Technical Report

ISO/TR 10300-30

Second edition
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Calculation of load capacity of bevel gears —

Part 30:
ISO rating system for bevel and hypoid gears — Sample calculations

Calcul de la capacité de charge des engrenages coniques — Partie 30: Système d'évaluation ISO pour engrenages conique et hypoïde — Type de calculs

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Contents

Foreword

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

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

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

This document was prepared by Technical Committee ISO/TC 60, *Gears*, Subcommittee SC 2, *Gear capacity calculation*.

This second edition cancels and replaces the first edition (ISO/TR 10300-30:2017), which has been technically revised.

The main changes are as follows:

— all sample calculations have been revised according to ISO 10300-1:2023, ISO 10300-2:2023 and ISO 10300-3:2023;

— all sample calculations include localised calculation method for Method B1.

A list of all parts in the ISO 10300 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The ISO 10300 series consists of International Standards, Technical Specifications (TS) and Technical Reports (TR) under the general title *Calculation of load capacity of bevel gears* (see Table 1).

— International Standards contain calculation methods that are based on widely accepted practices and have been validated.

— TS contain calculation methods that are still subject to further development.

— TR contain data that is informative, such as example calculations.

The procedures specified in ISO 10300-1 to ISO 10300-19 cover fatigue analyses for gear rating. The procedures described in ISO 10300-20 to ISO 10300-29 are predominantly related to the tribological behaviour of the lubricated flank surface contact. ISO 10300-30 to ISO 10300-39 include example calculations. The ISO 10300 series allows the addition of new parts under appropriate numbers to reflect knowledge gained in the future.

Requesting standardized calculations according to the ISO 10300 series without referring to specific parts requires the use of only those parts that are currently designated as International Standards (see Table 1 for listing). When requesting further calculations, the relevant part or parts of the ISO 10300 series need to be specified. The use of a Technical Specification as acceptance criteria for a specific design needs to be agreed in advance between manufacturer and purchaser.

Table 1 — Overview of the ISO 10300 series

Calculation of load capacity of bevel gears	**International Standard**	**Technical Specification**	**Technical Report**
Part 1: Introduction and general influence factors	X		
Part 2: Calculation of surface durability (macropitting)	X		
Part 3: Calculation of tooth root strength	X		
Part 4 to 19: to be assigned			
Part 20: Calculation of scuffing load capacity – Flash temperature method		X	
Part 21 to 29: to be assigned			
Part 30: ISO rating system for bevel and hypoid gears — Sample calculations			X
Part 32: ISO rating system for bevel and hypoid gears — Sample calculation for scuffing load capacity			X

NOTE At the time of publication of this document, some of the parts listed here were under development. Consult the ISO website.

This document was prepared with sample calculations for different bevel gear designs. They are intended for users of the ISO 10300 series to follow a whole calculation procedure formula by formula. Practical experience has shown that this way, to get into a complex subject, is very helpful.

However, this document is not intended for use by the average engineer. Rather, it is aimed at the well-versed engineer capable of selecting reasonable values for the parameters and factors in these formulae based on knowledge of similar designs and on awareness of the effects behind these formulae.

Calculation of load capacity of bevel gears —

Part 30: ISO rating system for bevel and hypoid gears — Sample calculations

1 Scope

This document provides sample calculations for the load capacity of different bevel gear designs, determined according to the methods and formulae of the ISO 10300 series. The initial geometric gear data necessary for these calculations are according to ISO 23509.

The term “bevel gear” is used to mean straight, helical (skew), spiral bevel, zerol and hypoid gear designs. Where this document pertains to one or more, but not all, the specific forms are identified.

The manufacturing process of forming the desired tooth form is not intended to imply any specific process, but rather to be general in nature and applicable to all calculation methods of the ISO 10300 series. The fact that there are bevel gear designs with tapered teeth and others where the tooth depth remains constant along the facewidth (uniform depth) does not require to apply Method B2 for the first and Method B1 for the second tooth configuration.

The rating system of the ISO 10300 series is based on virtual cylindrical gears and restricted to bevel gears whose virtual cylindrical gears have transverse contact ratios of $\varepsilon_{v\alpha} < 2$. Additionally, the given relations are valid for bevel gears of which the sum of profile shift coefficients of pinion and wheel is zero (see ISO 23509).

WARNING The user is cautioned that when the formulae are used for large average mean spiral angles, $(\beta_{m1} + \beta_{m2})/2 > 45°$, for effective pressure angles, $\alpha_e > 30°$ and/or for large facewidths, $b > 13\ m_{mn}$, to confirm the calculated results of the ISO 10300 series by experience.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 10300-1:2023, *Calculation of load capacity of bevel gears — Part 1: Introduction and general influence factors*

ISO 10300-2:2023, *Calculation of load capacity of bevel gears — Part 2: Calculation of surface durability (macropitting)*

ISO 10300-3:2023, *Calculation of load capacity of bevel gears — Part 3: Calculation of tooth root strength*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 10300-1, ISO 10300-2 and ISO 10300-3 apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

4 Symbols and abbreviated terms

For the purposes of this document, the symbols and units given in ISO 10300-1:2023, Table 1 and Table 2, ISO 10300-2:2023, Table 1 and Table 2, ISO 10300-3:2023, Table 1 and Table 2 as well as the abbreviated terms given in ISO 10300-2:2023, Table 3, and ISO 10300-3:2023, Table 3, apply.

Table 2 — Symbols and units used in ISO 10300 (all parts)

Symbol	Description or term	Unit
A	Auxiliary factor for calculating the dynamic factor K_{v-C}	—
A^*	Related area for calculating the load sharing factor Z_{LS}	mm
A_{sne}	Outer tooth thickness allowance	mm
a	Hypoid offset	mm
a_{rel}	Relative hypoid offset	—
a_v	Centre distance of virtual cylindrical gear pair	mm
a_{vn}	Centre distance of virtual cylindrical gear pair in normal section	mm
B	Accuracy grade according to ISO 17485	—
b	Facewidth	mm
b_b	Related base facewidth	—
b_{ce}	Calculated effective facewidth	mm
b_{eff}	Effective facewidth (e.g. measured length of contact pattern)	mm
b_v	Facewidth of virtual cylindrical gears	mm
$b_{v,eff}$	Effective facewidth of virtual cylindrical gears	mm
C_F	Correction factor of tooth stiffness for non-average conditions	—
C_{lb}	Correction factor for the length of contact lines	—
C_{ZL}, C_{ZR}, C_{ZV}	Constants for determining lubricant film factors	—
c_{ham}	Mean addendum factor of wheel	—
c_v	Empirical parameter to determine the dynamic factor	—
c_γ	Mean value of mesh stiffness per unit facewidth	N/(mm · µm)
$c_{\gamma 0}$	Mesh stiffness for average conditions	N/(mm · µm)
c'	Single stiffness	N/(mm · µm)
c_0'	Single stiffness for average conditions	N/(mm · µm)
d_e	Outer pitch diameter	mm
d_m	Mean pitch diameter	mm
d_T	Tolerance diameter according to ISO 17485	mm
d_v	Reference diameter of virtual cylindrical gear	mm
d_{va}	Tip diameter of virtual cylindrical gear	mm
d_{van}	Tip diameter of virtual cylindrical gear in normal section	mm
d_{vb}	Base diameter of virtual cylindrical gear	mm

Symbol	Description or term	Unit
d_{vbn}	Base diameter of virtual cylindrical gear in normal section	mm
d_{vf}	Root diameter of virtual cylindrical gear	mm
d_{vn}	Reference diameter of virtual cylindrical gear in normal section	mm
E	Modulus of elasticity, Young's modulus	N/mm²
E, G, H	Auxiliary variables for tooth form factor (Method B1)	—
e_{LS}	Exponent for the distribution of the load peaks along the lines of contact	—
F	Auxiliary variable for mid-zone factor	—
F_{mt}	Nominal tangential force at mid facewidth of the reference cone	N
F_{mtH}	Determinant tangential force at mid facewidth of the reference cone	N
F_n	Nominal normal force	N
F_{vmt}	Nominal tangential force of virtual cylindrical gears	N
f	Distance from the centre of the zone of action to a contact line	mm
f_{max}	Maximum distance to middle contact line	mm
f_{maxB}	Maximum distance to middle contact line at right side of the contact pattern	mm
f_{max0}	Maximum distance to middle contact line at left side of the contact pattern	mm
f_{pt}	Single pitch deviation	µm
$f_{p\ eff}$	Effective pitch deviation	µm
$f_{\alpha lim}$	Influence factor of limit pressure angle	
g_c	Length of contact line (Method B2)	mm
$g_{v\alpha}$	Length of path of contact of virtual cylindrical gear in transverse section	mm
$g_{v\alpha n}$	Related length of action in normal section	—
g_J	Length of action from mean point to point of load application (Method B2)	mm
g_η	Relative length of action within the contact ellipse	mm
HB	Brinell hardness	—
h_{am}	Mean addendum	mm
h_{a0}	Tool addendum	mm
h_{Fa}	Bending moment arm for tooth root stress (load application at tooth tip)	mm
h_{fm}	Mean dedendum	mm
h_{fP}	Dedendum of the basic rack profile	mm
h_m	Mean whole depth used for bevel spiral angle factor	mm
h_{vfm}	Relative mean virtual dedendum	—
h_N	Load height from critical section (Method B2)	mm
j_{en}	Outer normal backlash	mm

Symbol	Description or term	Unit
K	Constant; factor for calculating the dynamic factor K_{v-B}	—
K_A	Application factor	—
K_{F0}	Lengthwise curvature factor for bending stress	—
$K_{F\alpha}$	Transverse load factor for bending stress	—
$K_{F\alpha}*$	Preliminary transverse load factor for bending stress for non-hypoid gears	—
$K_{F\beta}$	Face load factor for bending stress	—
$K_{H\alpha}$	Transverse load factor for contact stress	—
$K_{H\alpha}*$	Preliminary transverse load factor for contact stress for non-hypoid gears	—
$K_{H\beta}$	Face load factor for contact stress	—
$K_{H\beta-be}$	Mounting factor	—
K_v	Dynamic factor	—
K_v*	Preliminary dynamic factor for non-hypoid gears	—
k'	Contact shift factor	—
k_c	Clearance factor	—
k_d	Depth factor	—
k_{hap}	Basic crown gear addendum factor (related to m_{mn})	—
k_{hfp}	Basic crown gear dedendum factor (related to m_{mn})	—
k_t	Circular thickness factor	—
l_b	Length of contact line (Method B1)	mm
l_{b0}	Theoretical length of contact line	mm
l_{bm}	Theoretical length of middle contact line	mm
m_{et}	Outer transverse module	mm
m_{mn}	Mean normal module	mm
m_{mt}	Mean transverse module	mm
m_{red}	Mass per unit facewidth reduced to the line of action of dynamically equivalent cylindrical gears	kg/mm
$m*$	Related individual gear mass per unit facewidth referred to the line of action	kg/mm
N	Reference speed related to resonance speed n_{E1}	—
N_L	Number of load cycles	—
n	Rotational speed	min^{-1}
n_{E1}	Resonance speed of pinion	min^{-1}
P	Nominal power	kW
p	Peak load	N/mm
p_{et}	Transverse base pitch (Method B2)	mm
p_{max}	Maximum peak load	N/mm
$p*$	Related peak load for calculating the load sharing factor (Method B1)	—

Symbol	Description or term	Unit
p_{mn}	Relative mean normal pitch	—
p_{nb}	Relative mean normal base pitch	—
p_{vet}	Transverse base pitch of virtual cylindrical gear (Method B1)	mm
q	Exponent in the formula for lengthwise curvature factor	—
q_{s}	Notch parameter	—
q_{s}	Notch parameter (Method B2)	—
Ra	= CLA = AA arithmetic average roughness	µm
R_{e}	Outer cone distance	mm
R_{m}	Mean cone distance	mm
R_{mpt}	Relative mean back cone distance	—
Rz	Mean roughness	µm
Rz_{10}	Mean roughness for gear pairs with relative curvature radius ρ_{rel} = 10 mm	µm
r_{c0}	Cutter radius	mm
r_{mf}	Tooth fillet radius at the root in mean section	mm
r_{mpt}	Mean pitch radius	mm
$r_{my\,0}$	Mean transverse radius to point of load application (Method B2)	mm
r_{va}	Relative mean virtual tip radius	—
r_{vn}	Relative mean virtual pitch radius	—
S_{F}	Safety factor for bending stress (against breakage)	—
$S_{F\,min}$	Minimum safety factor for bending stress	—
S_{H}	Safety factor for contact stress (against macropitting)	—
$S_{H\,min}$	Minimum safety factor for contact stress	—
s_{Fn}	Tooth root chord in calculation section	mm
s_{mn}	Mean normal circular thickness	mm
s_{N}	One-half tooth thickness at critical section (Method B2)	mm
s_{pr}	Amount of protuberance at the tool	mm
$T_{1,2}$	Nominal torque of pinion and wheel	Nm
u	Gear ratio of bevel gear	—
u_{v}	Gear ratio of virtual cylindrical gear	—
v_{et}	Tangential speed at outer end (heel) of the reference cone	m/s
$v_{et\,max}$	Maximum pitch line velocity at operating pitch diameter	m/s
v_{g}	Sliding velocity in the mean point P	m/s
$v_{g\,par}$	Sliding velocity parallel to the contact line	m/s
$v_{g\,vert}$	Sliding velocity vertical to the contact line	m/s
v_{mt}	Tangential speed at mid facewidth of the reference cone	m/s
v_{Σ}	Sum of velocities in the mean point P	m/s

Symbol	Description or term	Unit
$v_{\Sigma h}$	Sum of velocities in profile direction	m/s
$v_{\Sigma l}$	Sum of velocities in lengthwise direction	m/s
$v_{\Sigma\ vert}$	Sum of velocities vertical to the contact line	m/s
W_{m2}	Wheel mean slot width	mm
w	Angle of contact line relative to the root cone	°
x_{hm}	Profile shift coefficient	—
x_{sm}	Thickness modification coefficient (backlash included)	—
x_{smn}	Thickness modification coefficient (theoretical)	—
x_N	Tooth strength factor (Method B2)	mm
x_{oo}	Distance from mean section to point of load application	mm
Y_A	Root stress adjustment factor (Method B2)	—
Y_{BS}	Bevel spiral angle factor	—
Y_{Fa}	Tooth form factor for load application at the tooth tip (Method B1)	—
Y_{FS}	Combined tooth form factor for generated gears	—
Y_f	Stress concentration and stress correction factor (Method B2)	—
Y_i	Inertia factor (bending)	—
Y_J	Bending strength geometry factor (Method B2)	—
Y_{LS}	Load sharing factor (bending)	—
Y_{NT}	Life factor (bending)	—
$Y_{R\ rel\ T}$	Relative surface condition factor	—
Y_{Sa}	Stress correction factor for load application at the tooth tip	—
Y_{ST}	Stress correction factor for dimensions of the standard test gear	—
Y_X	Size factor for tooth root stress	—
$Y_{1,2}$	Tooth form factor of pinion and wheel (Method B2)	—
$Y_{\delta\ rel\ T}$	Relative notch sensitivity factor	—
Y_ε	Contact ratio factor for bending (Method B1)	—
y_p	Running-in allowance for pitch deviation related to the polished test piece	µm
y_J	Location of point of load application for maximum bending stress on path of action (Method B2)	mm
y_3	Location of point of load application on path of action for maximum root stress	mm
y_α	Running-in allowance for pitch error	µm
Z_A	Contact stress adjustment factor (Method B2)	—
Z_E	Elasticity factor	—
Z_{FW}	Facewidth factor	—
Z_{Hyp}	Hypoid factor	—

Symbol	Description or term	Unit
Z_I	Macropitting resistance geometry factor (Method B2)	—
Z_i	Inertia factor (macropitting)	—
Z_{KP}	Bevel gear factor (Method B1)	—
Z_L	Lubricant factor	—
Z_{LS}	Load sharing factor (Method B1)	—
$Z_{M\text{-}B}$	Mid zone factor	—
Z_{NT}	Life factor (macropitting)	—
Z_R	Roughness factor for contact stress	—
Z_S	Bevel slip factor	—
Z_v	Speed factor	—
Z_W	Work hardening factor	—
Z_X	Size factor	—
z	Number of teeth	—
z_v	Number of teeth of virtual cylindrical gear	—
z_{vn}	Number of teeth of virtual cylindrical gear in normal section	—
z_0	Number of blade groups of the cutter	—
α_a	Adjusted pressure angle (Method B2)	°
α_{an}	Normal pressure angle at tooth tip	°
$\alpha_{dD,C}$	Nominal design pressure angle for drive side/coast side	°
α_{et}	Effective pressure angle in transverse section	°
$\alpha_{eD,C}$	Effective pressure angle for drive side/coast side	°
α_f	Limit pressure angle in wheel root coordinates (Method B2)	°
α_{lim}	Limit pressure angle	°
$\alpha_{nD,C}$	Generated pressure angle for drive side/coast side	°
α_{vet}	Transverse pressure angle of virtual cylindrical gears	°
α_{Fan}	Load application angle at tooth tip of virtual cylindrical gear (Method B1)	°
α_L	Normal pressure angle at point of load application (Method B2)	°
β_{bm}	Mean base spiral angle	°
β_m	Mean spiral angle	°
β_v	Helix angle of virtual gear (Method B1), virtual spiral angle (Method B2)	°
β_{vb}	Helix angle at base circle of virtual cylindrical gear	°
β_B	Inclination angle of contact line	°
γ	Auxiliary angle for length of contact line calculation (Method B1)	°
γ'	Projected auxiliary angle for length of contact line	°
γ_a	Auxiliary angle for tooth form and tooth correction factor	°

Symbol	Description or term	Unit
δ	Pitch angle of bevel gear	°
δ_a	Face angle	°
δ_f	Root angle	°
$\varepsilon_{v\alpha}$	Transverse contact ratio of virtual cylindrical gears	—
$\varepsilon_{v\alpha n}$	Transverse contact ratio of virtual cylindrical gears in normal section	—
$\varepsilon_{v\beta}$	Face contact ratio of virtual cylindrical gears	—
$\varepsilon_{v\gamma}$	Virtual contact ratio (Method B1), modified contact ratio (Method B2)	—
ε_N	Load sharing ratio for bending (Method B2)	—
ε_{NI}	Load sharing ratio for macropitting (Method B2)	—
ζ_m	Pinion offset angle in axial plane	°
ζ_{mp}	Pinion offset angle in pitch plane	°
ζ_R	Pinion offset angle in root plane	°
θ	Auxiliary quantity for tooth form and tooth correction factors	—
θ_{mp}	Auxiliary angle for virtual facewidth (Method B1)	°
θ_{a2}	Addendum angle of wheel	°
θ_{f2}	Dedendum angle of wheel	°
θ_{v2}	Angular pitch of virtual cylindrical wheel	radiant
ν	Poisson’s ratio	—
ν_0	Lead angle of face hobbing cutter	°
ν_{40}, ν_{50}	Nominal kinematic viscosity of the oil at 40 °C and 50 °C, respectively	mm²/s
ξ	Assumed angle in locating weakest section	°
ξ_h	One half of angle subtended by normal circular tooth thickness at point of load application	°
ρ	Density of gear material	kg/mm³
ρ_{a0}	Cutter edge radius	mm
ρ_F	Fillet radius at point of contact of 30° tangent	mm
ρ_{Fn}	Fillet radius at point of contact of 30° tangent in normal section	mm
ρ_{fP}	Root fillet radius of basic rack for cylindrical gears	mm
ρ_{rel}	Radius of relative curvature vertical to contact line at virtual cylindrical gears	mm
ρ_t	Radius of relative profile curvature (Method B2)	mm
ρ_{va0}	Relative edge radius of tool	—
ρ'	Slip layer thickness	mm
Σ	Shaft angle	°
σ_F	Tooth root stress	N/mm²
σ_{F0}	Nominal tooth root stress	N/mm²
$\sigma_{F\,lim}$	Nominal stress number (bending)	N/mm²