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**Žerjavi - Splošno konstruiranje - 3.-6. del: Mejna stanja in dokaz nosilnosti strojnih delov - Hidravlični valji**

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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23.100.20	Hidravlični valji	Cylinders
53.020.20	Dvigala	Cranes

**SIST EN 13001-3-6:2026****en,fr,de**

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EUROPEAN STANDARD  
NORME EUROPÉENNE  
EUROPÄISCHE NORM

# EN 13001-3-6

March 2026

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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 European Standard was approved by CEN on 16 February 2026.

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## EN 13001-3-6:2026 (E)

### European foreword

This document (EN 13001-3-6:2026) has been prepared by Technical Committee CEN/TC 147 “Cranes - Safety”, the secretariat of which is held by SFS.

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of an identical text or by endorsement, at the latest by September 2026, and conflicting national standards shall be withdrawn at the latest by September 2026.

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 supersedes EN 13001-3-6:2018+A1:2021.

EN 13001-3-6:2026 includes the following significant technical changes with respect to EN 13001-3-6:2018+A1:2021:

- clause on materials for hydraulic cylinders was restructured (4.2);
- the general requirements changed to apply to all cylinder materials (4.2.1);
- the requirement for elongation was changed (4.2.1);
- conditions for flattening test of tube material were changed (4.2.2);
- conservative default value for efficiency of active cylinders was changed (5.1);
- the requirement for plates loaded perpendicularly was changed (5.2.2);
- 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.

Any feedback and questions on this document should be directed to the users' national standards body. A complete listing of these bodies can be found on the CEN website.

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, Türkiye and the United Kingdom.

## Introduction

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 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.

## EN 13001-3-6:2026 (E)

### 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 5 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 10164:2018, *Steel products with improved deformation properties perpendicular to the surface of the product — Technical delivery conditions*

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

EN 13001-3-1:2025, *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 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 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 724:2023, *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. No terms and definitions are listed in this document.

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**

<b>Symbols</b>	<b>Description</b>
$A\%$	Percentage elongation at fracture
$a$	Weld 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 stress

## EN 13001-3-6:2026 (E)

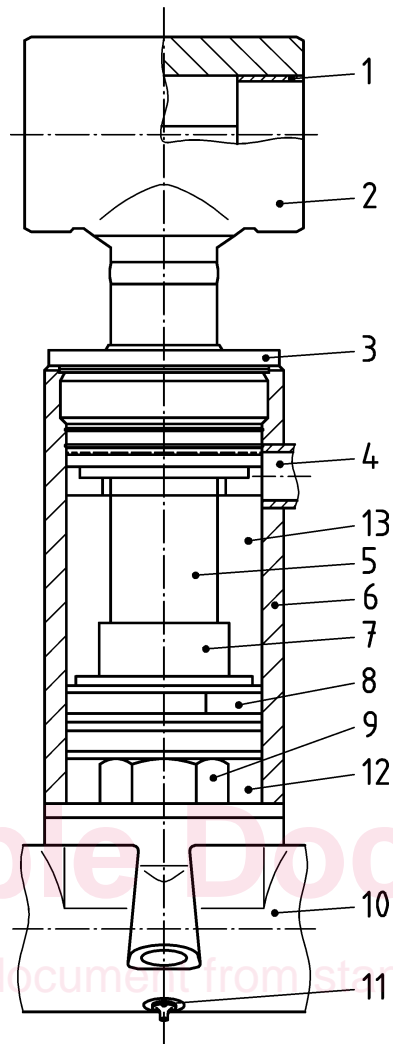
Symbols	Description
$h$	thickness of the cylinder bottom
$I$	Moment of inertia, generic
$I_1$	Moment of inertia of the tube
$I_2$	Moment of inertia of the rod
$L$	Overall length of the cylinder
$L_1$	Length of the cylinder tube
$L_2$	Length of the cylinder rod
$m$	Slope of the $\log \Delta\sigma - \log N$ 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
$R_o$	Outer radius of the tube
$r_o$	Outer radius of the piston rod
$R_w$	Middle radius of weld
$s_3$	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
$\beta_i$	Friction parameters
$\gamma_m$	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 ( $\gamma_R = \gamma_m \cdot \gamma_s$ )

Symbols	Description
$\gamma_s$	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
$\delta_{max}$	Maximum displacement
$\kappa$	Reduction factor for buckling
$\lambda_i$	Slenderness
$\mu_i$	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 or von Mises
$\sigma_t$	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

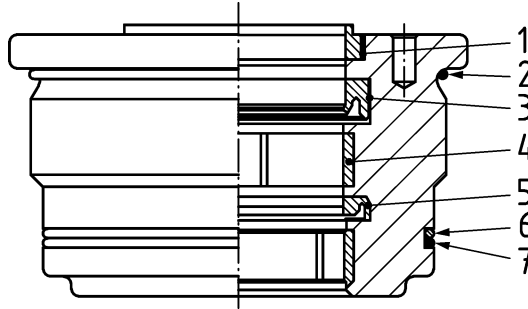
Terms which are used in this European Standard for the main parts of hydraulic cylinder are indicated in Figure 1, Figure 2 and Figure 3.

## EN 13001-3-6:2026 (E)

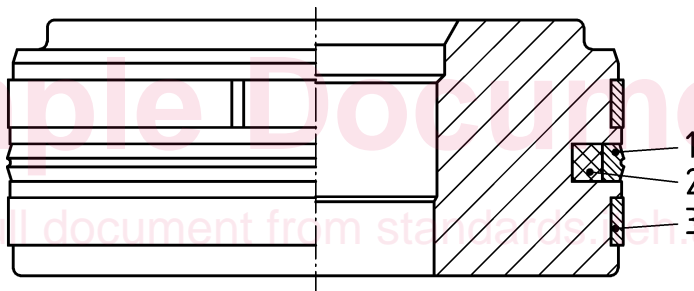
**Key**

- 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.

## EN 13001-3-6:2026 (E)

### 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 13001-3-1:2025;
- 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

Materials for cylinder tubes and pressurized piston rods shall comply with these general requirements:

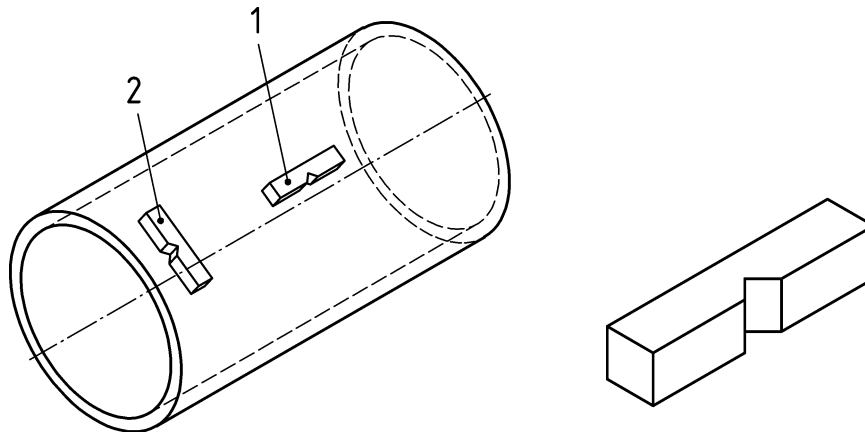
- the design value of  $f_y$  is limited to  $f_u/1,1$  for materials with  $f_u/f_y < 1,1$ ;
- the percentage elongation at fracture  $A \% \geq 7 \%$  on a gauge length  $L_0 = 5,65 \times \sqrt{S_0}$  (where  $S_0$  is the original cross-sectional area).

Grades and qualities of materials used in other parts of cylinders or mounting interfaces of cylinders shall be selected in accordance with EN 13001-3-1:2025.

##### 4.2.2 Additional mechanical properties

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 13001-3-1:2025. 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. See Figure 4. 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, which then shall be done 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:

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

where

- $C$  is a factor that depends on the yield stress of the tube;  
 $C$  shall be 0,07 for  $f_y \leq 400$  MPa and  $C$  shall be 0,05 for  $f_y > 400$  MPa;
- $D_o$  is the outer diameter of the tube;
- $t$  is the wall thickness of the tube.

## 5 Proof of static strength

### 5.1 General

A proof of static strength by calculation is intended to prevent excessive deformations due to yielding of the material, elastic instability and fracture of structural members or connections. Dynamic factors given in EN 13001-2:2021 or relevant product standards are used to produce equivalent static loads to simulate dynamic effects. Also, load increasing effects due to deformation shall be considered. The use of the theory of plasticity for calculation of ultimate load bearing capacity is not considered acceptable within the terms of this document. The proof shall be carried out for structural members and connections while taking into account the most unfavourable load effects from the load combinations A, B or C in accordance with EN 13001-2:2021 or relevant product standards.