TECHNICAL REPORT

ISO/TR 10300-32

First edition
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Calculation of load capacity of bevel gears —

Part 32: ISO rating system for bevel and hypoid gears — Sample calculation for scuffing load capacity

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Foreword

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

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

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

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*.

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

Requesting standardized calculations according to ISO 10300 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 ISO 10300 need to be specified. Use of a Technical Specification as acceptance criteria for a specific design need to be agreed in advance between manufacturer and purchaser.

Table 1 — Parts of ISO 10300 series (status as of DATE OF PUBLICATION)

Calculation of load capacity of bevel gears	International Standard	Technical Specification	Technical Report
Part 1: Introduction and general influence factors[a]	X		
Part 2: Calculation of surface durability (pitting)[a]	X		
Part 3: Calculation of tooth root strength[a]	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 Calculations of scuffing load capacity			X
[a] Under revision.			

This document and the other parts of ISO 10300 series provide a coherent system of procedures for the calculation of the load capacity of bevel and hypoid gears. ISO 10300 series is designed to facilitate the application of future knowledge and developments, also the exchange of information gained from experience.

Calculation of load capacity of bevel gears —

Part 32: ISO rating system for bevel and hypoid gears — Sample calculation for scuffing load capacity

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 face widths, $b > 13\ m_{mn}$, the calculated results of the ISO 10300 series should be confirmed by experience.

1 Scope

This document provides calculation examples for different bevel gear designs regarding the scuffing load capacity according to ISO/TS 10300-20. The initial geometry data of the gear necessary for these calculations are in accordance with 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 formulae in this document are based on virtual cylindrical gears and restricted to bevel gears whose virtual cylindrical gears have transverse contact ratios of $\varepsilon_{v\alpha} < 2$. The results are valid within the range of the applied factors as specified in ISO 10300-1 (see ISO 6336-2). 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).

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/TS 10300-20, *Calculation of load capacity of bevel gears — Part 20: Calculation of scuffing load capacity — Flash temperature method*

3 Terms and definitions

No terms and definitions are listed in this document.

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

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

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

4 Symbols

For the purposes of this document, the symbols and units given in ISO/TS 10300-20 apply.

5 Application

This document provides four sample calculations:

— Sample 1 is a rating of a spiral bevel gear pair without hypoid offset according to ISO/TS 10300-20 (see Annex A);

— Sample 2 is a rating of a hypoid gear set according to ISO/TS 10300-20 (see Annex B);

— Sample 3 is a rating of a hypoid gear set according to ISO/TS 10300-20 (see Annex C);

— Sample 4 is a rating of a hypoid gear set according to ISO/TS 10300-20 (see Annex D).

Annex A
(informative)

Sample 1: Rating of a spiral bevel gear pair without hypoid offset according to ISO/TS 10300-20

A.1 Initial data

Sample 1 is for a spiral bevel gear pair without hypoid offset which uses Method 0 according to ISO 23509 for calculation of gear geometry. The initial data for pitch cone parameters for this sample is shown in Table A.1 and the input data for tooth profile parameters in Table A.2.

Table A.1 — Initial data for pitch cone parameters

Symbol	Description	Method 0	Method 1	Method 2	Method 3
Σ	shaft angle	90°	X	X	X
a	hypoid offset	0 mm	X	X	X
$z_{1,2}$	number of teeth	14/39	X	X	X
d_{m2}	mean pitch diameter of wheel	—	—	X	—
d_{e2}	outer pitch diameter of wheel	176,893 mm	X	—	X
b_2	wheel face width	25,4 mm	X	X	X
β_{m1}	mean spiral angle of pinion	35°	X	—	—
β_{m2}	mean spiral angle of wheel	35°	—	X	X
r_{c0}	cutter radius	114,3 mm	X	X	X
z_0	number of blade groups (only face hobbing)	—	—	X	X

Table A.2 — Input data for tooth profile parameters

Data type I		Data type II	
Symbol	Description	Symbol	Description
α_{dD}	20°		
α_{dC}	20°		
$f_{\alpha lim}$	0		
x_{hm1}	—	c_{ham}	0,247 37
k_{hap}	—	k_d	2,000
k_{hfp}	—	k_c	0,125
x_{smn}	—	k_t W_{m2}	0,091 5 —
j_{et2}	0,127 mm		
θ_{a2}	2,134 2°		
θ_{f2}	6,493 4°		
ρ_{a01}	0,8 mm/0,8 mm		
ρ_{a02}	1,2 mm/1,2 mm		
$s_{pr1D,C}$	0 mm/0 mm		
$s_{pr2D,C}$	0 mm/0 mm		

Table A.3 and Table A.4 show geometry and operational data and text for explanation.

Table A.3 — Geometry data from calculation according to ISO 23509

Symbol	Description	Values	Symbol	Description	Value
$d_{m1,2}$	mean pitch diameter of pinion/wheel	54,918 mm/ 152,987 mm	ζ_{mp}	offset angle on pitch plane	0°
$h_{am1,2}$	mean addendum of pinion/ wheel	4,836 mm/ 1,591 mm	ζ_R	pinion offset angle on root plane	0°
$h_{fm1,2}$	mean dedendum of pinion/ wheel	2,394 mm/ 5,639 mm	$R_{e1,2}$	outer cone distance on pinion/wheel	93,973 mm
$\alpha_{eD,C}$	effective pressure angle for drive side/coast side	20°/20°	$R_{m1,2}$	mean cone distance on pinion/wheel	81,273 mm
$\alpha_{nD,C}$	generated pressure angle for drive side/coast side	20°/20°	$\delta_{1,2}$	pitch angle on pinion/wheel	19,747°/ 70,253°
α_{lim}	limit pressure angle	0°	$\delta_{a1,2}$	face angle on pinion/wheel	26,240°/ 72,387°
m_{mn}	mean normal module	3,213 mm	$\delta_{f1,2}$	root angle on pinion/wheel	17,613°/ 63,760°
k_{hfp}	basic crown gear dedendum factor	1,25	$x_{sm1,2}$	thickness modification coefficient on pinion/ wheel	0,037/ -0,055
ζ_m	pinion offset angle on axial plane	0,000°	m_{et2}	outer transverse module	4,536 mm
$s_{mn1,2}$	mean normal circular tooth thickness of pinion/wheel	6,465 mm/ 3,511 mm			

Table A.4 — Operation parameters and additional considerations

Symbol	Description	Value
Additional data		
	wheel profile	generated
	roughing/finishing method	face milling (ground)
b_{2eff}	effective face width on wheel	$0,85 \cdot b_2$
	profile crowning	low
	verification of contact pattern	checked under light test load for each gear
	mounting conditions of pinion and wheel	one member cantilever–mounted
Operation parameters		
T_1	pinion torque	300 Nm
n_1	pinion rotational speed	1 200 min^{-1}
K_A	application factor	1,1
	active flank	drive
	Run-In-Status	Run-In
Material data for pinion and wheel (case hardened steel)		
E	modulus of elasticity	210 000 N/mm^2
ν	Poisson's ratio	0,3
$\sigma_{H\,lim}$	allowable stress number (contact)	1 500 N/mm^2
$\sigma_{F\,lim}$	nominal stress number (bending)	480 N/mm^2
ρ_M	densitiy of pinion / wheel	7 800 kg/m^3 (according to ISO/TS 10300-20:2021, Table 5)

Table A.4 *(continued)*

Symbol	Description	Value
c_M	specific heat per unit mass of pinion / wheel	440 J/(kgK) (according to ISO/TS 10300-20:2021, Table 5)
λ_M	specific heat conductivity of pinion / wheel	45 W/(mK) (according to ISO/TS 10300-20:2021, Table 5)
surface hardness		same for pinion and wheel
Quality parameters		
Rz	flank roughness on pinion/wheel	8 µm/8 µm
Ra	flank roughness on pinion/wheel	1,33 µm/1,33 µm
Rz	tooth root roughness on pinion/wheel	16 µm/16 µm
f_{pt}	single pitch deviation on pinion/wheel	12 µm/26 µm
Lubrication parameters		
oil type		ISO-VG-150
θ_{Oil}	oil temperature	90 °C
$\theta_{Oil,Ref}$	reference oil temperature	90 °C
e_d	immersion depth	35,379 mm
T_{1T}	pinion torque of achieved load stage (load stage 12)	534,5 Nm (A/8,3/90 according to ISO 14635-1)
ν_{40}	kinematic viscosity at temperature 40 °C	150 mm²/s
ν_{100}	kinematic viscosity at temperature 100 °C	15 mm²/s
ρ_{15}	density at temperature 15 °C	890 kg/m³

A.2 Calculation of scuffing load capacity of Sample 1

The calculation results of the virtual cylindrical gear are listed in Table A.5, of stresses, velocities and coefficient of friction in Table A.6. Results of the calculation of the occurring contact temperature are shown in Table A.7, the permissible contact temperature in Table A.8. The results of the calculated safety factor can be found in Table A.9.

Table A.5 — Virtual cylindrical gear

Description	Formula	Result	References to ISO/TS 10300-20:2021
Length of path of contact in transverse section	$g_{\mathrm{v}\alpha} = g_{\mathrm{va1}} + g_{\mathrm{va2}} = \frac{1}{2}\left[\left(\sqrt{d_{\mathrm{va1}}^2 - d_{\mathrm{vb1}}^2} - d_{\mathrm{v1}} \sin\alpha_{\mathrm{vet}}\right) + \left(\sqrt{d_{\mathrm{va2}}^2 - d_{\mathrm{vb2}}^2} - d_{\mathrm{v2}} \sin\alpha_{\mathrm{vet}}\right)\right]$	13,121 mm	Formula (3)
Point A on the transverse path of contact	$g_{\mathrm{Y}}(\mathrm{A}) = -g_{\mathrm{va2}}$	-3,851 mm	Formula (1)
Point E on the transverse path of contact	$g_{\mathrm{Y}}(\mathrm{E}) = g_{\mathrm{va1}}$	9,27 mm	Formula (2)
Contact point Y on the transverse path of contact	$g_{\mathrm{Y}}(\mathrm{Y}) = (g_{\mathrm{Y}}(\mathrm{A}) + k_{\mathrm{s}} g_{\mathrm{v}\alpha}) + Y \cdot \frac{(1-2k_{\mathrm{s}}) g_{\mathrm{v}\alpha}}{i}$ with Y = 0...i; i = 10 NOTE In all following formulae, g_{Y} is a function of Y($g_{\mathrm{Y}} = g_{\mathrm{Y}}(\mathrm{Y})$)	-3,851 mm -2,539 mm -1,227 mm 0,085 mm 1,397 mm 2,709 mm 4,021 mm 5,334 mm 6,646 mm 7,958 mm 9,27 mm	Formula (4)

Table A.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Distance of the middle contact line in the zone of action	$f_{m,Y} = (g_{va2} - g_{v\alpha} / 2 + g_Y) \cdot \cos\beta_{vb}$	-5,526 mm -4,421 mm -3,316 mm -2,21 mm -1,105 mm 0 mm 1,105 mm 2,210 mm 3,316 mm 4,421 mm 5,526 mm	Formula (5)
Coordinates of the ends of the contact line	$x_{1,Y} = \dfrac{f_Y \cos\beta_{vb} + \tan\beta_{vb}\left(f_Y \sin\beta_{vb} + \dfrac{b_{v,eff}}{2}\right) + \dfrac{1}{2}(g_{v\alpha} + b_{v,eff}\tan\gamma)}{\tan\gamma + \tan\beta_{vb}} \geq 0$	10,795 mm 12,846 mm 14,896 mm 16,947 mm 18,997 mm 21,048 mm 21,59 mm 21,59 mm 21,59 mm 21,59 mm 21,59 mm	Formula (10)

Table A.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Coordinates of the ends of the contact line	$x_{2,Y} = \dfrac{f_Y \cos\beta_{vb} + \tan\beta_{vb}\left(f_Y \sin\beta_{vb} + \dfrac{b_{v,eff}}{2}\right) - \dfrac{1}{2}\left(g_{v\alpha} - b_{v,eff}\tan\gamma\right)}{\tan\gamma + \tan\beta_{vb}} \le b_{v,eff}$	0 mm 0 mm 0 mm 0 mm 0 mm 0,542 mm 2,593 mm 4,643 mm 6,694 mm 8,744 mm 10,795 mm	Formula (11)
Coordinates of the ends of the contact line	$y_{1,Y} = -x_{1,Y}\tan\beta_{vb} + f_Y\cos\beta_{vb} + \tan\beta_{vb}\left(f_Y \sin\beta_{vb} + \dfrac{b_{v,eff}}{2}\right)$	-6,561 mm -6,561 mm -6,561 mm -6,561 mm -6,561 mm -6,561 mm -5,595 mm -4,283 mm -2,971 mm -1,659 mm -0,347 mm	Formula (12)

Table A.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Coordinates of the ends of the contact line	$y_{2,Y} = -x_{2,Y} \tan\beta_{vb} + f_Y \cos\beta_{vb} + \tan\beta_{vb}\left(f_Y \sin\beta_{vb} + \frac{b_{v,eff}}{2}\right)$	0,347 mm 1,659 mm 2,971 mm 4,283 mm 5,595 mm 6,561 mm 6,561 mm 6,561 mm 6,561 mm 6,561 mm 6,561 mm	Formula (12)
Correction factor for the length of contact lines	$C_{lb,Y} = \sqrt{\left(1-\left(\frac{f_Y}{f_{max}}\right)^2\right)\left(1-\sqrt{\frac{b_{v,eff}}{b_v}}\right)^2}$	0,068 0,072 0,075 0,077 0,078 0,078 0,078 0,077 0,075 0,072 0,068	Formula (15)

Table A.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Theoretical length of contact line	$l_{b0m,Y} = \sqrt{(x_{1,Y} - x_{2,Y})^2 + (y_{1,Y} - y_{2,Y})^2}$	12,816 mm 15,25 mm 17,685 mm 20,119 mm 22,554 mm 24,345 mm 22,554 mm 20,119 mm 17,685 mm 15,25 mm 12,816 mm	Formula (14)
Length of contact line	$l_{bm,Y} = l_{b0m,Y}(1 - C_{lb,Y})$	11,942 mm 14,154 mm 16,365 mm 18,579 mm 20,802 mm 22,445 mm 20,802 mm 18,579 mm 16,365 mm 14,154 mm 11,942 mm	Formula (13)

Table A.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Distance of the tip contact line in the zone of action	$f_{t,Y} = f_{m,Y} + p_{vet} \cdot \cos\beta_{vb}$	3,959 mm 5,064 mm 6,17 mm 7,275 mm 8,38 mm 9,485 mm 10,59 mm 11,696 mm 12,801 mm 13,906 mm 15,011 mm	Formula (6)
Coordinates of the ends of the contact line	$x_{1,Y} = \dfrac{f_Y \cos\beta_{vb} + \tan\beta_{vb}\left(f_Y \sin\beta_{vb} + \dfrac{b_{v,eff}}{2}\right) + \dfrac{1}{2}\left(g_{v\alpha} + b_{v,eff}\tan\gamma\right)}{\tan\gamma + \tan\beta_{vb}} \geq 0$	21,59 mm 21,59 mm 21,59 mm 21,59 mm 21,59 mm 21,59 mm 21,59 mm 0 mm 0 mm 0 mm 0 mm	Formula (10)

Table A.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Coordinates of the ends of the contact line	$x_{2,\mathrm{Y}} = \dfrac{f_\mathrm{Y}\cos\beta_\mathrm{vb} + \tan\beta_\mathrm{vb}\left(f_\mathrm{Y}\sin\beta_\mathrm{vb} + \dfrac{b_\mathrm{v,eff}}{2}\right) - \dfrac{1}{2}\left(g_{\mathrm{v}\alpha} - b_\mathrm{v,eff}\tan\gamma\right)}{\tan\gamma + \tan\beta_\mathrm{vb}} \le b_\mathrm{v,eff}$	7,887 mm 9,938 mm 11,989 mm 14,039 mm 16,09 mm 18,14 mm 20,191 mm 0 mm 0 mm 0 mm 0 mm	Formula (11)
Coordinates of the ends of the contact line	$y_{1,\mathrm{Y}} = -x_{1,\mathrm{Y}}\tan\beta_\mathrm{vb} + f_\mathrm{Y}\cos\beta_\mathrm{vb} + \tan\beta_\mathrm{vb}\left(f_\mathrm{Y}\sin\beta_\mathrm{vb} + \dfrac{b_\mathrm{v,eff}}{2}\right)$	-2,207 mm -0,895 mm 0,417 mm 1,729 mm 3,041 mm 4,353 mm 5,665 mm 0 mm 0 mm 0 mm 0 mm	Formula (12)

Table A.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Coordinates of the ends of the contact line	$y_{2,Y} = -x_{2,Y} \tan \beta_{vb} + f_Y \cos \beta_{vb} + \tan \beta_{vb} \left(f_Y \sin \beta_{vb} + \frac{b_{v,eff}}{2} \right)$	6,561 mm 6,561 mm 6,561 mm 6,561 mm 6,561 mm 6,561 mm 6,561 mm 0 mm 0 mm 0 mm 0 mm	Formula (12)
Correction factor for the length of contact lines	$C_{lb,Y} = \sqrt{\left(1 - \left(\frac{f_Y}{f_{max}}\right)^2\right)\left(1 - \sqrt{\frac{b_{v,eff}}{b_v}}\right)^2}$	0,073 0,07 0,066 0,06 0,053 0,043 0,028 0 0 0 0	Formula (15)

Table A.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Theoretical length of contact line	$l_{b0t,Y}=\sqrt{(x_{1,Y}-x_{2,Y})^2+(y_{1,Y}-y_{2,Y})^2}$	16,268 mm 13,833 mm 11,399 mm 8,964 mm 6,53 mm 4,095 mm 1,661 mm 0 mm 0 mm 0 mm 0 mm	Formula (14)
Length of contact line	$l_{bt,Y}=l_{b0t,Y}(1-C_{lb,Y})$	15,078 mm 12,867 mm 10,652 mm 8,428 mm 6,186 mm 3,92 mm 1,615 mm 0 mm 0 mm 0 mm 0 mm	Formula (13)

Table A.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Distance of the root contact line in the zone of action	$f_{\mathrm{r,Y}} = f_{\mathrm{m,Y}} - p_{\mathrm{vet}} \cdot \cos\beta_{\mathrm{vb}}$	-15,011 mm -13,906 mm -12,801 mm -11,696 mm -10,59 mm -9,485 mm -8,38 mm -7,275 mm -6,17 mm -5,064 mm -3,959 mm	Formula (7)
Coordinates of the ends of the contact line	$x_{1,\mathrm{Y}} = \dfrac{f_{\mathrm{Y}} \cos\beta_{\mathrm{vb}} + \tan\beta_{\mathrm{vb}}\left(f_{\mathrm{Y}} \sin\beta_{\mathrm{vb}} + \dfrac{b_{\mathrm{v,eff}}}{2}\right) + \dfrac{1}{2}\left(g_{\mathrm{v}\alpha} + b_{\mathrm{v,eff}} \tan\gamma\right)}{\tan\gamma + \tan\beta_{\mathrm{vb}}} \geq 0$	0 mm 0 mm 0 mm 0 mm 1,399 mm 3,45 mm 5,5 mm 7,551 mm 9,601 mm 11,652 mm 13,703 mm	Formula (10)

Table A.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Coordinates of the ends of the contact line	$x_{2,\mathrm{Y}}=\dfrac{f_\mathrm{Y}\cos\beta_\mathrm{vb}+\tan\beta_\mathrm{vb}\left(f_\mathrm{Y}\sin\beta_\mathrm{vb}+\dfrac{b_\mathrm{v,eff}}{2}\right)-\dfrac{1}{2}\left(g_{\mathrm{v}\alpha}-b_\mathrm{v,eff}\tan\gamma\right)}{\tan\gamma+\tan\beta_\mathrm{vb}}\le b_\mathrm{v,eff}$	0 mm 0 mm 0 mm 0 mm 0 mm 0 mm 0 mm 0 mm 0 mm 0 mm 0 mm	Formula (11)
Coordinates of the ends of the contact line	$y_{1,\mathrm{Y}}=-x_{1,\mathrm{Y}}\tan\beta_\mathrm{vb}+f_\mathrm{Y}\cos\beta_\mathrm{vb}+\tan\beta_\mathrm{vb}\left(f_\mathrm{Y}\sin\beta_\mathrm{vb}+\dfrac{b_\mathrm{v,eff}}{2}\right)$	0 mm 0 mm 0 mm 0 mm -6,561 mm -6,561 mm -6,561 mm -6,561 mm -6,561 mm -6,561 mm -6,561 mm	Formula (12)

Table A.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Coordinates of the ends of the contact line	$y_{2,Y} = -x_{2,Y} \tan\beta_{vb} + f_Y \cos\beta_{vb} + \tan\beta_{vb}\left(f_Y \sin\beta_{vb} + \frac{b_{v,eff}}{2}\right)$	0 mm 0 mm 0 mm 0 mm -5,665 mm -4,353 mm -3,041 mm -1,729 mm -0,417 mm 0,895 mm 2,207 mm	Formula (12)
Correction factor for the length of contact lines	$C_{lb,Y} = \sqrt{\left(1-\left(\frac{f_Y}{f_{max}}\right)^2\right)\left(1-\sqrt{\frac{b_{v,eff}}{b_v}}\right)^2}$	0 0 0 0 0,028 0,043 0,053 0,06 0,066 0,07 0,073	Formula (15)

Table A.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Theoretical length of contact line	$l_{b0r,Y}=\sqrt{(x_{1,Y}-x_{2,Y})^2+(y_{1,Y}-y_{2,Y})^2}$	0 mm 0 mm 0 mm 0 mm 1,661 mm 4,095 mm 6,53 mm 8,964 mm 11,399 mm 13,833 mm 16,268 mm	Formula (14)
Length of contact line	$l_{br,Y}=l_{b0r,Y}(1-C_{lb,Y})$	0 mm 0 mm 0 mm 0 mm 1,615 mm 3,92 mm 6,186 mm 8,428 mm 10,652 mm 12,867 mm 15,078 mm	Formula (13)

Table A.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Related peak load for calculating the load sharing factor	$p_{t,Y}^{*} = \frac{w_Y}{w_{max}} = 1 - \left(\frac{\lvert f_{t,Y} \rvert}{\lvert f_{max} \rvert} \right)^e \geq 0$ with $e = 3$	0,958 0,911 0,839 0,736 0,597 0,416 0,186 0 0 0 0	Formula (20)
Related peak load for calculating the load sharing factor	$p_{m,Y}^{*} = \frac{w_Y}{w_{max}} = 1 - \left(\frac{\lvert f_{m,Y} \rvert}{\lvert f_{max} \rvert} \right)^e \geq 0$ with $e = 3$	0,884 0,941 0,975 0,993 0,999 1 0,999 0,993 0,975 0,941 0,884	Formula (20)

Table A.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Related peak load for calculating the load sharing factor	$p_{r,Y}^{*} = \frac{w_Y}{w_{max}} = 1 - \left(\frac{\lvert f_{r,Y} \rvert}{\lvert f_{max} \rvert} \right)^{e} \geq 0$ with $e = 3$	0 0 0 0 0,186 0,416 0,597 0,736 0,839 0,911 0,958	Formula (20)
Related area for calculating the load sharing factor X_{LS}	$A_{t,Y}^{*} = \frac{1}{4} \pi \cdot p_{t,Y}^{*} \cdot l_{bt,Y}$	11,339 mm 9,207 mm 7,021 mm 4,874 mm 2,9 mm 1,279 mm 0,236 mm 0 mm 0 mm 0 mm 0 mm	Formula (19)

Table A.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Related area for calculating the load sharing factor X_{LS}	$A^*_{m,Y} = \frac{1}{4}\pi \cdot p^*_{m,Y} \cdot l_{bm,Y}$	8,295 mm 10,459 mm 12,532 mm 14,484 mm 16,323 mm 17,628 mm 16,323 mm 14,484 mm 12,532 mm 10,459 mm 8,295 mm	Formula (19)
Related area for calculating the load sharing factor X_{LS}	$A^*_{r,Y} = \frac{1}{4}\pi \cdot p^*_{r,Y} \cdot l_{br,Y}$	0 mm 0 mm 0 mm 0 mm 0,236 mm 1,279 mm 2,9 mm 4,874 mm 7,021 mm 9,207 mm 11,339 mm	Formula (19)

Table A.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Local load sharing factor	$X_{LS,Y} = \sqrt{\dfrac{A^*_{m,Y}}{A^*_{t,Y} + A^*_{m,Y} + A^*_{r,Y}}}$	0,65 0,729 0,801 0,865 0,916 0,934 0,916 0,865 0,801 0,729 0,65	Formula (18)
Curvature factor	$X_Y = \dfrac{\tan\alpha_{vet}}{\sqrt{\dfrac{(d_{v1}/2 \cdot \sin\alpha_{vet} + g_Y)}{d_{vb1}/2}} \cdot \sqrt{\dfrac{(d_{v2}/2 \cdot \sin\alpha_{vet} - g_Y)}{d_{vb2}/2}}}$	1,193 1,113 1,049 0,997 0,953 0,916 0,884 0,856 0,831 0,809 0,79	Formula (17)

Table A.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Local equivalent radius of curvature vertical to the contact line in the contact point Y	$\rho_{\mathrm{rel,Y}} = \rho_{\mathrm{rel}} \dfrac{1}{X_{\mathrm{Y}}^2}$	8,761 mm 10,059 mm 11,317 mm 12,537 mm 13,716 mm 14,857 mm 15,958 mm 17,02 mm 18,042 mm 19,025 mm 19,969 mm	Formula (16)
Auxiliary value	$a = \dfrac{1}{K_{\mathrm{H}\beta} - 1}$	1,538	Formula (23)
Auxiliary value	$b_{\mathrm{Y}} = \dfrac{2}{l_{\mathrm{bm,Y}}}$	0,167 mm^{-1} 0,141 mm^{-1} 0,122 mm^{-1} 0,108 mm^{-1} 0,096 mm^{-1} 0,089 mm^{-1} 0,096 mm^{-1} 0,108 mm^{-1} 0,122 mm^{-1} 0,141 mm^{-1} 0,167 mm^{-1}	Formula (23)

Table A.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Auxiliary value	$z_{\mathrm{Y}}=[M_{\mathrm{Y}}Y]=\sqrt{\left(\frac{b_{\mathrm{v,eff}}}{2}-\frac{x_{1,\mathrm{Y}}+x_{2,\mathrm{Y}}}{2}\right)^2+\left(g_{\mathrm{va2}}-\frac{g_{\mathrm{v}\alpha}}{2}+g_{\mathrm{Y}}-\frac{y_{1,\mathrm{Y}}+y_{2,\mathrm{Y}}}{2}\right)^2}\leq\frac{l_{\mathrm{bm,Y}}}{2}$	5,971 mm 5,191 mm 3,973 mm 2,756 mm 1,539 mm 0 mm 1,539 mm 2,756 mm 3,973 mm 5,191 mm 5,971 mm	Formula (22)
Local face load factor for contact stress	$K_{\mathrm{H}\beta,\mathrm{Y}}=K_{\mathrm{H}\beta}\cdot\left[1-(b_{\mathrm{Y}}\cdot z_{\mathrm{Y}})^a\right]\geq 0$	0 0,626 1,107 1,396 1,563 1,65 1,563 1,396 1,107 0,626 0	Formula (21)

Table A.6 — Stresses, velocities and coefficient of friction

Description	Formula	Result	References to ISO/TS 10300-20:2021
Surface velocity in lengthwise direction	$w_{t1,2s} = v_{mt1,2} \cdot \sin \beta_{m1,2}$	1,979 m/s 1,979 m/s	Formula (28)
Pinion local surface velocity in profile direction	$w_{t1h,Y} = v_{mt1} \cdot \cos \beta_{m1} \left(\sin \alpha_{nD,C} + \frac{g_Y}{d_{v1}/2} \right)$	0,594 m/s 0,721 m/s 0,848 m/s 0,975 m/s 1,102 m/s 1,229 m/s 1,356 m/s 1,483 m/s 1,61 m/s 1,738 m/s 1,865 m/s	Formula (29)
Wheel local surface velocity in profile direction	$w_{t2h,Y} = v_{mt2} \cdot \cos \beta_{m2} \left(\sin \alpha_{nD,C} - \frac{g_Y}{d_{v2}/2} \right)$	1,015 m/s 0,998 m/s 0,982 m/s 0,966 m/s 0,949 m/s 0,933 m/s 0,916 m/s 0,9 m/s 0,884 m/s 0,867 m/s 0,851 m/s	Formula (30)

Table A.6 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Pinion local surface velocity	$w_{t1,Y} = \sqrt{w_{t1s}^2 + w_{t1h,Y}^2}$	2,066 m/s 2,106 m/s 2,153 m/s 2,206 m/s 2,265 m/s 2,33 m/s 2,399 m/s 2,473 m/s 2,551 m/s 2,634 m/s 2,719 m/s	Formula (31)
Wheel local surface velocity	$w_{t2,Y} = \sqrt{w_{t2s}^2 + w_{t2h,Y}^2}$	2,224 m/s 2,217 m/s 2,209 m/s 2,202 m/s 2,195 m/s 2,188 m/s 2,181 m/s 2,174 m/s 2,167 m/s 2,161 m/s 2,154 m/s	Formula (31)

Table A.6 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Angle between the surface velocities in lengthwise and tooth profile direction	$\omega_{\mathrm{wt1,Y}} = \arctan \frac{w_{\mathrm{t1h,Y}}}{w_{\mathrm{t1s}}}$	16,673 ° 19,996 ° 23,205 ° 26,241 ° 29,106 ° 31,856 ° 34,435 ° 36,841 ° 39,133 ° 41,31 ° 43,316 °	Formula (33)
Angle between the surface velocities in lengthwise and tooth profile direction	$\omega_{\mathrm{wt2,Y}} = \arctan \frac{w_{\mathrm{t2h,Y}}}{w_{\mathrm{t2s}}}$	27,158 ° 26,757 ° 26,413 ° 26,012 ° 25,611 ° 25,21 ° 24,866 ° 24,465 ° 24,064 ° 23,663 ° 23,262 °	Formula (33)

Table A.6 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Pinion local surface velocity vertical to the contact line	$w_{t1vert,Y} = w_{t1,Y} \cdot \sin(\lvert\beta_B\rvert + \lvert\omega_{wt1,Y}\rvert)$	1,038 m/s 1,162 m/s 1,285 m/s 1,409 m/s 1,533 m/s 1,656 m/s 1,78 m/s 1,903 m/s 2,027 m/s 2,151 m/s 2,274 m/s	Formula (32)
Wheel local surface velocity vertical to the contact line	$w_{t2vert,Y} = w_{t2,Y} \cdot \sin(\lvert\beta_B\rvert + \lvert\omega_{wt2,Y}\rvert)$	1,448 m/s 1,432 m/s 1,416 m/s 1,4 m/s 1,384 m/s 1,368 m/s 1,352 m/s 1,336 m/s 1,32 m/s 1,304 m/s 1,288 m/s	Formula (32)
Local sum of velocities in lengthwise direction	$v_{\Sigma s} = w_{t1s} + w_{t2s}$	3,958 m/s	Formula (36)

Table A.6 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Local sum of velocities in profile direction	$v_{\Sigma h,Y} = w_{t1h,Y} + w_{t2h,Y}$	1,608 m/s 1,719 m/s 1,83 m/s 1,94 m/s 2,051 m/s 2,162 m/s 2,273 m/s 2,383 m/s 2,494 m/s 2,605 m/s 2,716 m/s	Formula (37)
Local sum of velocities	$v_{\Sigma,Y} = \sqrt{v_{\Sigma h,Y}^2 + v_{\Sigma s}^2}$	4,272 m/s 4,315 m/s 4,36 m/s 4,408 m/s 4,458 m/s 4,51 m/s 4,564 m/s 4,62 m/s 4,678 m/s 4,738 m/s 4,8 m/s	Formula (35)

Table A.6 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Local sum of velocities vertical to the contact line	$v_{\Sigma\text{vert},\text{Y}} = w_{\text{t1vert},\text{Y}} + w_{\text{t2vert},\text{Y}}$	2,486 m/s 2,594 m/s 2,701 m/s 2,809 m/s 2,917 m/s 3,024 m/s 3,132 m/s 3,24 m/s 3,347 m/s 3,455 m/s 3,563 m/s	Formula (38)
Local sliding velocity in tooth lengthwise direction	$v_{\text{gs}} = v_{\text{mt1}} \cdot \cos\beta_{\text{m1}} \cdot (\tan\beta_{\text{m1}} - \tan\beta_{\text{m2}})$	0 m/s	Formula (40)
Local sliding velocity in profile direction	$v_{\text{gh},\text{Y}} = 2 \cdot v_{\text{mt1}} \cdot g_{\text{Y}} \cdot \left(\frac{1}{d_{\text{v1}}} + \frac{1}{d_{\text{v2}}}\right)$	-0,514 m/s -0,339 m/s -0,164 m/s 0,011 m/s 0,187 m/s 0,362 m/s 0,537 m/s 0,712 m/s 0,887 m/s 1,062 m/s 1,238 m/s	Formula (41)

Table A.6 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Local sliding velocity	$v_{g,Y} = \sqrt{v_{gh,Y}^2 + v_{gs}^2}$	0,514 m/s 0,339 m/s 0,164 m/s 0,011 m/s 0,187 m/s 0,362 m/s 0,537 m/s 0,712 m/s 0,887 m/s 1,062 m/s 1,238 m/s	Formula (39)
Local sliding-rolling-ratio	$s_{x,Y} = \frac{v_{g,Y}}{v_{\Sigma vert,Y}}$	0,207 0,131 0,061 0,004 0,064 0,12 0,171 0,22 0,265 0,307 0,347	Formula (42)

Table A.6 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Local contact stress	$\sigma_{H,Y}=\sqrt{\frac{F_n\cdot K_A\cdot K_V\cdot K_{H\beta,Y}\cdot K_{H\alpha}}{l_{bm,Y}\cdot \rho_{rel,Y}}}\cdot Z_E\cdot X_{LS,Y}$	0 N/mm^2 1259,775 N/mm^2 1612,589 N/mm^2 1744,476 N/mm^2 1765,967 N/mm^2 1712,67 N/mm^2 1637,245 N/mm^2 1497,191 N/mm^2 1277,178 N/mm^2 916,008 N/mm^2	Formula (25)
Local modified contact stress	$\sigma_{H,mod,Y}=\sigma_{H,Y}+\left(\frac{1}{6}\cdot e+0{,}25\right)\cdot \max(\sigma_{H,Y})\cdot\left(\frac{\lvert g_Y\rvert}{g_{va,max}}\right)^4$ with $e=3$	39,462 N/mm^2 1267,231 N/mm^2 1612,996 N/mm^2 1744,476 N/mm^2 1766,651 N/mm^2 1722,335 N/mm^2 1684,154 N/mm^2 1642,338 N/mm^2 1627,039 N/mm^2 1635,31 N/mm^2 1324,476 N/mm^2	Formula (24)
Power loss	$P_{VZP}=\left(0{,}000\,12\cdot {a_{rel}}^{1{,}234}+1{,}993\cdot 10^{-5}\right)\cdot T_1^{1{,}05}\cdot n_1^{0{,}65}\cdot Ra^{0{,}25}\cdot X_L$	0,857 kW	Formula (69)
Auxiliary variable	$[a\cdot b]_V=\frac{d_{m1}+d_{m2}}{2}\cdot\frac{b_1+b_2}{2}$	2 640,394 mm	Formula (71)

Table A.6 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Lubrication factor	$0{,}8 < X_\mathrm{S} = 0{,}8 \cdot \left[\dfrac{e_\mathrm{d}}{d_\mathrm{e2}}\right]^{-\mathrm{D}} < 3{,}7$	1,297	Formula (73)
Tip relief factor	$X_\mathrm{CA} = 1{,}0 \text{ for } B > 5$	1,000	Formula (76)
Bulk temperature	$\theta_\mathrm{M} = \theta_\mathrm{Oil} + 7\,400 \cdot \left(\dfrac{P_\mathrm{VZP}}{[a \cdot b]_\mathrm{V}}\right)^{0{,}72} \cdot \dfrac{X_\mathrm{S}}{1{,}2 X_\mathrm{CA}}$	115 °C	Formula (70)
Density at bulk temperature	$\rho_\theta = \rho_{15} \cdot \left[1 - 0{,}7 \cdot \dfrac{(\theta_\mathrm{M} + 273) - 288}{\rho_{15}}\right]$	820 kg/m^3	Formula (52)
Auxiliary variable	$A = \dfrac{\log[\log(\nu_{40} + 0{,}7) / \log(\nu_{100} + 0{,}7)]}{\log(313/373)}$	-3,419	Formula (50)
Auxiliary variable	$B = \log[\log(\nu_{40} + 0{,}7)] - A \cdot \log(313)$	8,870	Formula (51)
Kinematic viscosity at bulk temperature	$\log[\log(\nu_\theta + 0{,}7)] = A \cdot \log(\theta_\mathrm{M} + 273) + B$	10,484 mm^2/s	Formula (49)
Dynamic viscosity at bulk temperature	$\eta_\theta = 10^{-6} \cdot \nu_\theta \cdot \rho_\theta$	0,0086 Ns/m^2	Formula (48)
Pressure-viscosity-coefficient at 38 °C	$\alpha_{38} = 2{,}657 \cdot 10^{-8} \cdot \eta_{38}^{0{,}134\,8}$	0,000 000 021 m^2/N	Formula (58)
Pressure-viscosity-coefficient at bulk temperature	$\alpha_{\mathrm{p},\theta} = \alpha_{38} \cdot \left[1 + 516\left(\dfrac{1}{\theta_\mathrm{M} + 273} - \dfrac{1}{311}\right)\right]$	0,000 000 014 m^2/N	Formula (57)
Auxiliary variable	$G = 10^6 \cdot \alpha_{\mathrm{p},\theta} \cdot E'$	3 180,934	Formula (56)

Table A.6 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Auxiliary variable	$U_Y = \frac{\eta_M \cdot v_{\Sigma vert,Y}}{2\,000 \cdot \rho_{rel,Y} \cdot E'}$	0,000 000 000 005 3 0,000 000 000 004 8 0,000 000 000 004 5 0,000 000 000 004 2 0,000 000 000 004 0 0,000 000 000 003 8 0,000 000 000 003 7 0,000 000 000 003 6 0,000 000 000 003 4 0,000 000 000 003 4 0,000 000 000 003 3	Formula (61)
Auxiliary variable	$W_Y = \frac{2 \cdot \pi \cdot \sigma^2_{H,mod,Y}}{E'^2}$	0,000 000 184 0,000 189 468 0,000 306 966 0,000 359 049 0,000 368 235 0,000 349 993 0,000 334 648 0,000 318 236 0,000 312 334 0,000 315 518 0,000 206 972	Formula (62)

Table A.6 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Lubricating film thickness according to Ertl/Grubin	$h'_{0,Y} = 1{,}95 \cdot 10^{3} \cdot \rho_{rel,Y} \cdot G^{0,73} \cdot U_{Y}^{0,73} \cdot W_{Y}^{-0,09}$	0,146 µm 0,084 µm 0,085 µm 0,089 µm 0,093 µm 0,098 µm 0,103 µm 0,108 µm 0,113 µm 0,117 µm 0,126 µm	Formula (55)
Temperature coefficient of the dynamic viscosity	$\alpha_{th} = \dfrac{\ln(\eta_{\theta 38} / \eta_{\theta M})}{\theta_{M} - \theta_{38}}$	0,037	Formula (47)
Thermal load factor	$L_{Y} = 0{,}001 \cdot \dfrac{\eta_{M} \cdot \alpha_{th} \cdot v_{\Sigma vert,Y}^{2}}{4 \cdot \lambda}$	0,000 004 0,000 004 0,000 005 0,000 005 0,000 005 0,000 006 0,000 006 0,000 007 0,000 007 0,000 008 0,000 008	Formula (46)

Table A.6 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Thermal correction factor	$C_{\mathrm{th,Y}} = \dfrac{3,94}{3,94 + L_{\mathrm{Y}}^{0,62}}$	0,999 89 0,999 89 0,999 88 0,999 87 0,999 87 0,999 86 0,999 86 0,999 85 0,999 84 0,999 84 0,999 83	Formula (45)
Lubricating film thickness	$h_{0,\mathrm{Y}} = h'_{0,\mathrm{Y}} \cdot C_{\mathrm{th,Y}} \cdot 1,05 \cdot e^{-0,16 \cdot Rz}$	0,043 µm 0,024 µm 0,025 µm 0,026 µm 0,027 µm 0,029 µm 0,03 µm 0,032 µm 0,033 µm 0,034 µm 0,037 µm	Formula (44)

Table A.6 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Local relative lubricating film thickness	$\lambda_{z,Y} = \frac{h_{0,Y}}{Rz}$	0,005 0,003 0,003 0,003 0,003 0,004 0,004 0,004 0,004 0,004 0,005	Formula (43)
Lubricant factor	$X_L = 1{,}0$ for mineral oil	1	Table 4
Surface roughness structure factor	$C_{RS} = 1 + (0{,}30 \cdot \sin \beta_B)^{\varepsilon}$ with $\varepsilon = 2{,}0$	1,005	Formula (65)
Lubricating film thickness factor	$C_{\lambda,Y} = 1$ for bevel and hypoid gears	1	Formula (64)

Table A.6 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Local coefficient of friction	$\mu_{\mathrm{Y}} = 0{,}036 \cdot \left(\sigma_{\mathrm{H,mod,Y}}\right)^{0{,}10} \cdot \left(v_{\Sigma\mathrm{vert,Y}}\right)^{-0{,}2} \cdot \left(s_{\mathrm{x,Y}}\right)^{0{,}05} \cdot \left(C_{\lambda,\mathrm{Y}} \cdot \lambda_{\mathrm{z,Y}}\right)^{-0{,}10} \cdot X_{\mathrm{L}} \cdot C_{\mathrm{RS}}$	0,068 0,098 0,096 0,084 0,095 0,096 0,097 0,097 0,096 0,096 0,094	Formula (63)

Table A.7 — Occurring contact temperature

Description	Formula	Result	References to ISO/TS 10300-20:2021
Driving direction factor	X_Q for $(\varepsilon_f / \varepsilon_a) \leq 1{,}0$	1	Formula (81)
Running in factor according to Michaelis	$X_E = 1{,}0$	1	Formula (79)
Thermal contact coefficient	$B_{M1} = \sqrt{\rho_{M1} \cdot c_{M1} \cdot \lambda_{M1}}$	12 427,389	Formula (78)
Thermal contact coefficient	$B_{M2} = \sqrt{\rho_{M2} \cdot c_{M2} \cdot \lambda_{M2}}$	12 427,389	Formula (78)
Local flash temperature	$\theta_{fl,Y} = \frac{\sqrt{\pi}}{2} \cdot \mu_Y \cdot \sigma_{H,mod,Y} \cdot \frac{v_{g,Y} \cdot 10^6}{B_{M1}\sqrt{w_{t,vert1,Y}} + B_{M2}\sqrt{w_{t,vert2,Y}}} \cdot \sqrt{\frac{8\rho_{rel,Y} \cdot \sigma_{H,mod,Y}}{1\,000 \cdot E'}} \cdot \frac{X_E}{X_Q}$	0 K 28 K 20 K 1 K 27 K 52 K 76 K 99 K 123 K 150 K 125 K	Formula (77)

Table A.7 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Local contact temperature	$\theta_{C,Y} = \theta_M + \theta_{fl,Y}$	115 °C 142 °C 134 °C 116 °C 141 °C 167 °C 191 °C 214 °C 238 °C 265 °C 240 °C	Formula (68)

Table A.8 — Permissible contact temperature

Description	Formula	Result	References to ISO/TS 10300-20:2021
Pinion torque of the load stage 12 in the scuffing test A/8,3/90	T_{1T}	534,5 Nm	Table 6
Structure factor	X_W for steel with average austenitic content	1	Table 7
Relative material structure factor	$X_{WrelT} = \frac{X_W}{X_{WT}}$	1	Formula (91)
Limit temperature according to standard scuffing tests (A/8,3/90)	$\theta_{S,DIN} = 80 + 0{,}23 \cdot X_L \cdot T_{1T} + 1{,}4 \cdot X_L \cdot X_{WrelT} \cdot T_{1T}^{0{,}83} \cdot \left(\frac{100}{\nu_{40}}\right)^{0{,}02}$	458 °C	Formula (87)
Temperature factor	$X_T = 0{,}45 \cdot \left(\frac{\theta_{Oil}}{\theta_{Oil,ref}}\right) \cdot \left(\frac{X_S}{1{,}0}\right) \cdot \left(\exp\frac{2 \cdot a_{ref}}{d_{m1} + d_{m2}}\right)^{0{,}8}$ with $a_{ref} = 91{,}5$ mm	1,18	Formula (97)
Permissible temperature considering the influence of the contact temperature	$\theta_{SC} = \theta_{S,DIN} + (X_T - 1) \cdot C_{Th}$ with $C_{Th} = 0$; for $X_T > 1{,}0$	458 °C	Formula (94)
Contact time	$t_{C,Y} = \max(t_{C1,Y}, t_{C2,Y})$ where $t_{C1,2,Y} = \frac{2 \cdot b_{H,Y}}{w_{t1,2vert,Y}} \cdot 1\,000$	11,544 µs 380,357 µs 492,333 µs 541,558 µs 606,966 µs 648,406 µs 689,046 µs 725,185 µs 770,772 µs 826,872 µs 711,607 µs	Formula (102)

Table A.8 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Permissible temperature considering the contact time	$\theta_{S,Y} = \theta_{SC}$ for $t_{C,Y} \geq t_K$ or $\theta_{S,Y} = \theta_{SC} + C_S \cdot (t_K - t_{C,Y})$ for $t_{C,Y} < t_K$	574 °C 458 °C 458 °C 458 °C 458 °C 458 °C 458 °C 458 °C 458 °C 458 °C 458 °C	Formulae (100) and (101)

Table A.9 — Calculated safety factor

Description	Formula	Result	References to ISO/TS 10300-20:2021
Local safety factor regarding scuffing	$S_{S,Y} = \dfrac{\theta_{S,Y} - \theta_{Oil}}{\theta_{C,Y} - \theta_{Oil}} \geq S_{S,min}$	19,6 7,0 8,3 14,2 7,2 4,8 3,6 3,0 2,5 2,1 2,5	Formula (103)

Annex B
(informative)

Sample 2: Rating of a hypoid gear set according to ISO/TS 10300-20

B.1 Initial data

Sample 2 is for a hypoid gear pair which uses Method 1 according to ISO 23509 for calculation of gear geometry. The initial data for pitch cone parameters for this sample is shown in Table B.1 and the input data for tooth profile parameters in Table B.2.

Table B.1 — Initial data for pitch cone parameters

Symbol	Description	Method 0	Method 1	Method 2	Method 3
Σ	shaft angle	X	90°	X	X
a	hypoid offset	0,0	15 mm	X	X
$z_{1,2}$	number of teeth	X	13/42	X	X
d_{m2}	mean pitch diameter of wheel	—	—	X	—
d_{e2}	outer pitch diameter of wheel	X	170 mm	—	X
b_2	wheel face width	X	30 mm	X	X
β_{m1}	mean spiral angle of pinion	—	50°	—	—
β_{m2}	mean spiral angle of wheel	X	—	X	X
r_{c0}	cutter radius	X	63,5 mm	X	X
z_0	number of blade groups (only face hobbing)	X	—	X	X

Table B.2 — Input data for tooth profile parameters

Data type I		Data type II	
Symbol	**Description**	**Symbol**	**Description**
α_{dD}	20°		
α_{dC}	20°		
$f_{\alpha lim}$	1		
x_{hm1}	—	c_{ham}	0,35
k_{hap}	—	k_d	2,000
k_{hfp}	—	k_c	0,125
x_{smn}	—	k_t W_{m2}	0,1 —
j_{et2}	0,2 mm		
θ_{a2}	1°		
θ_{f2}	4°		
ρ_{a01}	0,8 mm		
ρ_{a02}	1,2 mm		
$s_{pr1D,C}$	0 mm/0 mm		
$s_{pr2D,C}$	0 mm/0 mm		

Table B.3 and Table B.4 show geometry and operational data and text for explanation.

Table B.3 — Geometry data from calculation according to ISO 23509

Symbol	Description	Values	Symbol	Description	Value
$d_{m1,2}$	mean pitch diameter of pinion/wheel	53,383 mm/ 141,877 mm	ζ_{mp}	offset angle on pitch plane	11,390°
$h_{am1,2}$	mean addendum of pinion/wheel	3,432 mm/ 1,848 mm	ζ_R	pinion offset angle on root plane	10,319°
$h_{fm1,2}$	mean dedendum of pinion/wheel	2,508 mm/ 4,092 mm	$R_{e1,2}$	outer cone distance on pinion/wheel	89,608 mm/ 91,468 mm
$\alpha_{eD,C}$	effective pressure angle for drive side/coast side	20°/20°	$R_{m1,2}$	mean cone distance on pinion/wheel	73,519 mm/ 76,337 mm
$\alpha_{nD,C}$	generated pressure angle for drive side/coast side	17,747°/ 22,253°	$\delta_{1,2}$	pitch angle on pinion/ wheel	21,288°/ 68,323°
α_{lim}	limit pressure angle	−2,253°	$\delta_{a1,2}$	face angle on pinion/ wheel	25,232°/ 69,323°
m_{mn}	mean normal module	2,640 mm	$\delta_{f1,2}$	root angle on pinion/ wheel	20,303°/ 64,324°
k_{hfp}	basic crown gear dedendum factor	1,25	$x_{sm1,2}$	thickness modification coefficient on pinion/ wheel	0,038/ −0,062
ζ_m	pinion offset angle on axial plane	10,603°	m_{et2}	outer transverse module	4,047 mm
$s_{mn1,2}$	mean normal circular tooth thickness of pinion/wheel	4,922 mm/ 3,241 mm			

Table B.4 — Operation parameters and additional considerations

Symbol	Description	Value
Additional data		
	wheel profile	generated
	roughing/finishing method	face milling (ground)
b_{2eff}	effective face width on wheel	$0,85 \cdot b_2$
	profile crowning	low
	verification of contact pattern	checked under light test load for each gear
	mounting conditions of pinion and wheel	one member cantilever–mounted
Operation parameters		
T_1	pinion torque	250 Nm
n_1	pinion rotational speed	1 200 min^{-1}
K_A	application factor	1,1
	active flank	drive
	Run-In-Status	Run-In
Material data for pinion and wheel (case hardened steel)		
E	modulus of elasticity	210 000 N/mm^2
ν	Poisson's ratio	0,3
$\sigma_{H\,lim}$	allowable stress number (contact)	1 500 N/mm^2
$\sigma_{F\,lim}$	nominal stress number (bending)	480 N/mm^2
ρ_M	densitiy of pinion / wheel	7 800 kg/m^3 (according to ISO/TS 10300-20:2021, Table 5)

Table B.4 *(continued)*

Symbol	Description	Value
c_{M}	specific heat per unit mass of pinion / wheel	440 J/(kgK) (according to ISO/TS 10300-20:2021, Table 5)
λ_{M}	specific heat conductivity of pinion / wheel	45 W/(mK) (according to ISO/TS 10300-20:2021, Table 5)
	surface hardness	same for pinion and wheel
Quality parameters		
Rz	flank roughness on pinion/wheel	8 µm/8 µm
Ra	flank roughness on pinion/wheel	1,33 µm/1,33 µm
Rz	tooth root roughness on pinion/wheel	16 µm/16 µm
f_{pt}	single pitch deviation on pinion/wheel	11,6 µm/23,5 µm
Lubrication parameters		
	oil type	ISO-VG-150
θ_{Oil}	oil temperature	90 °C
$\theta_{Oil,Ref}$	reference oil temperature	90 °C
e_{d}	immersion depth	34 mm
T_{1T}	pinion torque of achieved load stage (load stage 12)	534,5 Nm (A/8,3/90 according to ISO 14635-1)
ν_{40}	kinematic viscosity at temperature 40 °C	150 mm^2/s
ν_{100}	kinematic viscosity at temperature 100 °C	15 mm^2/s
ρ_{15}	density at temperature 15 °C	890 kg/m^3

B.2 Calculation of scuffing load capacity of Sample 2

The calculation results of the virtual cylindrical gear are listed in Table B.5, of stresses, velocities and coefficient of friction in Table B.6. Results of the calculation of the occurring contact temperature are shown in Table B.7, the permissible contact temperature in Table B.8. The results of the calculated safety factor can be found in Table B.9.

Table B.5 — Virtual cylindrical gear

Description	Formula	Result	References to ISO/TS 10300-20:2021
Length of path of contact in transverse section	$g_{v\alpha} = g_{va1} + g_{va2} = \frac{1}{2}\left[\left(\sqrt{d_{va1}^2 - d_{vb1}^2} - d_{v1}\sin\alpha_{vet}\right) + \left(\sqrt{d_{va2}^2 - d_{vb2}^2} - d_{v2}\sin\alpha_{vet}\right)\right]$	10,436 mm	Formula (3)
Point A on the transverse path of contact	$g_Y(A) = -g_{va2}$	-4,004 mm	Formula (1)
Point E on the transverse path of contact	$g_Y(E) = g_{va1}$	6,431 mm	Formula (2)
Contact point Y on the transverse path of contact	$g_Y(Y) = \left(g_Y(A) + k_s g_{v\alpha}\right) + Y \cdot \frac{(1-2k_s)g_{v\alpha}}{i}$ with Y = 0...i; i = 10 NOTE In all following formulae, g_Y is a function of Y $(g_Y = g_Y(Y))$	-4,004 mm -2,96 mm -1,917 mm -0,873 mm 0,17 mm 1,214 mm 2,257 mm 3,301 mm 4,344 mm 5,388 mm 6,431 mm	Formula (4)

Table B.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Distance of the middle contact line in the zone of action	$f_{m,Y} = (g_{va2} - g_{v\alpha}/2 + g_Y) \cdot \cos\beta_{vb}$	-3,937 mm -3,149 mm -2,362 mm -1,575 mm -0,787 mm 0 mm 0,787 mm 1,575 mm 2,362 mm 3,149 mm 3,937 mm	Formula (5)
Coordinates of the ends of the contact line	$x_{1,Y} = \dfrac{f_Y \cos\beta_{vb} + \tan\beta_{vb}\left(f_Y \sin\beta_{vb} + \dfrac{b_{v,eff}}{2}\right) + \dfrac{1}{2}(g_{v\alpha} + b_{v,eff}\tan\gamma)}{\tan\gamma + \tan\beta_{vb}} \geq 0$	12,44 mm 13,536 mm 14,633 mm 15,729 mm 16,826 mm 17,922 mm 19,019 mm 20,116 mm 21,212 mm 22,309 mm 23,405 mm	Formula (10)

Table B.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Coordinates of the ends of the contact line	$x_{2,\mathrm{Y}} = \dfrac{f_\mathrm{Y}\cos\beta_\mathrm{vb} + \tan\beta_\mathrm{vb}\left(f_\mathrm{Y}\sin\beta_\mathrm{vb} + \dfrac{b_\mathrm{v,eff}}{2}\right) - \dfrac{1}{2}\left(g_{\mathrm{v}\alpha} - b_\mathrm{v,eff}\tan\gamma\right)}{\tan\gamma + \tan\beta_\mathrm{vb}} \le b_\mathrm{v,eff}$	1,474 mm 2,57 mm 3,667 mm 4,764 mm 5,86 mm 6,957 mm 8,053 mm 9,15 mm 10,246 mm 11,343 mm 12,44 mm	Formula (11)
Coordinates of the ends of the contact line	$y_{1,\mathrm{Y}} = -x_{1,\mathrm{Y}}\tan\beta_\mathrm{vb} + f_\mathrm{Y}\cos\beta_\mathrm{vb} + \tan\beta_\mathrm{vb}\left(f_\mathrm{Y}\sin\beta_\mathrm{vb} + \dfrac{b_\mathrm{v,eff}}{2}\right)$	-5,218 mm -5,128 mm -5,039 mm -4,949 mm -4,859 mm -4,77 mm -4,68 mm -4,591 mm -4,501 mm -4,412 mm -4,322 mm	Formula (12)

Table B.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Coordinates of the ends of the contact line	$y_{2,Y} = -x_{2,Y} \tan\beta_{vb} + f_Y \cos\beta_{vb} + \tan\beta_{vb}\left(f_Y \sin\beta_{vb} + \frac{b_{v,eff}}{2}\right)$	4,322 mm 4,412 mm 4,501 mm 4,591 mm 4,68 mm 4,77 mm 4,859 mm 4,949 mm 5,039 mm 5,128 mm 5,218 mm	Formula (12)
Correction factor for the length of contact lines	$C_{lb,Y} = \sqrt{\left(1-\left(\frac{f_Y}{f_{max}}\right)^2\right)\left(1-\sqrt{\frac{b_{v,eff}}{b_v}}\right)^2}$	0,074 0,076 0,077 0,077 0,078 0,078 0,078 0,077 0,077 0,076 0,074	Formula (15)

Table B.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Theoretical length of contact line	$l_{b0m,Y} = \sqrt{(x_{1,Y} - x_{2,Y})^2 + (y_{1,Y} - y_{2,Y})^2}$	14,535 mm 14,535 mm 14,535 mm 14,535 mm 14,535 mm 14,535 mm 14,535 mm 14,535 mm 14,535 mm 14,535 mm 14,535 mm	Formula (14)
Length of contact line	$l_{bm,Y} = l_{b0m,Y}(1 - C_{lb,Y})$	13,455 mm 13,435 mm 13,419 mm 13,409 mm 13,402 mm 13,4 mm 13,402 mm 13,409 mm 13,419 mm 13,435 mm 13,455 mm	Formula (13)

Table B.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Distance of the tip contact line in the zone of action	$f_{t,Y} = f_{m,Y} + p_{vet} \cdot \cos\beta_{vb}$	3,857 mm 4,644 mm 5,432 mm 6,219 mm 7,006 mm 7,794 mm 8,581 mm 9,368 mm 10,156 mm 10,943 mm 11,73 mm	Formula (6)
Coordinates of the ends of the contact line	$x_{1,Y} = \dfrac{f_Y \cos\beta_{vb} + \tan\beta_{vb}\left(f_Y \sin\beta_{vb} + \dfrac{b_{v,eff}}{2}\right) + \dfrac{1}{2}\left(g_{v\alpha} + b_{v,eff}\tan\gamma\right)}{\tan\gamma + \tan\beta_{vb}} \geq 0$	23,294 mm 24,391 mm 24,879 mm 24,879 mm 24,879 mm 24,879 mm 24,879 mm 24,879 mm 24,879 mm 24,879 mm 24,879 mm	Formula (10)

Table B.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Coordinates of the ends of the contact line	$x_{2,\mathrm{Y}} = \dfrac{f_\mathrm{Y} \cos\beta_\mathrm{vb} + \tan\beta_\mathrm{vb}\left(f_\mathrm{Y}\sin\beta_\mathrm{vb} + \dfrac{b_\mathrm{v,eff}}{2}\right) - \dfrac{1}{2}\left(g_{\mathrm{v}\alpha} - b_\mathrm{v,eff}\tan\gamma\right)}{\tan\gamma + \tan\beta_\mathrm{vb}} \le b_\mathrm{v,eff}$	12,329 mm 13,425 mm 14,522 mm 15,618 mm 16,715 mm 17,812 mm 18,908 mm 20,005 mm 21,101 mm 22,198 mm 23,294 mm	Formula (11)
Coordinates of the ends of the contact line	$y_{1,\mathrm{Y}} = -x_{1,\mathrm{Y}}\tan\beta_\mathrm{vb} + f_\mathrm{Y}\cos\beta_\mathrm{vb} + \tan\beta_\mathrm{vb}\left(f_\mathrm{Y}\sin\beta_\mathrm{vb} + \dfrac{b_\mathrm{v,eff}}{2}\right)$	-4,331 mm -4,241 mm -3,622 mm -2,579 mm -1,535 mm -0,492 mm 0,552 mm 1,595 mm 2,639 mm 3,682 mm 4,726 mm	Formula (12)

Table B.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Coordinates of the ends of the contact line	$y_{2,\mathrm{Y}} = -x_{2,\mathrm{Y}} \tan\beta_{\mathrm{vb}} + f_{\mathrm{Y}} \cos\beta_{\mathrm{vb}} + \tan\beta_{\mathrm{vb}} \left(f_{\mathrm{Y}} \sin\beta_{\mathrm{vb}} + \frac{b_{\mathrm{v,eff}}}{2} \right)$	5,209 mm 5,298 mm 5,388 mm 5,477 mm 5,567 mm 5,657 mm 5,746 mm 5,836 mm 5,925 mm 6,015 mm 6,104 mm	Formula (12)
Correction factor for the length of contact lines	$C_{\mathrm{lb,Y}} = \sqrt{\left(1 - \left(\frac{f_{\mathrm{Y}}}{f_{\mathrm{max}}}\right)^2\right)\left(1 - \sqrt{\frac{b_{\mathrm{v,eff}}}{b_{\mathrm{v}}}}\right)^2}$	0,074 0,073 0,071 0,068 0,065 0,062 0,058 0,054 0,048 0,041 0,032	Formula (15)

Table B.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Theoretical length of contact line	$l_{\mathrm{b0t,Y}} = \sqrt{\left(x_{1,\mathrm{Y}} - x_{2,\mathrm{Y}}\right)^2 + \left(y_{1,\mathrm{Y}} - y_{2,\mathrm{Y}}\right)^2}$	14,535 mm 14,535 mm 13,728 mm 12,274 mm 10,821 mm 9,368 mm 7,914 mm 6,461 mm 5,007 mm 3,554 mm 2,1 mm	Formula (14)
Length of contact line	$l_{\mathrm{bt,Y}} = l_{\mathrm{b0t,Y}} \left(1 - C_{\mathrm{lb,Y}}\right)$	13,452 mm 13,477 mm 12,757 mm 11,436 mm 10,113 mm 8,786 mm 7,454 mm 6,115 mm 4,767 mm 3,408 mm 2,033 mm	Formula (13)

Table B.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Distance of the root contact line in the zone of action	$f_{\mathrm{r,Y}} = f_{\mathrm{m,Y}} - p_{\mathrm{vet}} \cdot \cos\beta_{\mathrm{vb}}$	-11,73 mm -10,943 mm -10,156 mm -9,368 mm -8,581 mm -7,794 mm -7,006 mm -6,219 mm -5,432 mm -4,644 mm -3,857 mm	Formula (7)
Coordinates of the ends of the contact line	$x_{1,\mathrm{Y}} = \dfrac{f_{\mathrm{Y}} \cos\beta_{\mathrm{vb}} + \tan\beta_{\mathrm{vb}} \left(f_{\mathrm{Y}} \sin\beta_{\mathrm{vb}} + \dfrac{b_{\mathrm{v,eff}}}{2} \right) + \dfrac{1}{2}\left(g_{\mathrm{v}\alpha} + b_{\mathrm{v,eff}} \tan\gamma \right)}{\tan\gamma + \tan\beta_{\mathrm{vb}}} \geq 0$	1,585 mm 2,681 mm 3,778 mm 4,874 mm 5,971 mm 7,067 mm 8,164 mm 9,261 mm 10,357 mm 11,454 mm 12,55 mm	Formula (10)

Table B.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Coordinates of the ends of the contact line	$x_{2,\mathrm{Y}} = \dfrac{f_\mathrm{Y}\cos\beta_\mathrm{vb} + \tan\beta_\mathrm{vb}\left(f_\mathrm{Y}\sin\beta_\mathrm{vb} + \dfrac{b_\mathrm{v,eff}}{2}\right) - \dfrac{1}{2}\left(g_{\mathrm{v}\alpha} - b_\mathrm{v,eff}\tan\gamma\right)}{\tan\gamma + \tan\beta_\mathrm{vb}} \le b_\mathrm{v,eff}$	0 mm 0 mm 0 mm 0 mm 0 mm 0 mm 0 mm 0 mm 0 mm 0,488 mm 1,585 mm	Formula (11)
Coordinates of the ends of the contact line	$y_{1,\mathrm{Y}} = -x_{1,\mathrm{Y}}\tan\beta_\mathrm{vb} + f_\mathrm{Y}\cos\beta_\mathrm{vb} + \tan\beta_\mathrm{vb}\left(f_\mathrm{Y}\sin\beta_\mathrm{vb} + \dfrac{b_\mathrm{v,eff}}{2}\right)$	-6,104 mm -6,015 mm -5,925 mm -5,836 mm -5,746 mm -5,657 mm -5,567 mm -5,477 mm -5,388 mm -5,298 mm -5,209 mm	Formula (12)

Table B.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Coordinates of the ends of the contact line	$y_{2,\mathrm{Y}} = -x_{2,\mathrm{Y}} \tan\beta_{\mathrm{vb}} + f_{\mathrm{Y}} \cos\beta_{\mathrm{vb}} + \tan\beta_{\mathrm{vb}} \left(f_{\mathrm{Y}} \sin\beta_{\mathrm{vb}} + \frac{b_{\mathrm{v,eff}}}{2} \right)$	-4,726 mm -3,682 mm -2,639 mm -1,595 mm -0,552 mm 0,492 mm 1,535 mm 2,579 mm 3,622 mm 4,241 mm 4,331 mm	Formula (12)
Correction factor for the length of contact lines	$C_{\mathrm{lb,Y}} = \sqrt{\left(1 - \left(\frac{f_{\mathrm{Y}}}{f_{\max}}\right)^2\right)\left(1 - \sqrt{\frac{b_{\mathrm{v,eff}}}{b_{\mathrm{v}}}}\right)^2}$	0,032 0,041 0,048 0,054 0,058 0,062 0,065 0,068 0,071 0,073 0,074	Formula (15)

Table B.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Theoretical length of contact line	$l_{b0r,Y} = \sqrt{(x_{1,Y} - x_{2,Y})^2 + (y_{1,Y} - y_{2,Y})^2}$	2,1 mm 3,554 mm 5,007 mm 6,461 mm 7,914 mm 9,368 mm 10,821 mm 12,274 mm 13,728 mm 14,535 mm 14,535 mm	Formula (14)
Length of contact line	$l_{br,Y} = l_{b0r,Y}(1 - C_{lb,Y})$	2,033 mm 3,408 mm 4,767 mm 6,115 mm 7,454 mm 8,786 mm 10,113 mm 11,436 mm 12,757 mm 13,477 mm 13,452 mm	Formula (13)

Table B.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Related peak load for calculating the load sharing factor	$p^*_{t,Y} = \frac{w_Y}{w_{max}} = 1 - \left(\frac{\lvert f_{t,Y} \rvert}{\lvert f_{max} \rvert} \right)^e \geq 0$ with $e = 3$	0,973 0,953 0,925 0,887 0,839 0,778 0,703 0,614 0,508 0,385 0,242	Formula (20)
Related peak load for calculating the load sharing factor	$p^*_{m,Y} = \frac{w_Y}{w_{max}} = 1 - \left(\frac{\lvert f_{m,Y} \rvert}{\lvert f_{max} \rvert} \right)^e \geq 0$ with $e = 3$	0,971 0,985 0,994 0,998 1 1 1 0,998 0,994 0,985 0,971	Formula (20)

Table B.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Related peak load for calculating the load sharing factor	$p^*_{r,Y} = \frac{w_Y}{w_{max}} = 1 - \left(\frac{\lvert f_{r,Y}\rvert}{\lvert f_{max}\rvert}\right)^e \geq 0$ with $e = 3$	0,242 0,385 0,508 0,614 0,703 0,778 0,839 0,887 0,925 0,953 0,973	Formula (20)
Related area for calculating the load sharing factor X_{LS}	$A^*_{t,Y} = \frac{1}{4}\pi \cdot p^*_{t,Y} \cdot l_{bt,Y}$	10,281 mm 10,087 mm 9,265 mm 7,968 mm 6,66 mm 5,367 mm 4,118 mm 2,949 mm 1,904 mm 1,03 mm 0,387 mm	Formula (19)

Table B.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Related area for calculating the load sharing factor X_{LS}	$A^*_{m,Y} = \frac{1}{4}\pi \cdot p^*_{m,Y} \cdot l_{bm,Y}$	10,265 mm 10,397 mm 10,474 mm 10,512 mm 10,524 mm 10,525 mm 10,524 mm 10,512 mm 10,474 mm 10,397 mm 10,265 mm	Formula (19)
Related area for calculating the load sharing factor X_{LS}	$A^*_{r,Y} = \frac{1}{4}\pi \cdot p^*_{r,Y} \cdot l_{br,Y}$	0,387 mm 1,03 mm 1,904 mm 2,949 mm 4,118 mm 5,367 mm 6,66 mm 7,968 mm 9,265 mm 10,087 mm 10,281 mm	Formula (19)

Table B.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Local load sharing factor	$X_{LS,Y} = \sqrt{\frac{A^*_{m,Y}}{A^*_{t,Y} + A^*_{m,Y} + A^*_{r,Y}}}$	0,7 0,695 0,696 0,7 0,703 0,704 0,703 0,7 0,696 0,695 0,7	Formula (18)
Curvature factor	$X_Y = \frac{\tan\alpha_{vet}}{\sqrt{\frac{(d_{v1}/2 \cdot \sin\alpha_{vet} + g_Y)}{d_{vb1}/2}} \cdot \sqrt{\frac{(d_{v2}/2 \cdot \sin\alpha_{vet} - g_Y)}{d_{vb2}/2}}}$	1,176 1,119 1,071 1,03 0,994 0,963 0,935 0,91 0,888 0,868 0,85	Formula (17)

Table B.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Local equivalent radius of curvature vertical to the contact line in the contact point Y	$\rho_{\mathrm{rel,Y}} = \rho_{\mathrm{rel}} \dfrac{1}{X_{\mathrm{Y}}^2}$	12,97 mm 14,311 mm 15,617 mm 16,889 mm 18,126 mm 19,329 mm 20,497 mm 21,631 mm 22,73 mm 23,795 mm 24,825 mm	Formula (16)
Auxiliary value	$a = \dfrac{1}{K_{\mathrm{H}\beta} - 1}$	1,538	Formula (23)
Auxiliary value	$b_{\mathrm{Y}} = \dfrac{2}{l_{\mathrm{bm,Y}}}$	0,149 mm^{-1} 0,149 mm^{-1} 0,149 mm^{-1} 0,149 mm^{-1} 0,149 mm^{-1} 0,149 mm^{-1} 0,149 mm^{-1} 0,149 mm^{-1} 0,149 mm^{-1} 0,149 mm^{-1} 0,149 mm^{-1}	Formula (23)

Table B.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Auxiliary value	$z_{\mathrm{Y}}=[M_{\mathrm{Y}}Y]=\sqrt{\left(\frac{b_{\mathrm{v,eff}}}{2}-\frac{x_{1,\mathrm{Y}}+x_{2,\mathrm{Y}}}{2}\right)^2+\left(g_{\mathrm{va}2}-\frac{g_{\mathrm{v}\alpha}}{2}+g_{\mathrm{Y}}-\frac{y_{1,\mathrm{Y}}+y_{2,\mathrm{Y}}}{2}\right)^2}\leq\frac{l_{\mathrm{bm,Y}}}{2}$	6,727 mm 5,814 mm 4,36 mm 2,907 mm 1,453 mm 0 mm 1,453 mm 2,907 mm 4,36 mm 5,814 mm 6,727 mm	Formula (22)
Local face load factor for contact stress	$K_{\mathrm{H}\beta,\mathrm{Y}}=K_{\mathrm{H}\beta}\cdot\left[1-(b_{\mathrm{Y}}\cdot z_{\mathrm{Y}})^{a}\right]\geq 0$	0 0,329 0,8 1,194 1,493 1,65 1,493 1,194 0,8 0,329 0	Formula (21)

Table B.6 — Stresses, velocities and coefficient of friction

Description	Formula	Result	References to ISO/TS 10300-20:2021
Surface velocity in lengthwise direction	$w_{t1,2s} = v_{mt1,2} \cdot \sin\beta_{m1,2}$	2,57 m/s 1,722 m/s	Formula (28)
Pinion local surface velocity in profile direction	$w_{t1h,Y} = v_{mt1} \cdot \cos\beta_{m1}\left(\sin\alpha_{nD,C} + \frac{g_Y}{d_{v1}/2}\right)$	0,356 m/s 0,434 m/s 0,513 m/s 0,592 m/s 0,67 m/s 0,749 m/s 0,827 m/s 0,906 m/s 0,984 m/s 1,063 m/s 1,141 m/s	Formula (29)
Wheel local surface velocity in profile direction	$w_{t2h,Y} = v_{mt2} \cdot \cos\beta_{m2}\left(\sin\alpha_{nD,C} - \frac{g_Y}{d_{v2}/2}\right)$	0,702 m/s 0,691 m/s 0,679 m/s 0,667 m/s 0,655 m/s 0,644 m/s 0,632 m/s 0,62 m/s 0,609 m/s 0,597 m/s 0,585 m/s	Formula (30)

Table B.6 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Pinion local surface velocity	$w_{t1,Y} = \sqrt{w_{t1s}^2 + w_{t1h,Y}^2}$	2,594 m/s 2,606 m/s 2,621 m/s 2,637 m/s 2,656 m/s 2,677 m/s 2,7 m/s 2,725 m/s 2,752 m/s 2,781 m/s 2,812 m/s	Formula (31)
Wheel local surface velocity	$w_{t2,Y} = \sqrt{w_{t2s}^2 + w_{t2h,Y}^2}$	1,86 m/s 1,855 m/s 1,851 m/s 1,847 m/s 1,842 m/s 1,838 m/s 1,834 m/s 1,83 m/s 1,826 m/s 1,822 m/s 1,819 m/s	Formula (31)

Table B.6 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Angle between the surface velocities in lengthwise and tooth profile direction	$\omega_{\mathrm{wt1,Y}} = \arctan \dfrac{w_{\mathrm{t1h,Y}}}{w_{\mathrm{t1s}}}$	7,907 ° 9,568 ° 11,287 ° 12,949 ° 14,61 ° 16,215 ° 17,819 ° 19,423 ° 20,97 ° 22,46 ° 23,95 °	Formula (33)
Angle between the surface velocities in lengthwise and tooth profile direction	$\omega_{\mathrm{wt2,Y}} = \arctan \dfrac{w_{\mathrm{t2h,Y}}}{w_{\mathrm{t2s}}}$	22,173 ° 21,83 ° 21,543 ° 21,199 ° 20,856 ° 20,512 ° 20,168 ° 19,824 ° 19,481 ° 19,137 ° 18,793 °	Formula (33)

Table B.6 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Pinion local surface velocity vertical to the contact line	$w_{t1vert,Y} = w_{t1,Y} \cdot \sin(\lvert\beta_B\rvert + \lvert\omega_{wt1,Y}\rvert)$	1,151 m/s 1,226 m/s 1,3 m/s 1,375 m/s 1,449 m/s 1,524 m/s 1,598 m/s 1,673 m/s 1,747 m/s 1,822 m/s 1,896 m/s	Formula (32)
Wheel local surface velocity vertical to the contact line	$w_{t2vert,Y} = w_{t2,Y} \cdot \sin(\lvert\beta_B\rvert + \lvert\omega_{wt2,Y}\rvert)$	1,211 m/s 1,2 m/s 1,189 m/s 1,178 m/s 1,167 m/s 1,156 m/s 1,145 m/s 1,134 m/s 1,122 m/s 1,111 m/s 1,1 m/s	Formula (32)
Local sum of velocities in lengthwise direction	$v_{\Sigma s} = w_{t1s} + w_{t2s}$	4,292 m/s	Formula (36)

Table B.6 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Local sum of velocities in profile direction	$v_{\Sigma h,Y} = w_{t1h,Y} + w_{t2h,Y}$	1,058 m/s 1,125 m/s 1,192 m/s 1,259 m/s 1,326 m/s 1,392 m/s 1,459 m/s 1,526 m/s 1,593 m/s 1,66 m/s 1,727 m/s	Formula (37)
Local sum of velocities	$v_{\Sigma,Y} = \sqrt{v_{\Sigma h,Y}^2 + v_{\Sigma s}^2}$	4,42 m/s 4,437 m/s 4,454 m/s 4,473 m/s 4,492 m/s 4,512 m/s 4,533 m/s 4,555 m/s 4,578 m/s 4,602 m/s 4,626 m/s	Formula (35)

Table B.6 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Local sum of velocities vertical to the contact line	$v_{\Sigma vert,Y} = w_{t1vert,Y} + w_{t2vert,Y}$	2,363 m/s 2,426 m/s 2,489 m/s 2,553 m/s 2,616 m/s 2,68 m/s 2,743 m/s 2,806 m/s 2,87 m/s 2,933 m/s 2,997 m/s	Formula (38)
Local sliding velocity in tooth lengthwise direction	$v_{gs} = v_{mt1} \cdot \cos\beta_{m1} \cdot (\tan\beta_{m1} - \tan\beta_{m2})$	0,848 m/s	Formula (40)
Local sliding velocity in profile direction	$v_{gh,Y} = 2 \cdot v_{mt1} \cdot g_Y \cdot \left(\frac{1}{d_{v1}} + \frac{1}{d_{v2}}\right)$	-0,539 m/s -0,398 m/s -0,258 m/s -0,118 m/s 0,023 m/s 0,163 m/s 0,304 m/s 0,444 m/s 0,585 m/s 0,725 m/s 0,866 m/s	Formula (41)

Table B.6 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Local sliding velocity	$v_{g,Y} = \sqrt{v_{gh,Y}^2 + v_{gs}^2}$	1,005 m/s 0,937 m/s 0,886 m/s 0,856 m/s 0,848 m/s 0,864 m/s 0,901 m/s 0,957 m/s 1,03 m/s 1,116 m/s 1,212 m/s	Formula (39)
Local sliding-rolling-ratio	$s_{x,Y} = \dfrac{v_{g,Y}}{v_{\Sigma vert,Y}}$	0,425 0,386 0,356 0,335 0,324 0,322 0,328 0,341 0,359 0,38 0,404	Formula (42)

Table B.6 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Local contact stress	$\sigma_{H,Y}=\sqrt{\frac{F_n \cdot K_A \cdot K_V \cdot K_{H\beta,Y} \cdot K_{H\alpha}}{l_{bm,Y} \cdot \rho_{rel,Y}}} \cdot Z_E \cdot X_{LS,Y}$	0 N/mm^2 714,738 N/mm^2 1068,47 N/mm^2 1264,287 N/mm^2 1369,83 N/mm^2 1396,183 N/mm^2 1288,167 N/mm^2 1117,141 N/mm^2 885,645 N/mm^2 554,287 N/mm^2 0 N/mm^2	Formula (25)
Local modified contact stress	$\sigma_{H,mod,Y}=\sigma_{H,Y}+\left(\frac{1}{6} \cdot e+0,25\right) \cdot \max(\sigma_{H,Y}) \cdot \left(\frac{\lvert g_Y \rvert}{g_{va,max}}\right)^4$ with $e=3$	157,304 N/mm^2 761,749 N/mm^2 1076,733 N/mm^2 1264,643 N/mm^2 1369,831 N/mm^2 1397,511 N/mm^2 1304,056 N/mm^2 1189,794 N/mm^2 1103,653 N/mm^2 1070,047 N/mm^2 1047,137 N/mm^2	Formula (24)
Power loss	$P_{VZP}=\left(0{,}000\,12 \cdot a_{rel}{}^{1,234}+1{,}993 \cdot 10^{-5}\right) \cdot T_1^{1,05} \cdot n_1^{0,65} \cdot Ra^{0,25} \cdot X_L$	1,335 kW	Formula (69)
Auxiliary variable	$[a \cdot b]_V=\frac{d_{m1}+d_{m2}}{2} \cdot \frac{b_1+b_2}{2}$	3 022,136 mm	Formula (71)

Table B.6 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Lubrication factor	$0{,}8 < X_S = 0{,}8 \cdot \left[\frac{e_d}{d_{e2}}\right]^{-D} < 3{,}7$	1,297	Formula (73)
Tip relief factor	$X_{CA} = 1{,}0 \text{ for } B > 5$	1,000	Formula (76)
Bulk temperature	$\theta_M = \theta_{Oil} + 7\,400 \cdot \left(\frac{P_{VZP}}{[a \cdot b]_V}\right)^{0{,}72} \cdot \frac{X_S}{1{,}2 X_{CA}}$	121 °C	Formula (70)
Density at bulk temperature	$\rho_\theta = \rho_{15} \cdot \left[1 - 0{,}7 \cdot \frac{(\theta_M + 273) - 288}{\rho_{15}}\right]$	816 kg/m^3	Formula (52)
Auxiliary variable	$A = \frac{\log[\log(\nu_{40} + 0{,}7) / \log(\nu_{100} + 0{,}7)]}{\log(313/373)}$	-3,419	Formula (50)
Auxiliary variable	$B = \log[\log(\nu_{40} + 0{,}7)] - A \cdot \log(313)$	8,870	Formula (51)
Kinematic viscosity at bulk temperature	$\log[\log(\nu_\theta + 0{,}7)] = A \cdot \log(\theta_M + 273) + B$	9,165 mm^2/s	Formula (49)
Dynamic viscosity at bulk temperature	$\eta_\theta = 10^{-6} \cdot \nu_\theta \cdot \rho_\theta$	0,0075 Ns/m^2	Formula (48)
Pressure-viscosity-coefficient at 38 °C	$\alpha_{38} = 2{,}657 \cdot 10^{-8} \cdot \eta_{38}^{0{,}1348}$	0,000 000 021 m^2/N	Formula (58)
Pressure-viscosity-coefficient at bulk temperature	$\alpha_{p,\theta} = \alpha_{38} \cdot \left[1 + 516\left(\frac{1}{\theta_M + 273} - \frac{1}{311}\right)\right]$	0,000 000 013 m^2/N	Formula (57)
Auxiliary variable	$G = 10^6 \cdot \alpha_{p,\theta} \cdot E'$	3 083,327	Formula (56)

Table B.6 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Auxiliary variable	$U_Y = \dfrac{\eta_M \cdot v_{\Sigma vert,Y}}{2\,000 \cdot \rho_{rel,Y} \cdot E'}$	0,000 000 000 002 9 0,000 000 000 002 8 0,000 000 000 002 6 0,000 000 000 002 5 0,000 000 000 002 3 0,000 000 000 002 3 0,000 000 000 002 2 0,000 000 000 002 1 0,000 000 000 002 1 0,000 000 000 002 0 0,000 000 000 002 0	Formula (61)
Auxiliary variable	$W_Y = \dfrac{2 \cdot \pi \cdot \sigma_{H,mod,Y}^2}{E'^2}$	0,000 002 919 0,000 068 462 0,000 136 786 0,000 188 695 0,000 221 39 0,000 230 428 0,000 200 64 0,000 167 02 0,000 143 711 0,000 135 092 0,000 129 369	Formula (62)

Table B.6 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Lubricating film thickness according to Ertl/Grubin	$h'_{0,\mathrm{Y}} = 1{,}95 \cdot 10^3 \cdot \rho_{\mathrm{rel,Y}} \cdot G^{0{,}73} \cdot U_{\mathrm{Y}}^{0{,}73} \cdot W_{\mathrm{Y}}^{-0{,}09}$	0,107 µm 0,085 µm 0,083 µm 0,084 µm 0,086 µm 0,089 µm 0,093 µm 0,097 µm 0,101 µm 0,105 µm 0,108 µm	Formula (55)
Temperature coefficient of the dynamic viscosity	$\alpha_{\mathrm{th}} = \dfrac{\ln(\eta_{\theta 38} / \eta_{\theta \mathrm{M}})}{\theta_{\mathrm{M}} - \theta_{38}}$	0,036	Formula (47)
Thermal load factor	$L_{\mathrm{Y}} = 0{,}001 \cdot \dfrac{\eta_{\mathrm{M}} \cdot \alpha_{\mathrm{th}} \cdot v_{\Sigma \mathrm{vert,Y}}^2}{4 \cdot \lambda}$	0,000 03 0,000 003 0,000 003 0,000 003 0,000 003 0,000 004 0,000 004 0,000 004 0,000 004 0,000 004 0,000 005	Formula (46)

Table B.6 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Thermal correction factor	$C_{\mathrm{th,Y}} = \dfrac{3{,}94}{3{,}94 + L_{\mathrm{Y}}^{0{,}62}}$	0,999 91 0,999 9 0,999 9 0,999 9 0,999 9 0,999 89 0,999 89 0,999 89 0,999 88 0,999 88 0,999 88	Formula (45)
Lubricating film thickness	$h_{0,\mathrm{Y}} = h'_{0,\mathrm{Y}} \cdot C_{\mathrm{th,Y}} \cdot 1{,}05 \cdot e^{-0{,}16 \cdot Rz}$	0,031 µm 0,025 µm 0,024 µm 0,024 µm 0,025 µm 0,026 µm 0,027 µm 0,028 µm 0,03 µm 0,031 µm 0,032 µm	Formula (44)

Table B.6 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Local relative lubricating film thickness	$\lambda_{z,Y} = \frac{h_{0,Y}}{Rz}$	0,004 0,003 0,003 0,003 0,003 0,003 0,003 0,004 0,004 0,004 0,004	Formula (43)
Lubricant factor	$X_L = 1,0$ for mineral oil	1	Table 4
Surface roughness structure factor	$C_{RS} = 1 + (0,30 \cdot \sin\beta_B)^{\varepsilon}$ with $\varepsilon = 2,0$	1,009	Formula (65)
Lubricating film thickness factor	$C_{\lambda,Y} = 1$ for bevel and hypoid gears	1	Formula (64)

Table B.6 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Local coefficient of friction	$\mu_{Y} = 0{,}036 \cdot \left(\sigma_{H,mod,Y}\right)^{0{,}10} \cdot \left(v_{\Sigma vert,Y}\right)^{-0{,}2} \cdot \left(s_{x,Y}\right)^{0{,}05} \cdot \left(C_{\lambda,Y} \cdot \lambda_{z,Y}\right)^{-0{,}10} \cdot X_{L} \cdot C_{RS}$	0,085 0,1 0,103 0,104 0,104 0,103 0,102 0,1 0,099 0,098 0,097	Formula (63)

Table B.7 — Occurring contact temperature

Description	Formula	Result	References to ISO/TS 10300-20:2021
Driving direction factor	$X_Q \text{ for } (\varepsilon_f / \varepsilon_a) \leq 1{,}0$	1	Formula (81)
Running in factor according to Michaelis	$X_E = 1{,}0$	1	Formula (79)
Thermal contact coefficient	$B_{M1} = \sqrt{\rho_{M1} \cdot c_{M1} \cdot \lambda_{M1}}$	12 427,389	Formula (78)
Thermal contact coefficient	$B_{M2} = \sqrt{\rho_{M2} \cdot c_{M2} \cdot \lambda_{M2}}$	12 427,389	Formula (78)
Local flash temperature	$\theta_{fl,Y} = \frac{\sqrt{\pi}}{2} \cdot \mu_Y \cdot \sigma_{H,mod,Y} \cdot \frac{v_{g,Y} \cdot 10^6}{B_{M1}\sqrt{w_{t,vert1,Y}} + B_{M2}\sqrt{w_{t,vert2,Y}}} \cdot \sqrt{\frac{8\rho_{rel,Y} \cdot \sigma_{H,mod,Y}}{1\,000 \cdot E'}} \cdot \frac{X_E}{X_Q}$	4 K 45 K 76 K 97 K 110 K 118 K 111 K 103 K 99 K 103 K 109 K	Formula (77)

Table B.7 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Local contact temperature	$\theta_{C,Y} = \theta_M + \theta_{fl,Y}$	124 °C 166 °C 197 °C 217 °C 231 °C 238 °C 232 °C 224 °C 220 °C 224 °C 230 °C	Formula (68)

Table B.8 — Permissible contact temperature

Description	Formula	Result	References to ISO/TS 10300-20:2021
Pinion torque of the load stage 12 in the scuffing test A/8,3/90	T_{1T}	534,5 Nm	Table 6
Structure factor	X_W for steel with average austenitic content	1	Table 7
Relative material structure factor	$X_{WrelT} = \frac{X_W}{X_{WT}}$	1	Formula (91)
Limit temperature according to standard scuffing tests (A/8,3/90)	$\theta_{S,DIN} = 80 + 0{,}23 \cdot X_L \cdot T_{1T} + 1{,}4 \cdot X_L \cdot X_{WrelT} \cdot T_{1T}^{0,83} \cdot \left(\frac{100}{v_{40}}\right)^{0,02}$	458 °C	Formula (87)
Temperature factor	$X_T = 0{,}45 \cdot \left(\frac{\theta_{Oil}}{\theta_{Oil,ref}}\right) \cdot \left(\frac{X_S}{1{,}0}\right) \cdot \left(\exp \frac{2 \cdot a_{ref}}{d_{m1} + d_{m2}}\right)^{0,8}$ with $a_{ref} = 91{,}5$ mm	1,235	Formula (97)
Permissible temperature considering the influence of the contact temperature	$\theta_{SC} = \theta_{S,DIN} + (X_T - 1) \cdot C_{Th}$ with $C_{Th} = 0$; for $X_T > 1{,}0$	458 °C	Formula (94)
Contact time	$t_{C,Y} = \max(t_{C1,Y}, t_{C2,Y})$ where $t_{C1,2,Y} = \frac{2 \cdot b_{H,Y}}{w_{t1,2vert,Y}} \cdot 1\,000$	61,432 µs 314,855 µs 490,215 µs 628,533 µs 737,649 µs 810,209 µs 809,508 µs 787,072 µs 774,784 µs 794,242 µs 819,077 µs	Formula (102)

Table B.8 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Permissible temperature considering the contact time	$\theta_{S,Y} = \theta_{SC}$ for $t_{C,Y} \geq t_K$ or $\theta_{S,Y} = \theta_{SC} + C_S \cdot (t_K - t_{C,Y})$ for $t_{C,Y} < t_K$	458 °C 458 °C 458 °C 458 °C 458 °C 458 °C 458 °C 458 °C 458 °C 458 °C 458 °C	Formulae (100) and (101)

Table B.9 — Calculated safety factor

Description	Formula	Result	References to ISO/TS 10300-20:2021
Local safety factor regarding scuffing	$S_{S,Y} = \dfrac{\theta_{S,Y} - \theta_{Oil}}{\theta_{C,Y} - \theta_{Oil}} \geq S_{S,min}$	10,7 4,9 3,4 2,9 2,6 2,5 2,6 2,8 2,8 2,8 2,6	Formula (103)

Annex C
(informative)

Sample 3: Rating of a hypoid gear set according to ISO/TS 10300-20

C.1 Initial data

Sample 3 is for a hypoid gear pair which uses Method 2 according to ISO 23509 for calculation of gear geometry. The initial data for pitch cone parameters for this sample is shown in Table C.1 and the input data for tooth profile parameters in Table C.2.

Table C.1 — Initial data for pitch cone parameters

Symbol	Description	Method 0	Method 1	Method 2	Method 3
Σ	shaft angle	X	X	90°	X
a	hypoid offset	0,0	X	31,75 mm	X
$z_{1,2}$	number of teeth	X	X	9/34	X
d_{m2}	mean pitch diameter of wheel	—	—	146,7 mm	—
d_{e2}	outer pitch diameter of wheel	X	X	—	X
b_2	wheel face width	X	X	26,0 mm	X
β_{m1}	mean spiral angle of pinion	—	X	—	—
β_{m2}	mean spiral angle of wheel	X	—	21,009°	X
r_{c0}	cutter radius	X	X	76,0 mm	X
z_0	number of blade groups (only face hobbing)	X	—	13	X

Table C.2 — Input data for tooth profile parameters

Data type I		Data type II	
Symbol	Description	Symbol	Description
α_{dD}	20°		
α_{dC}	20°		
$f_{\alpha lim}$	1		
x_{hm1}	—	c_{ham}	0,275
k_{hap}	—	k_d	2,000
k_{hfp}	—	k_c	0,125
x_{smn}	—	k_t W_{m2}	0,1 —
j_{et2}	0,2 mm		
θ_{a2}	0°		
θ_{f2}	0°		
ρ_{a01}	0,8 mm		
ρ_{a02}	1,2 mm		
$s_{pr1D,C}$	0 mm/0 mm		
$s_{pr2D,C}$	0 mm/0 mm		

Table C.3 and Table C.4 show geometry and operational data and text for explanation.

Table C.3 — Geometry data from calculation according to ISO 23509

Symbol	Description	Values	Symbol	Description	Value
$d_{m1,2}$	mean pitch diameter of pinion/wheel	51,258 mm/ 146,700 mm	ζ_{mp}	offset angle on pitch plane	23,969°
$h_{am1,2}$	mean addendum of pinion/wheel	5,840 mm/ 2,215 mm	ζ_R	pinion offset angle on root plane	21,647°
$h_{fm1,2}$	mean dedendum of pinion/wheel	3,222 mm/ 6,847 mm	$R_{e1,2}$	outer cone distance on pinion/wheel	76,755 mm/ 95,168 mm
$\alpha_{eD,C}$	effective pressure angle for drive side/coast side	20°/20°	$R_{m1,2}$	mean cone distance on pinion/wheel	61,186 mm/ 82,168 mm
$\alpha_{nD,C}$	generated pressure angle for drive side/coast side	15,868°/ 24,132°	$\delta_{1,2}$	pitch angle on pinion/ wheel	24,763°/ 63,212°
α_{lim}	limit pressure angle	-4,132°	$\delta_{a1,2}$	face angle on pinion/ wheel	24,765°/ 63,212°
m_{mn}	mean normal module	4,028 mm	$\delta_{f1,2}$	root angle on pinion/ wheel	24,765°/ 63,212°
k_{hfp}	basic crown gear dedendum factor	1,25	$x_{sm1,2}$	thickness modification coefficient on pinion/ wheel	0,04/ −0,06
ζ_m	pinion offset angle on axial plane	21,647°	m_{et2}	outer transverse module	4,997 mm
$s_{mn1,2}$	mean normal circular tooth thickness of pinion/wheel	7,969 mm/ 4,524 mm			

Table C.4 — Operation parameters and additional considerations

Symbol	Description	Value
Additional data		
	wheel profile	generated
	roughing/finishing method	face hobbing / face milling
b_{2eff}	effective face width on wheel	$0,85 \cdot b_2$
	profile crowning	low
	verification of contact pattern	checked under light test load for each gear
	mounting conditions of pinion and wheel	one member cantilever–mounted
Operation parameters		
T_1	pinion torque	250 Nm
n_1	pinion rotational speed	4 000 min^{-1}
K_A	application factor	1,1
	active flank	drive
	Run-In-Status	Run-In
Material data for pinion and wheel (case hardened steel)		
E	modulus of elasticity	210 000 N/mm^2
ν	Poisson’s ratio	0,3
$\sigma_{H\,lim}$	allowable stress number (contact)	1 500 N/mm^2
$\sigma_{F\,lim}$	nominal stress number (bending)	480 N/mm^2
ρ_M	densitiy of pinion / wheel	7 800 kg/m^3 (according to ISO/TS 10300-20:2021, Table 5)

Table C.4 *(continued)*

Symbol	Description	Value
c_M	specific heat per unit mass of pinion / wheel	440 J/(kgK) (according to ISO/TS 10300-20:2021, Table 5)
λ_M	specific heat conductivity of pinion / wheel	45 W/(mK) (according to ISO/TS 10300-20:2021, Table 5)
surface hardness		same for pinion and wheel
Quality parameters		
Rz	flank roughness on pinion/wheel	3 µm/3 µm
Ra	flank roughness on pinion/wheel	0,5 µm/0,5 µm
Rz	tooth root roughness on pinion/wheel	10 µm/10 µm
f_{pt}	single pitch deviation on pinion/wheel	12 µm/25 µm
Lubrication parameters		
oil type		ISO-VG-100
θ_{Oil}	oil temperature	90 °C
$\theta_{Oil,Ref}$	reference oil temperature	90 °C
	type of lubrication	Injection lubrication
T_{1T}	pinion torque of achieved load stage (load stage 12)	534,5 Nm (A/8,3/90 according to ISO 14635-1)
ν_{40}	kinematic viscosity at temperature 40 °C	100 mm^2/s
ν_{100}	kinematic viscosity at temperature 100 °C	11 mm^2/s
ρ_{15}	density at temperature 15 °C	880 kg/m^3

C.2 Calculation of scuffing load capacity of Sample 3

The calculation results of the virtual cylindrical gear are listed in Table C.5, of stresses, velocities and coefficient of friction in Table C.6. Results of the calculation of the occurring contact temperature are shown in Table C.7, the permissible contact temperature in Table C.8. The results of the calculated safety factor can be found in Table C.9.

Table C.5 — Virtual cylindrical gear

Description	Formula	Result	References to ISO/TS 10300-20:2021
Length of path of contact in transverse section	$g_{v\alpha} = g_{va1} + g_{va2} = \frac{1}{2}\left[\left(\sqrt{d_{va1}^2 - d_{vb1}^2} - d_{v1}\sin\alpha_{vet}\right) + \left(\sqrt{d_{va2}^2 - d_{vb2}^2} - d_{v2}\sin\alpha_{vet}\right)\right]$	16,279 mm	Formula (3)
Point A on the transverse path of contact	$g_Y(A) = -g_{va2}$	-5,378 mm	Formula (1)
Point E on the transverse path of contact	$g_Y(E) = g_{va1}$	10,9 mm	Formula (2)
Contact point Y on the transverse path of contact	$g_Y(Y) = (g_Y(A) + k_s g_{v\alpha}) + Y \cdot \frac{(1-2k_s) g_{v\alpha}}{i}$ with Y = 0...i; i = 10 NOTE In all following formulae, g_Y is a function of Y($g_Y = g_Y(Y)$)	-5,378 mm -3,751 mm -2,123 mm -0,495 mm 1,133 mm 2,761 mm 4,389 mm 6,017 mm 7,644 mm 9,272 mm 10,9 mm	Formula (4)

Table C.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Distance of the middle contact line in the zone of action	$f_{m,Y} = (g_{va2} - g_{v\alpha}/2 + g_Y) \cdot \cos\beta_{vb}$	-6,993 mm -5,594 mm -4,196 mm -2,797 mm -1,399 mm 0 mm 1,399 mm 2,797 mm 4,196 mm 5,594 mm 6,993 mm	Formula (5)
Coordinates of the ends of the contact line	$x_{1,Y} = \dfrac{f_Y \cos\beta_{vb} + \tan\beta_{vb}\left(f_Y \sin\beta_{vb} + \dfrac{b_{v,eff}}{2}\right) + \dfrac{1}{2}(g_{v\alpha} + b_{v,eff} \tan\gamma)}{\tan\gamma + \tan\beta_{vb}} \geq 0$	9,993 mm 12,192 mm 14,392 mm 16,592 mm 18,791 mm 19,986 mm 19,986 mm 19,986 mm 19,986 mm 19,986 mm 19,986 mm	Formula (10)

Table C.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Coordinates of the ends of the contact line	$x_{2,\mathrm{Y}} = \dfrac{f_\mathrm{Y} \cos\beta_\mathrm{vb} + \tan\beta_\mathrm{vb}\left(f_\mathrm{Y} \sin\beta_\mathrm{vb} + \dfrac{b_\mathrm{v,eff}}{2}\right) - \dfrac{1}{2}\left(g_{\mathrm{v}\alpha} - b_\mathrm{v,eff} \tan\gamma\right)}{\tan\gamma + \tan\beta_\mathrm{vb}} \le b_\mathrm{v,eff}$	0 mm 0 mm 0 mm 0 mm 0 mm 0 mm 1,195 mm 3,394 mm 5,594 mm 7,793 mm 9,993 mm	Formula (11)
Coordinates of the ends of the contact line	$y_{1,\mathrm{Y}} = -x_{1,\mathrm{Y}} \tan\beta_\mathrm{vb} + f_\mathrm{Y} \cos\beta_\mathrm{vb} + \tan\beta_\mathrm{vb}\left(f_\mathrm{Y} \sin\beta_\mathrm{vb} + \dfrac{b_\mathrm{v,eff}}{2}\right)$	-8,139 mm -7,822 mm -7,504 mm -7,187 mm -6,869 mm -5,953 mm -4,325 mm -2,697 mm -1,069 mm 0,559 mm 2,186 mm	Formula (12)

Table C.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Coordinates of the ends of the contact line	$y_{2,Y} = -x_{2,Y} \tan\beta_{vb} + f_Y \cos\beta_{vb} + \tan\beta_{vb}\left(f_Y \sin\beta_{vb} + \frac{b_{v,eff}}{2}\right)$	-2,186 mm -0,559 mm 1,069 mm 2,697 mm 4,325 mm 5,953 mm 6,869 mm 7,187 mm 7,504 mm 7,822 mm 8,139 mm	Formula (12)
Correction factor for the length of contact lines	$C_{lb,Y} = \sqrt{\left(1-\left(\frac{f_Y}{f_{max}}\right)^2\right)\left(1-\sqrt{\frac{b_{v,eff}}{b_v}}\right)^2}$	0,066 0,071 0,074 0,076 0,078 0,078 0,078 0,076 0,074 0,071 0,066	Formula (15)

Table C.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Theoretical length of contact line	$l_{b0m,Y} = \sqrt{\left(x_{1,Y} - x_{2,Y}\right)^2 + \left(y_{1,Y} - y_{2,Y}\right)^2}$	11,632 mm 14,192 mm 16,752 mm 19,312 mm 21,873 mm 23,263 mm 21,873 mm 19,312 mm 16,752 mm 14,192 mm 11,632 mm	Formula (14)
Length of contact line	$l_{bm,Y} = l_{b0m,Y}\left(1 - C_{lb,Y}\right)$	10,858 mm 13,186 mm 15,511 mm 17,839 mm 20,175 mm 21,448 mm 20,175 mm 17,839 mm 15,511 mm 13,186 mm 10,858 mm	Formula (13)

Table C.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Distance of the tip contact line in the zone of action	$f_{t,Y} = f_{m,Y} + p_{vet} \cdot \cos\beta_{vb}$	4,899 mm 6,297 mm 7,696 mm 9,094 mm 10,493 mm 11,891 mm 13,29 mm 14,688 mm 16,087 mm 17,485 mm 18,884 mm	Formula (6)
Coordinates of the ends of the contact line	$x_{1,Y} = \dfrac{f_Y \cos\beta_{vb} + \tan\beta_{vb}\left(f_Y \sin\beta_{vb} + \dfrac{b_{v,eff}}{2}\right) + \dfrac{1}{2}\left(g_{v\alpha} + b_{v,eff} \tan\gamma\right)}{\tan\gamma + \tan\beta_{vb}} \geq 0$	19,986 mm 19,986 mm 19,986 mm 19,986 mm 19,986 mm 19,986 mm 19,986 mm 0 mm 0 mm 0 mm 0 mm	Formula (10)

Table C.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Coordinates of the ends of the contact line	$x_{2,\mathrm{Y}} = \dfrac{f_\mathrm{Y} \cos\beta_\mathrm{vb} + \tan\beta_\mathrm{vb}\left(f_\mathrm{Y}\sin\beta_\mathrm{vb} + \dfrac{b_\mathrm{v,eff}}{2}\right) - \dfrac{1}{2}\left(g_{\mathrm{v}\alpha} - b_\mathrm{v,eff}\tan\gamma\right)}{\tan\gamma + \tan\beta_\mathrm{vb}} \le b_\mathrm{v,eff}$	6,7 mm 8,899 mm 11,099 mm 13,298 mm 15,498 mm 17,697 mm 19,897 mm 0 mm 0 mm 0 mm 0 mm	Formula (11)
Coordinates of the ends of the contact line	$y_{1,\mathrm{Y}} = -x_{1,\mathrm{Y}}\tan\beta_\mathrm{vb} + f_\mathrm{Y}\cos\beta_\mathrm{vb} + \tan\beta_\mathrm{vb}\left(f_\mathrm{Y}\sin\beta_\mathrm{vb} + \dfrac{b_\mathrm{v,eff}}{2}\right)$	-0,251 mm 1,377 mm 3,005 mm 4,633 mm 6,26 mm 7,888 mm 9,516 mm 0 mm 0 mm 0 mm 0 mm	Formula (12)

Table C.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Coordinates of the ends of the contact line	$y_{2,\mathrm{Y}} = -x_{2,\mathrm{Y}} \tan\beta_{\mathrm{vb}} + f_{\mathrm{Y}} \cos\beta_{\mathrm{vb}} + \tan\beta_{\mathrm{vb}} \left(f_{\mathrm{Y}} \sin\beta_{\mathrm{vb}} + \frac{b_{\mathrm{v,eff}}}{2} \right)$	7,664 mm 7,981 mm 8,299 mm 8,616 mm 8,934 mm 9,251 mm 9,569 mm 0 mm 0 mm 0 mm 0 mm	Formula (12)
Correction factor for the length of contact lines	$C_{\mathrm{lb,Y}} = \sqrt{\left(1 - \left(\frac{f_{\mathrm{Y}}}{f_{\mathrm{max}}}\right)^2\right)\left(1 - \sqrt{\frac{b_{\mathrm{v,eff}}}{b_{\mathrm{v}}}}\right)^2}$	0,073 0,069 0,064 0,057 0,048 0,035 0,007 0 0 0 0	Formula (15)

Table C.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Theoretical length of contact line	$l_{b0t,Y} = \sqrt{(x_{1,Y} - x_{2,Y})^2 + (y_{1,Y} - y_{2,Y})^2}$	15,465 mm 12,905 mm 10,344 mm 7,784 mm 5,224 mm 2,664 mm 0,103 mm 0 mm 0 mm 0 mm 0 mm	Formula (14)
Length of contact line	$l_{bt,Y} = l_{b0t,Y}(1 - C_{lb,Y})$	14,342 mm 12,017 mm 9,685 mm 7,339 mm 4,972 mm 2,569 mm 0,102 mm 0 mm 0 mm 0 mm 0 mm	Formula (13)

Table C.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Distance of the root contact line in the zone of action	$f_{r,Y} = f_{m,Y} - p_{vet} \cdot \cos\beta_{vb}$	-18,884 mm -17,485 mm -16,087 mm -14,688 mm -13,29 mm -11,891 mm -10,493 mm -9,094 mm -7,696 mm -6,297 mm -4,899 mm	Formula (7)
Coordinates of the ends of the contact line	$x_{1,Y} = \frac{f_Y \cos\beta_{vb} + \tan\beta_{vb}\left(f_Y \sin\beta_{vb} + \frac{b_{v,eff}}{2}\right) + \frac{1}{2}\left(g_{v\alpha} + b_{v,eff} \tan\gamma\right)}{\tan\gamma + \tan\beta_{vb}} \geq 0$	0 mm 0 mm 0 mm 0 mm 0,089 mm 2,288 mm 4,488 mm 6,687 mm 8,887 mm 11,087 mm 13,286 mm	Formula (10)

Table C.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Coordinates of the ends of the contact line	$x_{2,\mathrm{Y}} = \dfrac{f_\mathrm{Y} \cos\beta_\mathrm{vb} + \tan\beta_\mathrm{vb}\left(f_\mathrm{Y} \sin\beta_\mathrm{vb} + \dfrac{b_\mathrm{v,eff}}{2}\right) - \dfrac{1}{2}\left(g_{\mathrm{v}\alpha} - b_\mathrm{v,eff} \tan\gamma\right)}{\tan\gamma + \tan\beta_\mathrm{vb}} \le b_\mathrm{v,eff}$	0 mm 0 mm 0 mm 0 mm 0 mm 0 mm 0 mm 0 mm 0 mm 0 mm 0 mm	Formula (11)
Coordinates of the ends of the contact line	$y_{1,\mathrm{Y}} = -x_{1,\mathrm{Y}} \tan\beta_\mathrm{vb} + f_\mathrm{Y} \cos\beta_\mathrm{vb} + \tan\beta_\mathrm{vb}\left(f_\mathrm{Y} \sin\beta_\mathrm{vb} + \dfrac{b_\mathrm{v,eff}}{2}\right)$	0 mm 0 mm 0 mm 0 mm -9,569 mm -9,251 mm -8,934 mm -8,616 mm -8,299 mm -7,981 mm -7,664 mm	Formula (12)

Table C.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Coordinates of the ends of the contact line	$y_{2,Y} = -x_{2,Y} \tan\beta_{vb} + f_Y \cos\beta_{vb} + \tan\beta_{vb}\left(f_Y \sin\beta_{vb} + \frac{b_{v,eff}}{2}\right)$	0 mm 0 mm 0 mm 0 mm -9,516 mm -7,888 mm -6,26 mm -4,633 mm -3,005 mm -1,377 mm 0,251 mm	Formula (12)
Correction factor for the length of contact lines	$C_{lb,Y} = \sqrt{\left(1-\left(\frac{f_Y}{f_{max}}\right)^2\right)\left(1-\sqrt{\frac{b_{v,eff}}{b_v}}\right)^2}$	0 0 0 0 0,007 0,035 0,048 0,057 0,064 0,069 0,073	Formula (15)

Table C.5 *(continued)*

Description	**Formula**	**Result**	**References to ISO/TS 10300-20:2021**
Theoretical length of contact line	$l_{b0r,Y}=\sqrt{\left(x_{1,Y}-x_{2,Y}\right)^2+\left(y_{1,Y}-y_{2,Y}\right)^2}$	0 mm 0 mm 0 mm 0 mm 0,103 mm 2,664 mm 5,224 mm 7,784 mm 10,344 mm 12,905 mm 15,465 mm	Formula (14)
Length of contact line	$l_{br,Y}=l_{b0r,Y}\left(1-C_{lb,Y}\right)$	0 mm 0 mm 0 mm 0 mm 0,102 mm 2,569 mm 4,972 mm 7,339 mm 9,685 mm 12,017 mm 14,342 mm	Formula (13)

Table C.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Related peak load for calculating the load sharing factor	$p_{\mathrm{t,Y}}^{*} = \frac{w_{\mathrm{Y}}}{w_{\max}} = 1 - \left(\frac{\lvert f_{\mathrm{t,Y}}\rvert}{\lvert f_{\max}\rvert}\right)^{e} \geq 0$ with $e = 3$	0,951 0,895 0,808 0,684 0,514 0,293 0,013 0 0 0 0	Formula (20)
Related peak load for calculating the load sharing factor	$p_{\mathrm{m,Y}}^{*} = \frac{w_{\mathrm{Y}}}{w_{\max}} = 1 - \left(\frac{\lvert f_{\mathrm{m,Y}}\rvert}{\lvert f_{\max}\rvert}\right)^{e} \geq 0$ with $e = 3$	0,856 0,926 0,969 0,991 0,999 1 0,999 0,991 0,969 0,926 0,856	Formula (20)

Table C.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Related peak load for calculating the load sharing factor	$p_{r,Y}^{*}=\frac{w_{Y}}{w_{max}}=1-\left(\frac{\lvert f_{r,Y}\rvert}{\lvert f_{max}\rvert}\right)^{e}\geq 0$ with $e=3$	0 0 0 0 0,013 0,293 0,514 0,684 0,808 0,895 0,951	Formula (20)
Related area for calculating the load sharing factor X_{LS}	$A_{t,Y}^{*}=\frac{1}{4}\pi\cdot p_{t,Y}^{*}\cdot l_{bt,Y}$	10,707 mm 8,446 mm 6,148 mm 3,941 mm 2,007 mm 0,591 mm 0,001 mm 0 mm 0 mm 0 mm 0 mm	Formula (19)

Table C.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Related area for calculating the load sharing factor X_{LS}	$A^*_{m,Y} = \frac{1}{4}\pi \cdot p^*_{m,Y} \cdot l_{bm,Y}$	7,302 mm 9,594 mm 11,804 mm 13,882 mm 15,827 mm 16,845 mm 15,827 mm 13,882 mm 11,804 mm 9,594 mm 7,302 mm	Formula (19)
Related area for calculating the load sharing factor X_{LS}	$A^*_{r,Y} = \frac{1}{4}\pi \cdot p^*_{r,Y} \cdot l_{br,Y}$	0 mm 0 mm 0 mm 0 mm 0,001 mm 0,591 mm 2,007 mm 3,941 mm 6,148 mm 8,446 mm 10,707 mm	Formula (19)

Table C.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Local load sharing factor	$X_{LS,Y}=\sqrt{\dfrac{A^{*}_{m,Y}}{A^{*}_{t,Y}+A^{*}_{m,Y}+A^{*}_{r,Y}}}$	0,637 0,729 0,811 0,883 0,942 0,967 0,942 0,883 0,811 0,729 0,637	Formula (18)
Curvature factor	$X_Y=\dfrac{\tan\alpha_{vet}}{\sqrt{\dfrac{(d_{v1}/2\cdot\sin\alpha_{vet}+g_Y)}{d_{vb1}/2}}\cdot\sqrt{\dfrac{(d_{v2}/2\cdot\sin\alpha_{vet}-g_Y)}{d_{vb2}/2}}}$	1,331 1,191 1,093 1,019 0,962 0,916 0,878 0,847 0,821 0,8 0,781	Formula (17)

Table C.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Local equivalent radius of curvature vertical to the contact line in the contact point Y	$\rho_{\mathrm{rel,Y}} = \rho_{\mathrm{rel}} \dfrac{1}{X_{\mathrm{Y}}^2}$	7,911 mm 9,875 mm 11,737 mm 13,497 mm 15,155 mm 16,711 mm 18,165 mm 19,517 mm 20,767 mm 21,915 mm 22,961 mm	Formula (16)
Auxiliary value	$a = \dfrac{1}{K_{\mathrm{H}\beta} - 1}$	1,538	Formula (23)
Auxiliary value	$b_{\mathrm{Y}} = \dfrac{2}{l_{\mathrm{bm,Y}}}$	0,184 mm^{-1} 0,152 mm^{-1} 0,129 mm^{-1} 0,112 mm^{-1} 0,099 mm^{-1} 0,093 mm^{-1} 0,099 mm^{-1} 0,112 mm^{-1} 0,129 mm^{-1} 0,152 mm^{-1} 0,184 mm^{-1}	Formula (23)

Table C.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Auxiliary value	$z_{\mathrm{Y}} = [M_{\mathrm{Y}}Y] = \sqrt{\left(\frac{b_{\mathrm{v,eff}}}{2} - \frac{x_{1,\mathrm{Y}} + x_{2,\mathrm{Y}}}{2}\right)^2 + \left(g_{\mathrm{va2}} - \frac{g_{\mathrm{v}\alpha}}{2} + g_{\mathrm{Y}} - \frac{y_{1,\mathrm{Y}} + y_{2,\mathrm{Y}}}{2}\right)^2} \le \frac{l_{\mathrm{bm,Y}}}{2}$	5,429 mm 4,536 mm 3,256 mm 1,975 mm 0,695 mm 0 mm 0,695 mm 1,975 mm 3,256 mm 4,536 mm 5,429 mm	Formula (22)
Local face load factor for contact stress	$K_{\mathrm{H}\beta,\mathrm{Y}} = K_{\mathrm{H}\beta} \cdot \left[1 - (b_{\mathrm{Y}} \cdot z_{\mathrm{Y}})^a\right] \ge 0$	0 0,722 1,216 1,488 1,623 1,65 1,623 1,488 1,216 0,722 0	Formula (21)

Table C.6 — Stresses, velocities and coefficient of friction

Description	Formula	Result	References to ISO/TS 10300-20:2021
Surface velocity in lengthwise direction	$w_{t1,2s} = v_{mt1,2} \cdot \sin \beta_{m1,2}$	8,539 m/s 3,284 m/s	Formula (28)
Pinion local surface velocity in profile direction	$w_{t1h,Y} = v_{mt1} \cdot \cos \beta_{m1} \left(\sin \alpha_{nD,C} + \frac{g_Y}{d_{v1}/2} \right)$	0,708 m/s 1,2 m/s 1,693 m/s 2,186 m/s 2,678 m/s 3,171 m/s 3,664 m/s 4,156 m/s 4,649 m/s 5,142 m/s 5,634 m/s	Formula (29)
Wheel local surface velocity in profile direction	$w_{t2h,Y} = v_{mt2} \cdot \cos \beta_{m2} \left(\sin \alpha_{nD,C} - \frac{g_Y}{d_{v2}/2} \right)$	2,618 m/s 2,532 m/s 2,447 m/s 2,361 m/s 2,276 m/s 2,191 m/s 2,105 m/s 2,02 m/s 1,934 m/s 1,849 m/s 1,763 m/s	Formula (30)

Table C.6 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Pinion local surface velocity	$w_{t1,Y} = \sqrt{w_{t1s}^2 + w_{t1h,Y}^2}$	8,568 m/s 8,623 m/s 8,705 m/s 8,814 m/s 8,949 m/s 9,108 m/s 9,291 m/s 9,497 m/s 9,722 m/s 9,967 m/s 10,23 m/s	Formula (31)
Wheel local surface velocity	$w_{t2,Y} = \sqrt{w_{t2s}^2 + w_{t2h,Y}^2}$	4,197 m/s 4,144 m/s 4,092 m/s 4,042 m/s 3,993 m/s 3,945 m/s 3,898 m/s 3,852 m/s 3,808 m/s 3,766 m/s 3,724 m/s	Formula (31)

Table C.6 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Angle between the surface velocities in lengthwise and tooth profile direction	$\omega_{wt1,Y} = \arctan \frac{w_{t1h,Y}}{w_{t1s}}$	4,756 ° 8,021 ° 11,23 ° 14,381 ° 17,418 ° 20,397 ° 23,205 ° 25,955 ° 28,591 ° 31,054 ° 33,403 °	Formula (33)
Angle between the surface velocities in lengthwise and tooth profile direction	$\omega_{wt2,Y} = \arctan \frac{w_{t2h,Y}}{w_{t2s}}$	38,617 ° 37,643 ° 36,727 ° 35,753 ° 34,779 ° 33,747 ° 32,716 ° 31,627 ° 30,539 ° 29,393 ° 28,247 °	Formula (33)

Table C.6 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Pinion local surface velocity vertical to the contact line	$w_{\text{t1vert,Y}} = w_{\text{t1,Y}} \cdot \sin\left(\lvert\beta_{\text{B}}\rvert + \lvert\omega_{\text{wt1,Y}}\rvert\right)$	2,542 m/s 3,023 m/s 3,504 m/s 3,985 m/s 4,466 m/s 4,947 m/s 5,428 m/s 5,909 m/s 6,39 m/s 6,871 m/s 7,352 m/s	Formula (32)
Wheel local surface velocity vertical to the contact line	$w_{\text{t2vert,Y}} = w_{\text{t2,Y}} \cdot \sin\left(\lvert\beta_{\text{B}}\rvert + \lvert\omega_{\text{wt2,Y}}\rvert\right)$	3,267 m/s 3,183 m/s 3,1 m/s 3,017 m/s 2,933 m/s 2,85 m/s 2,766 m/s 2,683 m/s 2,6 m/s 2,516 m/s 2,433 m/s	Formula (32)
Local sum of velocities in lengthwise direction	$v_{\Sigma\text{s}} = w_{\text{t1s}} + w_{\text{t2s}}$	11,819 m/s	Formula (36)

Table C.6 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Local sum of velocities in profile direction	$v_{\Sigma h,Y} = w_{t1h,Y} + w_{t2h,Y}$	3,326 m/s 3,733 m/s 4,14 m/s 4,547 m/s 4,954 m/s 5,362 m/s 5,769 m/s 6,176 m/s 6,583 m/s 6,99 m/s 7,398 m/s	Formula (37)
Local sum of velocities	$v_{\Sigma,Y} = \sqrt{v_{\Sigma h,Y}^2 + v_{\Sigma s}^2}$	12,278 m/s 12,395 m/s 12,523 m/s 12,664 m/s 12,815 m/s 12,978 m/s 13,152 m/s 13,335 m/s 13,529 m/s 13,732 m/s 13,943 m/s	Formula (35)

Table C.6 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Local sum of velocities vertical to the contact line	$v_{\Sigma\mathrm{vert,Y}} = w_{\mathrm{t1vert,Y}} + w_{\mathrm{t2vert,Y}}$	5,809 m/s 6,207 m/s 6,604 m/s 7,002 m/s 7,399 m/s 7,797 m/s 8,194 m/s 8,592 m/s 8,989 m/s 9,387 m/s 9,784 m/s	Formula (38)
Local sliding velocity in tooth lengthwise direction	$v_{\mathrm{gs}} = v_{\mathrm{mt1}} \cdot \cos\beta_{\mathrm{m1}} \cdot (\tan\beta_{\mathrm{m1}} - \tan\beta_{\mathrm{m2}})$	5,258 m/s	Formula (40)
Local sliding velocity in profile direction	$v_{\mathrm{gh,Y}} = 2 \cdot v_{\mathrm{mt1}} \cdot g_{\mathrm{Y}} \cdot \left(\frac{1}{d_{\mathrm{v1}}} + \frac{1}{d_{\mathrm{v2}}}\right)$	-2,701 m/s -1,883 m/s -1,066 m/s -0,249 m/s 0,569 m/s 1,386 m/s 2,204 m/s 3,021 m/s 3,838 m/s 4,656 m/s 5,473 m/s	Formula (41)

Table C.6 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Local sliding velocity	$v_{g,Y} = \sqrt{v_{gh,Y}^2 + v_{gs}^2}$	5,911 m/s 5,585 m/s 5,365 m/s 5,264 m/s 5,289 m/s 5,438 m/s 5,701 m/s 6,064 m/s 6,51 m/s 7,023 m/s 7,59 m/s	Formula (39)
Local sliding-rolling-ratio	$s_{x,Y} = \dfrac{v_{g,Y}}{v_{\Sigma vert,Y}}$	1,018 0,9 0,812 0,752 0,715 0,697 0,696 0,706 0,724 0,748 0,776	Formula (42)

Table C.6 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Local contact stress	$\sigma_{H,Y}=\sqrt{\frac{F_n \cdot K_A \cdot K_V \cdot K_{H\beta,Y} \cdot K_{H\alpha}}{l_{bm,Y} \cdot \rho_{rel,Y}}} \cdot Z_E \cdot X_{LS,Y}$	0 N/mm² 1306,943 N/mm² 1595,052 N/mm² 1669,754 N/mm² 1651,948 N/mm² 1578,668 N/mm² 1508,893 N/mm² 1388,571 N/mm² 1199,146 N/mm² 877,329 N/mm² 0 N/mm²	Formula (25)
Local modified contact stress	$\sigma_{H,mod,Y}=\sigma_{H,Y}+\left(\frac{1}{6}\cdot e+0,25\right)\cdot \max(\sigma_{H,Y})\cdot\left(\frac{\lvert g_Y \rvert}{g_{va,max}}\right)^4$ with $e=3$	74,237 N/mm² 1324,497 N/mm² 1596,854 N/mm² 1669,759 N/mm² 1652,094 N/mm² 1583,822 N/mm² 1541,802 N/mm² 1504,817 N/mm² 1502,091 N/mm² 1533,068 N/mm² 1252,315 N/mm²	Formula (24)
Power loss	$P_{VZP}=\left(0,000\,12\cdot {a_{rel}}^{1,234}+1,993\cdot 10^{-5}\right)\cdot T_1^{1,05}\cdot n_1^{0,65}\cdot Ra^{0,25}\cdot X_L$	4,111 kW	Formula (69)
Auxiliary variable	$[a\cdot b]_V=\frac{d_{m1}+d_{m2}}{2}\cdot\frac{b_1+b_2}{2}$	2 827,781 mm	Formula (71)
Lubrication factor	$X_S=1,2$ for injection lubrication	1,2	Formula (72)

Table C.6 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Tip relief factor	$X_{CA} = 1{,}0 \text{ for } B > 5$	1,000	Formula (76)
Bulk temperature	$\theta_M = \theta_{Oil} + 7\,400 \cdot \left(\frac{P_{VZP}}{[a \cdot b]_V} \right)^{0{,}72} \cdot \frac{X_S}{1{,}2 X_{CA}}$	157 °C	Formula (70)
Density at bulk temperature	$\rho_\theta = \rho_{15} \cdot \left[1 - 0{,}7 \cdot \frac{(\theta_M + 273) - 288}{\rho_{15}} \right]$	781 kg/m^3	Formula (52)
Auxiliary variable	$A = \frac{\log[\log(\nu_{40} + 0{,}7) / \log(\nu_{100} + 0{,}7)]}{\log(313/373)}$	-3,585	Formula (50)
Auxiliary variable	$B = \log[\log(\nu_{40} + 0{,}7)] - A \cdot \log(313)$	9,248	Formula (51)
Kinematic viscosity at bulk temperature	$\log[\log(\nu_\theta + 0{,}7)] = A \cdot \log(\theta_M + 273) + B$	3,679 mm^2/s	Formula (49)
Dynamic viscosity at bulk temperature	$\eta_\theta = 10^{-6} \cdot \nu_\theta \cdot \rho_\theta$	0,002 9 Ns/m^2	Formula (48)
Pressure-viscosity-coefficient at 38 °C	$\alpha_{38} = 2{,}657 \cdot 10^{-8} \cdot \eta_{38}^{0{,}1348}$	0,000 000 019 m^2/N	Formula (58)
Pressure-viscosity-coefficient at bulk temperature	$\alpha_{p,\theta} = \alpha_{38} \cdot \left[1 + 516 \left(\frac{1}{\theta_M + 273} - \frac{1}{311} \right) \right]$	0,000 000 01 m^2/N	Formula (57)
Auxiliary variable	$G = 10^6 \cdot \alpha_{p,\theta} \cdot E'$	2 418,38	Formula (56)

Table C.6 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Auxiliary variable	$U_Y = \frac{\eta_M \cdot v_{\Sigma vert,Y}}{2\,000 \cdot \rho_{rel,Y} \cdot E'}$	0,000 000 000 004 6 0,000 000 000 003 9 0,000 000 000 003 5 0,000 000 000 003 2 0,000 000 000 003 0 0,000 000 000 002 9 0,000 000 000 002 8 0,000 000 000 002 7 0,000 000 000 002 7 0,000 000 000 002 7 0,000 000 000 002 7	Formula (61)
Auxiliary variable	$W_Y = \frac{2 \cdot \pi \cdot \sigma_{H,mod,Y}^2}{E'^2}$	0,000 000 65 0,000 206 979 0,000 300 853 0,000 328 951 0,000 322 028 0,000 295 962 0,000 280 467 0,000 267 172 0,000 266 205 0,000 277 298 0,000 185 034	Formula (62)

Table C.6 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Lubricating film thickness according to Ertl/Grubin	$h'_{0,Y} = 1{,}95 \cdot 10^3 \cdot \rho_{rel,Y} \cdot G^{0{,}73} \cdot U_Y^{0{,}73} \cdot W_Y^{-0{,}09}$	0,086 µm 0,057 µm 0,061 µm 0,065 µm 0,07 µm 0,076 µm 0,081 µm 0,085 µm 0,09 µm 0,094 µm 0,101 µm	Formula (55)
Temperature coefficient of the dyn. viscosity	$\alpha_{th} = \frac{\ln(\eta_{\theta 38} / \eta_{\theta M})}{\theta_M - \theta_{38}}$	0,03	Formula (47)
Thermal load factor	$L_Y = 0{,}001 \cdot \frac{\eta_M \cdot \alpha_{th} \cdot v_{\Sigma vert,Y}^2}{4 \cdot \lambda}$	0,000 005 0,000 006 0,000 007 0,000 008 0,000 009 0,000 010 0,000 011 0,000 012 0,000 013 0,000 014 0,000 015	Formula (46)

Table C.6 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Thermal correction factor	$C_{\mathrm{th,Y}} = \frac{3{,}94}{3{,}94 + L_{\mathrm{Y}}^{0{,}62}}$	0,999 86 0,999 85 0,999 84 0,999 83 0,999 81 0,999 8 0,999 79 0,999 78 0,999 76 0,999 75 0,999 74	Formula (45)
Lubricating film thickness	$h_{0,\mathrm{Y}} = h'_{0,\mathrm{Y}} \cdot C_{\mathrm{th,Y}} \cdot 1{,}05 \cdot e^{-0{,}16 \cdot Rz}$	0,056 µm 0,037 µm 0,039 µm 0,042 µm 0,046 µm 0,049 µm 0,052 µm 0,055 µm 0,058 µm 0,061 µm 0,066 µm	Formula (44)

Table C.6 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Local relative lubricating film thickness	$\lambda_{z,Y} = \frac{h_{0,Y}}{Rz}$	0,019 0,012 0,013 0,014 0,015 0,016 0,017 0,018 0,019 0,02 0,022	Formula (43)
Lubricant factor	$X_L = 1,0$ for mineral oil	1	Table 4
Surface roughness structure factor	$C_{RS} = 1 + (0,30 \cdot \sin\beta_B)^{\varepsilon}$ with $\varepsilon = 2,0$	1,004	Formula (65)
Lubricating film thickness factor	$C_{\lambda,Y} = 1$ for bevel and hypoid gears	1	Formula (64)

Table C.6 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Local coefficient of friction	$\mu_Y = 0{,}036 \cdot (\sigma_{H,mod,Y})^{0{,}10} \cdot (v_{\Sigma vert,Y})^{-0{,}2} \cdot (s_{x,Y})^{0{,}05} \cdot (C_{\lambda,Y} \cdot \lambda_{z,Y})^{-0{,}10} \cdot X_L \cdot C_{RS}$	0,058 0,079 0,079 0,078 0,076 0,074 0,073 0,072 0,071 0,07 0,068	Formula (63)

Table C.7 — Occurring contact temperature

Description	Formula	Result	References to ISO/TS 10300-20:2021
Driving direction factor	X_{Q} for $(\varepsilon_{f} / \varepsilon_{a}) \leq 1{,}0$	1	Formula (81)
Running in factor according to Michaelis	$X_{E} = 1{,}0$	1	Formula (79)
Thermal contact coefficient	$B_{M1} = \sqrt{\rho_{M1} \cdot c_{M1} \cdot \lambda_{M1}}$	12 427,389	Formula (78)
Thermal contact coefficient	$B_{M2} = \sqrt{\rho_{M2} \cdot c_{M2} \cdot \lambda_{M2}}$	12 427,389	Formula (78)
Local flash temperature	$\theta_{fl,Y} = \frac{\sqrt{\pi}}{2} \cdot \mu_{Y} \cdot \sigma_{H,mod,Y} \cdot \frac{v_{g,Y} \cdot 10^{6}}{B_{M1} \sqrt{w_{t,vert1,Y}} + B_{M2} \sqrt{w_{t,vert2,Y}}} \cdot \sqrt{\frac{8 \rho_{rel,Y} \cdot \sigma_{H,mod,Y}}{1\,000 \cdot E'}} \cdot \frac{X_{E}}{X_{Q}}$	2 K 253 K 339 K 364 K 364 K 353 K 356 K 365 K 391 K 436 K 339 K	Formula (77)

Table C.7 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Local contact temperature	$\theta_{C,Y} = \theta_M + \theta_{fl,Y}$	159 °C 410 °C 496 °C 521 °C 521 °C 510 °C 513 °C 522 °C 548 °C 593 °C 496 °C	Formula (68)

Table C.8 — Permissible contact temperature

Description	Formula	Result	References to ISO/TS 10300-20:2021
Pinion torque of the load stage 12 in the scuffing test A/8,3/90	T_{1T}	534,5 Nm	Table 6
Structure factor	X_W for steel with average austenitic content	1	Table 7
Relative material structure factor	$X_{WrelT} = \frac{X_W}{X_{WT}}$	1	Formula (91)
Limit temperature according to standard scuffing tests (A/8,3/90)	$\theta_{S,DIN} = 80 + 0{,}23 \cdot X_L \cdot T_{1T} + 1{,}4 \cdot X_L \cdot X_{WrelT} \cdot T_{1T}^{0{,}83} \cdot \left(\frac{100}{v_{40}}\right)^{0{,}02}$	460 °C	Formula (87)
Temperature factor	$X_T = 0{,}45 \cdot \left(\frac{\theta_{Oil}}{\theta_{Oil,ref}}\right) \cdot \left(\frac{X_S}{1{,}0}\right) \cdot \left(\exp \frac{2 \cdot a_{ref}}{d_{m1} + d_{m2}}\right)^{0{,}8}$ with $a_{ref} = 91{,}5\ \text{mm}$	1,131	Formula (97)
Permissible temperature considering the influence of the contact temperature	$\theta_{SC} = \theta_{S,DIN} + (X_T - 1) \cdot C_{Th}$ with $C_{Th} = 0$; for $X_T > 1{,}0$	460 °C	Formula (94)
Contact exposure time	$t_{C,Y} = \max(t_{C1,Y}, t_{C2,Y})$ where $t_{C1,2,Y} = \frac{2 \cdot b_{H,Y}}{w_{t1,2vert,Y}} \cdot 1\,000$	8,009 µs 149,981 µs 209,598 µs 258,999 µs 295,919 µs 321,971 µs 350,97 µs 379,486 µs 415,99 µs 462,89 µs 409,748 µs	Formula (102)

Table C.8 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Permissible temperature considering the contact time	$\theta_{S,Y} = \theta_{SC}$ for $t_{C,Y} \geq t_K$ or $\theta_{S,Y} = \theta_{SC} + C_S \cdot \left(t_K - t_{C,Y}\right)$ for $t_{C,Y} < t_K$	640 °C 460 °C 460 °C 460 °C 460 °C 460 °C 460 °C 460 °C 460 °C 460 °C 460 °C	Formulae (100) and (101)

Table C.9 — Calculated safety factor

Description	Formula	Result	References to ISO/TS 10300-20:2021
Local safety factor regarding scuffing	$S_{S,Y}=\frac{\theta_{S,Y}-\theta_{Oil}}{\theta_{C,Y}-\theta_{Oil}}\geq S_{S,min}$	7,9 1,2 0,9 0,9 0,9 0,9 0,9 0,9 0,8 0,7 0,9	Formula (103)

Annex D
(informative)

Sample 4: Rating of a hypoid gear set according to ISO/TS 10300-20

D.1 Initial data

Sample 4 is for a hypoid gear pair which uses Method 3 according to ISO 23509 for calculation of gear geometry. The initial data for pitch cone parameters for this sample is shown in Table D.1 and the input data for tooth profile parameters in Table D.2.

Table D.1 — Initial data for pitch cone parameters

Symbol	Description	Method 0	Method 1	Method 2	Method 3
Σ	shaft angle	X	X	X	90°
a	hypoid offset	0,0	X	X	40 mm
$z_{1,2}$	number of teeth	X	X	X	12/49
d_{m2}	mean pitch diameter of wheel	—	—	X	—
d_{e2}	outer pitch diameter of wheel	X	X	—	400 mm
b_2	wheel face width	X	X	X	60 mm
β_{m1}	mean spiral angle of pinion	—	X	–	—
β_{m2}	mean spiral angle of wheel	X	—	X	30°
r_{c0}	cutter radius	X	X	X	135 mm
z_0	number of blade groups (only face hobbing)	X	—	X	5

Table D.2 — Input data for tooth profile parameters

Data type I		Data type II	
Symbol	**Description**	**Symbol**	**Description**
α_{dD}	19°		
α_{dC}	21°		
$f_{\alpha lim}$	0		
x_{hm1}	0,2	c_{ham}	—
k_{hap}	1	k_d	—
k_{hfp}	1,25	k_c	—
x_{smn}	0,031	k_t W_{m2}	—
j_{et2}	0 mm		
θ_{a2}	0°		
θ_{f2}	0°		
ρ_{a01}	0,8 mm		
ρ_{a02}	1,2 mm		
$s_{pr1D,C}$	0 mm/0 mm		
$s_{pr2D,C}$	0 mm/0 mm		

Table D.3 and Table D.4 show geometry and operational data and text for explanation.

Table D.3 — Geometry data from calculation according to ISO 23509

Symbol	Description	Values	Symbol	Description	Value
$d_{m1,2}$	mean pitch diameter of pinion/wheel	99,377 mm/ 343,151 mm	ζ_{mp}	offset angle on pitch plane	12,922°
$h_{am1,2}$	mean addendum of pin-ion/wheel	7,278 mm/ 4,852 mm	ζ_R	pinion offset angle on root plane	12,265°
$h_{fm1,2}$	mean dedendum of pin-ion/wheel	6,368 mm/ 8,794 mm	$R_{e1,2}$	outer cone distance on pinion/wheel	191,947 mm/ 211,072 mm
$\alpha_{eD,C}$	effective pressure angle for drive side/coast side	20,731°/ 19,269°	$R_{m1,2}$	mean cone distance on pin-ion/wheel	159,088 mm/ 181,074 mm
$\alpha_{nD,C}$	generated pressure angle for drive side/coast side	19°/ 21°	$\delta_{1,2}$	pitch angle on pinion/wheel	18,200°/ 71,360°
α_{lim}	limit pressure angle	-1,731°	$\delta_{a1,2}$	face angle on pinion/wheel	18,200°/ 71,360°
m_{mn}	mean normal module	6,065 mm	$\delta_{f1,2}$	root angle on pinion/wheel	18,200°/ 71,360°
k_{hfp}	basic crown gear deden-dum factor	1,25	$x_{sm1,2}$	thickness modification coef-ficient on pinion/wheel	0,031/ −0,031
ζ_m	pinion offset angle on axial plane	12,265°	m_{et2}	outer transverse module	8,163 mm
$s_{mn1,2}$	mean normal circular tooth thickness of pinion/wheel	10,786 mm/ 8,268 mm			

Table D.4 — Operation parameters and additional considerations

Symbol	Description	Value
Additional data		
	wheel profile	non-generated
	roughing/finishing method	face hobbing (lapped)
b_{2eff}	effective face width on wheel	$0{,}85 \cdot b_2$
	profile crowning	low
	verification of contact pattern	checked under light test load for each gear
	mounting conditions of pinion and wheel	one member cantilever–mounted
Operation parameters		
T_1	pinion torque	3 000 Nm
n_1	pinion rotational speed	800 min^{-1}
K_A	application factor	1,1
	active flank	drive
	Run-In-Status	Run-In
Material data for pinion and wheel (case hardened steel)		
E	modulus of elasticity	210 000 N/mm^2
ν	Poisson's ratio	0,3
$\sigma_{H\,lim}$	allowable stress number (contact)	1 500 N/mm^2
$\sigma_{F\,lim}$	nominal stress number (bending)	480 N/mm^2
ρ_M	densitiy of pinion / wheel	7 800 kg/m^3 (according to ISO/TS 10300-20:2021, Table 5)

Table D.4 *(continued)*

Symbol	Description	Value
c_M	specific heat per unit mass of pinion / wheel	440 J/(kgK) (according to ISO/TS 10300-20:2021, Table 5)
λ_M	specific heat conductivity of pinion / wheel	45 W/(mK) (according to ISO/TS 10300-20:2021, Table 5)
	surface hardness	same for pinion and wheel
Quality parameters		
Rz	flank roughness on pinion/wheel	8 µm/8 µm
Ra	flank roughness on pinion/wheel	1,33 µm/1,33 µm
Rz	tooth root roughness on pinion/wheel	16 µm/16 µm
f_{pt}	single pitch deviation on pinion/wheel	14 µm/27 µm
Lubrication parameters		
	oil type	ISO-VG-150
θ_{Oil}	oil temperature	90 °C
$\theta_{Oil,Ref}$	reference oil temperature	90 °C
e_d	immersion depth	80 mm
T_{1T}	pinion torque of achieved load stage (LS 12)	534,5 Nm (A/8,3/90 according to ISO 14635-1)
ν_{40}	kinematic viscosity at temperature 40 °C	150 mm²/s
ν_{100}	kinematic viscosity at temperature 100 °C	15 mm²/s
ρ_{15}	density at temperature 15 °C	890 kg/m³

D.2 Calculation of scuffing load capacity of Sample 4

The calculation results of the virtual cylindrical gear are listed in Table D.5, of stresses, velocities and coefficient of friction in Table D.6. Results of the calculation of the occurring contact temperature are shown in Table D.7, the permissible contact temperature in Table D.8. The results of the calculated safety factor can be found in Table D.9.

Table D.5 — Virtual cylindrical gear

Description	Formula	Result	References to ISO/TS 10300-20:2021
Length of path of contact in transverse section	$g_{v\alpha} = g_{va1} + g_{va2} = \frac{1}{2}\left[\left(\sqrt{d_{va1}^2 - d_{vb1}^2} - d_{v1}\sin\alpha_{vet}\right) + \left(\sqrt{d_{va2}^2 - d_{vb2}^2} - d_{v2}\sin\alpha_{vet}\right)\right]$	25,101 mm	Formula (3)
Point A on the transverse path of contact	$g_Y(A) = -g_{va2}$	-11,174 mm	Formula (1)
Point E on the transverse path of contact	$g_Y(E) = g_{va1}$	13,927 mm	Formula (2)
Contact point Y on the transverse path of contact	$g_Y(\mathrm{Y}) = (g_Y(\mathrm{A}) + k_s g_{v\alpha}) + \mathrm{Y} \cdot \frac{(1-2k_s)g_{v\alpha}}{i}$ with Y = 0...i; i = 10 NOTE In all following formulae, g_Y is a function of Y$(g_Y = g_Y(\mathrm{Y}))$	-11,174 mm -8,664 mm -6,153 mm -3,643 mm -1,133 mm 1,377 mm 3,887 mm 6,397 mm 8,907 mm 11,417 mm 13,927 mm	Formula (4)

Table D.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Distance of the middle contact line in the zone of action	$f_{m,Y} = (g_{va2} - g_{v\alpha}\ /2 + g_Y) \cdot \cos\beta_{vb}$	-10,434 mm -8,347 mm -6,26 mm -4,174 mm -2,087 mm 0 mm 2,087 mm 4,174 mm 6,26 mm 8,347 mm 10,434 mm	Formula (5)
Coordinates of the ends of the contact line	$x_{1,Y} = \dfrac{f_Y \cos\beta_{vb} + \tan\beta_{vb}\left(f_Y \sin\beta_{vb} + \dfrac{b_{v,eff}}{2}\right) + \dfrac{1}{2}(g_{v\alpha} + b_{v,eff}\tan\gamma)}{\tan\gamma + \tan\beta_{vb}} \geq 0$	24,627 mm 27,894 mm 31,161 mm 34,428 mm 37,695 mm 40,962 mm 44,229 mm 47,496 mm 49,255 mm 49,255 mm 49,255 mm	Formula (10)

Table D.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Coordinates of the ends of the contact line	$x_{2,Y}=\dfrac{f_Y\cos\beta_{vb}+\tan\beta_{vb}\left(f_Y\sin\beta_{vb}+\dfrac{b_{v,eff}}{2}\right)-\dfrac{1}{2}\left(g_{v\alpha}-b_{v,eff}\tan\gamma\right)}{\tan\gamma+\tan\beta_{vb}}\le b_{v,eff}$	0 mm 0 mm 0 mm 1,759 mm 5,026 mm 8,293 mm 11,56 mm 14,826 mm 18,093 mm 21,36 mm 24,627 mm	Formula (11)
Coordinates of the ends of the contact line	$y_{1,Y}=-x_{1,Y}\tan\beta_{vb}+f_Y\cos\beta_{vb}+\tan\beta_{vb}\left(f_Y\sin\beta_{vb}+\dfrac{b_{v,eff}}{2}\right)$	-12,551 mm -12,224 mm -11,898 mm -11,572 mm -11,246 mm -10,92 mm -10,594 mm -10,267 mm -8,933 mm -6,423 mm -3,913 mm	Formula (12)

Table D.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Coordinates of the ends of the contact line	$y_{2,\mathrm{Y}} = -x_{2,\mathrm{Y}} \tan\beta_{\mathrm{vb}} + f_{\mathrm{Y}} \cos\beta_{\mathrm{vb}} + \tan\beta_{\mathrm{vb}} \left(f_{\mathrm{Y}} \sin\beta_{\mathrm{vb}} + \frac{b_{\mathrm{v,eff}}}{2} \right)$	3,913 mm 6,423 mm 8,933 mm 10,267 mm 10,594 mm 10,92 mm 11,246 mm 11,572 mm 11,898 mm 12,224 mm 12,551 mm	Formula (12)
Correction factor for the length of contact lines	$C_{\mathrm{lb,Y}} = \sqrt{\left(1 - \left(\frac{f_{\mathrm{Y}}}{f_{\max}}\right)^2\right)\left(1 - \sqrt{\frac{b_{\mathrm{v,eff}}}{b_{\mathrm{v}}}}\right)^2}$	0,072 0,074 0,076 0,077 0,078 0,078 0,078 0,077 0,076 0,074 0,072	Formula (15)

Table D.5 *(continued)*

Description	Formula	Result	References to ISO/TS 10300-20:2021
Theoretical length of contact line	$l_{b0m,Y} = \sqrt{(x_{1,Y} - x_{2,Y})^2 + (y_{1,Y} - y_{2,Y})^2}$	29,623 mm 33,553 mm 37,483 mm 39,297 mm 39,297 mm 39,297 mm 39,297 mm 39,297 mm 37,483 mm 33,553 mm 29,623 mm	Formula (14)
Length of contact line	$l_{bm,Y} = l_{b0m,Y}(1 - C_{lb,Y})$	27,503 mm 31,071 mm 34,642 mm 36,27 mm 36,24 mm 36,23 mm 36,24 mm 36,27 mm 34,642 mm 31,071 mm 27,503 mm	Formula (13)