SLOVENSKI STANDARD
# oSIST prEN 13001-3-6:2025

**01-marec-2025**

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**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

**Ta slovenski standard je istoveten z: prEN 13001-3-6**



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**ICS:**

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|---|---|---|
| 23.100.20 | Hidravlični valji | Cylinders |
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English Version

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

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

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

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

**CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels**



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## European foreword

This document (prEN 13001-3-6:2025) has been prepared by Technical Committee CEN/TC 147 "Cranes - Safety", the secretariat of which is held by SFS.

This document is currently submitted to the CEN Enquiry.

This document will supersede EN 13001-3-6:2018+A1:2021.

prEN 13001-3-6:2025 includes the following significant technical changes with respect to EN 13001-3-6:2018+A1:2021:

— conditions for flattening test of tube material were changed (4.2.1);

— conservative default value for efficiency of active cylinders was changed (5.1);

— the specific resistance factor for material was changed (5.2.2).

This document has been prepared under a standardization request addressed to CEN by the European Commission. The Standing Committee of the EFTA States subsequently approves these requests for its Member States.

For the relationship with EU Legislation, see informative Annex ZA, which is an integral part of this document.

# Introduction

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

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 the 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 requirements of this type-C standard are different from those which are stated in type-A or type-B standards, the requirements of this type-C standard take precedence over the requirements of the other standards for machines that have been designed and built according to the requirements of this type-C standard.

# 1 Scope

This document is to be used together with the other generic parts of the 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:

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

b) elastic instability (column buckling).

NOTE 2 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.

EN 10277:2018, *Bright steel products — Technical delivery conditions*

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*

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*

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

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 5817:2023, *Welding — Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) — Quality levels for imperfections (ISO 5817:2023)*

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

ISO 724:2023, *ISO general-purpose metric screw threads — Basic dimensions*

# 3 Terms, definitions, symbols and abbreviated terms

## 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 terminology 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 abbreviated terms

The essential symbols and abbreviated terms 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 |
| $f_{Rd\tau}$ | Limit design stress, shear |
| $F_S$ | Lateral force |
| $F_{Sd}$ | External design force |
| $f_u$ | Ultimate strength |

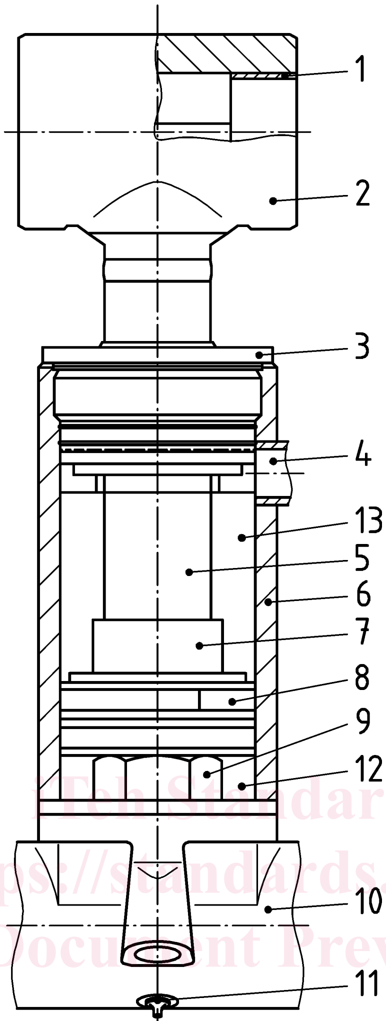
| | |
|---|---|
| $f_{w,Rd}$ | Limit design weld stress |
| $f_y$ | Yield strength |
| $h$ | thickness of the cylinder bottom |
| $I$ | Moment of inertia, generic |
| $I_1$ | Moment of inertia of the tube |
| $I_2$ | Moment of inertia of the rod |
| $L$ | Overall length of the cylinder |
| $L_1$ | Length of the cylinder tube |
| $L_2$ | Length of the cylinder rod |
| $m$ | Slope of the log $\Delta\sigma$ – 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 |
| $p_{i1}$ | 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 ($R = R_i + t/2$) |
| $r_i$ | 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 |
| $s_3$ | 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 |
| $\alpha$ | Angular misalignment, radians |
| $\gamma_m$ | General resistance factor ($\gamma_m$ = 1,1, see EN 13001-2) |
| $\gamma_{mf}$ | Fatigue strength specific resistance factor (see EN 13001-3-1) |

| | |
|---|---|
| $\gamma_R$ | Total resistance factor ($\gamma_R = \gamma_m \cdot \gamma_s$) |
| $\gamma_s$ | 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 |
| $\Delta p_{Sd}$ | Design pressure range on piston side |
| $\delta_{max}$ | Maximum displacement |
| $\kappa$ | Reduction factor for buckling |
| $\lambda$ | Slenderness |
| $\lambda_i$ | Friction parameters |
| $\mu_i$ | Friction factors |
| $\nu$ | Poisson’s ratio ($\nu$ = 0,3 for steel) |
| $\sigma_a$ | Axial stress in the tube |
| $\sigma_b$ | Lower extreme value of a stress range |
| $\sigma_r$ | Radial stress in the tube |
| $\sigma_{Sd}$ | Design stress, normal |
| $\sigma_t$ | Tangential stress in the tube (hoop stress) |
| $\sigma_u$ | Upper extreme value of a stress range |
| $\sigma_{w,Sd}$ | Weld design stress, normal |
| $\tau_{Sd}$ | 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.

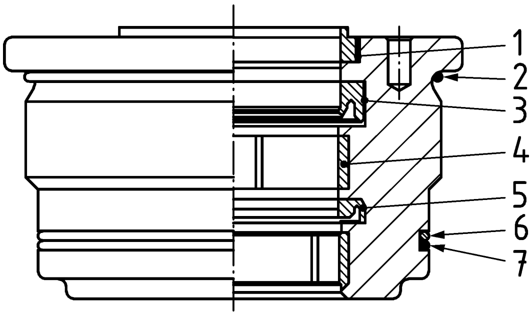





**Key**

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

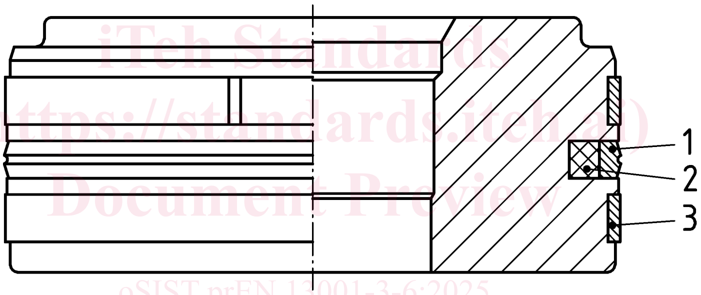
**Figure 1 — Complete cylinder**




**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;

— weld quality levels, in accordance with EN ISO 5817:2023 and EN 13001-3-1:2012+A2:2018;

— relevant limit states;

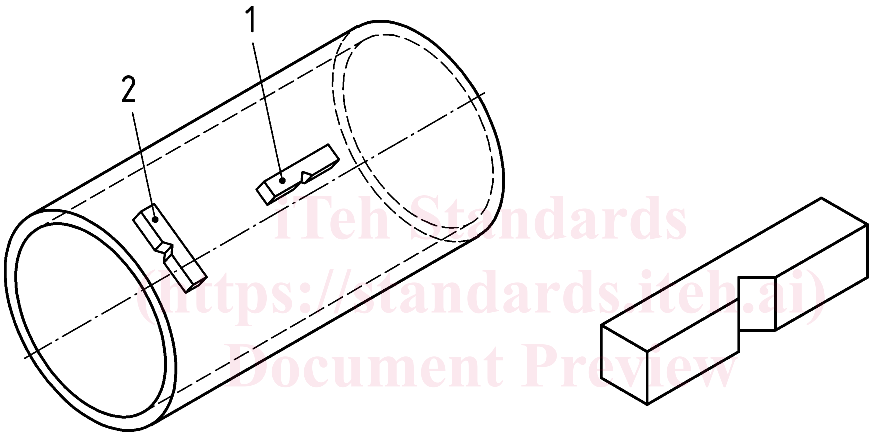
— results of the proof of competence calculation, and tests when applicable.

## 4.2 Materials for hydraulic cylinders

### 4.2.1 General requirements

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

— 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.






**Key**

1 sample cut out in longitudinal direction

2 sample cut out in transversal direction

**Figure 4 — Sample for impact toughness testing**

— Impact testing in the transversal direction of the tube material may be replaced by 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:

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

where

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

$C$ is 0,07 for $f_y \le 400$ MPa and $C$ is 0,05 for $f_y > 400$ MPa;

$D_o$ is the outer diameter of the tube;