SLOVENSKI STANDARD
SIST EN 13001-3-6:2018+A1:2021

01-september-2021

Žerjavi - Konstrukcija, splošno - 3-6. del: Mejna stanja in dokaz varnosti mehanizma - Hidravlični cilindri

Cranes - General design - Part 3-6: Limit states and proof of competence of machinery - Hydraulic cylinders

Krane - Konstruktion allgemein - Teil 3-6: Grenzzustände und Sicherheitsnachweis von Maschinenbauteilen - Hydraulikzylinder

Appareils de levage à charge suspendue - Conception générale - Partie 3-6 : États limites et vérification d'aptitude des éléments de mécanismes - Vérins hydrauliques

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ICS:

23.100.20	Hidravlični valji	Cylinders
53.020.20	Dvigala	Cranes

SIST EN 13001-3-6:2018+A1:2021 **en,fr,de**

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Cranes - General design - Part 3-6: Limit states and proof of competence of machinery - Hydraulic cylinders

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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 13001-3-6:2018+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of an identical text or by endorsement, at the latest by December 2021, and conflicting national standards shall be withdrawn at the latest by December 2021.

This document includes Amendment 1 approved by CEN on 21 May 2021.

This document supersedes EN 13001-3-6:2018.

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

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

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 European Standard has been prepared to be a harmonized 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 EN ISO 12100:2010.

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 that have been designed and built according to the provisions of this type C standard.

1 Scope

A1⟩ This document is to be used together with the other generic parts of EN 13001 series of standards, see Annex E, as well as pertinent crane type product EN standards, and as such they specify general conditions, requirements and methods to, by design and theoretical verification, prevent mechanical hazards of hydraulic cylinders that are part of the load carrying structures of cranes. Hydraulic piping, hoses and connectors used with the cylinders are not within the scope of this document, as well as cylinders made from other material than carbon steel.

NOTE 1 Specific requirements for particular crane types are given in the appropriate European product standards, see Annex E.

The significant hazardous situations and hazardous events that could result in risks to persons during intended use are identified in Annex F. Clauses 4 to 7 of this document provide requirements and methods to reduce or eliminate these risks: ⟨A1

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

b) elastic instability (column buckling).

A1⟩ NOTE 2 ⟨A1 EN 13001–3–6 deals only with the limit state method in accordance with EN 13001–1.

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.

A1⟩ *deleted text* ⟨A1

EN 10277-2:2008, *Bright steel products — Technical delivery conditions — Part 2: Steels for general engineering purposes*

A1⟩ EN 10297-1:2003, *Seamless circular steel tubes for mechanical and general engineering purposes — Technical delivery conditions — Part 1: Non-alloy and alloy steel tubes* ⟨A1

EN 10305-1:2016, *Steel tubes for precision applications — Technical delivery conditions — Part 1: Seamless cold drawn tubes*

EN 10305-2:2016, *Steel tubes for precision applications — Technical delivery conditions — Part 2: Welded cold drawn tubes*

A1⟩ EN 13001-1:2015, *Cranes — General design — Part 1: General principles and requirements*

EN 13001-2:2014, *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* ⟨A1

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

A1⟩ 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)* ⟨A1

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 8492:2013, *Metallic materials — Tube — Flattening test (ISO 8492:2013)*

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

ISO 724:1993, *ISO general-purpose metric screw threads — Basic dimensions*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 12100:2010 apply.

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

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

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

3.2 Symbols an abbreviations

The essential symbols and abbreviations are given in Table 1.

Table 1 — Symbols and abbreviations

Symbols	Description
$A\%$	Percentage elongation at fracture
a	Weld throat thickness
A_i, B_i, C_i, D_i	Constants
A_s	Stress area
D	Piston diameter
d	Rod diameter
$D_{a,i}$	Diameter of axles
D_p	Pressure affected diameter
D_w	Weld diameter
E	Modulus of elasticity
F	Compressive force
F_A	Compressive force
FE	Finite Elements
f_{Rd}	Limit design stress
$f_{Rd\sigma}$	Limit design stress, normal

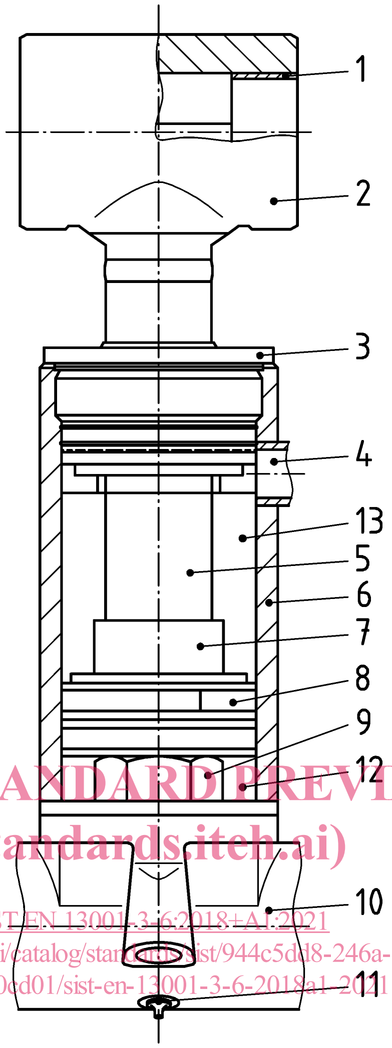
Symbols	Description
$f_{\mathrm{Rd}\tau}$	Limit design stress, shear
F_{S}	Lateral force
F_{Sd}	External design force
f_{u}	Ultimate strength
$f_{\mathrm{w,Rd}}$	Limit design weld stress
f_{y}	Yield strength
h	thickness of the cylinder bottom
I	Moment of inertia, generic
I_1	Moment of inertia of the tube
I_2	Moment of inertia of the rod
L	Overall length of the cylinder
L_1	Length of the cylinder tube
L_2	Length of the cylinder rod
m	Slope of the log Δ*σ* – log N curve
M_0	Shell section bending moment, acting at the intersection between tube and bottom
MB	Bending moment
N	Compressive force
N_{k}	Critical buckling load
N_{Rd}	Limit compressive design force
[A1⟩	*deleted text* ⟨A1]
p_{i1}	Maximum pressure in piston side chamber
p_{i2}	Maximum pressure in rod side chamber
p_{o}	Outer pressure
p_{Sd}	Design pressure
R	Middle radius of the tube ($R = R_{\mathrm{i}} + t/2$)
r_{i}	Inner radius of the tube
R_{i}	Inner radius of the tube
r_{o}	Outer radius of the tube
r_{r}	Outer radius of the piston rod

Symbols	Description
s_3	Stress history parameter (see EN 13001–3-1)
t	Wall thickness of the tube
T_0	Shell section transverse force, acting at the intersection between tube and bottom
x, y	Longitudinal and lateral coordinates
α	Angular misalignment, radians
γ_m	General resistance factor (γ_m = 1,1, see EN 13001–2)
γ_{mf}	Fatigue strength specific resistance factor (see EN 13001–3-1)
γ_R	Total resistance factor ($\gamma_R = \gamma_m \cdot \gamma_s$)
γ_s	Specific resistance factor
$\Delta\sigma$	Stress range
$\Delta\sigma_b$	Bending stress range in the tube
$\Delta\sigma_c$	Characteristic fatigue strength
$\Delta\sigma_m$	Membrane stress range in the tube (axial)
$\Delta\sigma_{Rd}$	Limit design stress range
$\Delta\sigma_{Sd}$	Design stress range
Δp_{Sd}	Design pressure range on piston side
δ_{max}	Maximum displacement
κ	Reduction factor for buckling
λ	Slenderness
λ_i	Friction parameters
μ_i	Friction factors
ν	Poisson's ratio (ν = 0,3 for steel)
σ_a	Axial stress in the tube
σ_b	Lower extreme value of a stress range
σ_r	Radial stress in the tube
σ_{Sd}	Design stress, normal
σ_t	Tangential stress in the tube (hoop stress)
σ_u	Upper extreme value of a stress range
$\sigma_{w,Sd}$	Weld design stress, normal

Symbols	Description
τ_{Sd}	Design stress, shear
$\tau_{w,Sd}$	Weld design stress, shear

3.3 Terminology

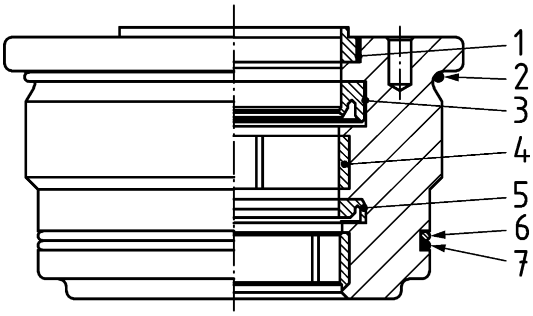
Terms which are used in this European Standard for the main parts of hydraulic cylinder are indicated in Figure 1 to Figure 3.



Key

1 bushing
2 rod head
3 cylinder head
4 oil connector
5 piston rod
6 cylinder tube
7 spacer
8 piston
9 nut
10 cylinder bottom
11 grease nipple
12 piston side chamber
13 rod side chamber

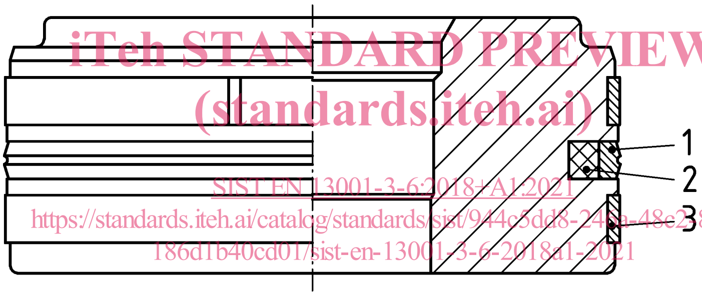
Figure 1 — Complete cylinder



Key

1 wiper
2 O-ring
3 secondary seal
4 guide ring (2 ×)
5 primary seal
6 backup ring
7 O-ring

Figure 2 — Cylinder head



Key

1 seal
2 pressure element
3 guide ring (2 ×)

Figure 3 — Piston

The figures above show some specific design features in order to exemplify the terminology. Other designs may be used.

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;

A1⟩ — weld quality levels, in accordance with EN ISO 5817:2014 and EN 13001-3-1:2012+A2:2018; ⟨A1

— relevant limit states;

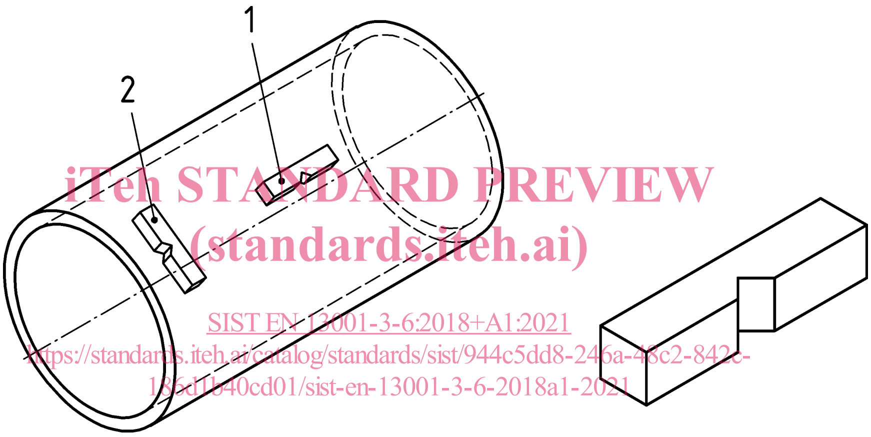
— results of the proof of competence calculation, and tests when applicable.

4.2 Materials for hydraulic cylinders

4.2.1 General requirements

A1⟩ The materials for cylinder tubes and piston rods shall fulfil the following requirements: ⟨A1

A1⟩ — The impact toughness shall be tested in accordance with EN ISO 148-1:2016 and shall meet the requirements stated in EN 13001-3-1:2012+A2:2018. Samples shall be cut out in the longitudinal direction. For cylinder tubes and tubes for pressurized piston rods, samples shall also be cut out in the transversal direction. The samples shall be prepared such that the axis of the notch is perpendicular to the surface of the tube. ⟨A1



Key

1 sample cut out in longitudinal direction

2 sample cut out in transversal direction

Figure 4 — Sample for impact toughness testing

A1⟩ — If the material thickness does not allow samples to be cut out in the transversal direction, the tube material shall instead pass a flattening test in accordance with EN ISO 8492:2013. Two flattening tests are required for welded tubes, one with the weld aligned with the press direction and one where the weld is placed 90 degrees from the press direction. The tube section shall be flattened down to a height H given by: ⟨A1

A1⟩

$$H = \frac{(1 + C) \cdot t}{C + \frac{t}{D_o}}$$

⟨A1

where

A1⟩ C is a factor that depends on the yield strength of the tube,