

DD CEN/TS 13001-3-5:2010



Cranes — General design

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

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Comments arising from the use of this Draft for Development are requested so that UK experience can be reported to the international organization responsible for its conversion to an international standard. A review of this publication will be initiated not later than 3 years after its publication by the international organization so that a decision can be taken on its status. Notification of the start of the review period will be made in an announcement in the appropriate issue of *Update Standards*.

According to the replies received by the end of the review period, the responsible BSI Committee will decide whether to support the conversion into an international Standard, to extend the life of the Technical Specification or to withdraw it. Comments should be sent to the Secretary of the responsible BSI Technical Committee at British Standards House, 389 Chiswick High Road, London W4 4AL.

The UK participation in its preparation was entrusted to Technical Committee MHE/3/1, Crane design.

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

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**Cranes - General design - Part 3-5: Limit states and proof of
competence of forged hooks**

Appareils à levage à charge suspendue - Conception
générale - Partie 3-5: Etats limites et vérification d'aptitude
des crochets forgés

Krane - Konstruktion allgemein - Teil 3-5: Grenzzustände
und Sicherheitshinweise von geschmiedeten Haken

This Technical Specification (CEN/TS) was approved by CEN on 31 August 2009 for provisional application.

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Foreword

This document (CEN/TS 13001-3-5:2010) has been prepared by Technical Committee CEN/TC 147 "Cranes - Safety", the secretariat of which is held by BSI.

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 Technical Specification is one part of the EN 13001 series. The other parts are as follows:

- *Part 1: General principles and requirements*
- *Part 2: Load effects*
- *Part 3-1: Limit states and proof of competence of steel structures*
- *Part 3-2: Limit states and proof of competence of wire ropes in reeving systems*
- *Part 3-3: Limit states and proof of competence of wheel/rail contacts*

According to the CEN/CENELEC International Regulations, the national standards organizations of the following countries are bound to announce this Technical Specification: 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, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

This Technical Specification has been prepared to provide a means for the mechanical design and theoretical verification of cranes to conform with essential health and safety requirements. This specification 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 Technical Specification is a type C standard.

The machinery concerned and the extent to which hazards are covered are indicated in the scope of this standard.

1 Scope

This Technical Specification should be used together with the other relevant parts of the standard series. As such, they specify general conditions, requirements and methods to prevent hazards in hooks as part of all types of cranes.

This Technical Specification covers the following parts of hooks and types of hooks:

- bodies of any type of point hooks made of steel forgings;
- machined shanks of hooks with a thread/nut suspension.

NOTE 1 Principles of this Technical Specification can be applied to other types of shank hooks and also where stress concentration factors relevant to that shank construction are determined and used. Plate hooks, which are those, assembled of one or several parallel parts of rolled steel plates are not covered in this Technical Specification.

This Technical Specification is applicable to hooks from materials with ultimate strength of no more than 800 N/mm² and yield stress of no more than 600 N/mm².

The following is a list of significant hazardous situations and hazardous events that could result in risks to persons during normal use and foreseeable misuse. Clauses 4 to 8 of this document are necessary to reduce or eliminate the risks associated with the following hazards:

- a) Exceeding the limits of strength (yield, ultimate, fatigue);
- b) Exceeding temperature limits of material;
- c) Unintentional disengagement of the load from the hook.

The requirements of this Technical Specification are stated in the main body of the document and are applicable to hook designs in general. The hook body and shank designs listed in Annexes A, B and G are only examples and should not be referred to as requirements of this Technical Specification.

This Technical Specification is applicable to cranes, which are manufactured after the date of approval of this standard by CEN, and serves as a reference base for product standards of particular crane types.

NOTE 2 This CEN/TS 13001-3-5 deals only with the limit state method in accordance with EN 13001-1.

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.

EN 10002-1, *Metallic materials — Tensile testing — Part 1: Method of test at ambient temperature*

EN 10045-1, *Metallic materials — Charpy impact test — Part 1: Test method*

EN 10025-3:2004, *Hot rolled products of structural steels — Part 3: Technical delivery conditions for normalized/normalized rolled weldable fine grain structural steels*

EN 10222-4:1998, *Steel forgings for pressure purposes — Part 4: Weldable fine grain steels with high proof strength*

EN 10228-3:1998, *Non-destructive testing of steel forgings — Part 3: Ultrasonic testing of ferritic or martensitic steel forgings*

- EN 10243-1:1999, *Steel die forgings — Tolerances on dimensions — Part 1: Drop and vertical press forgings*
- EN 10250-2:1999, *Open die steel forgings for general engineering purposes — Part 2: Non-alloy quality and special steels*
- EN 10250-3:1999, *Open die steel forgings for general engineering purposes — Part 3: Alloy special steels*
- EN 10254, *Steel closed die forgings — General technical delivery conditions*
- EN 13001-1:2004, *Cranes - General design — Part 1: General principles and requirements*
- EN 13001-2, *Crane safety — General design — Part 2: Load effects*
- CEN/TS 13001-3-2, *Cranes — General design — Part 3-2: Limit states and proof of competence of wire ropes in reeving systems*
- EN ISO 4287:1998, *Geometrical product specifications (GPS) — Surface texture: Profile method — Terms, definitions and surface texture parameters (ISO 4287:1997)*
- EN ISO 12100-1:2003, *Safety of machinery — Basic concepts, general principles for design — Part 1: Basic terminology, methodology (ISO 12100-1:2003)*
- ISO 965-1:1998, *ISO general purpose metric screw threads — Tolerances — Part 1: Principles and basic data*
- ISO 4306-1:2007, *Cranes — Vocabulary — Part 1: General*

3 Terms and definitions, symbols and abbreviations

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 12100-1:2003 and ISO 4306-1:2007 and the following apply.

3.1.1

hook shank

upper part of the hook, from which the hook is suspended to the hoist media of the crane

3.1.2

hook body

lower, curved part of the hook below the shank

3.1.3

hook seat

bottom part of the hook body, where the load lifting attachment is resting

3.1.4

hook suspension articulation

feature of the hook suspension, allowing the hook to tilt along the inclined load line

3.1.5

serially produced hook

hook which is designed, manufactured and released to the market as a stand alone component or as part of a hook block, without connection to a specific crane or application

3.2 Symbols and abbreviations

Table 1 — Symbols and abbreviations

Symbols, abbreviations	Description
A_{df}	Cross section area of the forged, shank
A_{d4}	Cross section area of the critical section of hook shank
A_v	Minimum impact toughness of material
a	Acceleration
a_1	Seat circle diameter
a_2	Throat opening
a_3	Height of the hook point
b_{max}	Maximum width in the critical hook body section
b_{ref}	Reference width
C	Total number of working cycles during the design life of crane
C_t	Relative tilting resistance of the hook suspension
c_e	Coefficient for load eccentricity
D	Cumulative damage in fatigue (Palmgren-Miner hypothesis)
d_1	Diameter of the forged shank
d_3	Principal diameter of thread
d_4	Diameter of the undercut section of the shank
d_5	Thread core diameter
e_R	Distance of the vertical load line from the centre line of the shank
F	Vertical force
F_H	Vertical force on hook due to occasional or exceptional loads
$F_{Rd,s}, F_{Rd,f}$	Limit design forces, static / fatigue
$F_{Sd,s}$	Vertical design force for the proof of static strength
$F_{Sd,f}$	Vertical design force for the proof of fatigue strength
f_1, f_2, f_3	Factors of further influences
f_{Rd}	Limit design stress
f_y	Yield stress
f_u	Ultimate strength
g	Acceleration due to gravity, $g = 9,81 \text{ m/s}^2$
$H_{Sd,s}$	Horizontal design force of hook
$H_{Sd,f}$	Horizontal design force for the proof of fatigue strength
h_1, h_2	Section heights of the hook body
h	Vertical distance from the seat bottom of the hook body to the centre of the articulation
h_s	Vertical distance from the seat bottom of the hook body to critical section of hook shank
i	Index for a lifting cycle or a stress cycle
I	Reference moment of inertia for curved beam
I_{df}	Moment of inertia of the forged shank
I_{d4}	Moment of inertia of the critical section of hook shank
k_C	Conversion factor for stress spectrum and classified duty
k_h, k_s	Stress spectrum factors

Table 1 (continued)

kQ	Load spectrum factor, in accordance with EN 13001-1
k_5^+, k_6^+	Specific spectrum ratio factors, $m = 5 / 6$
lg	Log to the base of 10
M_1, M_2, M_3, M_4	Bending moments of hook shank
$M_{1,i}, M_{2,i}, M_{3,i}$	Bending moments of hook shank for the proof of fatigue strength, lifting cycle i
$M_{Sd,s}$	Static design bending moment
m	Slope parameter of the characteristic fatigue design curve
m_{RC}	Mass of rated hoist load
m_i	Mass of the hook load in a lifting cycle i
N	Total number of stress cycles / lifting cycles
N_D	Reference number of stress cycles, $ND = 2 \times 10^6$
p	Pitch of thread
p_a	Average number of accelerations related to one lifting cycle
R	Radius of hook body curvature
R_a	Average depth of surface profile according to EN ISO 4287:1998
R_z	Maximum depth of surface profile according to EN ISO 4287:1998
r_g	Relief radius of the undercut
r_{th}	Thread bottom radius
s	Length of undercut
S_h, S_s	Stress history parameters
S_Q	Load history parameter
t	Depth of thread
T	Operation temperature
u_{S_r}, u_T	Depths of notches
α	Angle
α_{S_r}, α_T	Stress concentration factors
β	Angle or direction of hook inclination
$\beta_m, \beta_{nS_r}, \beta_{nT}$	Notch effect factors
ϕ_2	Dynamic factor for hoisting an unrestrained grounded load
ϕ_5	Dynamic factor for changes of acceleration of a movement
γ_n	Risk coefficient
γ_p	Partial safety factor
γ_m	General resistance coefficient
γ_{sm}	Specific resistance coefficient
$\gamma_{R_r}, \gamma_{R_T}$	Fatigue strength specific resistance factors
η_1	Edge distance of a hook body section
ν	Factor for load component
ν_H, ν_S	Relative numbers of stress cycles
μ	Factor for mean stress influence
σ_a	Shank stress due to axial force
σ_b	Shank stress due to bending moment
σ_m	Mean stress in a stress cycle
σ_A	Stress amplitude in a stress cycle
σ_{Sd}	Design stress

Table 1 (continued)

σ_M	Basic fatigue strength amplitude, un-notched piece
σ_p	Total stress range in a pulsating stress cycle
σ_W	Fatigue strength amplitude, notched piece
$\sigma_{Tmax}, \sigma_{T1}, \sigma_{T2}$	Transformed stress amplitudes
$\Delta\sigma_c$	Characteristic fatigue strength
$\Delta\sigma_{Rd}$	Limit fatigue design stress
$\Delta\sigma_{Sd,i}$	Stress range in a lifting cycle i
$\Delta\sigma_{Sd,max}$	Maximum stress range

4 General requirements

4.1 Materials

The hook material in the finished product shall have sufficient ductility to permanently deform before losing the ability to carry the load, at the temperatures specified for the use of the hook. Hook material, after forging and heat treatment, shall have minimum Charpy-V impact toughness in accordance with Table 2.

Table 2 — Impact test requirement for hook material

Operation temperature	Impact test temperature	Minimum impact toughness A_v
$T \geq -30\text{ °C}$	-20 °C	27 J
$-30\text{ °C} > T \geq -40\text{ °C}$	-30 °C	
$-40\text{ °C} > T \geq -50\text{ °C}$	-40 °C	

European standards specify materials and their properties. This standard gives a preferred selection. For forged hooks, the material grades and qualities in accordance with Table 3 should be used. For more detailed information see the specific European Standard.

Table 3 — Preferred materials for forged hooks

Material standard	Selected qualities	
EN 10025-3	S275N S355N	S420N
EN 10222-4	P285NH P285QH P355NH P355QH	P420NH P420QH
EN 10250-2	S235J2 S355J2	
EN 10250-3	25CrMo4+QT 34CrMo4+QT 36CrNiMo4+QT	34CrNiMo6+QT 30CrNiMo8+QT

Grades and qualities other than those mentioned in the above standards and in Table 3 may be used, if the mechanical properties and the chemical composition are guaranteed by the manufacturer and conform to the qualities of the standards referenced in Table 3.

The mechanical properties (yield stress, ultimate strength) are dependent upon the thickness of the forged hook body. As a ruling thickness, either the largest width of the hook seat or the diameter of the shank shall be used, whichever is greater.

For standardisation purposes, a classification of material grades for forged hooks is specified in Table 4. In cases where the hook material is specified through the class reference, the values of mechanical properties given in Table 4 shall be used as design values and shall be guaranteed as minimum values by the hook manufacturer.

Table 4 — Material properties for classified material grades

Material class reference	Mechanical properties	
	Yield stress f_y N/mm ²	Ultimate strength f_u N/mm ²
M	215	340
P	315	490
S	380	540
T	500	700
V	600	800

A selection of material qualities conforming to classes of Table 4 for hook sizes in accordance with Annexes A and B is given in Annex F. Another selection of material qualities may be used, as long as the requirements of Table 4 are met and guaranteed by the hook manufacturer.

4.2 Workmanship

The manufacturing process, factory tests and delivery conditions shall meet the requirements of EN 10254.

Each hook body shall be forged hot in one piece. The macroscopic flow lines of the forging shall follow the body outline of the hook. Excess metal from the forging operation shall be removed cleanly leaving the surface free from sharp edges.

Profile cutting from a plate is not permissible for forged hooks.

The surface roughness of the hook seat in the finished product shall be equal to or better than R_z 500 μm . Grinding may be used to reach the required surface quality. Any grinding marks shall be in a circumferential direction in respect to the seat circle.

After heat treatment, furnace scale shall be removed and the hook body shall be free from harmful defects, including cracks. Hook forging shall be inspected for defects using appropriate NDT-methods according to EN 10228-3. Requirements of quality class 1 of EN 10228-3:1998 shall be met.

No welding shall be carried out at any stage of manufacture.

4.3 Manufacturing tolerances

The dimensional tolerances according to EN 10243-1 for forging grade F shall be fulfilled, except as modified herein.

The seat circle diameter and the throat opening shall be within [0 ; + 7 %] of the nominal dimension. The point height dimension a_3 shall be within [- 7 % ; + 7 %] of the nominal dimension.

The centre line of the machined shank shall not deviate from the seat centre more than $\pm 0,02 a_1$.

The shape of the hook in its own plane shall be such that the centres of the material sections specified by the two flanks of a section shall fall between two parallel planes with a spacing of $0,05 d_1$.

4.4 Heat treatment

Each forged hook shall either be hardened from a temperature above the AC_3 point and tempered, or normalized from a temperature above the AC_3 point. The tempering temperature shall be at least 475 °C.

The normalizing or tempering conditions shall be at least as effective as a temperature of 475 °C maintained for a period of 1 h.

4.5 Proof loading

As part of the manufacturing process, a hook may be proof loaded. This initial proof loading can further assist the Quality Assurance Management process as well as improve the fatigue performance of the hook in general. If proof loading is applied, the process of proof loading shall be as follows:

- a) Proof loading is applied after forging, subsequent to heat treatment and shank machining;
- b) The proof load force shall be applied between the hook seat and the shank suspension nut, either as a straight pull parallel to the hook shank or the load applied as in test loading in accordance with Figure 7;
- c) A relative permanent set due to proof loading measured at the gap opening shall not exceed 0,25 %;
- d) For batch-produced hooks the proof loading shall be applied to each hook in the batch;
- e) Magnitude of proof load shall be such that the stress in the intrados exceeds the yield stress of the material;
- f) In general, the magnitude of proof load should be related to the static limit design force of the hook body and be within limits between $1,0 \times F_{Rd,s}$ and $1,2 \times F_{Rd,s}$;
- g) After proof loading, the hook shall be inspected for defects using appropriate NDT-methods and found free from harmful flaws, defects and cracks;
- h) Proof loaded hook shall be stamped with symbol "PL" adjacent to the hook type marking.

NOTE Benefits derived from the application of the proof loading in subsequent fatigue performance and to the QA Management process are not addressed within this standard.

4.6 Hook body geometry

Proportions of hook sections shall be such that stresses do not exceed stresses in the critical sections specified in 5.5.1.

The seat of a hook shall be of circular shape. In a single hook, the centre of curvature shall coincide with the centreline of the machined shank. In a ramshorn hook, the seat circle shall be tangential in respect to the outer edge of the forged shank.

A ramshorn hook shall be symmetrical in respect to the centre line of the shank.

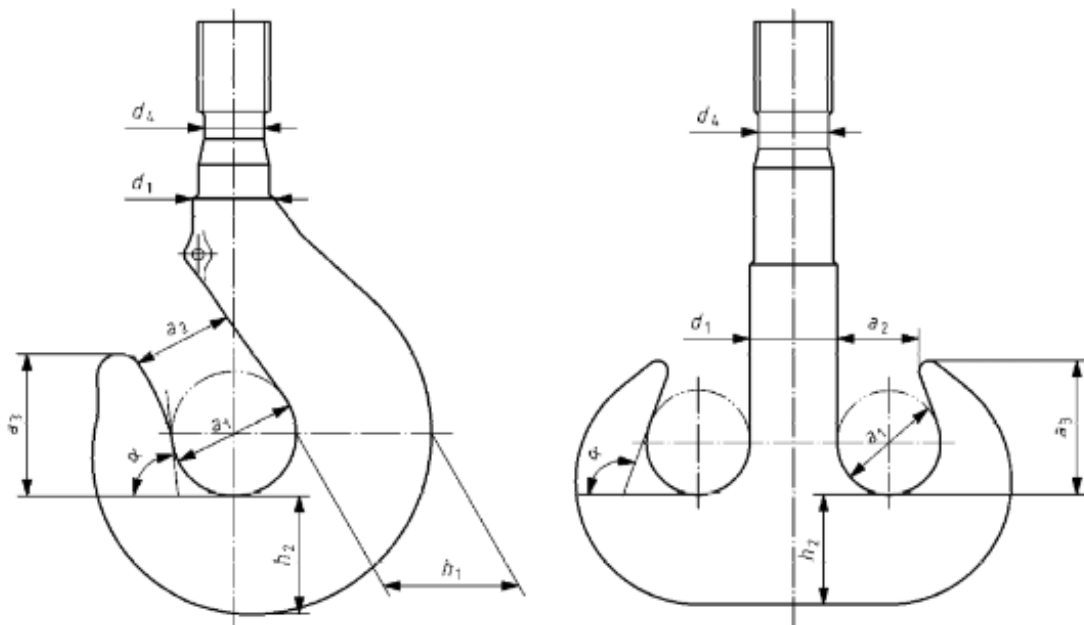


Figure 1 — Hook dimensions

The diameter of the forged shank (d_1) shall be proportioned to circle diameter (a_1) as follows: $d_1 \geq 0,55 a_1$.

The bifurcation point between the inner edge and the seat circle (a_1) shall be from the horizontal in minimum as follows: for a single hook $\alpha \geq 60^\circ$, for a ramshorn hook $\alpha \geq 90^\circ$

The full throat opening (a_2), without consideration to a latch shall be proportioned to the seat circle diameter as follows: $a_2 \leq 0,85 a_1$. The effective throat opening with a latch shall be in minimum $a_e \geq 0,7 a_1$.

The point height of a hook (a_3) shall be in minimum as follows: $a_3 \geq a_1$.

Annexes A and B present example sets of hook body dimensions, which fulfil the requirements of this clause.

4.7 Hook shank machining

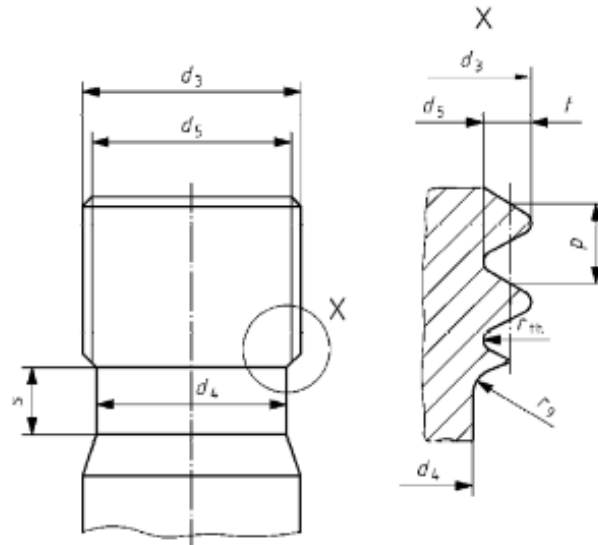


Figure 2 — Machined dimensions of shank

The length of the threaded portion of the shank shall be not less than $0,8 d_3$.

The pitch of the thread (p) shall be proportioned to the principal diameter of the thread (d_3) as follows: $0,055 d_3 \leq p \leq 0,15 d_3$.

The depth of the thread (t) shall be proportioned to the pitch of the thread (p) as follows: $0,45 p \leq t \leq 0,61 p$.

The bottom radius of the thread profile (r_{th}) shall be no less than $0,14 p$. A thread type, where the bottom radius is not specified, shall not be used.

The shank shall be undercut (with a diameter d_4) below the last threads for a length (s) proportioned to the undercut depth as follows: $s \geq 2 (d_3 - d_4)$. The undercut shall reach deeper than the core diameter of the thread profile (d_5), in minimum as follows: $d_4 \leq (d_5 - 0,3 \text{ mm})$. The undercut shall be machined with a form ground tool to a surface finish of $R_a \leq 3,2 \mu\text{m}$ and shall be free from machining marks and defects.

There shall be a relief radius in a transition from the threaded part to the undercut part. The relief radius (r_9) shall be proportioned to the diameter of the undercut (d_4) as follows: $r_9 \geq 0,06 d_4$. The shape of the relief transition need not be a complete quadrant of a circle.

The thinnest section of the machined shank (consequently d_4) shall fulfil the condition $d_4 \geq 0,65 d_1$, where d_1 is the diameter of the forged part of the shank, see Figure 1

The whole machined section of the shank shall have a radius at each change in diameter. The machined section shall not reach the curved part of the forged body.

Screwed threads shall comply with the tolerance requirements of ISO 965-1 (coarse series) and be of medium fit class 6g.

Annex G presents example sets of machined shank and thread dimensions, which fulfil the geometric requirements.

4.8 Nut

The material grade of the nut shall be equal to that of the hook

The height of the nut shall be such that the threaded length of the hook shank is fully engaged with the nut thread.

The nut shall be positively locked to the shank against rotation to prevent the nut from unscrewing. The locking shall not interfere with the lower two thirds of the nut/shank thread connection. The locking shall allow relative axial movement between the shank and the nut due to play in the threaded connection. Alternatively, if the nut is locked by a dowel or other similar fixing media, it is essential during the locking process that the nut/shank load bearing thread flanks are in direct contact to ensure resultant unimpaired load transmission.

The nut shall rest on an anti-friction bearing, enabling the hook body to rotate about the vertical axis. The contact surface of the nut resting on the bearing shall meet the requirements as stipulated by the related bearing. The height position of the contact surface shall fall within the lower half of the thread connection.

Screwed threads of the nut shall comply with the tolerance requirements of ISO 965-1 (coarse series) and be of medium fit class 6H. The bottom radius of the thread profile for the nut shall be not less than 0,07 p, where p is the pitch of the thread. A thread type, where the bottom radius is not specified, shall not be used.

4.9 Hook suspension

In general, and always for serially produced hook blocks, the hook suspension together with hoist rope reeving system shall be such that the system allows free tilting of the hook in any inclined direction of the load line. In cases where this articulation of the hook suspension is not provided, this shall be specially taken into consideration in the design calculations of the hook. In cases, where by changing the crane/hook block configuration or position the hook suspension can be brought to a rigid position, this shall be taken into account in the design calculation of the hook.

The same load actions as specified for the hook shall be taken into account in the design of the hook suspension.

5 Static strength

5.1 General

The proof of static strength for hooks shall be carried out in accordance with principles of EN13001-1 and EN13001-2. The general design limit for static strength is yielding of the material.

The proof shall be delivered for the specified critical sections of the hook, taking into account the most unfavourable load effects from the load combinations A, B or C in accordance with EN 13001-2. The relevant partial safety factors γ_p shall be applied. The risk coefficients γ_n shall be applied when required in the specific application or as specified in the relevant European crane type standard.

5.2 Vertical design load

The vertical design force for a hook $F_{Sd,s}$ when hoisting the rated hook load, shall be calculated as follows:

$$F_{Sd,s} = \phi \times m_{RC} \times g \times \gamma_p \times \gamma_n \quad (1)$$

$$\text{with } \phi = \max \left\{ \phi_2 ; \left(1 + \phi_5 \times \frac{a}{g} \right) \right\}$$

where

ϕ_2 is the dynamic factor, when hoisting an unrestrained grounded load, see EN 13001-2;

ϕ_5 is the dynamic factor for loads caused by hoist acceleration, see EN 13001-2;

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- a is the vertical acceleration or deceleration;
- m_{RC} is the mass of the rated hook load;
- g is the acceleration due to gravity, $g = 9,81 \text{ m/s}^2$;
- γ_p is the partial safety factor, see EN13001-2;
- $\gamma_p = 1,34$ for regular loads (load combinations A);
- $\gamma_p = 1,22$ for occasional loads (load combinations B);
- $\gamma_p = 1,10$ for exceptional loads (load combinations C);
- γ_n is the risk coefficient.

Other load actions and combinations of EN13001-2 may produce vertical forces on the hook, whose load actions shall also be analysed. The vertical design force in such cases is expressed in a general format as follows:

$$F_{Sd,s} = F_H \times \gamma_p \times \gamma_n \quad (2)$$

where

- F_H is a vertical force on hook due to other load action than hoisting a rated load; e.g. a test load or a peak load in an overload condition;
- γ_p is the partial safety factor as above, see EN13001-2;
- γ_n is the risk coefficient.

5.3 Horizontal design force

The horizontal forces that are most significant for the strength of hooks are those caused by horizontal accelerations of the crane motions. Other horizontal forces e.g. due to wind or sideways pull actions shall be taken into account, if significant. The horizontal force shall be assumed to act at the bottom of the hook seat.

The horizontal design force of hook $H_{Sd,a}$ due to horizontal accelerations shall be calculated as follows:

$$H_{Sd,s} = \min \left\{ \begin{array}{l} m_{RC} \times a \times \phi_5 \times \gamma_p \times \gamma_n \\ C_t \times F_{Sd,s} / h \end{array} \right\} \quad (3)$$

where

- m_{RC} is the mass of the rated hook load;
- a is the acceleration or deceleration of a horizontal motion;
- ϕ_5 is the dynamic factor for loads caused by horizontal acceleration, see EN 13001-2. For hook suspensions, which are not rigidly connected in horizontal direction to the moving part of the crane, it shall be set $\phi_5 = 1$;
- γ_p is the partial safety factor as for Equation (1);
- γ_n is the risk coefficient;

C_t is the relative tilting resistance of the hook suspension in accordance with Annex I;

$F_{Sd,s}$ is the vertical design force in accordance with 5.2, related to the loading condition where $H_{Sd,s}$ is specified;

h is the vertical distance from the seat bottom of the hook body to the centre of the articulation.

5.4 Bending moment of the shank

5.4.1 General

The following load action shall be taken into consideration, when determining the total bending moment of the hook shank:

- Horizontal forces, see 5.4.2;
- Inclination of the hook suspension, see 5.4.3;
- Eccentric action of vertical force in the hook seat, see 5.4.4;
- Ramshorn hook, half of the rated load on one prong only, see 5.4.5.

The bending moments caused through these load actions shall be addressed to the same load combinations, which the primary loads or operational conditions causing the bending belong to.

5.4.2 Bending moment due to horizontal force

This clause covers the shank bending moment due to external horizontal forces. The moment M_1 shall be calculated at the critical hook shank section due to the horizontal design force $H_{Sd,s}$.

$$M_1 = H_{Sd,s} \times h_s \quad (4)$$

where

$H_{Sd,s}$ is the horizontal design force in accordance with 5.3;

h_s is the vertical distance from the seat bottom of the hook body to the upper end of the thinnest part of the hook shank.

5.4.3 Bending moment due to inclination of hook suspension

Where the arrangement of the hoist mechanism or hook/hook block is such that the hook suspension may be brought to an inclined position in a loaded condition, the bending moment at the shank caused by this inclination shall be considered in the design calculations. Such an inclination may be caused e.g. by:

- Differences in hoist travel distances between two separate hoist drives carrying a load beam with a hook, see Figure 3;
- Tilting of a single rope reeving during hoisting/lowering motion, see Figure 4;
- Tilting of a crane part, to which a hook is rigidly attached; or
- Two-blocking of a bottom block in the uppermost hoist position with a crane part, after which this crane part is tilted.

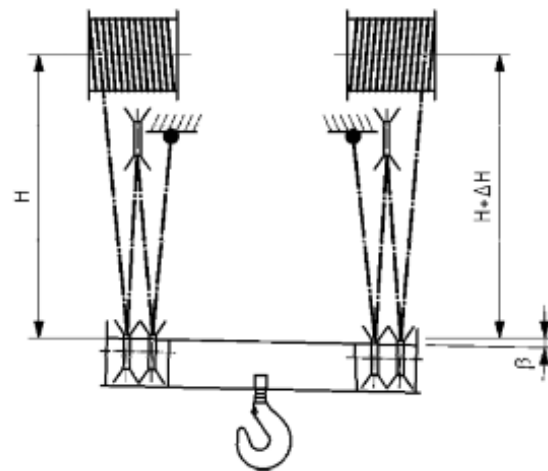


Figure 3 — Tilting of a hook in case of different hoist travel distances

Due to an inclination, the vertical force has a force component perpendicular to the axis of the hook shank. This force shall be taken into account in the same way as the horizontal forces. The bending moment M_2 caused at the critical hook shank section is proportional to the vertical design force as follows:

$$M_2 = F_{Sd,s} \times h_s \times \sin(\beta) \quad (5)$$

where

$F_{Sd,s}$ is the vertical design force in accordance with 5.2, related to the condition with a hook inclination β ;

β is the maximum, total inclination in each relevant load combination;

h_s is the vertical distance from the seat bottom of the hook body to the upper end of the thinnest part of the hook shank.

In a rope balanced hook suspension with multiple rope falls and a single running rope coming from the drum, the hoisting/lowering movement causes the hook suspension to tilt, see Figure 4. The inclination is calculated as follows:

$$\beta = \arctan(C_t/h) \quad (6)$$

where

C_t is the relative tilting resistance of the hook suspension in accordance with Annex I;

h is the vertical distance from the seat bottom of the hook body to the centre of the articulation.

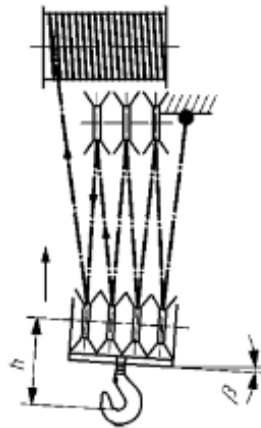


Figure 4 — Tilting of a hook suspension in a single rope reeving system

The maximum inclination, the related vertical force and the consequent moment M_2 shall be calculated separately for all relevant loading conditions of the crane.

5.4.4 Bending moment due to eccentricity of vertical force

A hoist load attachment may not always settle in the middle of the hook seat. The deviation of the vertical load action line from the centre line of the shank causes a bending moment, which shall be calculated as follows:

$$M_3 = c_e \times F_{Sd,s} \times a_1 \quad (7)$$

where

$F_{Sd,s}$ is the vertical design force in accordance with 5.2;

a_1 is the seat circle diameter of the hook body;

c_e is a coefficient for the eccentricity;

$c_e = 0,05$.

NOTE A smaller eccentricity may be used in the design calculations, if a positive, mechanical means is provided ensuring the hoist load attachment to settle closer to the hook seat centre.

5.4.5 Special case for a ramshorn hook

As a special loading case for ramshorn hooks it shall be assumed, that half of the vertical force acts on one prong while the other prong is unloaded. This loading case is addressed in the calculations to the load combination C.

For a ramshorn hook with one-sided loading, the bending moment M_4 caused at the critical hook shank section is calculated as follows:

$$M_4 = F_{Sd,s} / 2 \times \left[e_R \times (1 - h_s / h) + h_s / h \times \min \left\{ \frac{e_R}{C_t} \right\} \right] \quad (8)$$

with

--

$$e_R = (a_1 + d_1)/2$$

where

$F_{Sd,s}$ is the vertical design force in accordance with 5.2 and γ_p for load combination C;

d_1 is the diameter of the forged shank;

a_1 is the seat circle diameter of the hook;

e_R is the distance of the vertical load line from the centre line of the shank;

h is the vertical distance from the seat bottom of the hook body to the centre of the articulation;

h_b is the vertical distance from the seat bottom of the hook body to the upper end of the thinnest part of the hook shank;

C_t is the relative tilting resistance of the hook suspension, see Annex I.

5.4.6 Design bending moment of the shank

In general, the design bending moment at the critical shank section $M_{Sd,s}$ for the loading conditions in accordance with 5.4.2 to 5.4.4 shall be calculated separately for each relevant load combination as follows:

$$M_{Sd,s} = \min \left\{ \begin{array}{l} (M_1 + M_2 + M_3) \\ C_t \times F_{Sd,s} \end{array} \right\} \quad (9)$$

where

M_1 to M_3 are the bending moments in accordance with 5.4.2 to 5.4.4;

C_t is the relative tilting resistance of the hook suspension, see Annex I;

$F_{Sd,s}$ is the vertical design force in accordance with 5.2.

Additionally to the above, the design bending moment in accordance with the special case of 5.4.5 shall be taken into account in a load combination C as follows:

$$M_{Sd,s} = M_4 \quad (10)$$

where

M_4 is the bending moment in accordance with 5.4.5.

5.5 Hook body, design stresses

5.5.1 Loadings

The vertical design force $F_{Sd,s}$ is divided into two force components, acting in the centre of the seat circle symmetrically on the opposite sides of the vertical centre line and in an angle α in respect to vertical, see Figure 5.

As a minimum value of α , it shall be assumed that $\alpha = 45^\circ$.

For ramshorn hooks, an equal load distribution is assumed between the two prongs in load combinations A and B.

As a special loading case, for ramshorn hooks it shall be assumed that half of the vertical force acts on one prong while the other prong is unloaded. This loading case is addressed in the calculations to the load combination C.

The horizontal forces are neglected in the hook body calculations.

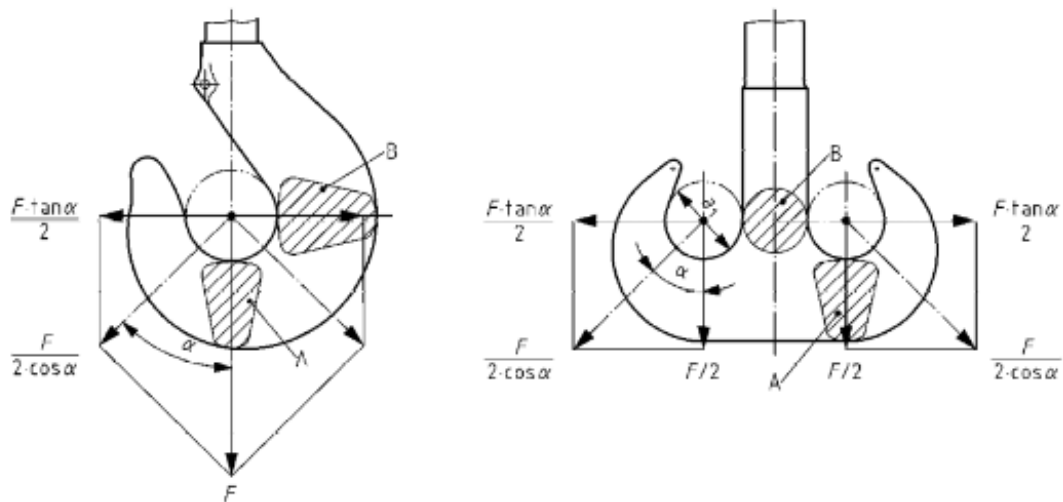


Figure 5 — Load actions on hook body and critical sections for calculation

5.5.2 Stress calculation methods

Stresses in the designated sections of a hook body shall be analysed either by the theory of curved beam bending in accordance with Annex H, by finite element methods or by full scale experiments. Stresses in section B of a ramshorn hook may, however be analysed by the conventional beam bending theory.

The following clauses are based upon the theory of curved beam bending.

5.5.3 Design stresses

The design stresses σ_{Sd} in sections A and B of single hooks and in the section A of ramshorn hooks shall be calculated as follows:

$$\sigma_{Sd,s} = \frac{\nu \times F_{Sd,s} \times R \times \eta_1}{I} \times \frac{1}{1 - \eta_1/R} \quad (11)$$

with

$$R = a_1 / 2 + \eta_1$$

and

$$\nu = 1 \quad \text{for section B of single hooks;}$$

$$\nu = 0,5 \times \tan \alpha \quad \text{for section A of single and ramshorn hooks, } \alpha = 45^\circ;$$

where

R is the hook curvature radius determined by the centroid of the section;

$F_{Sd,s}$ is the vertical design force in accordance with 5.2;

- I is the reference moment of inertia for curved beam;
- a_1 is the seat circle diameter of the hook;
- η_1 is the absolute value of the coordinate y at inner edge of the particular section;
- α is the angle of the load action lines in respect to vertical, see Figure 5.

The quantities η_1 and I are section specific values and shall be calculated in accordance with Annex H.

The design stress in the section B of ramshorn hook for the special case of 5.4.5 shall be calculated as follows:

$$\sigma_{Sd,s} = \frac{F}{A_{d1}} + \frac{F \times (a_1 + d_1) \times d_1 / 4}{I_{d1}} \quad (12)$$

with

$$F = F_{Sd,s} / 2$$

where

- $F_{Sd,s}$ is the vertical design force in accordance with 5.2 and γ_b for load combination C;
- A_{d1} is the cross section area of the forged shank;
- I_{d1} is the moment of inertia of the forged shank;
- d_1 is the diameter of the forged shank;
- a_1 is the seat circle diameter of the hook.

5.6 Hook shank, design stresses

The vertical design forces in accordance with 5.2 and the design bending moments in accordance with 5.4 shall be taken into account in the proof calculations of a hook shank. In general, the critical section of the shank is the undercut part immediately below the threaded section with a diameter d_s , see Figure 1. Maximum design stress $\sigma_{Sd,s}$ is calculated as a nominal stress without stress concentration factors and using conventional beam bending theory as follows:

$$\sigma_{Sd,s} = \frac{F_{Sd,s}}{A_{d4}} + \frac{M_{Sd,s} \times d_s / 2}{I_{d4}} \quad (13)$$

where

- $F_{Sd,s}$ is the vertical design hook force;
- $M_{Sd,s}$ is the design bending moment in the critical section, see 5.4.6;
- A_{d4} is the cross section area of the critical section of the hook shank;
- I_{d4} is the moment of inertia of the critical section of the hook shank.

5.7 Hook, proof of static strength

5.7.1 General for hook body and shank

Both for the hook body and the hook shank, it shall be proven for relevant load actions specified in 5.2 to 5.4 that

$$\sigma_{Sd,s} \leq f_{Rd} = f_1 \times \frac{f_y}{\gamma_w \times \gamma_{ms}} \quad (14)$$

where

$\sigma_{Sd,s}$ is the maximum design stress in accordance with 5.5 and 5.6 in the critical section;

f_{Rd} is the limit design stress;

f_y is the yield stress of the material in the finished product;

f_1 is the influence factor for the operation temperature;

$\gamma_w = 1,1$ is the general resistance coefficient in accordance with EN 13001-2;

γ_{ms} is the specific resistance coefficient for the section as follows:

$\gamma_{ms} = 0,75$ for the hook body section B of single hooks;

$\gamma_{ms} = 0,90$ for other sections.

In the absence of other data, the factor f_1 taking into consideration the reduction of the yield stress in high temperatures may be calculated as follows:

$$\begin{aligned} f_1 &= 1 && \text{For } -50 \text{ }^\circ\text{C} \leq T \leq 100 \text{ }^\circ\text{C} \\ f_1 &= 1 - 0,25 \times (T - 100) / 150 && \text{For } 100 \text{ }^\circ\text{C} < T \leq 250 \text{ }^\circ\text{C} \end{aligned} \quad (15)$$

where

T is the operation temperature in degrees Celsius ($^\circ\text{C}$).

5.7.2 The use of static limit design force for verification of the hook body

In cases where the selected hook body is in accordance with Annexes A or B, the proof of static strength may be based on the static limit design force shown in Annex C, and it shall be proven for all relevant load actions and combinations specified in 5.2 that

$$F_{Sd,s} \leq f_1 \times F_{Rd,s} \quad (16)$$

where

$F_{Sd,s}$ is the vertical design force in accordance with 5.2;

$F_{Rd,s}$ is the static limit design force in accordance with Annex C;

f_1 is the influence factor for the operation temperature in accordance with Equation (15).

NOTE 1 Additionally, the proof of static strength for the shank is carried out in accordance with 5.7.1.

The static limit design force covers the proof of static strength for sections A and B of single hooks and for the section A of ramshorn hooks. It is calculated as follows:

$$F_{Rd,s} = \frac{f_y}{\gamma_w \times \gamma_{sw}} \times \frac{I \times (1 - \eta_1 / R)}{v \times R \times \eta_1} \quad (17)$$

For a single hook the static limit design force is calculated separately for the two sections A and B and the smaller value of the two is used.

NOTE 2 The dimensions of the ramshorn hooks in Annex B are proportioned such, that the section B of the hook body does not become governing in respect to static strength of the body, i.e. the proof of a special case in 5.4.5 is not required.

6 Fatigue strength

6.1 General

The proof of fatigue strength for hooks shall be carried out in accordance with principles of EN 13001-1 and EN 13001-2. A hook shall have the design life in minimum equal to that of the related crane or hoist.

The proof shall be delivered for the specified critical sections of the hook, taking into account the most unfavourable load effects from the load combinations A in accordance with EN 13001-2, setting all partial safety factors $\gamma_p = 1$ and the risk coefficients $\gamma_n = 1$.

The number of stress cycles for the proof shall be based on the total number of working cycles during the design life of the crane, as specified in EN 13001-1. In general, for the hook body, one lifting cycle induces one stress cycle. If a working cycle consists of several lifting cycles, this shall be taken into account, when counting the stress cycles. For the hook shank, additionally the number of positioning movements in accordance with EN 13001-1 shall be taken into account, when counting the number of bending stress cycles.

6.2 Vertical fatigue design force

The vertical design force $F_{Sd,i}$ for a lifting cycle i shall be calculated as follows:

$$F_{Sd,i} = \phi_2 \times m_i \times g \quad (18)$$

where

ϕ_2 is the dynamic factor, when hoisting an unrestrained grounded load, see EN 13001-2;

m_i is the mass of the hook load in a lifting cycle i ;

g is the acceleration due to gravity, $g = 9,81 \text{ m/s}^2$.

6.3 Horizontal fatigue design force

The horizontal design force $H_{Sd,i}$ for a lifting cycle i due to horizontal accelerations shall be calculated as follows:

$$H_{Sd,i} = \min \left\{ \begin{array}{l} m_i \times a \times \phi_3 \\ C_f \times m_i \times g / h \end{array} \right\} \quad (19)$$

where

m_i is the mass of the hook load in a lifting cycle i ;

- a is the acceleration or deceleration of a horizontal motion;
- ϕ_5 is the dynamic factor for loads caused by horizontal acceleration, see EN 13001-2. For hook suspensions, which are not rigidly connected in horizontal direction to the moving part of the crane, it shall be set $\phi_5 = 1$;
- C_t is the relative tilting resistance of the hook suspension, see Annex I;
- g is the acceleration due to gravity, $g = 9,81 \text{ m/s}^2$;
- h is the vertical distance from the seat bottom of the hook body to the centre of the articulation.

6.4 Fatigue design bending moment of shank

6.4.1 Bending moment due to horizontal force

The moment $M_{t,i}$ shall be calculated at the critical hook shank section, due to the horizontal design force $H_{Sd,t,i}$ in accordance with 6.3:

$$M_{t,f,i} = H_{Sd,f,i} \times h_s \quad (20)$$

where

$H_{Sd,t,i}$ is the horizontal design force in a lifting cycle i in accordance with 6.3;

h_s is the vertical distance from the seat bottom of the hook body to the upper end of the thinnest part of the hook shank.

6.4.2 Bending moment due to inclination of hook suspension

The basis causing inclination and the method of calculation shall be taken into consideration in analogy to 5.4.3. For the proof of fatigue strength the consideration, which of the loading events of load combination A are regular loadings, shall be based upon the crane configuration and application.

As a minimum, the following shall be considered to occur regularly in each lifting cycle: In a rope balanced hook suspension with multiple numbers of falls and a single running rope coming from the drum, the hoisting/lowering movement causes the hook suspension to tilt, see Figure 4. The bending moment $M_{2,i}$ caused at the critical hook shank section is calculated as follows:

$$M_{2,f,i} = F_{Sd,f,i} \times h_s \times \sin(\beta) \quad (21)$$

where

$F_{Sd,f,i}$ is the vertical design force in a lifting cycle i , in accordance with 6.2;

h_s is the vertical distance from the seat bottom of the hook body to the upper end of the thinnest part of the hook shank;

β is the inclination of the hook suspension in accordance with Equation (6).

6.4.3 Bending moment due to eccentricity of vertical force

A hoist load attachment may not always settle in the middle of the hook seat. The deviation of the vertical load action line from the centre line of the shank causes a bending moment, which shall be calculated as follows:

$$M_{3,f,i} = c_e \times F_{Sd,f,i} \times a_1 \quad (22)$$

where

$F_{Sd,i}$ is the vertical design force in a lifting cycle i , in accordance with 6.2;

a_1 is the seat circle diameter of the hook body;

c_e is a coefficient for the eccentricity, $c_e = 0,05$.

NOTE A smaller eccentricity may be used in the design calculations, if a positive, mechanical means is provided ensuring the hoist load attachment settles closer to the hook seat centre.

6.5 Proof of fatigue strength, hook body

6.5.1 Design stress calculation

The proof of fatigue strength is based on cumulative effect of stress ranges in the critical sections. It is assumed that the load is grounded in each lifting cycle, i.e. the hook load range is from zero to the full load, with due consideration to the dynamic factors.

Calculation of the stress ranges is comparable to that of the static design stress in 5.5.3, when applying the vertical fatigue design load from 6.2:

$$\Delta\sigma_{Sd,i} = \sigma_{Sd,s} \text{ in accordance with Equation (11) in 5.5.3, when setting } F_{Sd,s} = F_{Sd,i}$$

where

i is the index of a lifting cycle;

$\Delta\sigma_{Sd,i}$ is the stress range in a cycle i ;

$F_{Sd,i}$ is the vertical fatigue design force in accordance with 6.2.

6.5.2 Stress history in general

The cumulative fatigue effect of the stress history from all of the stress cycles is condensed to a single stress history parameter s_h . This is calculated as follows:

$$s_h = k_h \times v_h \quad (23)$$

with

$$k_h = \frac{1}{N} \sum_{i=1}^N \left(\frac{\Delta\sigma_{Sd,i}}{\Delta\sigma_{Sd,max}} \right)^m \quad (24)$$

and

$$v_h = \frac{N}{N_D} \quad (25)$$

where

k_h is the stress spectrum factor;

v_h is the relative number of stress cycles;

- i is the index of a lifting cycle;
- N is the total number of lifting cycles;
- $N_D = 2 \times 10^6$ is the reference number of cycles;
- $\Delta\sigma_{Sd,i}$ is the stress range in a cycle i ;
- $\Delta\sigma_{Sd,max}$ is the maximum stress range;
- $m = 6$ is the slope parameter of the characteristic fatigue design curve.

The total number of lifting cycles (N) shall conform to the total number of working cycles (C) during the design life of the crane as specified in EN 13001-1.

6.5.3 Stress history based upon classified duty

The hook body represents a special case, where the stress variations depend upon the hoist load variations, only. Because of this, the stress history parameter can be derived directly from the classes Q and U of EN 13001-1, instead of using a case specific stress history and detailed calculation of s_h in accordance with 6.5.2. In cases where the intended duty is specified through the classes Q and U only, the calculation of s_h shall be carried out as presented herein.

A load history parameter s_Q is defined by the equation

$$s_Q = kQ \times N / N_D \quad (26)$$

where

- kQ is the load spectrum factor in accordance with Table 4, see also EN 13001-1;
- N is the total number of lifting cycles. Typically, for a hook this shall be taken as the number work cycles (C) specified for the crane through the class U of EN 13001-1. Each intermediate grounding of the load within a work cycle shall, however, be counted as an additional lifting cycle and added to the value of N ;
- $N_D = 2 \times 10^6$ is the reference number of cycles.

The load spectrum factor (kQ) is calculated by a Wöhler curve slope with an exponent of 3, whereas the hook body fatigue is related to a slope $m = 6$. For a load distribution with a given shape, a conversion factor can be calculated to create a connection between the load spectrum of EN 13001-1 and the stress history parameter of hooks. For a classified duty shapes of load distributions given in Annex E shall be applied

In cases where the load spectrum is specified through the classification of EN 13001-1, the stress history parameter s_h for a hook body shall be calculated as follows:

$$s_h = \frac{s_Q}{(k_h^*)^m} \quad (27)$$

with

$$k_h^* = \sqrt[3]{\frac{kQ}{k_h}} \quad (28)$$

where

k_6^* is the specific spectrum ratio factor. Standardized, conventional values in accordance with Table 5 shall be used for design of hook body. See also Annex E.

Table 5 — Specific spectrum ratio factors k_6^*

Class Q of EN 13001-1:2004	Load spectrum factor kQ	Factor k_6^* for $m = 6$
Q ₀	0,031 3	1,34
Q ₁	0,062 5	1,27
Q ₂	0,125	1,20
Q ₃	0,250	1,14
Q ₄	0,500	1,08
Q ₅	1,000	1,00

6.5.4 Limit fatigue design stress

The basic assumption is that the fatigue strength curves in the $\log(\sigma)/\log(N)$ -scale are straight lines, with the same slope (m) for all material grades. This is a reasonable approximation in the range of high number of stress cycles, where fatigue is the governing design criteria.

The limit fatigue design stress at the reference point N_D is calculated as follows:

$$\Delta\sigma_{Rd} = f_1 \times f_2 \times \Delta\sigma_c \quad (29)$$

where

$\Delta\sigma_{Rd}$ is the limit fatigue design stress;

$\Delta\sigma_c$ is the characteristic fatigue strength at $N_D = 2 \times 10^6$ cycles, dependent on the material;

f_1 is the influence factor for the operation temperature, in accordance with Equation (31);

f_2 is the influence factor for the material thickness, in accordance with Equation (32).

The characteristic fatigue strength $\Delta\sigma_c$ is dependent upon the ultimate strength of the material. For the classified material grades in accordance with Table 4, the fatigue strength shall be taken from Table 6.

Table 6 — Characteristic fatigue strength of forged hook materials

Material class	$\Delta\sigma_c$ N/mm ²
M	170
P	220
S	235
T	280
V	305

For other materials and in cases where the classified material grades are not applied, the characteristic fatigue strength $\Delta\sigma_c$ shall be calculated as follows:

$$\Delta\sigma_c = 0,315 \times f_u \times 1g \frac{13\,001}{f_u} \quad (30)$$

where

f_u is the ultimate strength of the material in newtons per square millimetre (N/mm²).

The influence factor f_1 for the operation temperature is calculated as follows:

$$\begin{aligned} f_1 &= 1 - 0,1 \times (T - 100) / 150 && \text{for } 100 \text{ }^\circ\text{C} \leq T \leq 250 \text{ }^\circ\text{C} \\ f_1 &= 1 && \text{for } -50 \text{ }^\circ\text{C} \leq T \leq 100 \text{ }^\circ\text{C} \end{aligned} \quad (31)$$

where

T is the operation temperature in degrees Celsius (°C).

The influence factor f_2 for the material thickness is calculated as follows:

$$\begin{aligned} f_2 &= \left(\frac{b_{ref}}{b_{max}} \right)^{0,167} && \text{for } 25 \text{ mm} \leq b_{max} \leq 150 \text{ mm} \\ f_2 &= 1 && \text{for } b_{max} < 25 \text{ mm} \\ f_2 &= 0,74 && \text{for } b_{max} > 150 \text{ mm} \end{aligned} \quad (32)$$

where

b_{ref} is the reference width, $b_{ref} = 25$ mm;

b_{max} is the maximum width in the critical hook body section, see Figure 5 in 5.5.1.

6.5.5 Execution of the proof

The proof shall be carried out separately for all relevant sections of the hook body.

For the proof of fatigue strength, it shall be proven that

$$\Delta\sigma_{Sd,max} \leq \frac{\Delta\sigma_{Rd}}{\gamma_{HF} \times \sqrt[3]{S_h}} = \frac{k_6^* \times \Delta\sigma_{Rd}}{\gamma_{HF} \times \sqrt[3]{S_Q}} \quad (33)$$

where

$\Delta\sigma_{Sd,max}$ is the maximum stress range within the total stress history;

$\Delta\sigma_{Rd}$ is the limit fatigue design stress in accordance with Equation (29);

γ_{HF} is the fatigue strength specific resistance factor in accordance with Table 7;

- $M = 6$ is the slope parameter of the characteristic fatigue design curve;
 s_h is the stress history parameter;
 k_6^* is the specific spectrum ratio factor;
 s_Q is the load history parameter.

Table 7 — Fatigue strength specific resistance factor

Section of hook	γ_H
Section A of single and ramshorn hooks	1,35
Section B of single hooks	1,25

For the calculation utilizing the classification in accordance with EN 13001-1, the values for the following conversion factor are given in Annex E:

$$k_C = k_6^* / \sqrt[3]{s_Q} \quad (34)$$

6.5.6 The use of fatigue limit design force for verification of the hook body

In cases where the selected hook body is in accordance with Annexes A or B, the proof of fatigue strength may be based on the fatigue limit design force shown in Annex D, and it shall be proven for all relevant load actions and combinations specified in 6.2 that

$$F_{Sd,f} \leq \frac{f_1 \times F_{Rd,f}}{\sqrt[3]{s_h}} = \frac{f_1 \times k_6^* \times F_{Rd,f}}{\sqrt[3]{s_Q}} \quad (35)$$

where

$F_{Sd,f}$ is the maximum vertical fatigue design load in accordance with 6.2;

$F_{Rd,f}$ is the fatigue limit design force in accordance with Annex D;

f_1 is the influence factor for the operation temperature in accordance with Equation (31).

The fatigue limit design force is calculated as follows:

$$F_{Rd,f} = \frac{f_2 \times \Delta \sigma_c}{\gamma_H f} \times \frac{I \times (1 - \eta_1 / R)}{v \times R \times \eta_1} \quad (36)$$

For a single hook, the fatigue limit design force is calculated separately for the two sections A and B and the smaller value of the two is used.

6.6 Proof of fatigue strength, hook shank

6.6.1 General

The number of stress cycles is derived from the total number of lifting cycles (N), which shall conform to the total number of working cycles (C) during the design life of the crane as specified in accordance with EN 13001-1.

The following symbols are used throughout 6.6:

- N is the total number of lifting cycles for the crane;
- p_a is the average number of accelerations related to one lifting cycle, see EN13001-1;
- i is the index of a stress/lifting cycle;
- $N_D = 2 \times 10^6$ is the reference number of cycles;
- m is the slope parameter of a characteristic fatigue design curve;
- f_u is the ultimate strength of the material;
- f_y is the yield stress of the material.

6.6.2 Design stress calculation

The design stresses shall be calculated in the undercut section of the shank immediately below the threads with a diameter d_4 , see Figure 1. Basic stresses are calculated without stress concentration factors and using conventional beam bending theory. The following equations are general and apply in 6.6 for any vertical design force and design bending moment:

$$\sigma_a(F) = \frac{F}{A_{d4}} \quad (37)$$

$$\sigma_b(M) = \frac{M \times d_4 / 2}{I_{d4}} \quad (38)$$

where

- σ_a is the shank stress (axial) due to vertical design force;
- σ_b is the shank stress (bending) due to design bending moment;
- F is the vertical design force in a fatigue load cycle;
- M is the design bending moment in a fatigue load cycle;
- A_{d4} is the cross section area of the critical section of the hook shank;
- I_{d4} is the moment of inertia of the critical section of the hook shank.

6.6.3 Applied stress cycles

Within each lifting cycle, the following two types of stress cycles shall be considered, as relevant:

Cycle Type 1: A stress cycle due to lifting a load and lowering it down on the ground, with due consideration to the bending stress due to inclination of hook suspension and eccentricity of the vertical load. The specifics of each stress cycle (i) are as follows:

- Axial stress is $\sigma_{a1} = \sigma_a(F_{Sd,f,i})$ (Equation (37)), where $F_{Sd,f,i}$ is in accordance with 6.2;
- Bending stress is $\sigma_{b1} = \sigma_b(M)$ (Equation (38)), where $M = \max[M_{2,f,i}, M_{3,f,i}]$ in accordance with 6.4.2 and 6.4.3;

22

- c) Pulsating stress cycle from 0 to $\sigma_{a1} + \sigma_{b1}$, mean stress $\sigma_{m1,i} = (\sigma_{a1} + \sigma_{b1})/2$, stress amplitude $\sigma_{A1,i} = \sigma_{m1,i}$;
d) The total number of stress cycles is $N_1 = N$.

Cycle Type 2: A stress cycle due to horizontal acceleration and resulting load sway shall be taken into consideration as follows:

- e) Axial stress as in Cycle Type 1;
f) Bending stress is $\sigma_{b2,j} = \sigma_b(M_{1,f,j})$ (see Equation (38)), where $M_{1,f,j}$ is in accordance with 6.4.1;
g) Each stress cycle with a mean stress $\sigma_{m2,j} = \sigma_{a1,i}$ and stress amplitude $\sigma_{A2,i} = \sigma_{b2,j}$;
h) The total number of stress cycles is $N_2 = p_a \times N$.

Within each lifting cycle, the hook load specific for that cycle shall be used.

NOTE The axial stresses within the Cycle Type 2 may be calculated without the effect of the factor ϕ_2 in 6.2.

The parameter p_a shall be selected in accordance with Table 8.

Table 8 — Average number of horizontal accelerations p_a

Type of application	p_a
1. Process applications, where horizontal load movements are regularly a part of each work cycle	8
2. Special applications, where horizontal movements are operated at all times under control of a signaller, with low speeds and short distances	2
3. A special load sway control is used in the drive system of the horizontal movement	2
4. All other applications and serially produced hooks, where the application is not known	4

6.6.4 Basic fatigue strength of material

The basic, alternating fatigue strength of the material, for zero mean stress ($\sigma_m = 0$) and for the reference number of stress cycles $N_D = 2\,000\,000$ is calculated based upon the ultimate strength of the material as follows:

$$\sigma_M = 0,45 \times f_u \quad (39)$$

6.6.5 Stress concentration effects from geometry

The factors covered herein are the stress concentration factor α and, as a final outcome, the notch effect factor β_n . Both of them shall be calculated separately for the shoulder and for the thread bottom in accordance with the equations in Table 9. The maximum value of the two β_n shall be used in the proof of fatigue strength of the shank.

NOTE The thread is assumed to be of a single lead type.

Table 9 — Parameters for calculation of stress concentration factors

	Shoulder	Thread
Mean thread diameter d_e	$d_e = 0,6 \times d_3 + 0,4 \times d_5$	
Depth of notch	$u_s = \frac{(d_e - d_4)}{2}$	$u_T = \frac{(d_e - d_5)}{2}$
Factor φ	$\varphi = \frac{1}{2 + 4 \times \sqrt{\frac{u_s}{r_9}}}$	$\varphi = \frac{1}{2 + 4 \times \sqrt{\frac{u_T}{r_{th}}}}$
Factor χ	$\chi = \frac{2 \times (1 + \varphi)}{r_9}$	$\chi = \frac{2 \times (1 + \varphi)}{r_{th}}$
Support factor n	$n = 1 + \sqrt{\chi} \times 10^{-[0,33 + f_3 f^{*12}]}$	
Geometric stress concentration factor	α_s (Equation (40))	α_T (Equation (41))
Notch effect factor	$\beta_n = \frac{\alpha_s}{n}$	$\beta_n = \frac{\alpha_T}{n}$

$$\alpha_s = 1 + \frac{1,1}{\sqrt{0,22 \times \frac{r_9}{u_s} + 2,74 \times \frac{r_9}{d_4} \times \left(1 + 2 \frac{r_9}{d_4}\right)^2}} \quad (40)$$

$$\alpha_T = 1,8 \times \left(\frac{p}{d_5}\right)^{0,3} \times \left(\frac{u_T}{r_{th}}\right)^{0,2} \times \left(\frac{p}{u_s}\right)^{0,1} \times \left(\frac{d_4}{d_5}\right)^3 \times \left(1 + \frac{1}{\sqrt{0,22 \times \frac{r_{th}}{u_T} + 2,74 \times \frac{r_{th}}{d_5} \times \left(1 + 2 \frac{r_{th}}{d_5}\right)^2}}\right) \quad (41)$$

The geometric symbols in Table 9 and in Equations (40) and (41) are according to those in the Figure 2. The yield stress f_y in the equation for n shall be in newtons per square millimetre (N/mm²).

6.6.6 Fatigue strength of notched shank

The further calculation is done for the more critical of the two shank sections. The basic material fatigue strength is reduced to a comparable value in respect to nominal stresses in the shank.

$$\sigma_{B'} = f_1 \times \frac{\sigma_M}{\left(\beta_n + \frac{1}{f_3} - 1\right)} \quad (42)$$

with

$$f_3 = 1 - 0,29 \times \lg \frac{R_o}{0,4} \times \lg \frac{f_n}{200} \quad (43)$$

where

σ_M is the basic fatigue strength of the material;

β_h is the maximum of β_{hS} and β_{hT} ;

f_1 is the influence factor for the operation temperature, in accordance with Equation (31);

f_3 is the factor for the surface roughness influence;

R_o is the surface finish grade in micrometres (μm) within the limits $0,4 \mu\text{m} \leq R_o \leq 3,2 \mu\text{m}$;

f_u is the ultimate strength of the material in newtons per square millimetre (N/mm^2), $f_u \geq 300 \text{ N}/\text{mm}^2$.

NOTE The factor for reducing the material strength by increasing diameter is not applicable in this document. The true material properties for the actual diameter are used in the design calculations.

6.6.7 Mean stress influence

The above σ_w values apply for a pure alternating stress with zero mean stress. Hook shank represents a type of component, where the reduction of fatigue strength by increasing mean stress shall be considered. The mean stress influence is illustrated through a principal Smith Diagram in Figure 6. Characteristics of the diagram are as follows:

- The fatigue strength σ_w is fixed at mean stress $\sigma_m = 0$;
- Upper limit line of the diagram is specified through a mean stress influence factor μ ;
- Stress amplitudes at a related mean stress shall be within the lower and upper limits of the diagram.

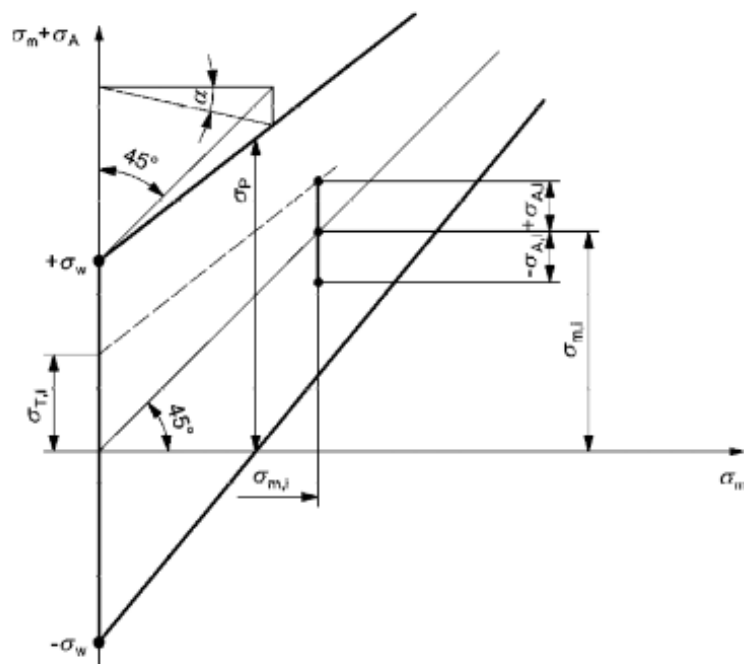


Figure 6 — Smith diagram and transformation of stress amplitude

The upper limit line of the diagram is specified through the assumption that with pulsating stress, the total stress variation is limited to $\sigma_p = 1,7 \sigma_W$. From this rule, the mean stress influence factor is calculated in accordance with EN 13001-1 as follows:

$$\mu = \tan(\alpha) = \frac{\sigma_W}{1,7 \times \sigma_W / 2} - 1 = 0,1765 \quad (44)$$

NOTE The mean stress influence parameters μ and α correspond to the parameters μ_1 and α_1 of EN 13001-1 so, that in this document α is counted always positive.

6.6.8 Transformation of stresses to a constant mean stress

The stress amplitudes with related mean stresses as specified in 6.6.3 are transformed to a stress amplitude with an equal fatigue influence using the methodology shown in EN 13001-1. Transformation to a stress cycle with a mean stress zero is made as follows:

$$\text{Cycle Type 1: } \sigma_{T1,i} = \sigma_{A1,i} + \mu \times \sigma_{m1,i} \quad (45)$$

$$\text{Cycle Type 2: } \sigma_{T2,i} = \sigma_{A2,i} + \mu \times \sigma_{m2,i} \quad (46)$$

where

$\sigma_{T1,i}, \sigma_{T2,i}$ are the transformed stress amplitudes at zero mean stress,

μ is the mean stress influence factor.

The transformation of $\sigma_{A,i}$ to $\sigma_{T,i}$ is illustrated in Figure 6.

6.6.9 Stress history parameter in general

The cumulative fatigue effect of the stress history from all of the stress cycles is condensed into a single stress history parameter s_s . This is calculated as follows:

$$s_s = k_s \times v_s \quad (47)$$

with

$$k_s = \frac{1}{N + p_a \times N} \times \left[\sum_{i=1}^N \left(\frac{\sigma_{T1,i}}{\sigma_{Tmax}} \right)^m + p_a \times \sum_{i=1}^N \left(\frac{\sigma_{T2,i}}{\sigma_{Tmax}} \right)^m \right] \quad (48)$$

and

$$v_s = \frac{N + p_a \times N}{N_D} \quad (49)$$

where

σ_{Tmax} is the maximum of the transformed stress amplitudes $\sigma_{T1,i}$ and $\sigma_{T2,i}$,

k_s is the stress spectrum factor for the hook shank,

v_s is the relative number of stress cycles,

i is the index of a lifting cycle,

..

N is the total number of lifting cycles,

$m = 5$ is the slope parameter of the characteristic fatigue design curve.

6.6.10 Stress history parameter based upon classified duty

The hook shank represents a special case, where the magnitudes of stress variations are directly proportional to the hoist load variations. Because of this, the stress history parameter can be derived directly from the classes Q and U of EN 13001-1:2004, instead of using a case specific stress history and detailed calculation in accordance with 6.6.9.

The load spectrum factor (kQ) is calculated by a Wöhler curve slope with an exponent of 3, whereas the hook shank fatigue is related to a slope $m = 5$. For a load distribution with a given shape, a conversion factor can be calculated to create a connection between the load spectrum of EN 13001-1 and the stress history parameter of hook shank. For a classified duty shapes of load distributions given in Annex E shall be applied

In cases where the intended duty is specified through the classes Q and U of EN 13001-1:2004, the stress history parameter shall be calculated as follows:

$$s_s = k_s \times v_s \quad (50)$$

with

$$k_s = \frac{1}{1 + p_a} \times \frac{kQ}{(k_s^*)^m} \left[\left(\frac{\sigma_{T1,max}}{\sigma_{T,max}} \right)^m + p_a \times \left(\frac{\sigma_{T2,max}}{\sigma_{T,max}} \right)^m \right] \quad (51)$$

$$v_s = \frac{N}{N_D} \times (1 + p_a) \quad (52)$$

and

$$k_s^* = \sqrt[5]{\frac{kQ}{k_s}} \quad (53)$$

where

kQ is the load spectrum factor in accordance with Table 10;

$\sigma_{T1,max}, \sigma_{T2,max}$ are the maximums of the transformed stress amplitudes in Cycle Types 1 and 2;

N is the total number of lifting cycles. Typically for a hook this shall be taken as equal to the number work cycles (C) specified for the crane through the class U of EN 13001-1:2004. Each intermediate grounding of the load within a work cycle shall, however, be counted as an additional lifting cycle and added to the value of N ;

k_s^* is the specific spectrum ratio factor. Standardized, conventional values in accordance with Table 10 shall be used for design of hook shank. See also Annex E.

Table 10 – Specific spectrum ratio factors k_s^*

Class Q of EN 13001-1:2004	Load spectrum factor kQ	Factor k_s^* for $m = 5$
Q ₀	0,031 3	1,28
Q ₁	0,062 5	1,22
Q ₂	0,125	1,17
Q ₃	0,250	1,12
Q ₄	0,500	1,07
Q ₅	1,000	1,00

6.6.11 Execution of the proof

For the proof of fatigue strength it shall be proven that

$$\sigma_{Tmax} \leq \frac{\sigma_W}{\gamma_{SF} \times \sqrt[m]{s_s}} \quad (54)$$

where

σ_{Tmax} is the maximum, transformed stress amplitude within the total stress history;

σ_W is the limit fatigue design stress in accordance with Equation (42);

$\gamma_{SF} = 1,35$ is the fatigue strength specific resistance factor for hook shank;

$m = 5$ is the slope parameter of the characteristic fatigue design curve;

s_s is the stress history parameter.

6.7 Fatigue design of hook shanks for serially produced hooks

The following design assumptions shall be used as a minimum for the design of hook shanks in serially produced hooks with a finished shank:

- Fatigue limit design force of the hook body shall be used as a fatigue design force for the shank;
- Number of shank bending cycles due to horizontal load sway is $p_a = 4$;
- For calculation of horizontal fatigue design force in 6.3 the horizontal acceleration is set $a = 0,2 \text{ m/s}^2$ and $\phi_s = 1$;
- Hook suspension tilting resistance is assumed to correspond to a horizontal force in the hook seat equal to 2 % of the vertical force.

7 Verification of conformity with the requirements

7.1 General

Conformity with the requirements given in Clauses 5 and 6 shall be verified by design calculations.

The design assumptions, e.g. intended duty and the intended hook capacity, shall conform to the corresponding design parameters of the related crane. This conformity shall be verified by engineering assessment.

All verifications in accordance with Clause 7 shall be documented as a part of the technical file. See also Annex K for required documentation.

7.2 Verification of manufacture

Manufacturing conformity shall be verified through adherence to a written description of the hook manufacturing process, documented and certified by the manufacturer.

Conformity with the dimensional and material requirements shall be verified by measurements and tests. The results shall be recorded and retained by the hook manufacturer.

The test pieces for tensile and impact testing shall be taken longitudinally at the upper part of the hooks shank, preferably at a distance of 1/3 radius from the shanks surface. As an alternative, e.g. where the shank is too small, tests may be carried out on sample material selected from the same material melt and subjected to identical heat treatment. A tensile test of material shall be carried out in accordance with EN 10002-1. The impact test shall be carried out in accordance with EN 10045-1.

7.3 Test loading

In addition to what is given in 7.1, the static strength and the general integrity of a hook shall be tested through a load test.

A hook shall be test loaded either as a component or together with the test loading of the related crane or hoist.

In the component testing, the test load shall correspond to the static limit design force of the hook. The suspension between the hook shank and the test equipment shall correspond to the intended suspension in the related crane or hook block. The load attachment on the hook shall be such, that it produces a resultant load effect on the hook in accordance with Figure 7.

When tested together with the crane, the same test loads, dynamic and static, shall be used as for the crane. The suspension between the hook shank and the crane shall be the same or equal to the suspension in the intended use. The load attachment on the hook shall be either in accordance with Figure 7 or in cases, where the crane is used solely for a special application, in accordance with the attachment of that application.

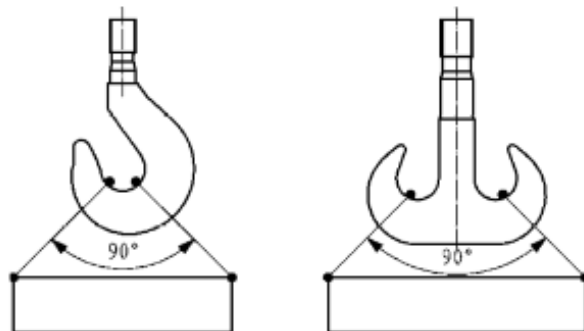


Figure 7 — Suspension of a test load on hook

The test load shall effect symmetrically on two similar slings resting in the hook seat and with a 90° angle between the sling directions, see Figure 7. For a ramshorn hook, the test load shall be shared equally between the two prongs.

A hook shall be able to withstand the test load without excessive permanent deflection. The throat-opening dimension shall be measured before and after the test loading, using the specific measure points (1), see Figure 8. A permanent set shall not exceed 0,15 %. The hook shall be surface detected by a suitable NDT method after the test. There shall be found no cracks or surface flaking in the hook body or shank

7.4 Test sampling

Material tests and test loading are to be carried out on either each individual hook or on the production batch principle.

Hooks having a ruling thickness 150 mm or greater, shall have all tests carried out on each and every hook.

Hooks having a ruling thickness less than 150 mm may be batch tested. The maximum batch size shall comprise the number of hooks, which can be manufactured from the same raw material cast or billet and undergoes identical heat treatment.

8 Information for use

8.1 Maintenance and inspection

The hook shall be handled as an issue of its own in the maintenance and inspection manuals of the related crane.

Maintenance of the following items shall be addressed as a minimum in the maintenance manual:

- a) Thrust bearing under the nut;
- b) Crosshead hinge.

The following items shall be addressed as a minimum in the inspection instruction, with their related frequency of inspection and rejection criteria:

- d) Deformation (gap opening) of the hook body;
- e) Wear of the hook body;

- f) Inspection for surface defects, cracks and corrosion, with the hook suspension disassembled for the inspection of shank;
- g) Safety locking of the nut;
- h) Safety latch, if provided.

The acceptable wear depth of the hook body at the bottom of the seat is 5 % of the nominal height of the body section, dimension h_2 in Annex A. The worn areas shall have smooth transition to adjacent areas. They shall be free of any sharp marks or edges, or defects opening onto the surface.

8.2 Marking

The hook body shall have a permanent marking positioned as item 2 in Figure 8 specifying the following:

- a) Size and shape of hook using a unique identification, e.g. hook number in accordance with Annex A or B;
- b) Material designation, either the class symbol in accordance with 4.1 or other documented designation;
- c) Number of the reference standard or specification;
- d) If relevant, marking of the proof loading, see 4.5.

EXAMPLE A hook fulfilling the requirements of this Technical Specification, size and shape being according to number 12 of Annex A and being made from material P should have a marking:

RS12 – P – EN 13001

Additionally the hook may be marked with a designation or symbol identifying the manufacturer. The hook body itself shall have no marking indicating either the load or the duty classification.

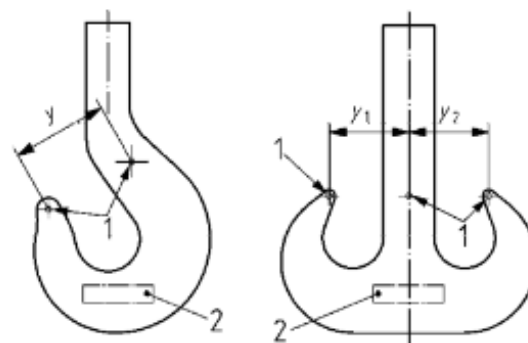


Figure 8 — Markings of a hook

The hook shall have permanent centre punch markings placed as item 1 in Figure 8. As appropriate dimensions y or y_1 and y_2 are to be recorded and placed within hook documentation.

NOTE The fixed hoist media, from which the hook is suspended, will be marked as a part of the crane, indicating the mass of the rated load and the related duty classification, as required by the relevant crane type standard.

8.3 Safe use

The following issues of safe use shall be, as a minimum, addressed in the user's manual of either the related crane or the stand alone hook / hook block as a component:

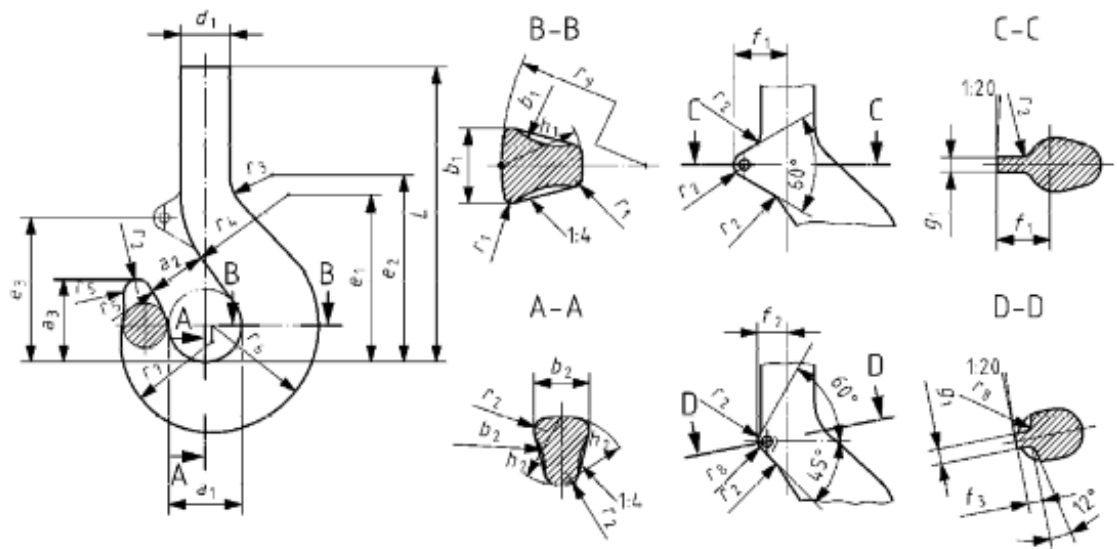
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CEN/TS 13001-3-5:2010 (E)

- a) Free functioning of the hook suspension articulation (hinge), allowing the hook to align without obstacles in the direction of the load, either vertically or inclined during load sway;
- b) Instructions for lashing a load on the hook, maximum 90 degrees angle between the slings;
- c) Shape requirement of the load attachment set on the hook, to avoid damage of the surface of the hook seat;
- d) The two prongs of a ramshorn hook shall be loaded symmetrically and equally;
- e) In cases, where a safety latch is provided, it shall be allowed to close freely after the load is attached;
- f) Temperature limits of the hook.

Annex A
 (informative)

Sets of single hooks

A.1 A series of single hooks of type RS/RSN, dimensions of forgings



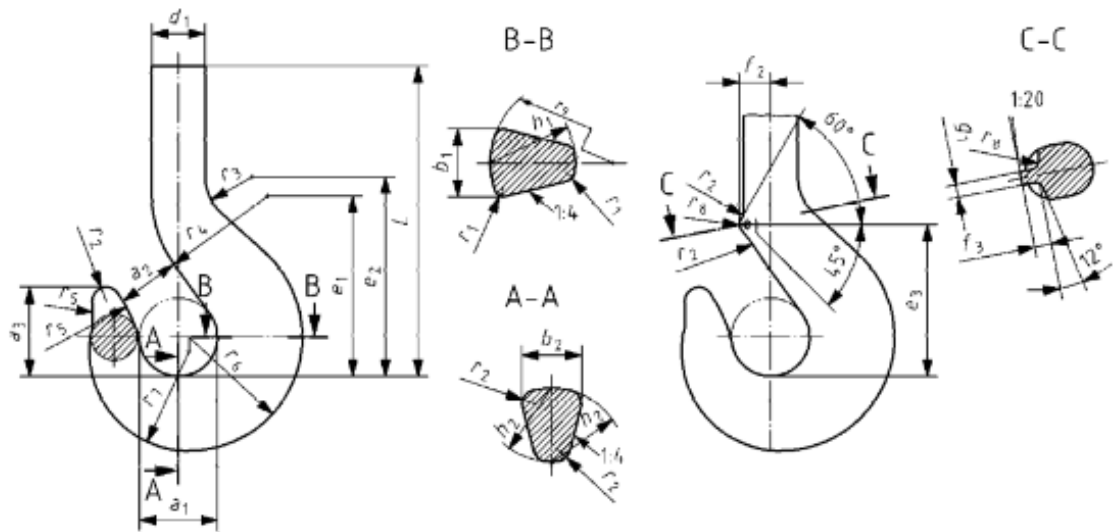
Key
 Designations: RS without forged nose for latch
 RSN with forged nose for latch

Figure A.1 — Symbols of dimensions for single hooks with concave flanks

Table A.1 — Dimensions of forgings for single hooks in millimetres (mm)

Single Hook No.	a ₁	a ₂	a ₃	b ₁	b ₂	d ₁	e ₁	e ₂	h ₁	h ₂	r ₁	r ₂	r ₃	r ₄	r ₅	r ₆	r ₇	r ₉	e ₃	f ₁	f ₂	f ₃	g ₁	r ₈	L
006	25	20	28	13	11	14	60	60	17	14	2	3	32	53	53	27	26	34	52	14,5	-	-	6,5	-	100
010	28	22	32	16	13	16	67	68	20	17	2	3,5	35	60	60	31	30	40	60	16,5	-	-	7	-	109
012	30	24	34	19	15	16	71	73	22	19	2,5	4	37	63	63	34	33	44	63	18	-	-	7,5	-	115
020	34	27	39	21	18	20	81	82	26	22	2,5	4,5	40	71	71	39	37	52	70	20	-	-	8,5	-	138
025	36	28	41	22	19	20	85	88	28	24	3	5	43	75	75	42	40	56	74	22	-	-	9	-	144
04	40	32	45	27	22	24	96	100	34	29	3,5	5,5	46	85	85	49	45	68	83	25	-	-	10	-	155
05	43	34	49	29	24	24	102	108	37	31	4	6	48	90	90	53	48	74	89	26	-	-	10,5	-	167
08	48	38	54	35	29	30	115	120	44	37	4,5	7	52	100	100	61	56	88	100	29	-	-	12	-	186
1	50	40	57	38	32	30	120	128	48	40	5	8	55	106	106	65	60	96	105	31	-	-	12,5	-	197
1.6	56	45	64	45	38	36	135	146	56	48	6	9	60	118	118	76	68	112	118	35	-	-	14	-	224
2.5	63	50	72	53	45	42	152	167	67	58	7	10	65	132	132	90	78	134	132	40	-	-	16	-	253
4	71	56	80	63	53	48	172	190	80	67	8	12	71	150	150	103	90	160	148	45	-	-	16	-	285
5	80	63	90	71	60	53	194	215	90	75	9	14	80	170	170	114	100	180	165	51	-	-	18	-	318
6	90	71	101	80	67	60	218	240	100	85	10	16	90	190	190	131	112	200	185	57	-	-	18	-	380
8	100	80	113	90	75	67	242	268	112	95	11	18	100	212	212	146	125	224	210	64	-	-	23	-	418
10	112	90	127	100	85	75	256	286	125	106	12	20	65	165	236	163	140	250	221	-	46	26	23	12	452
12	125	100	143	112	95	85	292	316	140	118	14	22	70	185	265	182	160	280	252	-	53	34	28	16	510
16	140	112	160	125	106	95	325	357	160	132	16	25	80	210	300	204	180	320	280	-	58	35	33	16	582
20	160	125	180	140	118	106	370	405	180	150	18	28	90	240	335	232	200	360	330	-	68	45	33	20	653
25	180	140	202	160	132	118	415	455	200	170	20	32	100	270	375	262	224	400	360	-	74	45	38	20	724
32	200	160	225	180	150	132	465	510	224	190	22	36	115	300	425	292	250	448	400	-	80	45	38	20	796
40	224	180	252	200	170	150	517	567	250	212	25	40	130	335	475	326	280	500	447	-	93	55	42	25	893
NOTE	Dimensions based upon DIN 15400 series of hooks.																			Dimensions for guidance.					

A.2 A series of single hooks of type RF/RFN, dimensions of forgings



Key

Designations: RF without forged nose for latch
 RFN with forged nose for latch

Figure A.2 — Symbols of dimensions for single hooks with straight flanks

Table A.2 — Dimensions of forgings for single hooks in millimetres (mm)

Single Hook No.	a ₁	a ₂	a ₃	b ₁	b ₂	d ₁	e ₁	e ₂	h ₁	h ₂	r ₁	r ₂	r ₃	r ₄	r ₅	r ₆	r ₇	r ₈	e ₃	f ₂	f ₃	g ₁	r ₈	L
10	112	90	127	100	85	75	256	286	125	106	12	20	65	165	236	163	140	250	221	46	26	23	12	460
12	125	100	143	112	95	85	292	316	140	118	14	22	70	185	265	182	160	280	252	53	34	28	16	525
16	140	112	160	125	106	95	325	357	160	132	16	25	80	210	300	204	180	320	280	58	35	33	16	595
20	160	125	180	140	118	106	370	405	180	150	18	28	90	240	335	232	200	360	330	68	45	33	20	665
25	180	140	202	160	132	118	415	455	200	170	20	32	100	270	375	262	224	400	360	74	45	38	20	735
32	200	160	225	180	150	132	465	510	224	190	22	36	115	300	425	292	250	448	400	80	45	38	20	810
40	224	180	252	200	170	150	517	567	250	212	25	40	130	335	475	326	280	500	447	93	55	42	25	905
50	250	200	285	224	190	170	575	635	280	236	28	45	150	370	530	363	315	560	485	100	55	42	25	990
63	280	224	320	250	212	190	655	710	315	265	32	50	160	420	600	408	355	630	550	108	60	45	25	1 120
80	315	250	358	280	236	212	727	802	355	300	36	56	180	470	670	460	400	710	598	113	60	45	25	1 270
100	355	280	402	315	265	236	827	902	400	335	40	63	200	530	750	516	450	800	688	130	70	50	30	1 415
125	400	315	450	355	300	265	920	1 020	450	375	45	71	230	600	850	579	500	900	750	138	70	50	30	1 590
160	450	355	505	400	335	300	1 035	1 145	500	425	50	80	250	675	950	654	560	1 000	825	147	70	55	30	1 790
200	500	400	565	450	375	335	1 150	1 275	560	475	56	90	285	750	1 060	729	630	1 120	900	154	70	55	30	2 048
250	560	450	635	500	425	375	1 280	1 430	630	530	63	100	320	840	1 180	815	710	1 260	980	164	70	60	30	2 305
NOTE	Dimensions based upon DIN 15400 series of hooks<																			Dimensions for guidance.				

A.3 A series of single hooks of type B, dimensions of forgings

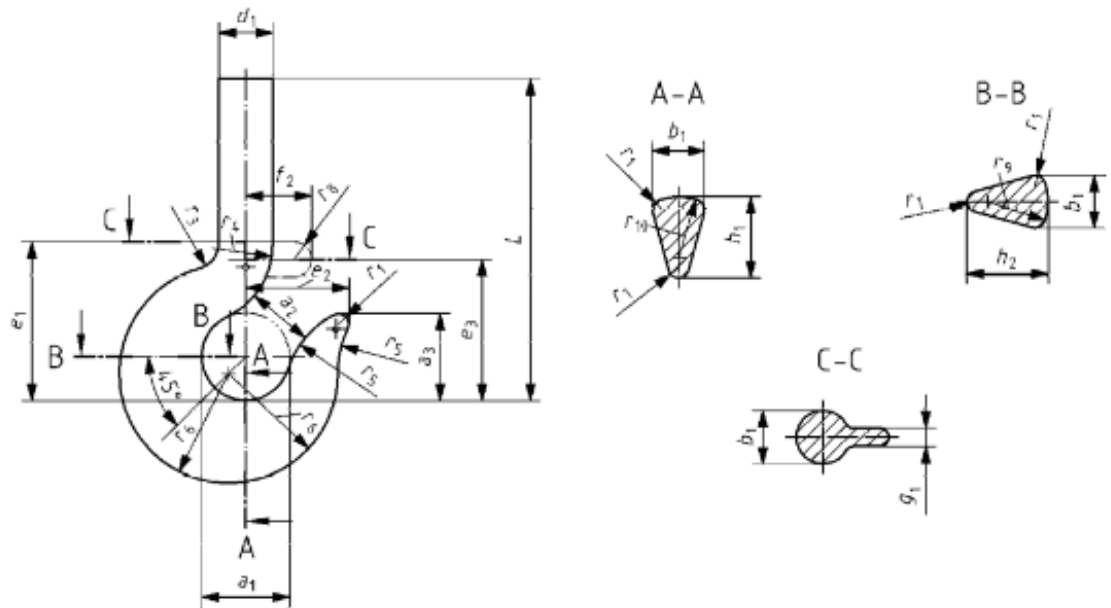


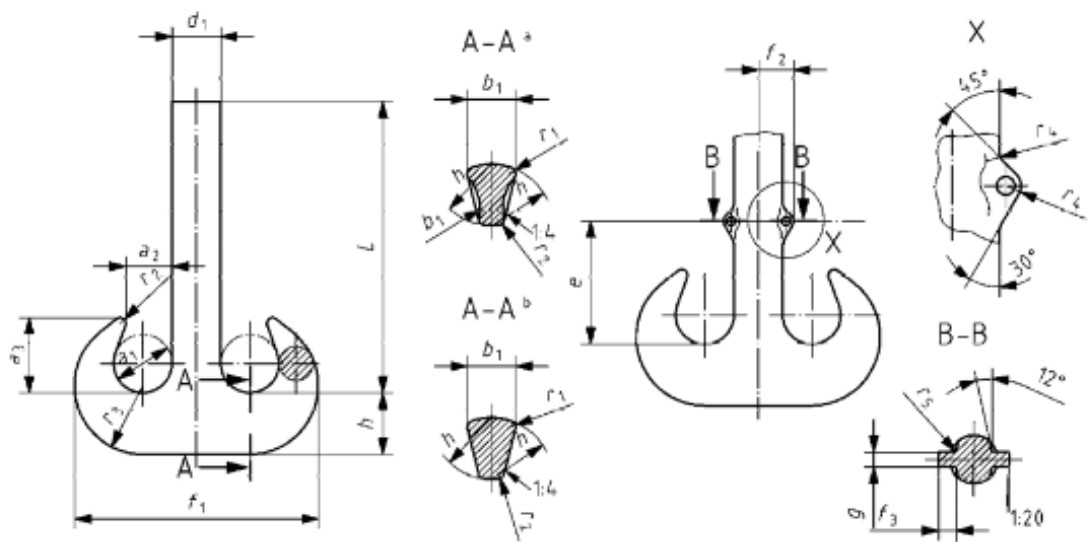
Figure A.3 — Symbols of dimensions for single hooks

Table A.3 Dimensions of forgings for single hooks in millimetres (mm)

Single Hook No.	a ₁	a ₂	a ₃	b ₁	d ₁	e ₁	e ₂	h ₁	h ₂	r ₁	r ₉	r ₁₀	r ₃	r ₄	r ₅	r ₆	e ₃	f ₂	r ₈	g ₁
	(1)	0,75 a ₁		0,60 a ₁				0,93 a ₁	0,93 a ₁	0,12 a ₁			0,30 a ₁	0,92 a ₁	1,00 a ₁	1,25 a ₁				
B 0.8	26	20	26	16	17	47	31	24	24	3	18	13	8	24	26	32	41,8	19,7	5,2	5,2
B 1.6	37	28	37	22	23	66,5	44	34	34	4	26	18	11	34	37	46	59,1	27,7	7,4	7,4
B 2.5	46	34	46	28	28	83	55	43	43	6	32	23	14	42	46	58	73,8	34,7	9,2	9,2
B 4	58	44	58	35	33	105	70	54	54	7	41	29	17	53	58	72	93,4	43,6	11,6	11,6
B 5	65	49	65	39	38	118	78	60	60	8	46	32	20	60	65	81	105	48,8	13	13
B 6.3	73	55	73	44	44	139	88	68	68	9	51	13	22	67	73	91	124	54,9	14,6	14,6
B 8	83	62	84	50	50	151	100	77	77	10	58	18	25	76	83	104	134	62,4	16,6	16,6
B 10	92	69	92	55	55	167	110	86	86	11	64	46	28	85	92	115	149	68,9	18,4	18,4
B 12.5	103	77	104	62	60	187	124	96	96	12	72	52	31	95	103	129	166	77,4	20,6	20,6
B 16	117	88	117	70	65	212	140	109	109	14	82	58	35	108	117	146	189	87,7	23,4	23,4
B 20	131	98	132	79	75	237	157	122	122	16	92	66	39	120	131	164	211	98,5	26,2	26,2
B 25	146	110	146	88	85	264	175	136	136	18	102	73	44	134	146	182	235	110	29,2	29,2
B 32	159	119	160	95	90	288	191	148	148	19	111	80	48	146	159	199	256	119	31,8	31,8
B 40	173	130	173	104	105	314	208	161	161	21	121	86	52	159	173	216	279	130	34,6	34,6
B 50	191	143	191	115	115	346	229	178	178	23	134	95	57	176	191	239	308	143	38,2	38,2
B 63	205	154	205	123	125	372	246	191	191	25	144	102	62	189	205	256	331	154	41	41
Dimensions based upon BS 2903 series of hooks.																	Dimensions for guidance			
NOTE 1	Second row gives a ratio of dimensions to a measure a ₁ .																			
NOTE 2	Nose for attachment of latch is optional.																			
NOTE 3	See G.4 for typical dimensions of machined shank.																			
NOTE 4	Length of hook shank "L" to suit application.																			

Annex B
 (informative)

A series of ramshorn hooks of type RS/RSN and RF/RFN, dimensions of forgings



Key

Designations: RS/RSN concave flanks (a), without or with nose
 RF/RFN straight flanks (b), without or with nose

Figure B.1 — Symbols of dimensions for ramshorn hooks

Table B.1 — Dimensions of forgings for ramshorn hooks in millimetres (mm)

Ramshorn Hook No.	a ₁	a ₂	a ₃	b ₁	d ₁	f ₁	H	r ₁	r ₂	r ₃	e	f ₂	f ₃	g	r ₄	r ₅	L
05	34	27	44	22	24	130	27	3	3	36	80	20	12	10	6	1,6	165
08	38	30	49	26	30	150	33	4	3	41	83	22	12	10,5	6	1,6	183
1	40	32	52	28	30	158	36	4	3,5	44	96	22	14	12	7	1,6	195
1.6	45	36	59	34	36	183	43	5	4	51	100	28	14	12,5	7	1,6	222
2.5	50	40	65	40	42	208	50	6	4,5	58	112	30	14	14	7	1,6	250
4	56	45	73	48	48	238	60	7	5,5	67	124	33	23	16	10	2,5	280
5	63	50	82	53	53	266	67	8	6,5	75	143	40	23	16	10	2,5	312
6	71	56	92	60	60	301	75	9	7	85	160	44	23	18	10	2,5	375
8	80	63	103	67	67	337	85	10	8	95	182	48	23	18	10	2,5	415
10	90	71	116	75	75	377	95	11	9	106	192	54	27	23	12	3	450
12	100	80	130	85	85	421	106	125	10	118	210	60	27	23	12	3	510
16	112	90	146	95	95	471	118	14	11	132	237	69	36	28	16	4	580
20	125	100	163	106	106	531	132	16	12,5	150	265	75	36	33	16	4	650
25	140	112	182	118	118	598	150	18	14	170	315	86	45	33	20	5	715
32	160	125	205	132	132	672	170	20	16	190	335	94	45	38	20	5	790
40	180	140	230	150	150	754	190	22	18	212	375	104	45	38	20	5	885
50	200	160	260	170	170	842	212	25	20	236	420	120	56	42	25	6	965
63	224	180	292	190	190	944	236	28	22	265	460	131	56	42	25	6	1 090
80	250	200	325	212	212	1 062	265	32	25	300	515	144	56	45	25	6	1 235
100	280	224	364	236	236	1 186	300	36	28	335	575	157	56	45	25	6	1 375
125	315	250	408	265	265	1 330	335	40	32	375	645	178	68	50	30	8	1 550
160	355	280	458	300	300	1 505	375	45	36	425	725	198	68	50	30	8	1 745
200	400	315	515	335	335	1 685	425	50	40	475	800	218	68	55	30	8	1 998
250	450	355	580	375	375	1 885	475	56	45	530	875	240	68	55	30	8	2 250
NOTE 1 Hook sizes 50-250 preferably with straight flanks. NOTE 2 Dimensions based upon DIN 15400 series of hooks.											Dimensions for guidance.						

Annex C (normative)

Static limit design forces of hook bodies

C.1 Static limit design forces of hook bodies for hooks of type RS and RF

Table C.1 — Static limit design forces in kilonewtons (kN)

Valid for temperature influence factor $f_t = 1$ ($T \leq 100$ °C)

Hook No.	Single hooks, types RS and RF					Ramshorn hooks, types RS and RF					Hook No.
	Classified material grades					Classified material grades					
	M	P	S	T	V	M	P	S	T	V	
006	4,0	5,9	7,1	9,3	11,2	-	-	-	-	-	006
010	5,9	8,6	10,4	14	16	-	-	-	-	-	010
012	7,8	11,5	14	18	22	-	-	-	-	-	012
020	10,3	15	18	24	29	-	-	-	-	-	020
025	11,7	17	21	27	33	-	-	-	-	-	025
04	18	26	32	41	50	-	-	-	-	-	04
05	21	31	37	49	58	18	27	32	42	51	05
08	30	45	54	71	85	27	40	48	63	75	08
1	37	54	65	85	102	32	47	56	74	89	1
1.6	51	75	90	119	142	47	69	83	109	131	1.6
2.5	73	107	129	169	203	65	95	115	151	181	2.5
4	104	153	184	242	291	95	139	167	220	264	4
5	132	193	233	307	368	117	171	206	272	326	5
6	165	242	292	384	460	148	216	261	343	412	6
8	208	305	368	484	580	187	274	331	435	522	8
10	257	377	455	599	719	234	342	413	543	652	10
12	324	474	572	753	904	295	433	522	687	825	12
16	414	607	732	963	1 156	367	538	649	854	1 024	16
20	520	763	920	1 210	1 452	459	672	811	1 067	1 281	20
25	660	967	1 166	1 535	1 841	583	855	1 031	1 356	1 628	25
32	832	1 219	1 471	1 935	2 322	739	1 082	1 305	1 718	2 061	32
40	1 032	1 512	1 824	2 400	2 880	935	1 369	1 652	2 174	2 609	40
50	1 308	1 917	2 313	3 043	3 651	1 184	1 734	2 092	2 753	3 304	50
63	1 644	2 408	2 905	3 822	4 587	1 471	2 155	2 599	3 420	4 104	63
80	2 075	3 040	3 667	4 826	5 791	1 846	2 705	3 263	4 294	5 153	80
100	2 630	3 854	4 649	6 117	7 341	2 335	3 422	4 128	5 431	6 517	100
125	3 334	4 885	5 893	7 754	9 305	2 923	4 282	5 166	6 797	8 156	125
160	4 167	6 105	7 364	9 690	11 628	3 695	5 414	6 531	8 593	10 311	160
200	5 257	7 702	9 292	12 226	14 671	4 688	6 868	8 285	10 901	13 081	200
250	6 575	9 634	11 622	15 292	18 350	5 857	8 581	10 352	13 621	16 345	250

C.2 Static limit design forces of hook bodies for a series of hooks of type B, with additional materials

Table C.2 — Static limit design forces $F_{Rd,s}$ in kilonewtons (kN)

Valid for temperature influence factor $f_t = 1$ ($T \leq 100$ °C)

Hook No.	Single hooks, type B						Hook No.	
	Classified material grades					Additional materials		
	M	P	S	T	V	f_y N/mm ²		$F_{Rd,s}$
B 0.8	6,6	9,7	11,7	15,4	18,5	430	13,2	B 0.8
B 1.6	13,0	19,0	22,9	30,1	36,2		25,9	B 1.6
B 2.5	21,3	31,1	37,6	49,4	59,3		42,5	B 2.5
B 4	33,2	48,6	58,6	77,2	92,6		66,4	B 4
B 5	41,1	60,2	72,7	95,6	115		82,2	B 5
B 6.3	52,6	77,1	93,0	122	147		105	B 6.3
B 8	67,4	98,8	119	157	188		135	B 8
B 10	83,2	122	147	194	232		166	B 10
B 12.5	104	152	184	242	290		208	B 12.5
B 16	134	197	237	312	374	400	250	B 16
B 20	169	248	299	394	473		315	B 20
B 25	210	308	372	489	587		392	B 25
B 32	247	362	437	575	690		460	B 32
B 40	294	431	520	684	821		547	B 40
B 50	359	527	635	836	1 003		669	B 50
B 63	414	606	731	962	1 154		770	B 63

Annex D
(normative)

Fatigue limit design forces of hook bodies

D.1 Fatigue limit design forces of hook bodies for hooks of type RS and RF

Table D.1 — Fatigue limit design forces $F_{Rd,f}$ in kilonewtons (kN)

Factors f_2 and γ_{Hf} incorporated, temperature influence factor $f_T = 1$ ($T \leq 100$ °C)

Hook No.	Single hooks, types RS and RF					Ramshorn hooks, types RS and RF					Hook No.
	Classified material grades					Classified material grades					
	M	P	S	T	V	M	P	S	T	V	
006	2,1	2,7	2,9	3,4	3,8	-	-	-	-	-	006
010	3,1	4,0	4,2	5,1	5,5	-	-	-	-	-	010
012	4,1	5,3	5,6	6,7	7,3	-	-	-	-	-	012
020	5,4	6,9	7,4	8,8	9,6	-	-	-	-	-	020
025	6,1	7,9	8,4	10	11	-	-	-	-	-	025
04	9,2	12	13	15	16	-	-	-	-	-	04
05	11	14	15	18	19	11	14	15	17	19	05
08	15	19	21	25	27	16	20	22	26	28	08
1	18	23	25	29	32	18	23	25	30	33	1
1.6	24	31	33	40	43	26	33	36	43	46	1.6
2.5	33	43	46	55	60	35	45	48	57	62	2.5
4	47	60	64	77	84	49	64	68	81	88	4
5	58	75	80	95	104	60	77	83	98	107	5
6	71	92	98	117	127	74	96	102	122	133	6
8	88	113	121	144	157	92	119	127	152	165	8
10	107	138	147	176	191	113	146	156	186	202	10
12	132	170	182	217	236	140	181	193	230	251	12
16	165	214	228	272	296	170	220	235	281	306	16
20	204	264	282	336	365	209	271	289	344	375	20
25	255	330	352	420	457	261	338	361	430	468	25
32	321	416	444	529	576	324	420	448	534	582	32
40	398	516	551	656	715	402	520	555	662	721	40
50	505	654	698	832	907	508	657	702	837	911	50
63	635	821	877	1 045	1 139	631	817	872	1 039	1 132	63
80	801	1 037	1 108	1 320	1 438	792	1 025	1 095	1 305	1 421	80
100	1 016	1 315	1 404	1 673	1 822	1 002	1 297	1 385	1 650	1 798	100
125	1 288	1 666	1 780	2 121	2 310	1 254	1 623	1 734	2 066	2 250	125
160	1 609	2 082	2 224	2 650	2 887	1 585	2 052	2 192	2 611	2 844	160
200	2 030	2 627	2 806	3 344	3 642	2 011	2 603	2 780	3 313	3 609	200
250	2 539	3 286	3 510	4 182	4 556	2 513	3 252	3 474	4 139	4 509	250

D.2 Fatigue limit design forces of hook bodies for a series of hooks of type B, with additional materials

Table D.2 — Fatigue limit design forces $F_{Rd,f}$ in kilonewtons (kN)
 Factors f_2 and γ_{M2} incorporated, temperature influence factor $f_1 = 1$ ($T \leq 100$ °C)

Hook No.	Single hooks, type B						f_u N/mm ²	$F_{Rd,f}$	Hook No.
	Classified material grades					$F_{Rd,f}$			
	M	P	S	T	V				
B 0.8	3,5	4,5	4,8	5,7	6,2	620	5,2	B 0.8	
B 1.6	6,8	8,8	9,3	11,1	12,1		10,3	B 1.6	
B 2.5	10,9	14,1	15,0	17,9	19,5		16,5	B 2.5	
B 4	16,4	21,2	22,6	27,0	29,4		24,9	B 4	
B 5	19,9	25,8	27,5	32,8	35,7		30,2	B 5	
B 6.3	25,0	32,3	34,5	41,2	44,8		37,9	B 6.3	
B 8	31,3	40,6	43,3	51,6	56,2		47,6	B 8	
B 10	38,1	49,3	52,6	62,7	68,3		57,8	B 10	
B 12.5	46,7	60,4	64,5	76,9	83,7		70,9	B 12.5	
B 16	58,9	76,3	81,5	97,1	106		90,0	B 16	
B 20	72,9	94,4	101	120	131	111	B 20		
B 25	89,0	115	123	147	160	136	B 25		
B 32	103	134	143	170	185	158	B 32		
B 40	121	157	167	199	217	185	B 40		
B 50	145	188	201	239	261	222	B 50		
B 63	165	214	229	272	297	253	B 63		

Annex E
(normative)

Hook body calculation and specific spectrum ratio factors

E.1 Conversion factor for hook body calculation, when classified duty is utilized

Table E.1 — Conversion factor $k_C = k_c^* / \sqrt[3]{s_Q}$

	Class Q	Q ₀	Q ₁	Q ₂	Q ₃	Q ₄	Q ₅
	kQ(3)	0,031 3	0,062 5	0,125	0,25	0,5	1,0
	Factor k_c^*	1,34	1,27	1,20	1,14	1,08	1
Class U	C [cycles]						
U ₀	16 000	5,34	4,51	3,79	3,21	2,71	2,24
U ₁	31 500	4,77	4,03	3,39	2,87	2,42	2,00
U ₂	63 000	4,25	3,59	3,02	2,56	2,16	1,78
U ₃	125 000	3,79	3,20	2,69	2,28	1,92	1,59
U ₄	250 000	3,38	2,85	2,40	2,03	1,71	1,41
U ₅	500 000	3,01	2,54	2,14	1,81	1,53	1,26
U ₆	1 000 000	2,68	2,26	1,90	1,61	1,36	1,12
U ₇	2 000 000	2,39	2,02	1,70	1,44	1,21	1,00
U ₈	4 000 000	2,13	1,80	1,51	1,28	1,08	0,89
U ₉	8 000 000	1,89	1,60	1,35	1,14	0,96	0,79

E.2 Specific spectrum ratio factors

The presentation of distributions with discrete values can be shown as spectrum or as accumulated spectrum. Figure E.1 illustrates both presentations for discrete distributions.

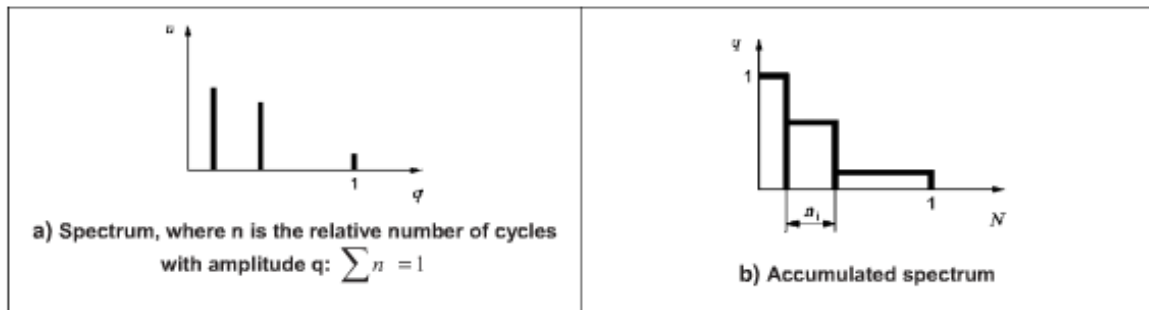


Figure E.1 — Discrete distributions

The presentation of distributions given by continuous functions can be shown as density function or as accumulated density function. Figure E.2 illustrates both presentations for distributions given by continuous functions.

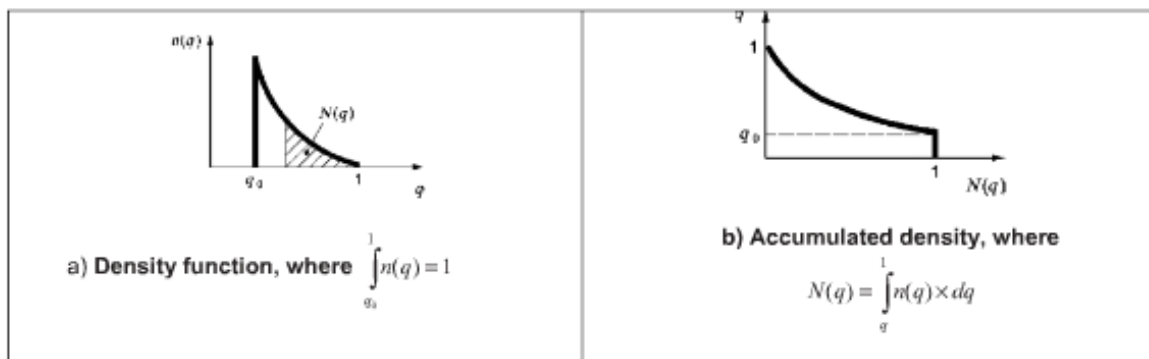


Figure E.2 — Continuous distributions

NOTE Whereas $n(q)$ gives the relative number of cycles with amplitude q , the accumulated value of $N(q)$ gives the number of cycles with amplitudes greater than q .

The stress spectrum factor k_m can be calculated from the density function or from the accumulated density by

$$k_m = \int_{q_0}^1 q^m \times n \times dq = \int_0^1 q^m \times dN$$

The specific spectrum ratio factors (see 6.5.3) then follows as

$$k_m^* = \sqrt[m]{\frac{KQ}{k_m}} = \sqrt[m]{\frac{k_3}{k_m}}$$

E.3 Underlying spectra for the specific spectrum ratio factors




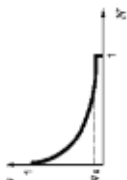
In cases where the load spectrum of the crane is specified through the class Q only, the shape of load distribution in accordance with Table E.3 shall be assumed. Consequently, the specific spectrum ratio factors as given in Table E.2 can be derived and shall be used for calculation of the stress history parameter s_h for the hook.


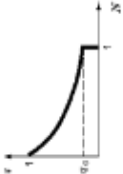
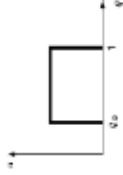

Table E.2 — Specific spectrum ratio factors

Class Q of EN 13001-1:2004	Load spectrum factor kQ	Factor k'_5 for m = 5	Factor k'_6 for m = 6
Q ₀	0,031 3	1,28	1,34
Q ₁	0,062 5	1,22	1,27
Q ₂	0,125	1,17	1,20
Q ₃	0,25	1,12	1,14
Q ₄	0,5	1,07	1,08
Q ₅	1	1	1

Table E.3 gives the underlying density functions and accumulated density functions for Table E.2.

Table E.3 — Underlying density and accumulated density functions

Class	Density Function	Accumulated Density Function
Q₀, Q₁	 $n = 4 \times \frac{(1-q)^3}{(1-q_0)^4}$ $k_{(m)} = \frac{4}{(1-q_0)^4} \times \left[\frac{1-q_0^{m+1}}{m+1} - 3 \times \frac{1-q_0^{m+2}}{m+2} + 3 \times \frac{1-q_0^{m+3}}{m+3} - \frac{1-q_0^{m+4}}{m+4} \right]$	 <p style="text-align: center;">$N_{(q)} = \left(\frac{1-q}{1-q_0} \right)^4$ or $q_{(N)} = 1 - (1 - q_0) \times \sqrt[4]{N}$</p> <p style="text-align: center;">; for Class Q₀: $q_0 = 0,028$; for Class Q₁: $q_0 = 0,185$</p>
Q₂	 $n = 3 \times \frac{(1-q)^2}{(1-q_0)^3}$	 <p style="text-align: center;">$N_{(q)} = \left(\frac{1-q}{1-q_0} \right)^3$ or $q_{(N)} = 1 - (1 - q_0) \times \sqrt[3]{N}$</p>
	$k_{(m)} = \frac{3}{(1-q_0)^3} \times \left[\frac{1-q_0^{m+1}}{m+1} - 2 \times \frac{1-q_0^{m+2}}{m+2} + \frac{1-q_0^{m+3}}{m+3} \right]$ <p style="text-align: center;">; for Class Q₂: $q_0 = 0,277$</p>	

<p>Q₃</p>	 $n = 2 \times \frac{1-q}{(1-q_0)^2}$	 $N_{(q)} = \left(\frac{1-q}{1-q_0} \right)^2 \quad \text{or} \quad q_{(N)} = 1 - (1 - q_0) \times \sqrt{N}$
$k_{(m)} = \frac{2}{(1-q_0)^2} \times \left[\frac{1-q_0^{m+1}}{m+1} - \frac{1-q_0^{m+2}}{m+2} \right]; \text{ for Class Q}_3: q_0 = \mathbf{0,394}$		
<p>Q₄</p>	 $n = \frac{1}{1-q_0}$	 $N_{(q)} = \frac{1-q}{1-q_0} \quad \text{or} \quad q_{(N)} = 1 - (1 - q_0) \times N$
$k_{(m)} = \frac{1}{1-q_0} \times \frac{1-q_0^{m+1}}{m+1}; \text{ for Class Q}_4: q_0 = \mathbf{0,545}$		

Annex F (normative)

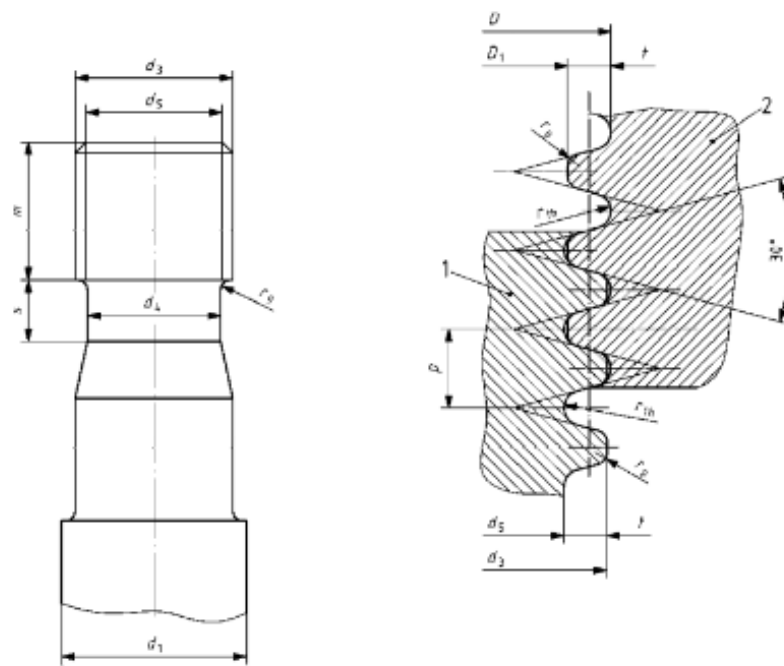
A selection of material qualities for hooks of type RS and RF

Hook Number	Material class					Ruling thickness mm					
	M	P	S	T	V						
006	S235J2	S355J2 P355NH	P420NH	34CrMo4+QT	34CrNiMo6+QT	13					
010						16					
012						19					
020						21					
025						22					
04						27					
05						29					
08						35					
1						38					
1.6						45					
2.5						53					
4						63					
5						71					
6						P285QH	P420QH	25CrMo4+QT	36CrNiMo4+QT	30CrNiMo8+QT	80
8											90
10	100										
12	112										
16	125										
20	140										
25	160										
32	180										
40	200										
50	224										
63	S355J2 P355QH	P420QH	34CrNiMo6+QT	36CrNiMo4+QT	30CrNiMo8+QT	250					
80						280					
100						315					
125						355					
160						400					
200	450										
250	500										

Annex G
 (informative)

Sets of hook shank and thread designs

G.1 A series of hook shank and thread designs, a knuckle thread



Key
 1 hook shank
 2 nut

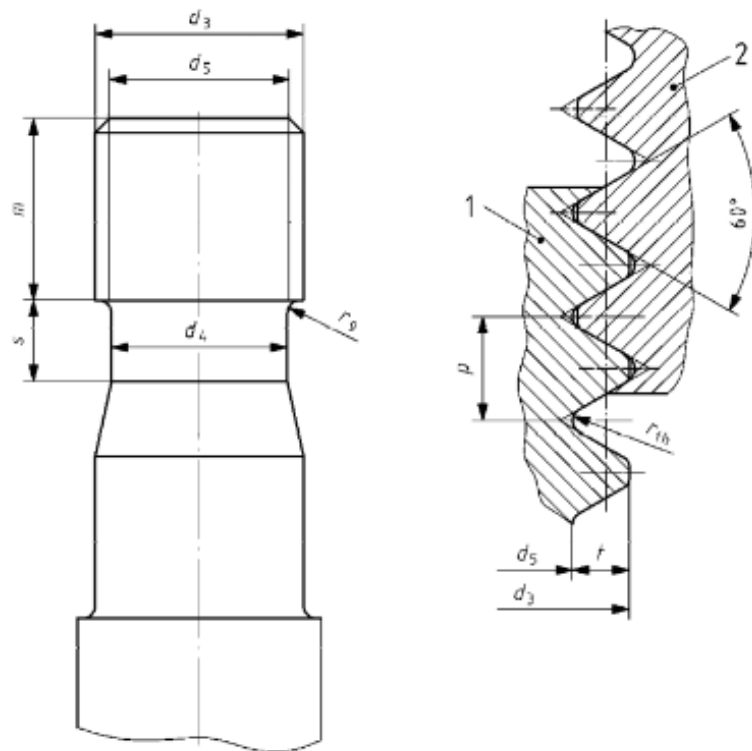
Figure G.1 — Symbols of dimensions for a hook shank and thread

Table G.1 — Dimensions of hook shank and thread in millimetres (mm)

(d ₁)	Thread Designation	d ₃	p	d ₄	d ₅	r ₉	s	r _{th}	r _p	t	m	(D)	(D ₁)
60	Rd 50 x 6	50	6	42	43,4	4	20	1,33	0,92	3,3	45	50,6	44
67	Rd 56 x 6	56	6	48	49,4	4	20	1,33	0,92	3,3	50	56,6	50
75	Rd 64 x 8	64	8	54	55,2	4	25	1,77	1,23	4,4	56	64,8	56
85	Rd 72 x 8	72	8	62	63,2	4	25	1,77	1,23	4,4	63	72,8	64
95	Rd 80 x 10	80	10	68	69,0	6	30	2,21	1,54	5,5	71	81	70
106	Rd 90 x 10	90	10	78	79,0	6	30	2,21	1,54	5,5	80	91	80
118	Rd 100 x 12	100	12	85	86,8	6	40	2,65	1,84	6,6	90	101,2	88
132	Rd 110 x 12	110	12	95	96,8	6	40	2,65	1,84	6,6	100	111,2	98
150	Rd 125 x 14	125	14	108	109,6	8	45	3,10	2,15	7,7	112	126,4	111
170	Rd 140 x 16	140	16	120	122,4	10	50	3,54	2,46	8,8	125	141,6	124
190	Rd 160 x 18	160	18	138	140,2	10	55	3,98	2,77	9,9	140	161,8	142
212	Rd 180 x 20	180	20	156	158,0	12	60	4,42	3,07	11,0	160	182	160
236	Rd 200 x 22	200	22	173	175,8	12	70	4,86	3,38	12,1	180	202,2	178
265	Rd 225 x 24	225	24	196	198,6	12	80	5,31	3,69	13,2	200	227,4	201
300	Rd 250 x 28	250	28	217	219,2	15	90	6,19	4,30	15,4	225	252,8	222
335	Rd 280 x 32	280	32	242	244,8	18	100	7,07	4,92	17,6	250	283,2	248
375	Rd 320 x 36	320	36	278	280,4	20	110	7,96	5,53	19,8	280	323,6	284

NOTE The nut dimensions (D and D₁) and the forged shank diameter (d₁) are for guidance only. The shank machining and thread may be applied for any forged sizes and types within the requirements of this standard.

G.2 A series of hook shank and thread designs, a metric thread



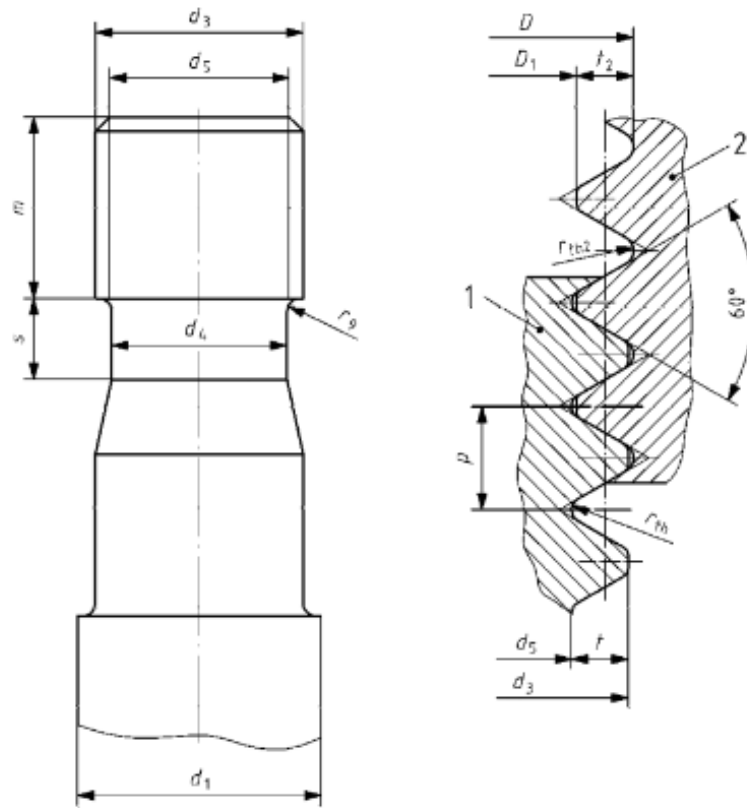
- Key:**
1 hook shank
2 nut

Figure G.2 — Symbols of dimensions for a hook shank and thread

Table G.2 — Dimensions of hook shank and thread in millimetres (mm)

Thread Designation	d ₃	p	d ₄	d ₅	r ₉	s	r _{th}	t	m
M 10 x 1,5	10	1,5	7,5	8,16	1,0	5	0,21	0,92	9
M 12 x 1,75	12	1,75	9,0	9,85	1,2	6	0,25	1,07	11
M 14 x 2	14	2	11,2	11,55	1,4	6	0,28	1,23	14
M 16 x 2	16	2	12,5	13,55	1,2	7	0,28	1,23	15
M 20 x 2,5	20	2,5	16,6	16,93	1,6	8	0,35	1,53	18
M 24 x 3	24	3	20,0	20,32	2,0	9	0,42	1,84	22
M 30 x 3,5	30	3,5	25,4	25,71	2,0	11	0,49	2,15	27
M 33 x 3,5	33	3,5	28,4	28,71	3,3	11	0,49	2,15	33
M 36 x 4	36	4	30,0	31,09	2,0	12	0,56	2,45	32
M 39 x 4	39	4	33,8	34,09	3,9	12	0,56	2,45	39
M 42 x 4,5	42	4,5	36,2	36,48	3,0	13	0,63	2,76	36
M 45 x 4,5	45	4,5	38,5	39,48	3,0	13	0,63	2,76	40
M 48 x 5	48	5	41,6	41,87	4,8	15	0,70	3,07	48
M 52 x 5	52	5	45,6	45,87	5,2	15	0,70	3,07	52
M 60 x 5,5	60	5,5	53,0	53,25	6,0	17	0,77	3,37	60
M 68 x 6	68	6	60,3	60,64	6,8	18	0,84	3,68	68
M 72 x 6	72	6	64,3	64,64	7,2	18	0,84	3,68	72
M 80 x 6	80	6	72,3	72,64	8,0	18	0,84	3,68	80
M 90 x 6	90	6	82,3	82,64	9,0	18	0,84	3,68	90
M 100 x 8	100	8	89,9	90,19	10,0	24	1,12	4,91	100
M 110 x 8	110	8	99,9	100,19	11,0	24	1,12	4,91	110

G.3 A series of hook shank and thread designs, a modified metric thread



- Key:**
 1 hook shank
 2 nut

Figure G.3 — Symbols of dimensions for a hook shank and thread

Table G.3 — Dimensions of hook shank and thread in millimetres (mm)

(d ₁)	Thread Designation	d ₃	p	d ₄	D ₅	r ₉	s	r _{th}	t	m	(D)	(D ₁)	(r _{th2})	(t ₂)
60	ATS 52 x 5	52	5	46	46,587	10	15,41	1,083	2,71	43	52,361	47,670	0,361	2,35
67	ATS 56 x 5,5	56	5,5	50	50,046	11	18,41	1,191	2,98	48	56,396	51,237	0,397	2,58
75	ATS 64 x 6	64	6	57	57,505	12	21,48	1,299	3,25	54	64,433	58,804	0,433	2,81
85	ATS 72 x 6	72	6	65	65,505	14	26,48	1,299	3,25	61	72,430	66,804	0,430	2,81
95	ATS 80 x 7	80	7	72	72,422	16	29,55	1,516	3,79	67	80,505	73,938	0,505	3,28
106	ATS 90 x 7	90	7	82	82,422	19	34,55	1,516	3,79	77	90,505	83,938	0,505	3,28
118	ATS 100 x 8	100	8	91	91,340	20	37,61	1,732	4,33	85	100,577	93,072	0,577	3,75
132	ATS 110 x 8	110	8	101	101,340	22	42,61	1,732	4,33	96	110,577	103,072	0,577	3,75
150	ATS 125 x 10	125	10	113	114,175	25	46,82	2,165	5,41	106	125,722	116,340	0,722	4,69
170	ATS 140 x 10	140	10	128	129,175	28	56,82	2,165	5,41	120	140,722	131,340	0,722	4,69
190	ATS 160 x 12	160	12	146	147,010	32	62,95	2,598	6,50	134	160,866	149,608	0,866	5,63
212	ATS 180 x 12	180	12	166	167,010	36	72,95	2,598	6,50	154	180,866	169,608	0,866	5,63
236	ATS 200 x 14	200	14	183	184,845	40	77,16	3,031	7,58	170	201,000	187,876	1,01	6,56
265	ATS 225 x 14	225	14	208	209,845	45	92,16	3,031	7,58	192	226,010	212,876	1,01	6,57
300	ATS 250 x 16	250	16	230	232,680	50	101,36	3,464	8,66	211	251,155	236,144	1,155	7,51
335	ATS 280 x 16	280	16	260	262,680	56	121,36	3,464	8,66	240	281,155	266,144	1,155	7,51
375	ATS 320 x 18	320	18	298	300,515	63	137,50	3,897	9,74	268	321,199	304,412	1,299	8,39

NOTE The nut dimensions and the forged shank diameter (d₁) are for guidance only. The shank machining and thread may be applied for any forged sizes and types within the requirements of this standard.

G.4 Hook shank and thread designs for hooks of type B

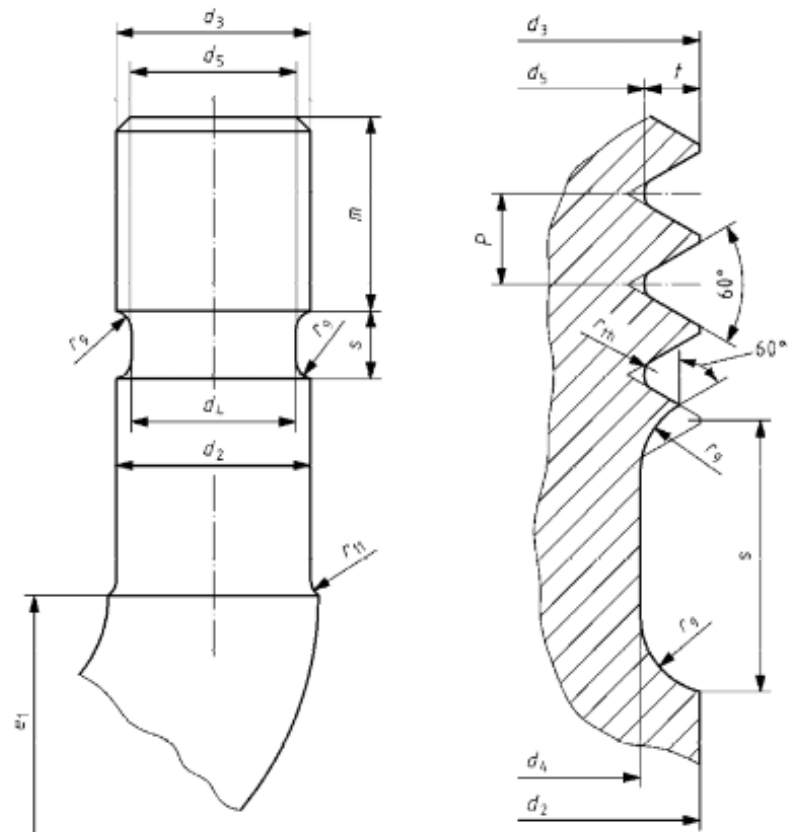


Figure G.4 — Symbols of dimensions for a hook shank and thread

NOTE Width of undercut, s , is measured from the shoulder of the shank to the crest of the last full thread.

Table G.4 — Dimensions of hook shank and thread in millimetres (mm)

Hook No.	d_2	Thread Designation	d_3	p	d_4	d_5	r_9	s	r_{th}	t	r_{th11}	m
B 0.8	15	M14 x 2	14	2	11,25	11,55	1,5	6	0,28	1,23	2	14
B 1.6	20	M20 x 2,5	20	2,5	16,63	16,93	2	7,5	0,35	1,53	2	20
B 2.5	25	M24 x 3	24	3	20,02	20,32	2,5	9	0,42	1,84	3	24
B 4	30	M30 x 3,5	30	3,5	25,41	25,71	3	10,5	0,49	2,15	3	30
B 5	35	M33 x 3,5	33	3,5	28,41	28,71	3,5	10,5	0,49	2,15	4	33
B 6.3	40	M39 x 4	39	4	33,79	34,09	4	12	0,56	2,45	4	39
B 8	45	M42 x 4,5	42	4,5	36,18	36,48	4,5	13,5	0,63	2,76	5	42
B 10	50	M48 x 5	48	5	41,57	41,87	5	15	0,7	3,07	5	48
B 12.5	55	M52 x 5	52	5	45,57	45,87	5,5	15	0,7	3,07	6	52
B 16	60	M60 x 5,5	60	5,5	52,95	53,25	6	16,5	0,77	3,37	6	60
B 20	70	M68 x 6	68	6	60,34	60,64	7	18	0,84	3,68	7	70
B 25	80	M72 x 6	72	6	64,34	64,64	8	18	0,84	3,68	8	72
B 32	85	M80 x 6	80	6	72,34	72,64	8,5	18	0,84	3,68	9	80
B 40	100	M 90 x 6	90	6	82,34	82,64	10	18	0,84	3,68	10	90
B 50	110	M100 x 8	100	8	89,89	90,19	11	24	1,12	4,91	11	100
B 63	120	M110 x 8	110	8	99,89	100,19	12	24	1,12	4,91	12	110

NOTE 1 For explanation of dimension e , see A.3.
 NOTE 2 Width of undercut, s , is measured from the shoulder of the shank to the crest of the last full thread.

Annex H (normative)

Bending of curved beams

H.1 Basic equations for stresses

The stresses calculated below represent true primary tensile stresses in the cross section of a curved beam, derived from the theory of elasticity and with the assumption of no plastic behaviour of material.

The equations below are in a general format of equations for a curved beam and they apply to an analogous problem of stress distribution in a cross section of the curved part of the hook bowl body. The designations refer to Figure H.1. For a curved beam with a solid section, a reference moment of inertia is calculated as follows:

$$I = \int_{-\eta_1}^{+\eta_2} \frac{y^2 \times b(y)}{1 + \frac{y}{R}} dy \quad (\text{H.1})$$

where

y is the distance in radial direction, measured from the centroid of cross section; taken as positive between the centroid and the extrados of the section and negative between the intrados and centroid of the section;

b is the width of the section at a location y ;

R is the radius of curvature of centroid axis of the curved beam at the cross section under consideration;

η_1 is the absolute value of the coordinate y at the inside radius;

η_2 is the absolute value of the coordinate y at the outside radius.

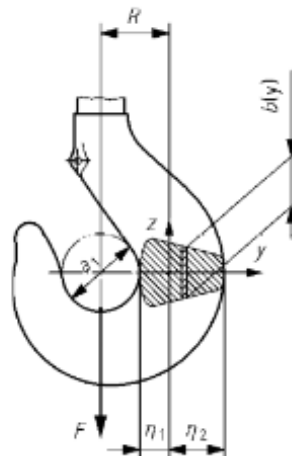


Figure H.1 — Symbols for curved beam bending calculation

The maximum tensile stress in the cross section shown is at the intrados and is calculated as follows:

$$\sigma = \frac{F \times R \times \eta_1}{I} \times \frac{1}{1 - \eta_1 / R} \quad (\text{H.2})$$

where

F is the force acting perpendicularly to the plane of the section and through the centre of the curvature;

R is the radius of curvature of centroid axis of the hook bowl at the cross section under consideration;

η_1 is the absolute value of the coordinate y at the intrados;

I is the a reference moment of inertia of the section in accordance with Equation (H.1).

NOTE Equation (H.2) contains the combined effect of direct tension and bending moment. The equation is only valid in the case, where the force causing the bending acts through the centre of the beam curvature. Under such a loading configuration the neutral axis coincides with the centroid of the section.

H.2 Approximation of the reference moment of inertia

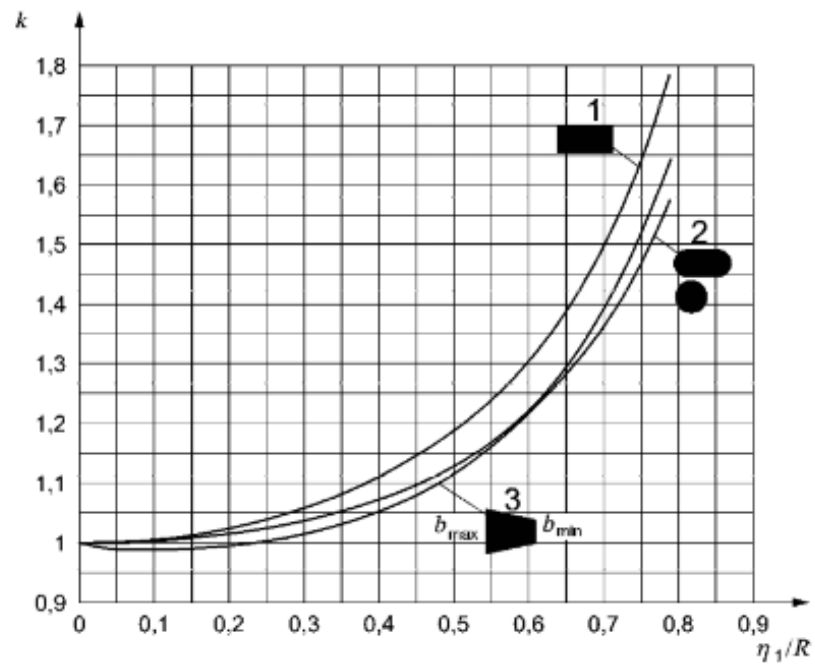
The reference moment of inertia of a curved beam may be expressed as follows:

$$I = k \times I_z = k \times \int_{-\eta_1}^{+\eta_2} y^2 \times b(y) \times dy \quad (\text{H.3})$$

where

I_z is the conventional moment of inertia of the section about the z-axis;

k is a conversion factor, depending of the shape of the section and the relative curvature, see Figure H.2.



Key

- 1 Rectangular section
- 2 Circular and rounded sections
- 3 Trapezoidal section

with $0,45 < b_{min}/b_{max} < 0,55$, where b_{max} is the larger, inner edge width of the section and b_{min} is the smaller, outer edge width of the section.

For cross sections of hooks of type B, k may be taken as $k = 1,05$ both on Section A and B in Figure 5.

Figure H.2 — Factor k for a selection of section types

Annex I (normative)

Calculation of hook suspension tilting resistance, articulation by a hinge or a rope reeving system

I.1 General

The hook tilting resistance factor C_t represents the friction in the hook suspension resisting the tilting of the hook. It is a characteristic of the suspension only and its value is independent upon external loadings. The factor C_t is defined through Equation (I.1) as follows:

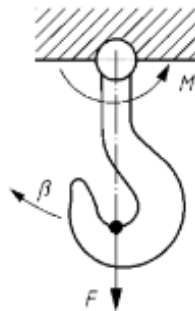
$$C_t = \frac{M}{F} \quad (\text{I.1})$$

where

C_t is the hook tilting resistance factor;

M is the moment resisting the tilting movement of the hook, see Figure I.1;

F is the vertical force acting on the hook.



Key

β direction of the tilting movement

Figure I.1 — General presentation of hook tilting resistance

I.2 Articulation of hook by a hinge

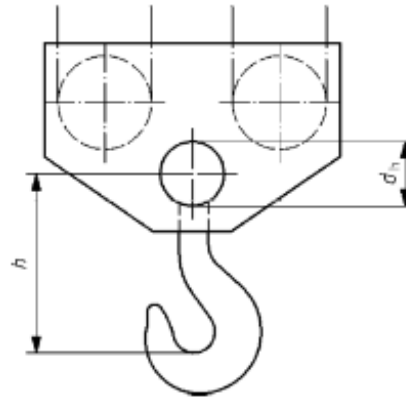


Figure I.2 — A hook suspension with a hook articulation by a hinge

Rope reeving system is such that the hook suspension stays horizontal, when the hook is tilted along the load line. Tilting resistance factor is calculated as follows:

$$C_t = \frac{M}{F} = \mu \times \frac{d_h}{2} \quad (1.2)$$

where

d_h is the diameter of the sliding surface of the hinge;

μ is the friction in the hinge, to be taken as follows:

$\mu = 0,1$ for non-grease able, special coated bearing bushings;

$\mu = 0,25$ for re-grease able, bronze/steel bearing bushings;

$\mu = 0,4$ for non-grease able steel/steel hinges;

$\mu = 0$ (zero) for hinges with anti-friction bearings.

As the tilting resistance is significant for the fatigue of the hook shank, the friction figures represent long term values to be expected in practice. This shall be taken into consideration, if the friction values should be based upon tests.

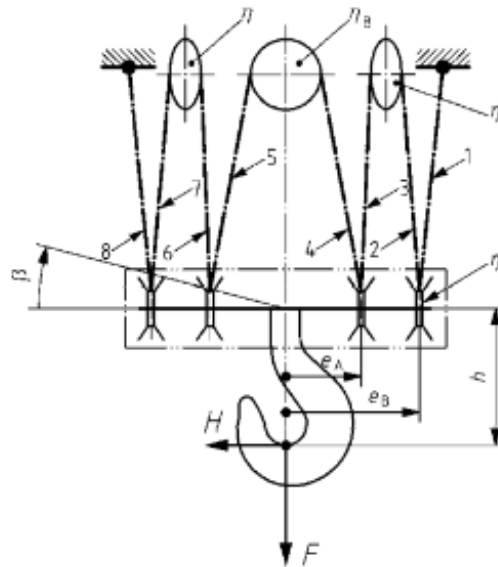
I.3 Articulation of a hook suspension by a balanced rope reeving

Due to a wide variety of possible configurations, an example only is given here, i.e. the calculation of the resistance factor for an eight-fall rope system.

In a balanced rope reeving system, for example that shown in Figure I.3, differential tensions are generated within the individual rope falls due to sheave losses, when the hook suspension is tilted e.g. due to a horizontal force on the hook.

The sample reeving system assumes:

- Symmetry about the hook centre line;
- Sheaves are similar except that the middle sheave has a different efficiency than the others.



Key

- β direction of the tilting
- h distance from the hook seat to the centre of the articulation
- H horizontal force causing the tilting

Figure I.3 — An example of a rope reeving system

When the hook suspension is tilted, maximum force is generated in rope fall no. 1, minimum force in fall no. 8, and the rope forces fulfil a relationship as depicted within Table I.1.

Table I.1 — Rope forces in a tilted condition

Rope no. (l)	1	2	3	4	5	6	7	8
Rope force R_l	R_1	$\eta \times R_1$	$\eta^2 \times R_1$	$\eta^3 \times R_1$	$\eta_B \times \eta^3 \times R_1$	$\eta_B \times \eta^4 \times R_1$	$\eta_B \times \eta^5 \times R_1$	$\eta_B \times \eta^6 \times R_1$

where

R_1 is the force in rope fall no. 1, the extreme rope on the descending side of the reeving;

η is the efficiency of a basic sheave, see CEN/TS 13001-3-2;

η_B is the efficiency of the middle sheave.

Equilibrium condition in vertical direction presumes that the sum of the rope forces equals to the vertical force acting on the hook. From this we can derive Equation (I.3) for the rope force R_1 .

$$R_1 = \frac{F}{1 + \eta + \eta^2 + \eta^3 + \eta_B \times \eta^3 + \eta_B \times \eta^4 + \eta_B \times \eta^5 + \eta_B \times \eta^6} \quad (I.3)$$

where

F is the vertical force acting on the hook.

The other rope forces R_i are derived based upon Equation (I.3) and the equations in Table I.1. Forces R_i combine with distances e_i and generate a turning moment about the central vertical axis; this moment is derived as per Equation (I.4):

$$M = \sum_{i=1}^8 R_i \times e_i \quad (I.4)$$

where

e_i is the horizontal coordinate of the rope (i) from the hook suspension centre. Coordinates are taken positive on the descending side of the hook suspension, see Figure I.3.

By placing the contents of Table I.1 and Equation (I.3) to Equation (I.4), we get finally the tilting resistance C_t for this specific rope reeving system as follows:

$$C_t = \frac{M}{F} = \frac{e_B \times (1 + \eta - \eta_B \times \eta^5 - \eta_B \times \eta^6) + e_A \times (\eta^2 + \eta^3 - \eta_B \times \eta^3 - \eta_B \times \eta^4)}{1 + \eta + \eta^2 + \eta^3 + \eta_B \times \eta^3 + \eta_B \times \eta^4 + \eta_B \times \eta^5 + \eta_B \times \eta^6} \quad (I.5)$$

where

e_A, e_B are the horizontal distances of the sheaves from the hook suspension centre, see Figure I.3.

Annex J (informative)

Guidance for the selection of a hook size using the Annexes C to E

J.1 General

In cases where a hook body in accordance with Annex A or B is used, the proofs of static and fatigue strength of the hook body can be done using the limit design forces in Annexes C and D.

Additionally, the proof of competence for the machined shank with a chosen design shall be carried out in accordance with appropriate subclauses in Clauses 5 and 6.

All the assessments, choices of values and conclusions concerning the case specific loads and factors are given as an example only. Those shall not be considered as a general guidance for the same.

J.2 Case description

Search for a minimum size hook for the following case:

- a) Mass of the rated load of the crane/hook is $m_{RC} = 50$ t;
- b) Governing load factor ϕ is $\phi_2 = 1,21$;
- c) Operating temperature for the hook is $T = 150$ °C;
- d) Governing load case is regular loads $\gamma_p = 1,34$;
- e) Normal crane application, the risk factor is $\gamma_r = 1$;
- f) Chosen to use a single hook from Annex A;
- g) Chosen to use the material class T;
- h) The use of the crane is specified through the classification as follows: number of cycles in accordance with class U₅ and load spectrum class Q₄.

J.3 Proof of static strength

Starting point is the condition given in Equation (16). The influence factor f_1 for the operation temperature is calculated in accordance with Equation (15):

$$f_1 = 1 - 0,25 \times (T - 100) / 150 = 0,9167 \quad (\text{J.1})$$

The minimum, required static limit design force of the hook can be written, based upon Equations (1) and (16) as follows:

$$F_{Rd,s} \geq \frac{F_{Sd,s}}{f_1} = \frac{\phi_2 \times m_{RC} \times g \times \gamma_p \times \gamma_r}{f_1} = \frac{1,21 \times 50 \times 9,81 \times 1,34}{0,9167} = 868 \text{ [kN]} \quad (\text{J.2})$$

The hook is then searched from Table C.1 from the material column "T". The hook number 16 has a static limit design force $F_{Rd,s} = 963$ kN, which fulfils the requirement in Equation (J.2).

J.4 Proof of fatigue strength

Starting point is the condition given in Equation (35). The influence factor f_1 for the operation temperature is calculated in accordance with Equation (31):

$$f_1 = 1 - 0,1 \times (T - 100) / 150 = 0,967 \quad (\text{J.3})$$

The value for the conversion factor k_C is found from Annex E at intersection of row U5 and column Q₄.

$$k_C = k_6^* / \sqrt[3]{s_Q} = 1,53 \quad (\text{J.4})$$

The minimum, required fatigue limit design force of the hook can be written, based upon Equations (18) and (35) as follows:

$$F_{Rd,f} \geq \frac{F_{Sd,f}}{f_1 \times \left(\frac{k_6^*}{\sqrt[3]{s_Q}} \right)} = \frac{\phi_2 \times m_{RC} \times g}{f_1 \times k_C} = \frac{1,21 \times 50 \times 9,81}{0,967 \times 1,53} = 401 \text{ [kN]} \quad (\text{J.5})$$

The hook is then searched from Table D.1 from the material column "T". The hook number 25 has a fatigue limit design force $F_{Rd,f} = 420$ kN, which fulfils the requirement in Equation (J.5).

J.5 Final selection of hook

The selection of hook body shall meet both design criteria for static and fatigue strength. Consequently, the larger of the resulting hooks in J.3 and J.4 shall be chosen. For this case the minimum single hook of those in Annex A is the hook number 25, of material class T.

The final selection of the hook, which depends on the detailed shank design, shall have to take into account also the results of calculations in accordance with Clauses 5 and 6.

Annex K (normative)

Information to be provided by the hook manufacturer

The hook manufacturer shall provide the following information for the Technical File of the crane.

Information to be provided by the hook manufacturer	
General	Manufacturer
	Unique manufacturers traceability hook marking
	Serial or lot number of the hook / date of manufacturing
	Single / ramshorn hook
	With or without a safety latch
	Mass of the hook, in kilograms (kg)
Dimensions	Size code and standard for forged dimensions
	Length of hook: L , in millimetres (mm)
	Size code and standard for shank dimensions (if hook is supplied with a finished shank)
	Certificate of dimensions
	Gap measure(s): y , y_1 , y_2 , in millimetres (mm)
Material	Grade and standard
	Raw material certificate
	Heat treatment certificate
	Finished forging material certificate
Manufacturing	Process type / description
	NDT inspection certificate
	Load test certificate (if relevant)
	Proof loading certificate, if applied
Optional info	Static limit design force of the hook body, in kilonewtons (kN)
	Fatigue limit design force of the hook body, in kilonewtons (kN)

Annex L (informative)

Selection of a suitable set of crane standards for a given application

Is there a product standard in the following list that suits the application?	
EN 13000	<i>Cranes — Mobile cranes</i>
EN 14439	<i>Cranes — Safety — Tower cranes</i>
EN 14985	<i>Cranes — Slewing jib cranes</i>
prEN 15011	<i>Cranes — Bridge and gantry cranes</i>
EN 13852-1	<i>Cranes — Offshore cranes — Part 1: General-purpose offshore cranes</i>
EN 13852-2	<i>Cranes — Offshore cranes — Part 2: Floating cranes</i>
EN 14492-1	<i>Cranes — Power driven winches and hoists — Part 1: Power driven winches</i>
EN 14492-2	<i>Cranes — Power driven winches and hoists — Part 2: Power driven hoists</i>
EN 12999	<i>Cranes — Loader cranes</i>
EN 13157	<i>Cranes — Safety — Hand powered cranes</i>
EN 13155	<i>Cranes — Safety — Non-fixed load lifting attachments</i>
EN 14238	<i>Cranes — Manually controlled load manipulating devices</i>
EN 15056	<i>Cranes — Requirements for container handling spreaders</i>

YES

NO

Use it directly, plus the standards
that are referred to.

Use the following:	
EN 13001-1	<i>Cranes — General design — Part 1: General principles and requirements</i>
EN 13001-2	<i>Cranes — General design — Part 2: Load effects</i>
prEN 13001-3-1	<i>Cranes — General design — Part 3-1: Limit states and proof of competence of steel structures</i>
CEN/TS 13001-3-2	<i>Cranes — General design — Part 3-2: Limit states and proof of competence of wire ropes in reeving systems</i>
prCEN/TS 13001-3-3	<i>Cranes — General design — Part 3-3: Limit states and proof of competence of wheel/rail contacts</i>
CEN/TS 13001-3-5	<i>Cranes — General design — Part 3-5: Limit states and proof of competence of forged hooks</i>
EN 13135-1	<i>Cranes — Equipment — Part 1: Electrotechnical equipment</i>
EN 13135-2	<i>Cranes — Equipment — Part 2: Non-electrotechnical equipment</i>
EN 13557	<i>Cranes — Controls and control stations</i>
EN 12077-2	<i>Cranes safety — Requirements for health and safety — Part 2: Limiting and indicating devices</i>
EN 13586	<i>Cranes — Access</i>
EN 14502-1	<i>Cranes — Equipment for lifting persons — Part 1: Suspended baskets</i>
EN 14502-2	<i>Cranes — Equipment for the lifting of persons — Part 2: Elevating control stations</i>
EN 12644-1	<i>Cranes — Information for use and testing — Part 1: Instructions</i>
EN 12644-2	<i>Cranes — Information for use and testing — Part 1: Marking</i>

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- [2] EN ISO 12100-2, *Safety of machinery — Basic concepts, general principles for design — Part 2: Technical principles (ISO 12100-2:2003)*
- [3] DIN 15400, *Lifting hooks; materials, mechanical properties, lifting capacity and stresses*
- [4] BS 2903, *Specification for higher tensile steel hooks for chains, slings, blocks and general engineering purposes*