 3-2: Limit states and proof of competence of wire ropes in reeving systems*

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

EN ISO 642, *Steel - Hardenability test by end quenching (Jominy test) (ISO 642)*

EN ISO 643, *Steels - Micrographic determination of the apparent grain size (ISO 643)*

EN ISO 898-2, *Mechanical properties of fasteners made of carbon steel and alloy steel - Part 2: Nuts with specified property classes - Coarse thread and fine pitch thread (ISO 898-2)*

EN ISO 4287, *Geometrical product specifications (GPS) - Surface texture: Profile method - Terms, definitions and surface texture parameters (ISO 4287)*

EN ISO 6892-1, *Metallic materials - Tensile testing - Part 1: Method of test at room temperature (ISO 6892-1)*

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

ISO 965-1, *ISO general purpose metric screw threads — Tolerances — Part 1: Principles and basic data*

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 ISO 4306-1:2007 and the following apply.

3.1.1
hook shank
upper part of the hook, from which the hook is suspended to the hoist media of the crane

3.1.2
hook body
lower, curved part of the hook below the shank

3.1.3
hook seat
bottom part of the hook body, where the load lifting attachment is resting

3.1.4
hook articulation
feature of the hook suspension, allowing the hook to tilt along the inclined load line

3.1.5
stand alone hook
hook which is designed, manufactured and released to the market as a component or as part of a hook block, without connection to a specific crane or application

3.1.6
total deformation ratio
ratio of the area of the cast cross section to the forged cross section

NOTE The following terms might also be used in technical literature for the same: reduction rate, reduction ratio, forging reduction.

3.2 Symbols and abbreviations

Table 1 — Symbols and abbreviations

Symbols, abbreviations	Description
A_{d1}	Cross section area of the forged, shank
A_{d4}	Cross section area of the critical section of hook shank
A_v	Minimum impact toughness of material
a	Acceleration
a_1	Seat circle diameter
a_2	Throat opening
a_3	Height of the hook point
b_{max}	Maximum width in the critical hook body section
b_{ref}	Reference width
C	Total number of working cycles during the design life of crane
C_t	Relative tilting resistance of the hook suspension
c_e	Coefficient for load eccentricity
D	Cumulative damage in fatigue (Palmgren-Miner hypothesis)
d_1	Diameter of the forged shank
d_3	Principal diameter of thread
d_4	Diameter of the undercut section of the shank
d_5	Thread core diameter
e_R	Distance of the vertical load line from the centre line of the shank
F	Vertical force
F_H	Vertical force on hook due to occasional or exceptional loads
$F_{Rd,s}$, $F_{Rd,f}$	Limit design forces, static/fatigue
$F_{Sd,s}$	Vertical design force for the proof of static strength
$F_{Sd,f}$	Vertical design force for the proof of fatigue strength
f_1, f_2, f_3	Factors of further influences
f_{Rd}	Limit design stress
f_y	Yield stress
f_u	Ultimate strength
g	Acceleration due to gravity, g = 9,81 m/s^2
$H_{Sd,s}$	Horizontal design force of hook
$H_{Sd,f}$	Horizontal design force for the proof of fatigue strength
h_1, h_2	Section heights of the hook body
h	Vertical distance from the seat bottom of the hook body to the centre of the articulation

Symbols, abbreviations	Description
h_s	Vertical distance from the seat bottom of the hook body to critical section of hook shank
i	Index for a lifting cycle or a stress cycle
I	Reference moment of inertia for curved beam
I_{d1}	Moment of inertia of the forged shank
I_{d4}	Moment of inertia of the critical section of hook shank
k_C	Conversion factor for stress spectrum and classified duty
k_h, k_s	Stress spectrum factors
kQ	Load spectrum factor, in accordance with EN 13001–1
k_5*	Specific spectrum ratio factor with m = 5
lg	Log to the base of 10
M_1, M_2, M_3, M_4	Bending moments of hook shank
$M_{1,f,i}$, $M_{2,f,i}$, $M_{3,f,i}$	Bending moments of hook shank for the proof of fatigue strength, lifting cycle i
$M_{Sd,s}$	Static design bending moment
m	Slope parameter of the characteristic fatigue design curve
m_{RC}	Mass of rated hoist load
m_i	Mass of the hook load in a lifting cycle i
N	Total number of stress cycles/lifting cycles
N_D	Reference number of stress cycles, $N_D = 2 \times 10^6$
p	Pitch of thread
p_a	Average number of accelerations related to one lifting cycle
R	Radius of hook body curvature
R_a	Average depth of surface profile in accordance with EN ISO 4287:1998
R_z	Maximum depth of surface profile in accordance with EN ISO 4287:1998
r_9	Relief radius of the undercut
r_{th}	Thread bottom radius
s	Length of undercut
s_h, s_s	Stress history parameters
s_Q	Load history parameter
t	Depth of thread
T	Operation temperature
u_S, u_T	Depths of notches
α	Angle
α_S, α_T	Stress concentration factors
β	Angle or direction of hook inclination
β_n, β_{nS}, β_{nT}	Notch effect factors

Symbols, abbreviations	Description
ϕ_2	Dynamic factor for hoisting an unrestrained grounded load
ϕ_5	Dynamic factor for changes of acceleration of a movement
γ_n	Risk coefficient
γ_p	Partial safety factor
γ_m	General resistance coefficient
γ_{sm}	Specific resistance coefficient
γ_{Hf}, γ_{Sf}	Fatigue strength specific resistance factors
η_1	Edge distance of a hook body section
ν	Factor for load component
ν_h, ν_s	Relative numbers of stress cycles
μ	Factor for mean stress influence
σ_a	Shank stress due to axial force
σ_b	Shank stress due to bending moment
σ_m	Mean stress in a stress cycle
σ_A	Stress amplitude in a stress cycle
σ_{Sd}	Design stress
σ_M	Basic fatigue strength amplitude, un-notched piece
σ_p	Total stress range in a pulsating stress cycle
σ_W	Fatigue strength amplitude, notched piece
σ_{Tmax}, σ_{T1}, σ_{T2}	Transformed stress amplitudes
$\Delta\sigma_c$	Characteristic fatigue strength
$\Delta\sigma_{Rd}$	Limit fatigue design stress
$\Delta\sigma_{Sd,i}$	Stress range in a lifting cycle i
$\Delta\sigma_{Sd,max}$	Maximum stress range

4 General requirements

4.1 Materials

4.1.1 General

The hook material shall fulfill the requirements of this clause independent of the material standard applied (see 4.1.2) and independent whether classification of the material is applied or not (see 4.1.3).

The hook material in the finished product shall have sufficient ductility to permanently deform before losing the ability to carry the load, at the temperatures specified for the use of the hook. Particularly the hook material shall fulfill the following conditions:

— the ratio of ultimate strength (f_u) to yield stress (f_y) $f_u/f_y \geq 1{,}2$;

— the percentage elongation at fracture $A \geq 10\ \%$ on a gauge length $L_0 = 5{,}65 \times \sqrt{S_0}$ (where S_0 is the original cross-sectional area).

The hook material, after forging and heat treatment, shall have minimum Charpy-V impact toughness in accordance with Table 2.

Table 2 — Impact test requirement for hook material

Operation temperature	Impact test temperature	Minimum impact toughness A_v
$T \geq 0$ °C	+20 °C	27 J
$T \geq -20$ °C	−0 °C	27 J
$T \geq -30$ °C	−20 °C	27 J
$T \geq -40$ °C	−30 °C	35 J
$T \geq -50$ °C	−40 °C	35 J

To satisfy the requirements of the operating temperature, the manufacturer shall select the steel, which after suitable heat treatment, shall be consistent with achieving the chosen mechanical property grade for the selected hook form, taking into account its individual ruling thickness.

The steel shall be fully killed, stabilized against strain age embrittlement, ensured by having sufficient content of aluminium (minimum of 0,025 %). The steel shall have an austenitic grain size of 8 or finer in accordance with EN ISO 643.

The steel shall contain no more sulphur and phosphorus than the limits given in Table 3.

Table 3 — Sulphur and phosphorus content

Element	Maximum mass content as determined by	
	Cast analysis [%]	Check analysis [%]
Sulphur (S)	0,020	0,025
Phosphorus (P)	0,020	0,025
Sum of S + P	0,035	0,045

Where quenched and tempered steel is used, the hardenability of the steel shall fulfil the requirement of the Jominy-ratio given in Table 4. The Jominy-ratio J30/J1,5 is the ratio between J30 and J1,5, where J30 and J1,5 mean the hardness at depths 30 mm and 1,5 mm correspondingly, determined by Jominy face-quenching test in accordance with EN ISO 642. The tests shall be carried out per melt and the values be given in the technical hook information, see Annex J. For more information on hardening properties and hardness profiles, see EN 10083-3.

Table 4 — Hardenability of quenched and tempered materials, Jominy-ratio

Ultimate strength f_u N/mm²	Minimum required Jominy-ratio J30/J1,5	Typical material qualities
$540 \leq f_u < 800$	65 %	34CrMo4+QT
$800 \leq f_u$	93 %	34CrNiMo6+QT 30CrNiMo8+QT

4.1.2 Typical standards and grades

European Standards specify materials and their properties. A selection of suitable material grades and qualities for forged hooks is given in Table 5. For more detailed information, see the specific European Standard.

Table 5 — Suitable materials for forged hooks

Material standard	Selected qualities	
EN 10025–3	S355N	S420N
EN 10222–4	P355NH P355QH	P420NH P420QH
EN 10250–2	S355J2	
EN 10083–3	25CrMo4+QT	34CrNiMo6+QT
EN 10250–3	34CrMo4+QT 36CrNiMo4+QT	30CrNiMo8+QT

Grades and qualities other than those mentioned in the above standards and in Table 5 may be used, if the requirements of 4.1.1 are fulfilled and the mechanical properties and the chemical composition are specified in a manner corresponding to relevant European Standards.

4.1.3 Classification of hook materials

For practical purposes, a classification of materials for forged hooks is presented in Table 6. In cases where the hook material is specified through the class reference, the values of mechanical properties given in Table 6 shall be used as design values and shall be specified as minimum values by the hook manufacturer.

Table 6 — Mechanical properties for classified materials

Material class reference	Mechanical properties	
	Yield stress f_y N/mm²	Ultimate strength f_u N/mm²
P	315	490
S	390	540
T	490	700
V	620	800
W	770	970

Classification of material is not mandatory. Acceptable strength properties of hook material are not limited to those shown in Table 6.

4.2 Workmanship

The manufacturing process, factory tests and delivery conditions shall meet the requirements of EN 10254 or EN 10250-1 as relevant.

Each hook body shall be forged hot in one piece. The macroscopic flow lines of the forging shall follow the body outline of the hook in the areas of the highest tensile stresses. Excess metal from the forging operation shall be removed cleanly leaving the surface free from sharp edges. The total deformation ratio shall be in accordance with the Table 7.