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# Cranes — Proof of competence of steel structures

*Appareils de levage à charge suspendue — Vérification d'aptitude des charpentes en acier*

Reference number
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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html

The committee responsible for this document is ISO/TC 96, *Cranes*, Subcommittee SC 10, *Design principles and requirements*.

This second edition cancels and replaces the first edition (ISO 20332:2008), which has been technically revised.

This corrected version of ISO 20332:2016 incorporates a correction in Formula (67).

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# 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 can give specific proof-of-competence requirements for particular crane types.

Proof-of-competence determinations, 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, and brittle fracture.

According to 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. Though it does not preclude the validity of allowable stress methodology, ISO 20332 deals only with the limit state method.

Proof-of-competence calculations for components of accessories (e.g. handrails, 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 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.

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, *Geometrical product specifications (GPS) — ISO code system for tolerances on linear sizes — Part 2: Tables of standard tolerance classes and limit deviations for holes and shafts*. Corrected by ISO 286-2:2010/Cor 1:2013.

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

ISO 898-1:2013, *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 4042:1999, *Fasteners — Electroplated coatings*

ISO 4301-1:2016, *Cranes and lifting appliances — Classification — Part 1: General*

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

ISO 5817:2014, *Welding — Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) — Quality levels for imperfections*

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

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

ISO 8686-1:2012, *Cranes — Design principles for loads and load combinations — Part 1: General*

ISO 8686-2, *Cranes — Design principles for loads and load combinations — Part 2: Mobile cranes*

ISO 8686-3, *Cranes — Design principles for loads and load combinations— Part 3: Tower cranes*

ISO 8686-4, *Cranes — Design principles for loads and load combinations— Part 4: Jib cranes*

ISO 8686-5, *Cranes — Design principles for loads and load combinations— Part 5: Overhead travelling and portal bridge cranes*

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

ISO 9587:2007, *Metallic and other inorganic coatings — Pretreatments of iron or steel to reduce the risk of hydrogen embrittlement*

ISO 12100, *Safety of machinery — Basic concepts, general principles for design — Risk assessment and risk reduction*

ISO 15330:1999, *Fasteners — Preloading test for the detection of hydrogen embrittlement — Parallel bearing surface method*

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

## 3 Terms, definitions, symbols and abbreviated terms

For the purposes of this document, the terms and definitions given in ISO 12100, ISO 17659, ISO 4306-1:2007, Clause 6, and the following terms, definitions, symbols and abbreviated terms (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

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

| Symbol | 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 |
| $c$ | 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 |
| $d_0$ | Diameter of the hole |
| $E$ | Modulus of elasticity |
| $e_1$, $e_2$ | Edge distances |
| $F$ | Force |
| $F_b$ | Tensile force in bolt |
| $F_{b,Rd}$ | Limit design bearing force |
| $F_{b,Sd}$, $F_{bi,Sd}$ | Design bearing force |
| $\Delta F_b$ | Additional force |
| $F_{cr}$ | Reduction in the compression force due to external tension |
| $F_{cs,Rd}$ | Limit design tensile force |
| $F_d$ | Limit force |
| $F_{e,t}$ | External force (on bolted connection) |
| $F_k$ | Characteristic value (force) |
| $F_p$ | Preloading force in bolt |

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**Table 1** (*continued*)

| Symbols | Description |
|---|---|
| $F_{p,d}$ | Design preloading force |
| $F_{Rd}$ | Limit design force |
| $F_{Sd}$ | Design force of the element |
| $F_{s,Rd}$ | Limit design slip force per bolt and friction interface |
| $F_{t1,Rd}$, $F_{t2,Rd}$ | Limit design tensile forces per bolt |
| $F_{t,Sd}$ | External tensile force per bolt |
| $F_{v,Rd}$ | Limit design shear force per bolt/pin and shear plane |
| $F_{v,Sd}$ | 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 |
| $f_{w,\,Rd}$ | 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 |
| $h$ | 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 |


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**Table 1** (*continued*)

| Symbols | Description |
|---|---|
| $k^*$ | Specific spectrum ratio factor |
| $k_{\sigma x}$, $k_\tau$ | 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 $\sigma$/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 |
| $r$ | Radius of wheel |
| $S$ | Class of stress history parameter, $s$ |
| $S_d$ | Design stresses or forces |

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**Table 1** (*continued*)

| Symbols | Description |
|---|---|
| $s_m$ | 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 |
| $\alpha$ | Characteristic factor for bearing connection |
| $\alpha_w$ | Characteristic factor for limit weld stress |
| $\gamma_{mf}$ | Fatigue strength specific resistance factor |
| $\gamma_m$ | General resistance factor |
| $\gamma_p$ | Partial safety factor |
| $\gamma_R$ | Total resistance factor |
| $\gamma_{Rb}$ | Total resistance factor of bolt |
| $\gamma_{Rc}$ | Total resistance factor for tension on sections with holes |
| $\gamma_{Rm}$ | Total resistance factor of members |
| $\gamma_{Rp}$ | Total resistance factor of pins |
| $\gamma_{Rs}$ | Total resistance factor of slip-resistance connection |
| $\gamma_s$ | Specific resistance factor |
| $\gamma_{sb}$ | Specific resistance factor of bolt |
| $\gamma_{sm}$ | Specific resistance factor of members |
| $\gamma_{sp}$ | Specific resistance factor of pins |
| $\gamma_{ss}$ | Specific resistance factor of slip-resistance connection |
| $\gamma_{st}$ | Specific resistance factor for tension on sections with holes |
| $\Delta\delta_t$ | Additional elongation |
| $\delta_p$ | Elongation from preloading |
| $\theta_i$ | Incline of diagonal members |
| $\kappa$ | Dispersion angle |
| $\lambda$ | Width of contact area in weld direction |
| $\mu$ | Slip factor |


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**Table 1** (*continued*)

| Symbols | Description |
|---|---|
| $\nu$ | Relative total number of stress cycles (normalized) |
| $\nu_D$ | Ratio of diameters |
| $\sigma$ | Indicate the respective stress |
| $\Delta_\sigma$ | Stress range |
| $\Delta\sigma_i$ | Stress range *i* |
| $\Delta\hat{\sigma}$ | Maximum stress range |
| $\sigma_b$ | Lower extreme value of stress cycle |
| $\Delta\sigma_c$ | Characteristic fatigue strength (normal stress) |
| $\sigma_e$ | Reference stress for plate buckling |
| $\sigma_m$ | 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 $k^* = 1$ |
| $\sigma_{Sd}$ | Design stress (normal) |
| $\Delta\sigma_{Sd}$ | Design stress range (normal) |
| $\sigma_{Sd,x}$ | Design compressive longitudinal stress |
| $\sigma_{Sd,y}$ | Design compressive transverse stress |
| $\sigma_u$ | Upper extreme value of stress cycle |
| $\sigma_{w,\,Sd}$ | Design weld stress (normal) |
| $\sigma_x$, $\sigma_y$ | Normal stress component in direction *x*, *y* |
| $\hat{\sigma}_a$ | Maximum stress amplitude |
| min $\sigma$, max $\sigma$ | Extreme values of stresses |
| $\tau$ | Shear stress |
| $\Delta\tau_c$ | Characteristic fatigue strength (shear stress) |
| $\tau_{Sd}$ | 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) |
| $\phi_i$ | Dynamic factor |
| $\Psi$ | Stress ratio across plate fields |

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