BS EN 13001-3-2:2014

BSI Standards Publication

Cranes — General design

Part 3-2: Limit states and proof of competence of wire ropes in reeving systems

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National foreword

This British Standard is the UK implementation of EN 13001-3-2:2014. It supersedes DD CEN/TS 13001-3-2:2004, which is withdrawn.

This standard, together with BS EN 13001-1:2004+A1:2009, BS EN 13001-2:2014, BS EN 13001-3-1:2012+A1:2013, BS EN 13001-3-3:2014, BS EN 13001-3-4 and DD CEN/TS 13001-3-5:2010, supersedes BS 2573-1:1983 and BS 2573-2:1980, which will be withdrawn on publication of all parts of the BS EN 13001 series.

Users' attention is drawn to the fact that neither BS 2573-1:1983 nor BS 2573-2:1980 should be used in conjunction with the EN 13001 series as they are not complementary. The BS 2573 series will remain current until all parts of the BS EN 13001 series cited above have been published to ensure that a coherent package of standards remains available in the UK during the transition to European standards.

The UK participation in its preparation was entrusted by Technical Committee MHE/3, Cranes and derricks, to Subcommittee MHE/3/1, Crane design.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

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Appareils de levage à charge suspendue - Conception générale - Partie 3-2 : Etats limites et vérification d'aptitude des câbles en acier mouflés

Krane - Konstruktion allgemein - Teil 3-2: Grenzzustände und Sicherheitsnachweis von Drahtseilen in Seiltrieben

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Foreword

This document (EN 13001-3-2:2014) has been prepared by Technical Committee CEN/TC 147 “Crane — Safety”, the secretariat of which is held by BSI.

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of an identical text or by endorsement, at the latest by February 2015 and conflicting national standards shall be withdrawn at the latest by February 2015.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes CEN/TS 13001-3-2:2008.

CEN/TC 147/WG 2 has reviewed CEN/TS 13001-3-2:2008 to adapt the standard to the technical progress.

The major changes in this document are in the following clauses:

— 6.3 and 6.5;

— there are new issues in Clause 7.

The provisions of this standard shall not be mandatory to cranes manufactured within the first 12 months following the date of availability (DAV) of the standard.

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.

This European Standard is one Part of EN 13001, *Cranes — General design*. 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 3-3: Limit states and proof of competence of wheel/rail contacts*

— *Part 3-4: Limit states and proof of competence of machinery*

— *Part 3-5: Limit states and proof of competence of forged hooks*

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.

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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 to 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.

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.

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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 mechanical hazards of wire ropes of cranes by design and theoretical verification.

NOTE Specific requirements for particular types of cranes are given in the appropriate European Standard for the particular crane type.

The following is a list of significant hazardous situations and hazardous events that could result in risks to persons during intended use and reasonably foreseeable misuse. Clauses 5 to 6 of this standard are necessary to reduce or eliminate risks associated with the following hazard:

- exceeding the limits of strength (yield, ultimate, fatigue).

This European Standard is not applicable to cranes which are manufactured before the date of its publication as EN and serves as reference base for the European Standards for particular crane types (see Annex C).

EN 13001-3-2 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 1990:2002, *Eurocode — Basis of structural design*

EN 12385-2, *Steel wire ropes — Safety — Part 2: Definitions, designation and classification*

EN 12385-4, *Steel wire ropes — Safety — Part 4: Stranded ropes for general lifting applications*

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

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

EN 13411-1, *Terminations for steel wire ropes — Safety — Part 1: Thimbles for steel wire rope slings*

EN 13411-2, *Terminations for steel wire ropes — Safety — Part 2: Splicing of eyes for wire rope slings*

EN 13411-3, *Terminations for steel wire ropes — Safety — Part 3: Ferrules and ferrule-securing*

EN 13411-4, *Terminations for steel wire ropes — Safety — Part 4: Metal and resin socketing*

EN 13411-6, *Terminations for steel wire ropes — Safety — Part 6: Asymmetric wedge socket*

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

ISO 4306-1:2007, *Cranes — Vocabulary — Part 1: General*

ISO 4309, *Cranes — Wire ropes — Care and maintenance, inspection and discard*

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3 Terms, 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 the basic list of definitions as provided in EN 1990:2002 apply. For the definitions of loads, Clause 6 of ISO 4306-1:2007 applies.

3.2 Symbols and abbreviations

The symbols and abbreviations used in this Part of the EN 13001 are given in Table 1.

Table 1— Symbols and abbreviations

Symbols, abbreviations	Description
a	Acceleration
C	Total number of working cycles (see EN 13001–1) during design life of crane
D	Relevant diameter
D_{drum}	Minimum pitch diameter of drum
D_{sheave}	Minimum pitch diameter of sheave
D_{comp}	Minimum pitch diameter of compensating sheave
d	Rope diameter
$d_{bearing}$	Diameter of bearing or shaft
F_{equ}	Equivalent force
F_{gd}	Part of F_{equ} induced by gravity, exclusive of mass of payload, amplified by γ_p
F_{gl}	Part of F_{equ} induced by gravity forces of mass of payload, amplified by γ_p
F_o	Part of F_{equ} induced by any other forces, amplified by γ_p
$F_{Rd,s}$	Limit design rope force for the proof of static strength
$F_{Rd,f}$	Limit design rope force for the proof of fatigue strength
$F_{Sd,s}$	Design rope force for the proof of static strength
F_r	Part of F_{equ} induced by resistances, amplified by γ_p
$F_{Sd,f}$	Design rope force for the proof of fatigue strength
F_t	Part of F_{equ} induced by rope tightening forces, amplified by γ_p
F_u	Minimum rope breaking force
F_w	Part of F_{equ} induced by wind forces, amplified by γ_p
f_f	Factor of further influences
f_{f1}	Factor of diameter ratio influence
f_{f2}	Factor tensile strength of wire influence

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Symbols, abbreviations	Description
f_{f3}	Factor of fleet angle influence
f_{f4}	Factor of lubrication influence
f_{f5}	Factor of multilayer drum influence
f_{f6}	Factor of groove radius influence
f_{f7}	Factor of rope type influence
f_{S1}	Rope force increasing factor from rope reeving efficiency
f_{S2}	Rope force increasing factor from non parallel falls
f_{S3}	Rope force increasing factor from horizontal acceleration
f_{si}^{*}	Rope force increasing factors in fatigue
g	Acceleration due to gravity
i	Index for cycles of lifting and lowering
i_{max}	Total number of movements
k_r	Rope force spectrum factor
l_r	Number of ropes used during design life of the crane
q	Normalized height distribution
m_H	Mass of hoist load (see EN 13001–2)
m_{Hr}	Mass of hoist load that is acting on the rope falls under consideration
m_r	Rotatory rope driven mass
m_t	Translational rope driven mass
n_s	Number of fixed sheave between drum and moving part
n_m	Mechanical advantage
n_r	Number of ropes reeved from a drum
R_0	Minimum tensile strength of the wire used in the rope
R_{Dd}	Reference ratio of rope bending diameter to rope diameter
R_r	Tensile strength level of wire
r_g	Groove radius
s_r	Rope force history parameter
t	Rope type factor
w	Number of relevant bendings per movement
w_c	Bending count
w_D	Number of bendings at reference point
w_{tot}	Total number of bendings

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Symbols, abbreviations	Description
z, z_i, z_{min}, z_{max}, z_{ref}	Height coordinates
α	Angle of slope
β, β_{max}	Angles between falls and line of acting force
γ	Angle between gravity and projected rope in plane of F_h and g
γ_n	Risk coefficient
γ_p	Partial safety factor
γ_{rb}	Minimum rope resistance factor (static)
γ_{rf}	Minimum rope resistance factor (fatigue)
δ	Design fleet angle
ε	Angle between sheave planes
η_s	Efficiency of single sheave
η_{tot}	Total rope reeving efficiency
ν_r	Relative total number of bendings
ϕ	Dynamic factor for inertial or gravity effects
ϕ^*	Dynamic factor for inertial or gravity effects in fatigue
ϕ_2	Dynamic factor for hoisting an unrestrained grounded load
ϕ_5	Dynamic factor for loads caused by acceleration
ϕ_6	Dynamic factor for test load
ω	Angle between the sheave groove sides

4 General

4.1 Running ropes

Running wire ropes in cranes are stressed by loads and by bendings. Together these constitute a cumulative fatigue effect on the rope, which is expressed as a rope force history parameter s_r. The rope force history parameter is independent of time.

The proof of competence for static strength and the proof of competence for fatigue strength shall be fulfilled for the selection of ropes and components.

4.2 Stationary ropes

Stationary ropes are considered as part of the crane structure.

Clause 7 gives the requirements for the proof of competence for static strength and for fatigue strength of stationary ropes.

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4.3 Discard criteria

To ensure safe use of the rope, the discard criteria in accordance with ISO 4309 shall be applied.

When polymer sheaves are used exclusively in conjunction with single-layer spooling, the deterioration of the rope is likely to advance at a greater rate internally than externally and the discard criteria in accordance with ISO 4309 cannot be applied.

4.4 Rope and rope terminations

The wire rope should be in accordance with EN 12385-4. Rope terminations shall meet the requirements of EN 13411-1, EN 13411-2, EN 13411-3, EN 13411-4 and EN 13411-6.

4.5 Documentation

The documentation of the proof of competence shall include:

— design assumptions including calculation models;

— applicable loads and load combinations;

— rope specification and number of ropes specified for the design;

— relevant limit states;

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

5 Proof of static strength

5.1 General

For the proof of static strength it shall be proven that for all relevant load combinations of EN 13001-2

$$F_{\mathrm{Sd,s}} \leq F_{\mathrm{Rd,s}} \tag{1}$$

where

$F_{\mathrm{Sd,s}}$ is the design rope force;

$F_{\mathrm{Rd,s}}$ is the limit design rope force.

5.2 Vertical hoisting

5.2.1 Design rope force

The design rope force $F_{\mathrm{Sd,s}}$ in vertical hoisting shall be calculated as follows:

$$F_{\mathrm{Sd,s}} = \frac{m_{\mathrm{Hr}} \cdot g}{n_{\mathrm{m}}} \cdot \phi \times f_{\mathrm{S1}} \times f_{\mathrm{S2}} \times f_{\mathrm{S3}} \times \gamma_{\mathrm{p}} \times \gamma_{\mathrm{n}} \tag{2}$$

where

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