DRAFT INTERNATIONAL STANDARD
ISO/DIS 20332

ISO/TC **96**/SC **10** Secretariat: **DIN**

Voting begins on: **2013-09-26** Voting terminates on: **2013-12-26**

Cranes — Proof of competence of steel structures

Appareils de levage à charge suspendue — Vérification d'aptitude des structures en acier
[Revision of first edition (ISO 20332:2008)]

ICS: 53.020.20

Reference number
ISO/DIS 20332:2013(E)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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

ISO 20332 was prepared by Technical Committee ISO/TC 96, *Cranes - Safety*, Subcommittee SC 10, *Design principles and requirements*.

This second edition cancels and replaces the first edition (ISO 20332:2008). All parts in the document linked to the subject "limit states" have been technically revised. This has been a complied revision of the document.

Cranes — Proof of competence of steel structures

1 Scope

This International Standard sets forth general conditions, requirements, methods and parameter values for performing proof-of-competence determinations of the steel structures of cranes based upon the limit state method. It is intended to be used together with the loads and load combinations of the applicable parts of ISO 8686.

This International Standard is general and covers cranes of all types. Other International Standards may give specific proof-of-competence requirements for particular crane types.

Proofs of competence, by theoretical calculations and/or testing, are intended to prevent hazards related to the performance of the structure by establishing the limits of strength, e.g. yield, ultimate, fatigue, brittle fracture.

In accordance with ISO 8686-1, there are two general approaches to proof-of-competence calculations: the limit state method employing partial safety factors, and the allowable stress method employing a global safety factor. ISO 20332 however deals only with the limit state method.

Proof-of-competence calculations for components of accessories (e.g. hand rails, stairs, walkways, cabins) are not covered by this International Standard. However, the influence of such attachments on the main structure needs to be considered.

2 Normative references

The following referenced documents are indispensable for the application 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.

ISO 148-1:2009, *Metallic materials — Charpy pendulum impact test — Part 1: Test method*

ISO 273:1979, *Fasteners — Clearance holes for bolts and screws*

ISO 286-2:2010, *ISO system of limits and fits — Part 2: Tables of standard tolerance grades and limit deviations for holes and shafts,* corrected by ISO 286-2:1988/Cor 1:2006

ISO 404:1992, *Steel and steel products — General technical delivery requirements*

ISO 898-1:2009, *Mechanical properties of fasteners made of carbon steel and alloy steel — Part 1: Bolts, screws and studs with specified property classes — Coarse thread and fine pitch thread*

ISO 4301-1:1986, *Cranes and lifting appliances — Classification — Part 1: General*

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

ISO 5817:2003, *Welding — Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) — Quality levels for imperfections,* corrected by ISO 5817:2003/Cor 1:2006

ISO 7452:2013, *Hot-rolled structural steel plates - Tolerances on dimensions and shape*

ISO 7788:1985, *Steel - Surface finish of hot-rolled plates and wide flats - Delivery requirements*

ISO 8686 (all parts), *Cranes — Design principles for loads and load combinations — Part 1: General*

ISO 9013:2002, *Thermal cutting — Classification of thermal cuts — Geometrical product specification and quality tolerances*

ISO 12100-1:2004+A1:2009, *Safety of machinery — Basic concepts, general principles for design — Part 1: Basic terminology, methodology*

ISO 12100-2:2004+A1:2009, *Safety of machinery — Basic concepts, general principles for design — Part 2: Technical principles*

ISO 17659:2002, *Welding — Multilingual terms for welded joints with illustrations*

3 Terms, definitions, symbols and abbreviations

For the purposes of this document, the terms and definitions given in ISO 12100-1, ISO 12100-2, ISO 17659 and ISO 4306-1:2007, Clause 6, and the following terms, definitions, symbols and abbreviations (see Table 1) apply.

3.1
grade of steel
marking that defines the strength of steel, usually defining yield stress, f_y, sometimes also ultimate strength, f_u

3.2
quality of steel
marking that defines the impact toughness and test temperature of steel

Table 1 — Main symbols and abbreviations used in this International Standard

Symbols	Description
A	Cross-section
A_{eq}	Equivalent area for calculation
A_n	Net cross-sectional area at bolt or pin holes
A_r	Minor area of the bolt
A_S	Stress area of the bolt
a	Geometric dimension
a_{hi}	Geometric dimension for weld penetration
a_r	Effective weld thickness
b	Geometric dimension
D_A	Diameter of available cylinder of clamped material
D_i	Inner diameter of hollow pin
D_o	Outer diameter of hollow pin
d	Diameter (shank of bolt, pin)
d_h	Diameter of the hole
d_w	Diameter of the contact area of the bolt head
d_o	Diameter of the hole
E	Modulus of elasticity
e_1, e_2	Edge distances

Table 2 *(continued)*

Symbols	Description
F	Force
F_{b}	Tensile force in bolt
$F_{\mathrm{b,\,Rd}}$	Limit design bearing force
$F_{\mathrm{b,Sd}}$; $F_{\mathrm{bi,Sd}}$	Design bearing force
ΔF_{b}	Additional force
F_{cr}	Reduction in the compression force due to external tension
$F_{\mathrm{cs,Rd}}$	Limit design tensile force
F_{d}	Limit force
$F_{\mathrm{e,t}}$	External force (on bolted connection)
F_{k}	Characteristic value (force)
F_{p}	Preloading force in bolt
$F_{\mathrm{p,\,d}}$	Design preloading force
F_{Rd}	Limit design force
F_{Sd}	Design force of the element
$F_{\mathrm{s,\,Rd}}$	Limit design slip force per bolt and friction interface
$F_{\mathrm{t1,\,Rd}}$, $F_{\mathrm{t2,\,Rd}}$	Limit design tensile force per bolt
$F_{\mathrm{t,\,Sd}}$	External tensile force per bolt
$F_{\mathrm{v,\,Rd}}$	Limit design shear force per bolt/pin and shear plane
$F_{\mathrm{v,\,Sd}}$	Design shear force per bolt/pin and shear plane
$F_{\sigma,\tau}$	Acting normal/shear force
f	Out-of-plane imperfection of plate field
$f_{b,Rd,x}$	Limit design compressive longitudinal stress
$f_{b,Rd,y}$	Limit design compressive transverse stress
$f_{b,Rd,\tau}$	Limit design buckling shear stress
f_{d}	Limit stress
f_{k}	Characteristic value (stress)
f_{Rd}	Limit design stress
f_{u}	Ultimate strength of material
f_{ub}	Ultimate strength of bolts
f_{uw}	Ultimate strength of the weld
$f_{\mathrm{w,\,Rd}}$	Limit design weld stress
f_{y}	Yield stress of material or 0,2 % offset yield strength
f_{yb}	Yield stress of bolts
f_{yk}	Yield stress (minimum value) of base material or member
f_{yp}	Yield stress of pins

Table 2 *(continued)*

Symbols	Description
h	Thickness of workpiece
h_d	Distance between weld and contact area of acting load
I	Moment of inertia
K_b	Stiffness (slope) of bolt
K_c	Stiffness (slope) of flanges
k_m	Stress spectrum factor based on m of the detail under consideration
k^*	Specific spectrum ratio factor
$k_{\sigma x}$, k_τ	Buckling factors for plate fields
L	Length of compressed member
l_k	Effective clamped length
l_m	Gauge length for imperfection of plate field
l_r	Effective weld length
l_w	Weld length
l_1	Effective length for tension without threat
l_2	Effective length for tension with threat
M_Rd	Limit design bending moment
M_Sd	Design bending moment
m	(negative inverse) slope constant of log σ/log N curve
N	Number of stress cycles to failure by fatigue
N_c	Compressive force
N_k	Critical buckling load of compressed member
N_{Rd}	Limit design compressive force
• N_{Sd}	Design compressive force
N_ref	Number of cycles at the reference point
N_t	Total number of occurrences
NC	Notch class
NDT	Non destructive testing
n_i	Number of stress cycles with stress amplitude of range i
• n	Number of equally loaded bolts
P_s	Probability of survival
p_1, p_2	Distances between bolt centres
Q	Shear force
q_i	Impact toughness parameter
R_d	Design resistance

Table 2 *(continued)*

Symbols	Description
r	Radius of wheel
S	Class of stress history parameter, s
S_d	Design stresses or forces
s_m	Stress history parameter
T	Temperature
TIG	Tungsten inert gas
t	Thickness
U	Class of working cycles
u	Shape factor
v	Diameter ratio
W_{el}	Elastic section modulus
α	Characteristic factor for bearing connection
α_w	Characteristic factor for limit weld stress
γ_{mf}	Fatigue strength specific resistance factor
γ_m	General resistance factor
γ_p	Partial safety factor
γ_R	Total resistance factor
γ_{Rb}	Total resistance factor of bolt
γ_{Rc}	Total resistance factor for tension on sections with holes
γ_{Rm}	Total resistance factor of members
γ_{Rp}	Total resistance factor of pins
γ_{Rs}	Total resistance factor of slip-resistance connection
γ_s	Specific resistance factor
γ_{sb}	Specific resistance factor of bolt
γ_{sm}	Specific resistance factor of members
γ_{sp}	Specific resistance factor of pins
γ_{ss}	Specific resistance factor of slip-resistance connection
γ_{st}	Specific resistance factor for tension on sections with holes
• $\Delta\delta_t$	Additional elongation
δ_p	Elongation from preloading
Θ_i	Incline of diagonal members
κ	Dispersion angle

Table 2 *(continued)*

Symbols	Description
λ	Width of contact area in weld direction
μ	Slip factor
ν	Relative total number of stress cycles (normalized)
ν_D	Ratio of diameters
σ	Indicate the respective stress
$\Delta\sigma$	Stress range
$\Delta\sigma_i$	Stress range *i*
$\Delta\hat{\sigma}$	Maximum stress range
σ_b	Lower extreme value of stress cycle
$\Delta\sigma_c$	Characteristic fatigue strength (normal stress)
σ_e	Reference stress for plate buckling
σ_m	Constant mean stress selected for one-parameter classification of stress cycles
$\Delta\sigma_{Rd}$	Limit design stress range (normal)
$\Delta\sigma_{Rd,1}$	Limit design stress range for k^* = 1
σ_{Sd}	Design stress (normal)
$\Delta\sigma_{Sd}$	Design stress range (normal)
$\sigma_{Sd,x}$	Design compressive longitudinal stress
$\sigma_{Sd,y}$	Design compressive transverse stress
σ_u	Upper extreme value of stress cycle
$\sigma_{w, Sd}$	Design weld stress (normal)
σ_x, σ_y	Normal stress component in direction x, y
$\hat{\sigma}_a$	Maximum stress amplitude
min σ, *max* σ	Extreme values of stresses
τ	Shear stress
$\Delta\tau_c$	Characteristic fatigue strength (shear stress)
τ_{Sd}	Design stress (shear)
$\Delta\tau_{Sd}$	Design stress range (shear)
$\Delta\tau_{Rd}$	Limit design stress range (shear)
$\tau_{w, Sd}$	Design weld stress (shear)
ϕ_i	Dynamic factor
Ψ	Stress ratio across plate fields

4 General

4.1 General principles

Proof-of-competence calculations shall be done for components, members and details exposed to loading or repetitive loading cycles that could cause failure, cracking or distortion interfering with crane functions.

NOTE See ISO 8686 for further information applicable to the various types of crane. Not all calculations are applicable for every crane type.

4.2 Documentation

The documentation of the proof of competence calculations shall include:

- design assumptions including calculation models;
- applicable loads and load combinations;
- material properties;
- weld quality classes in accordance with ISO 5817;
- properties of connecting elements;
- relevant limit states;
- results of the proof of competence calculations. and tests when applicable.

4.3 Alternative methods

The competence may be verified by experimental methods in addition to, or in coordination with, the calculations. The magnitude and distribution of loads during tests shall correspond to the design loads and load combinations for the relevant limit states.

Alternatively, advanced and recognized theoretical or experimental methods generally may be used, provided that they conform to the principles of this International Standard.

4.4 Materials of structural members

It is recommended that steels in accordance with the following International Standards should be used:

- ISO 630 as amended [1];
- ISO 6930-1 [7];
- ISO 4950 [3];
- ISO 4951-1, ISO 4951-2 and ISO 4951-3 [4], [5], [6].

Where other steels are used, the specific values of strengths f_u and f_y shall be specified. The mechanical properties and the chemical composition shall be specified in accordance with ISO 404. Furthermore, the following conditions shall be fulfilled:

- the design value of f_y shall be limited to $f_u/1{,}05$ for materials with $f_u/f_y < 1{,}05$;

