Contents

Page

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 second edition cancels and replaces the first edition (ISO/TS 6336-21:2017), which has been technically revised.

The main changes are as follows:

— bevel gear related content has been removed after the publication of ISO/TS 10300-20:2021 which precisely covers bevel gears;

— subclause 5.1 has been rearranged.

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

The ISO 6336 series 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.

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

Requesting standardized calculations according to ISO 6336 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 6336 need to be specified. The use of a technical specification as acceptance criteria for a specific design needs to be agreed in advance between the manufacturer and the purchaser.

Table 1 — Overview of ISO 6336

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 — Flash temperature method*		X	
Part 21: *Calculation of scuffing load capacity — Integral temperature method*		X	
Part 22: *Calculation of micropitting load capacity* (replaces ISO/TR 15144-1)		X	
Part 30: *Calculation examples for the application of ISO 6336-1 parts 1,2,3,5*			X
Part 31: *Calculation examples of micropitting load capacity* (replaces: ISO/TR 15144-2)			X
At the time of publication of this document, some of the parts listed here were under development. Consult the ISO website.			

This document describes the surface damage "warm scuffing" for cylindrical (spur and helical) gears for generally used gear materials and different heat treatments. "Warm scuffing" is characterized by typical scuffing and scoring marks, which can lead to increasing power loss, dynamic load, noise and wear. For "cold scuffing", generally associated with low temperature and low speed, under approximately 4 m/s, and through-hardened, heavily loaded gears, the formulae are not suitable.

There is a particularly severe form of gear tooth surface damage in which seizure or welding together of areas of tooth surfaces occurs due to absence or breakdown of a lubricant film between the contacting tooth flanks of mating gears caused by high temperature and high pressure. This form of damage is termed "scuffing" and most relevant when surface velocities are high. Scuffing can also occur for relatively low sliding velocities when tooth surface pressures are high enough, either generally or, because of uneven surface geometry and loading, in discrete areas.

Risk of scuffing damage varies with the properties of gear materials, the lubricant used, the surface roughness of tooth flanks, the sliding velocities and the load. Excessive aeration or the presence of contaminants in the lubricant such as metal particles in suspension, also increases the risk of scuffing damage. Consequences of the scuffing of high-speed gears include a tendency to high levels of dynamic loading due to increase of vibration, which usually leads to further damage by scuffing, pitting or tooth breakage.

High surface temperatures due to high surface pressures and sliding velocities can initiate the breakdown of lubricant films. On the basis of this hypothesis, two approaches to relate temperature to lubricant film breakdown are presented:

— the flash temperature method (presented in ISO/TS 6336-20), based on contact temperatures which vary along the path of contact;

— the integral temperature method (presented in this document), based on the weighted average of the contact temperatures along the path of contact.

The integral temperature method is based on the assumption that scuffing is likely to occur when the mean value of the contact temperature (integral temperature) is equal to or exceeds a corresponding critical value. The risk of scuffing of an actual gear unit can be predicted by comparing the integral temperature with the critical value, derived from a gear test for scuffing resistance of lubricants. The calculation method takes account of all significant influencing parameters, i.e. the lubricant (mineral oil with and without EP-additives, synthetic oils), the surface roughness, the sliding velocities, the load, etc.

In order to ensure that all types of scuffing and comparable forms of surface damage due to the complex relationships between hydrodynamical, thermodynamical and chemical phenomena are dealt with, further methods of assessment can be necessary. The development of such methods is the objective of ongoing research.

Calculation of load capacity of spur and helical gears —

Part 21:
Calculation of scuffing load capacity — Integral temperature method

1 Scope

This document specifies the integral temperature method for calculating the scuffing load capacity of cylindrical gears.

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

ISO 1122-2, *Vocabulary of gear terms — Part 2: Definitions related to worm gear geometry*

ISO 1328-1, *Cylindrical gears — ISO system of flank tolerance classification — Part 1: Definitions and allowable values of deviations relevant to flanks of gear teeth*

3 Terms and definitions

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 1122-2 apply.

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

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

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

3.2 Symbols and units

The symbols used in this document are given in Table 2.

Table 2 — Symbols and units

Symbol	Description	Unit
a	Centre distance	mm
B_M	Thermal contact coefficient	$N/(mm \cdot s^{1/2} \cdot K)$
b	Facewidth, smaller value of pinion or wheel	mm
C_1, C_2, C_{2H}	Weighting factors	—
C_a	Nominal tip relief	µm
C_{eff}	Effective tip relief	µm
c_v	Specific heat capacity per unit volume	$N/(mm^2 \cdot K)$