INTERNATIONAL STANDARD

ISO 6336-2

Third edition
2019-11

Calculation of load capacity of spur and helical gears —

Part 2:
Calculation of surface durability (pitting)

Calcul de la capacité de charge des engrenages cylindriques à dentures droite et hélicoïdale —

Partie 2: Calcul de la tenue en fatigue à la pression de contact (écaillage)

Reference number
ISO 6336-2:2019(E)

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Published in Switzerland

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Foreword

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

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

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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

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

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

This third edition cancels and replaces the second edition (ISO 6336-2:2006), which has been technically revised. It also incorporates the Technical Corrigendum ISO 6336-2:2006/Cor.1:2008.

The main changes compared to the previous edition are as follows:

— modification of the helix angle factor Z_β;

— integration of 13.3.3 "Surface-hardened steel pinion with ductile iron gear".

A list of all parts in the ISO 6336 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

ISO 6336 (all parts) consists of International Standards, Technical Specifications (TS) and Technical Reports (TR) under the general title *Calculation of load capacity of spur and helical gears* (see Table 1).

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

— Technical Specifications (TS) contain calculation methods that are still subject to further development.

— Technical Reports (TR) contain data that is informative, such as example calculations.

The procedures specified in parts 1 to 19 of the ISO 6336 series cover fatigue analyses for gear rating. The procedures described in parts 20 to 29 of the ISO 6336 series are predominantly related to the tribological behavior of the lubricated flank surface contact. Parts 30 to 39 of the ISO 6336 series include example calculations. The ISO 6336 series allows the addition of new parts under appropriate numbers to reflect knowledge gained in the future.

Requesting calculation according to the ISO 6336 series without referring to specific parts requires the use of only those parts that are designated as International Standards (see Table 1 for listing). If Technical Specifications (TS) are requested as part of the load capacity calculation they need to be specified. Use of a Technical Specification as acceptance criteria for a specific design is subject to commercial agreement.

Table 1 — Parts of the ISO 6336 series (status as of DATE OF PUBLICATION)

Calculation of load capacity of spur and helical gears	International Standard	Technical Specification	Technical Report
Part 1: Basic principles, introduction and general influence factors	X		
Part 2: Calculation of surface durability (pitting)	X		
Part 3: Calculation of tooth bending strength	X		
Part 4: Calculation of tooth flank fracture load capacity		X	
Part 5: Strength and quality of materials	X		
Part 6: Calculation of service life under variable load	X		
Part 20: Calculation of scuffing load capacity (also applicable to bevel and hypoid gears) — Flash temperature method *(replaces: ISO/TR 13989-1)*		X	
Part 21: Calculation of scuffing load capacity (also applicable to bevel and hypoid gears) — Integral temperature method *(replaces: ISO/TR 13989-2)*		X	
Part 22: Calculation of micropitting load capacity *(replaces: ISO/TR 15144-1)*		X	
Part 30: Calculation examples for the application of ISO 6336 parts 1,2,3,5			X
Part 31: Calculation examples of micropitting load capacity *(replaces: ISO/TR 15144-2)*			X

Hertzian pressure, which serves as a basis for the calculation of the contact stress, is the basic principle used in this document for the assessment of the surface durability of cylindrical gears. It is a significant indicator of the stress generated during tooth flank engagement. However, it is not the sole cause of pitting, and nor are the corresponding subsurface shear stresses. There are other contributory influences, for example, coefficient of friction, direction and magnitude of sliding and the influence of lubricant on the distribution of pressure. Development has not yet advanced to the stage of directly including these in calculations of load-bearing capacity; however, allowance is made for them to some degree in the derating factors and the choice of material property values.

Despite the shortcomings, Hertzian pressure is useful as a working hypothesis. This is attributable to the fact that, for a given material, limiting values of Hertzian pressure are preferably derived from fatigue tests on gear specimens; thus, additional relevant influences are included in the values. Therefore, if the reference datum is located in the application range, Hertzian pressure is acceptable as a design basis for extrapolating from experimental data to values for gears of different dimensions.

Several methods have been approved for the calculation of the permissible contact stress and the determination of a number of factors (see ISO 6336-1).

Calculation of load capacity of spur and helical gears —

Part 2:
Calculation of surface durability (pitting)

IMPORTANT — The user of this document is cautioned that when the method specified is used for large helix angles (β > 30°) and large normal pressure angles (α_n > 25°), the calculated results should be confirmed by experience as by Method A. In addition, it is important to note that the best correlation has been obtained for helical gears when high accuracy and optimum modifications are employed.

1 Scope

This document specifies the fundamental formulae for use in the determination of the surface load capacity of cylindrical gears with involute external or internal teeth. It includes formulae for all influences on surface durability for which quantitative assessments can be made. It applies primarily to oil-lubricated transmissions, but can also be used to obtain approximate values for (slow-running) grease-lubricated transmissions, as long as sufficient lubricant is present in the mesh at all times.

The given formulae are valid for cylindrical gears with tooth profiles in accordance with the basic rack standardized in ISO 53. They can also be used for teeth conjugate to other basic racks where the actual transverse contact ratio is less than $\varepsilon_{\alpha n}$ = 2,5. The results are in good agreement with other methods (see References [5], [7], [10], [12]).

These formulae cannot be directly applied for the assessment of types of gear tooth surface damage such as plastic yielding, scratching, scuffing and so on, other than that described in Clause 4.

The load capacity determined by way of the permissible contact stress is called the “surface load capacity” or “surface durability”.

If this scope does not apply, refer to ISO 6336-1:2019, Clause 4.

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 53:1998, *Cylindrical gears for general and heavy engineering — Standard basic rack tooth profile*

ISO 1122-1:1998, *Vocabulary of gear terms — Part 1: Definitions related to geometry*

ISO 4287:1997, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Terms, definitions and surface texture parameters*

ISO 4287:1997/Cor 1:1998, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Terms, definitions and surface texture parameters — TECHNICAL CORRIGENDUM 1*

ISO 4287:1997/Cor 2:2005, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Terms, definitions and surface texture parameters — TECHNICAL CORRIGENDUM 2*

ISO 4287:1997/Amd 1:2009, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Terms, definitions and surface texture parameters — AMENDMENT 1: Peak count number*

ISO 4288:1996, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Rules and procedures for the assessment of surface texture*

ISO 6336-1, *Calculation of load capacity of spur and helical gears — Part 1: Basic principles, introduction and general influence factors*

ISO 6336-5, *Calculation of load capacity of spur and helical gears — Part 5: Strength and quality of materials*

3 Terms, definitions, symbols and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 1122-1:1998, and ISO 6336-1 apply.

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

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

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

3.2 Symbols and abbreviated terms

For the purposes of this document, the symbols and abbreviated terms given in ISO 1122-1:1998, ISO 6336-1 and Table 2 apply.

Table 2 — Abbreviated terms and symbols used in this document

Abbreviated terms	
Term	**Description**
A, B, C, D, E	points on path of contact (pinion root to pinion tip, regardless of whether pinion or wheel drives, only for geometrical considerations)
AA	arithmetic average roughness (alternative name for *Ra*)
CLA	center line average roughness (alternative name for *Ra*)
Eh	material designation for case-hardened wrought steel
GG	material designation for grey cast iron
GGG	material designation for nodular cast iron (perlitic, bainitic, ferritic structure)
GTS	material designation for black malleable cast iron (perlitic structure)
HB	Brinell hardness

[a] For external gears a, d, d_a, z_1 and z_2 are positive; for internal gearing, a, d, da and z_2 have a negative sign, z_1 has a positive sign. All calculated diameters have a negative sign for internal gearing.

Table 2 *(continued)*

Abbreviated terms		
Term	**Description**	
IF	material designation for flame or induction hardened wrought special steel	
M	module	
ME ML MQ	symbols identifying quality classes for material and heat-treatment requirements, ISO 6336-5 shall apply	
NT	material designation for nitrided wrought steel, nitriding steel	
NV	material designation for through-hardened wrought steel, nitrided, nitrocarburized	
St	material designation for normalized base steel (σ_B < 800 N/mm^2)	
V	material designation for through-hardened wrought special steel, alloy or carbon (σ_B ≥ 800 N/mm^2)	
VI	kinematic viscosity index	
Symbols		
Symbol	**Description**	**Unit**
b	face width	mm
b_B	face width of one helix on a double helical gear	mm
b_{vir}	virtual face width	mm
C	constant, coefficient	—
	relief of tooth flank	µm
$C_{ZL,\,ZR,\,Zv}$	factors for determining lubricant film factors	—
d	diameter (without subscript, reference diameter [a])	mm
d_b	base diameter	mm
d_{Na}	active tip diameter	mm
d_{Nf}	active root diameter	mm
E	modulus of elasticity	N/mm^2
F_t	(nominal) transverse tangential load at reference cylinder per mesh	N
f	deviation, tooth deformation	µm
f_{ZCa}	auxiliary factor	—

[a] For external gears a, d, d_a, z_1 and z_2 are positive; for internal gearing, a, d, da and z_2 have a negative sign, z_1 has a positive sign. All calculated diameters have a negative sign for internal gearing.

Table 2 *(continued)*

Symbols		
Symbol	**Description**	**Unit**
h	tooth depth (without subscript, root circle to tip circle)	mm
h_{fP}	dedendum of basic rack of cylindrical gears (ISO 53:1998 shall apply)	mm
K	constant, factors concerning tooth load	—
K_A	application factor	—
$K_{H\alpha}$	transverse load factor (contact stress)	—
$K_{H\beta}$	face load factor (contact stress)	—
K_v	dynamic factor	—
K_γ	mesh load factor (takes into account the uneven distribution of the load between meshes for multiple transmission paths)	—
M	moment of a force	Nm
m_n	normal module	mm
N_L	number of load cycles	—
p_{bt}	transverse base pitch	mm
Ra	arithmetic mean roughness value, $Ra \cong 1/6\ Rz$	µm
Rz	mean peak-to-valley roughness (ISO 4287:1997 including ISO 4287:1997/Cor 1:1998, ISO 4287:1997/Cor 2:2005, ISO 4287:1997/Amd 1:2009 and ISO 4288:1996 shall apply)	µm
Rz_H	equivalent roughness	µm
r	radius (without subscript, reference radius)	mm
S_H	safety factor for pitting	—
$S_{H\,min}$	minimum required safety factor for pitting	—
S_{H1}	safety factor for pitting of pinion	—
S_{H2}	safety factor for pitting of wheel	—
u	gear ratio $(z_2/z_1) \geq 1$[a]	—
v	circumferential velocity (without subscript at the reference circle)	m/s
v_w	circumferential velocity at the pitch line	m/s
x	profile shift coefficient	—
Z	factor related to contact stress	—

[a] For external gears a, d, d_a, z_1 and z_2 are positive; for internal gearing, a, d, da and z_2 have a negative sign, z_1 has a positive sign. All calculated diameters have a negative sign for internal gearing.

