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**Cylindrical gears — ISO system of  
flank tolerance classification —**

**Part 1:  
Definitions and allowable values of  
deviations relevant to flanks of gear  
teeth**

*Engrenages cylindriques — Système ISO de classification des  
tolérances sur flancs —*

*Partie 1: Définitions et valeurs admissibles des écarts pour les flancs  
de la denture*

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 1328-1 was prepared by Technical Committee ISO/TC 60, *Gears*.

This second edition cancels and replaces the first edition (ISO 1328-1:1995), which has been technically revised. In particular, the following are the major changes:

- the scope of applicability has been expanded;
- revisions have been made to the formulae which define the flank tolerances;
- annexes have been added to describe additional methods for analysis of modified profiles and helices;
- the evaluation of runout, previously handled in ISO 1328-2, has been brought back into this part of ISO 1328.

ISO 1328 consists of the following parts, under the general title *Cylindrical gears — ISO system of flank tolerance classification*:

- *Part 1: Definitions and allowable values of deviations relevant to flanks of gear teeth*
- *Part 2: Definitions and allowable values of deviations relevant to radial composite deviations and runout information<sup>1)</sup>*

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1) It is intended that, upon revision, the main element of the title of Part 2 will be aligned with the main element of the title of Part 1.

## Introduction

ISO 1328:1975 (third edition, withdrawn) included definitions and allowable values of gear element deviations, along with advice on appropriate inspection methods.

The first edition of this part of ISO 1328 retained the definitions and allowable values for gear flank deviations (single pitch, cumulative pitch, total cumulative pitch, total profile and total helix), while the advice on appropriate inspection methods was given in ISO/TR 10064-1 (listed in [Clause 2](#)).

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# Cylindrical gears — ISO system of flank tolerance classification —

## Part 1:

## Definitions and allowable values of deviations relevant to flanks of gear teeth

**IMPORTANT** — It is strongly recommended that any user of this part of ISO 1328 be very familiar with the methods and procedures outlined in ISO/TR 10064-1. Use of techniques other than those of ISO/TR 10064-1 combined with the limits described in this part of ISO 1328 might not be suitable.

**CAUTION** — The use of the flank tolerance classes for the determination of gear performance requires extensive experience with specific applications. Users of this part of ISO 1328 are cautioned against the direct application of tolerance values for unassembled (loose) gears to a projected performance of an assembly using these gears.

### 1 Scope

This part of ISO 1328 establishes a tolerance classification system relevant to manufacturing and conformity assessment of tooth flanks of individual cylindrical involute gears. It specifies definitions for gear flank tolerance terms, the structure of the flank tolerance class system, and allowable values.

This part of ISO 1328 provides the gear manufacturer and the gear buyer with a mutually advantageous reference for uniform tolerances. Eleven flank tolerance classes are defined, numbered 1 to 11, in order of increasing tolerance. Formulae for tolerances are provided in 5.3. These tolerances are applicable to the following ranges:

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$$5 \text{ mm} \leq d \leq 15\,000 \text{ mm}$$

$$0,5 \text{ mm} \leq m_n \leq 70 \text{ mm}$$

$$4 \text{ mm} \leq b \leq 1\,200 \text{ mm}$$

$$\beta \leq 45^\circ$$

where

$d$  is the reference diameter;

$m_n$  is the normal module;

$b$  is the facewidth (axial);

$z$  is the number of teeth;

$\beta$  is the helix angle.

See [Clause 4](#) for required and optional measuring methods.

Gear design is beyond the scope of this part of ISO 1328.

Surface texture is not considered in this part of ISO 1328. For additional information on surface texture, see ISO/TR 10064-4.

## 2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable to its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 701, *International gear notation — Symbols for geometrical data*

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

ISO 1328-2, *Cylindrical gears — ISO system of accuracy — Part 2: Definitions and allowable values of deviations relevant to radial composite deviations and runout information*

ISO/TR 10064-1, *Code of inspection practice — Part 1: Inspection of corresponding flanks of gear teeth*

ISO/TS 16610-1, *Geometrical product specifications (GPS) — Filtration — Part 1: Overview and basic concepts*

ISO 16610-21, *Geometrical product specifications (GPS) — Filtration — Part 21: Linear profile filters: Gaussian filters*

ISO 21771, *Gears — Cylindrical involute gears and gear pairs — Concepts and geometry*

## 3 Terms, definitions and symbols

### 3.1 Fundamental terms and symbols

For the purposes of this part of ISO 1328, the following terms, definitions and symbols apply.

NOTE 1 For other definitions of geometric terms related to gearing, see ISO 701, ISO 1122-1 and ISO 21771.

NOTE 2 Some of the symbols and terminology contained in this part of ISO 1328 might differ from those used in other documents and International Standards.

NOTE 3 The terminology and symbols used in this part of ISO 1328 are listed, in alphabetical order, by term in [Table 1](#), and in alphabetical order, by symbol in [Table 2](#). The text of terms used in [Table 1](#) has been adjusted to form groups of logical terms. Subscript “T” is used for tolerance values.

**Table 1 — Terms, listed in alphabetical order, with symbols**

Term	Symbol	Unit
Active tip diameter	$d_{Na}$	mm
Active tip diameter point on line of action	$N_a$	–
Adjacent pitch difference	$f_u$	$\mu\text{m}$
Adjacent pitch difference tolerance	$f_{uT}$	$\mu\text{m}$
Adjacent pitch difference, individual	$f_{ui}$	$\mu\text{m}$
Amount of root relief	$C_{\alpha f}$	$\mu\text{m}$
Amount of tip relief	$C_{\alpha a}$	$\mu\text{m}$
Base diameter	$d_b$	mm
Contact pattern evaluation	$c_p$	–
Contact point tangent at base circle	$T$	–



Table 1 (continued)

Term	Symbol	Unit
Cumulative pitch deviation (index deviation), individual	$F_{pi}$	$\mu\text{m}$
Cumulative pitch deviation (index deviation), total	$F_p$	$\mu\text{m}$
Cumulative pitch (index) tolerance, total	$F_{pT}$	$\mu\text{m}$
Facewidth (axial)	$b$	mm
Flank tolerance class	$A$	-
Helix angle	$\beta$	deg
Helix deviation, total	$F_\beta$	$\mu\text{m}$
Helix evaluation length	$L_\beta$	mm
Helix form deviation	$f_{f\beta}$	$\mu\text{m}$
Helix form filter cutoff	$\lambda_\beta$	mm
Helix form tolerance	$f_{f\beta T}$	$\mu\text{m}$
Helix slope deviation	$f_{H\beta}$	$\mu\text{m}$
Helix slope tolerance	$f_{H\beta T}$	$\mu\text{m}$
Helix tolerance, total	$F_{\beta T}$	$\mu\text{m}$
Individual radial measurement	$r_i$	$\mu\text{m}$
Length of path of contact	$g_\alpha$	mm
Maximum length of tip relief	$L_{C\alpha a, \max}$	mm
Maximum length of root relief	$L_{C\alpha f, \max}$	mm
Measurement diameter	$d_M$	mm
Middle profile zone	$L_{\alpha m}$	-
Minimum length of tip relief	$L_{C\alpha a, \min}$	mm
Minimum length of root relief	$L_{C\alpha f, \min}$	mm
Normal module	$m_n$	mm
Number of teeth	$z$	-
Number of pitches in a sector	$k$	-
Pitch, transverse circular on measurement diameter	$p_{tM}$	mm
Pitch point	$C$	-
Pitch span deviation	$F_{pSk}$	$\mu\text{m}$
Profile control diameter	$d_{Cf}$	mm
Profile deviation, total	$F_\alpha$	$\mu\text{m}$
Profile evaluation length	$L_\alpha$	mm
Profile form deviation	$f_{f\alpha}$	$\mu\text{m}$
Profile form filter cutoff	$\lambda_\alpha$	mm
Profile form tolerance	$f_{f\alpha T}$	$\mu\text{m}$
Profile slope deviation	$f_{H\alpha}$	$\mu\text{m}$
Profile slope tolerance	$f_{H\alpha T}$	$\mu\text{m}$
Profile tolerance, total	$F_{\alpha T}$	$\mu\text{m}$
Radial composite deviation, tooth-to-tooth <sup>a</sup>	$f_i''$	$\mu\text{m}$
Radial composite deviation, total <sup>a</sup>	$F_i''$	$\mu\text{m}$

Table 1 (continued)

Term	Symbol	Unit
Reference diameter	$d$	mm
Root form diameter	$d_{Ff}$	mm
Root relief zone	$L_{C\alpha f}$	–
Runout	$F_R$	$\mu\text{m}$
Sector pitch deviation	$F_{pk}$	$\mu\text{m}$
Sector pitch tolerance	$F_{pkT}$	$\mu\text{m}$
Single flank composite deviation, total	$F_{is}$	$\mu\text{m}$
Single flank composite tolerance, total	$F_{isT}$	$\mu\text{m}$
Single flank composite deviation, tooth-to-tooth	$f_{is}$	$\mu\text{m}$
Single flank composite tolerance, tooth-to-tooth	$f_{isT}$	$\mu\text{m}$
Single pitch deviation	$f_p$	$\mu\text{m}$
Single pitch deviation (individual)	$f_{pi}$	$\mu\text{m}$
Single pitch tolerance	$f_{pT}$	$\mu\text{m}$
Start of active profile diameter	$d_{Nf}$	mm
Start of active profile point on line of action	$N_f$	–
Tip corner chamfer	$h_k$	mm
Tip diameter	$d_a$	mm
Tip form diameter	$d_{Fa}$	mm
Tip relief zone	$L_{C\alpha a}$	–
Tooth thickness	$s$	mm
Working pitch diameter	$d_w$	mm
Working transverse pressure angle	$\alpha_{wt}$	deg

<sup>a</sup> Symbols given in ISO 1328-2.

Table 2 — Symbols, listed in alphabetical order, with terms

Symbol	Term	Unit
$A$	Flank tolerance class	–
$b$	Facewidth (axial)	mm
$C$	Pitch point	–
$C_{\alpha a}$	Amount of tip relief	$\mu\text{m}$
$C_{\alpha f}$	Amount of root relief	$\mu\text{m}$
$c_p$	Contact pattern evaluation	–
$d$	Reference diameter	mm
$d_a$	Tip diameter	mm
$d_b$	Base diameter	mm
$d_{Cf}$	Profile control diameter	mm
$d_{Fa}$	Tip form diameter	mm
$d_{Ff}$	Root form diameter	mm
$d_M$	Measurement diameter	mm

Table 2 (continued)

Symbol	Term	Unit
$d_{Na}$	Active tip diameter	mm
$d_{Nf}$	Start of active profile diameter	mm
$d_w$	Working pitch diameter	mm
$F_i''$	Radial composite deviation, total <sup>a</sup>	$\mu\text{m}$
$F_{is}$	Single flank composite deviation, total	$\mu\text{m}$
$F_{isT}$	Single flank composite tolerance, total	$\mu\text{m}$
$F_p$	Cumulative pitch deviation (index deviation), total	$\mu\text{m}$
$F_{pi}$	Cumulative pitch deviation (index deviation), individual	$\mu\text{m}$
$F_{pk}$	Sector pitch deviation	$\mu\text{m}$
$F_{pkT}$	Sector pitch tolerance	$\mu\text{m}$
$F_{pT}$	Cumulative pitch (index) tolerance, total	$\mu\text{m}$
$F_{pSk}$	Pitch span deviation	$\mu\text{m}$
$F_r$	Runout	$\mu\text{m}$
$F_\alpha$	Profile deviation, total	$\mu\text{m}$
$F_{\alpha T}$	Profile tolerance, total	$\mu\text{m}$
$F_\beta$	Helix deviation, total	$\mu\text{m}$
$F_{\beta T}$	Helix tolerance, total	$\mu\text{m}$
$f_{f\alpha}$	Profile form deviation	$\mu\text{m}$
$f_{f\alpha T}$	Profile form tolerance	$\mu\text{m}$
$f_{f\beta}$	Helix form deviation	$\mu\text{m}$
$f_{f\beta T}$	Helix form tolerance	$\mu\text{m}$
$f_{H\alpha}$	Profile slope deviation	$\mu\text{m}$
$f_{H\alpha T}$	Profile slope tolerance	$\mu\text{m}$
$f_{H\beta}$	Helix slope deviation	$\mu\text{m}$
$f_{H\beta T}$	Helix slope tolerance	$\mu\text{m}$
$f_i''$	Radial composite deviation, tooth-to-tooth <sup>a</sup>	$\mu\text{m}$
$f_{is}$	Single flank composite deviation, tooth-to-tooth	$\mu\text{m}$
$f_{isT}$	Single flank composite tolerance, tooth-to-tooth	$\mu\text{m}$
$f_p$	Single pitch deviation	$\mu\text{m}$
$f_{pi}$	Single pitch deviation (individual)	$\mu\text{m}$
$f_{pT}$	Single pitch tolerance	$\mu\text{m}$
$f_u$	Adjacent pitch difference	$\mu\text{m}$
$f_{ui}$	Adjacent pitch difference, individual	$\mu\text{m}$
$f_{uT}$	Adjacent pitch difference tolerance	$\mu\text{m}$
$g_\alpha$	Length of path of contact	mm
$h_k$	Tip corner chamfer	mm
$k$	Number of pitches in a sector	-
$L_{\alpha m}$	Middle profile zone	-
$L_{C\alpha a}$	Tip relief zone	-

Table 2 (continued)

Symbol	Term	Unit
$L_{C\alpha f}$	Root relief zone	–
$L_{c\alpha a, \max}$	Maximum length of tip relief	mm
$L_{c\alpha a, \min}$	Minimum length of tip relief	mm
$L_{c\alpha f, \max}$	Maximum length of root relief	mm
$L_{c\alpha f, \min}$	Minimum length of root relief	mm
$L_{\alpha}$	Profile evaluation length	mm
$L_{\beta}$	Helix evaluation length	mm
$m_n$	Normal module	mm
$N_a$	Active tip diameter point on line of action	–
$N_f$	Start of active profile point on line of action	–
$p_{tM}$	Pitch, transverse circular on measurement diameter	mm
$r_i$	Individual radial measurement	$\mu\text{m}$
$s$	Tooth thickness	mm
$T$	Contact point at tangent at base circle	–
$z$	Number of teeth	–
$\alpha_{wt}$	Working transverse pressure angle	deg
$\beta$	Helix angle	deg
$\lambda_{\alpha}$	Profile form filter cutoff	mm
$\lambda_{\beta}$	Helix form filter cutoff	mm

<sup>a</sup> Symbols given in ISO 1328-2.

## 3.2 General dimensions

### 3.2.1 reference diameter

$d$   
diameter of reference circle

Note 1 to entry: The reference diameter is used to calculate values of tolerances.

Note 2 to entry: See ISO 21771:2007, 4.2.4.

### 3.2.2 measurement diameter

$d_M$   
diameter of the circle concentric with the *datum axis* (3.2.7) where the probe is in contact with the tooth flanks during the measurement of helix, pitch or tooth thickness deviations

Note 1 to entry: The measurement diameter is usually near the middle of the flank.

Note 2 to entry: See ISO/TR 10064-3.

### 3.2.3 profile form filter cutoff

$\lambda_{\alpha}$   
wavelength where 50 % of the amplitude of the involute profile measurement data is transmitted as a result of the Gaussian low-pass filter, thereby including only longer wavelength deviations

Note 1 to entry: See 4.4.6 and Annex C.

**3.2.4****helix form filter cutoff** $\lambda_\beta$ 

wavelength where 50 % of the amplitude of the helix measurement data is transmitted as a result of the Gaussian low-pass filter, thereby including only longer wavelength deviations

Note 1 to entry: See [4.4.6](#) and [Annex C](#).

**3.2.5****roll path length**

length of roll

linear distance along a base tangent line from its contact with the base circle to the given point on the involute profile in the transverse plane

Note 1 to entry: Roll path length is an alternative to roll angle for specification of selected diameter positions on an involute profile.

Note 2 to entry: See [Figure 1](#) and ISO 21771:2007, 4.3.8.

**3.2.6****length of path of contact** $g_\alpha$ 

*roll path length* ([3.2.5](#)) from the start of active profile,  $d_{Nf}$ , to the tip form diameter,  $d_{Fa}$ , or to the point where contact stops due to undercut on the mating part (end of active profile)

**3.2.7****datum axis**

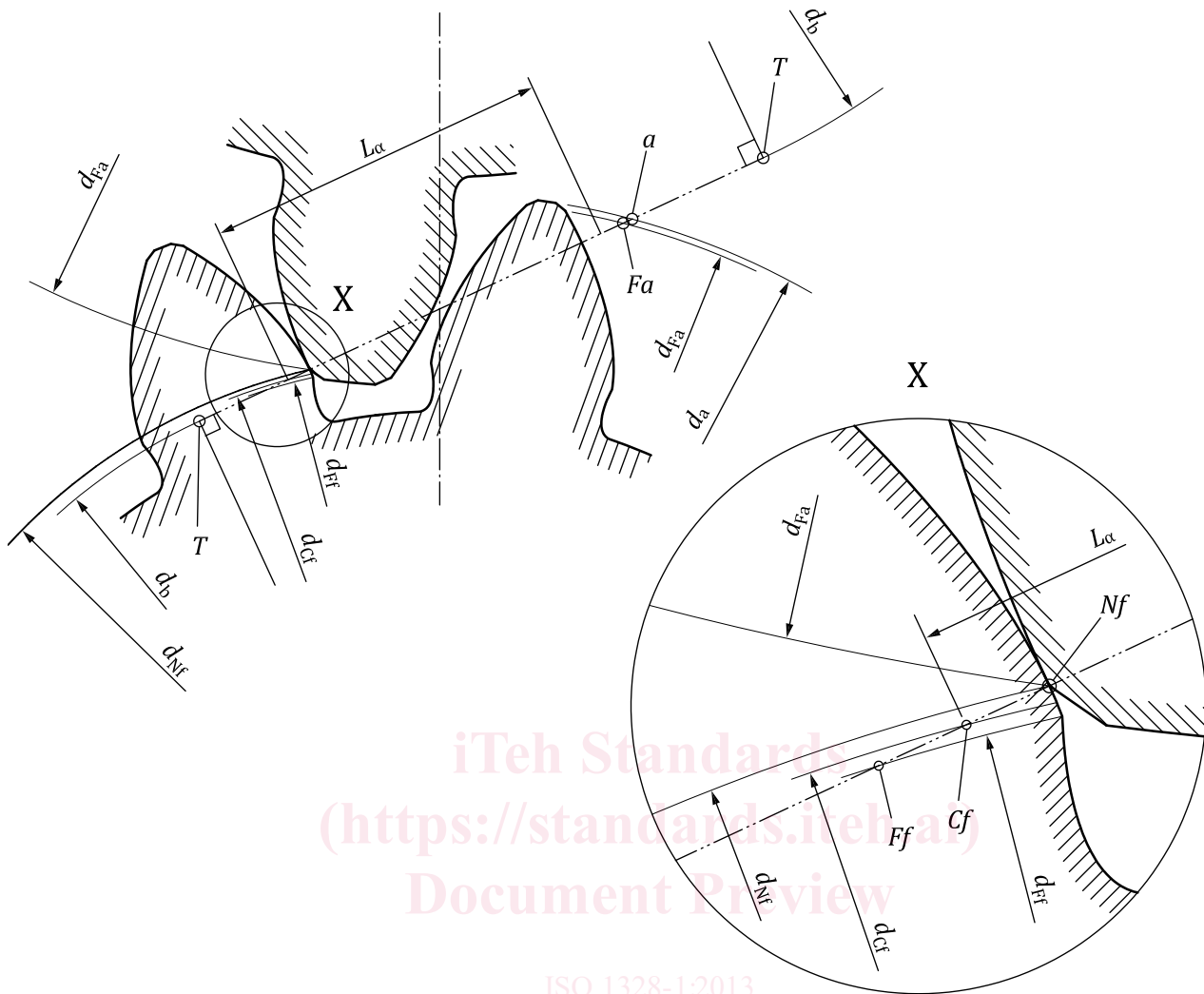
axis to which the gear details, and in particular the pitch, profile and helix tolerances, are defined

Note 1 to entry: The datum axis of the gear is defined by the datum surfaces.

Note 2 to entry: See ISO/TR 10064-3.

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- |   |   |
|---|---|
| <p><math>L_\alpha</math> evaluation length</p> <p>Points on line of action</p> <p>a tip</p> <p>Cf profile control</p> <p>Fa tip form</p> <p>Ff root form</p> <p>Nf start of active profile</p> <p>T tangency to base circle</p> <p>----- line of action</p> | <p>Diameters</p> <p><math>d_a</math> tip</p> <p><math>d_b</math> base</p> <p><math>d_{Cf}</math> profile control</p> <p><math>d_{Fa}</math> tip form, where tip break starts</p> <p><math>d_{Ff}</math> root form, where involute starts</p> <p><math>d_{Nf}</math> start of active profile</p> |
|---|---|

NOTE Diameters on mating gear have the same symbols, but different values.

**Figure 1 — Diameters and roll path length for an external gear pair**