

KRAANAD. ÜLDINE EHITUS. OSA 3-6: MASINATE
PIIRSEISUNDID JA KÕLBLIKKUSE TÕENDAMINE.
HÜDROSILINDRID

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

EESTI STANDARDI EESSÕNA

NATIONAL FOREWORD

See Eesti standard EVS-EN 13001-3-6:2018+A1:2021 sisaldab Euroopa standardi EN 13001-3-6:2018+A1:2021 ingliskeelset teksti.	This Estonian standard EVS-EN 13001-3-6:2018+A1:2021 consists of the English text of the European standard EN 13001-3-6:2018+A1:2021.
Standard on jõustunud sellekohase teate avaldamisega EVS Teatajas.	This standard has been endorsed with a notification published in the official bulletin of the Estonian Centre for Standardisation and Accreditation.
Euroopa standardimisorganisatsioonid on teinud Euroopa standardi rahvuslikele liikmetele kättesaadavaks 16.06.2021.	Date of Availability of the European standard is 16.06.2021.
Standard on kättesaadav Eesti Standardimis- ja Akrediteerimiskeskusest.	The standard is available from the Estonian Centre for Standardisation and Accreditation.

Tagasisidet standardi sisu kohta on võimalik edastada, kasutades EVS-i veebilehel asuvat tagasiside vormi või saates e-kirja meiliaadressile standardiosakond@evs.ee.

ICS 23.100.20, 53.020.20

Standardite reprodutseerimise ja levitamise õigus kuulub Eesti Standardimis- ja Akrediteerimiskeskusele. Andmete paljundamine, taastekitamine, kopeerimine, salvestamine elektroonsesse süsteemi või edastamine ükskõik millises vormis või millisel teel ilma Eesti Standardimis- ja Akrediteerimiskeskuse kirjaliku loata on keelatud.

Kui Teil on küsimusi standardite autorikaitse kohta, võtke palun ühendust Eesti Standardimis- ja Akrediteerimiskeskusega: Koduleht www.evs.ee; telefon 605 5050; e-post info@evs.ee

The right to reproduce and distribute standards belongs to the Estonian Centre for Standardisation and Accreditation. No part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying, without a written permission from the Estonian Centre for Standardisation and Accreditation.

If you have any questions about copyright, please contact Estonian Centre for Standardisation and Accreditation:

Homepage www.evs.ee; phone +372 605 5050; e-mail info@evs.ee

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 13 November 2017 and includes Amendment 1 approved by CEN on 9 May 2021.

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. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.


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.

CEN members are the national standards bodies of 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 United Kingdom.



EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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

Contents	Page
European foreword.....	4
Introduction	5
1 Scope.....	6
2 Normative references.....	6
3 Terms, definitions and symbols.....	7
3.1 Terms and definitions	7
3.2 Symbols and abbreviations	7
3.3 Terminology.....	10
4 General.....	12
4.1 Documentation.....	12
4.2 Materials for hydraulic cylinders	13
4.2.1 General requirements	13
4.2.2 Grades and qualities	14
5 Proof of static strength.....	14
5.1 General.....	14
5.2 Limit design stresses.....	16
5.2.1 General.....	16
5.2.2 Limit design stress in structural members.....	16
5.2.3 Limit design stresses in welded connections.....	17
5.3 Linear stress analysis	17
5.3.1 General.....	17
5.3.2 Typical load cases and boundary conditions	17
5.3.3 Cylinder tube	19
5.3.4 Cylinder bottom.....	20
5.3.5 Piston rod welds.....	21
5.3.6 Cylinder head.....	22
5.3.7 Cylinder tube and piston rod threads.....	22
5.3.8 Thread undercuts and locking wire grooves	22
5.3.9 Oil connector welds.....	23
5.3.10 Connecting interfaces to crane structure.....	23
5.4 Nonlinear stress analysis	24
5.4.1 General.....	24
5.4.2 Standard cylinder with end moments	24
5.4.3 Support leg.....	24
5.5 Execution of the proof	25
5.5.1 Proof for load bearing components.....	25
5.5.2 Proof for bolted connections.....	25
5.5.3 Proof for welded connections.....	26
6 Proof of fatigue strength.....	26
6.1  General	26
6.2 Stress histories.....	26
6.3 Execution of the proof	28
6.4 Limit design stress range	28
6.5 Details for consideration.....	28

6.5.1	General	28
6.5.2	Bottom weld.....	29
6.5.3	Notch stress at oil connectors	31
6.5.4	Cylinder head	32
6.5.5	Piston rod	34
6.5.6	Cylinder head bolts	36
6.5.7	Cylinder head flange weld	36
6.5.8	Mechanical interfaces	39
7	Proof of elastic stability	39
7.1	General	39
7.2	Critical buckling load	39
7.3	Limit compressive design force.....	41
7.4	Execution of the proof.....	42
Annex A	(informative) Critical buckling load for common buckling cases.....	43
A.1	General	43
A.2	Buckling case A	44
A.3	Buckling case B	44
A.4	Buckling case C	45
A.5	Buckling case D.....	45
A.6	Buckling case E	45
A.7	Buckling case F	46
A.8	Buckling case G	46
Annex B	(informative) Second order analysis of two important cases	47
B.1	Compressed cylinder with end moments and angular misalignment.....	47
B.2	Compressed cylinder with lateral end force and angular misalignment	48
B.3	Axial stresses for cases in B.1 and B.2	49
Annex C	(informative) Shell section forces and moments for cylinder bottom	50
Annex D	(informative) Fatigue analysis of bottom weld for more complex cases	53
Annex E	(informative) Selection of a suitable set of crane standards for a given application.....	56
Annex F	(informative) List of hazards	58
Annex ZA	(informative) Relationship between this European Standard and the essential requirements of Directive 2006/42/EC aimed to be covered.....	59
Bibliography	60

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**.

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.

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

Ⓐ 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: Ⓐ

- 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.

Ⓐ *deleted text* Ⓐ

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

Ⓐ 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 13001-1:2015, *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* Ⓐ

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 5817:2014, *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 and 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