INTERNATIONAL STANDARD

ISO 1328-1

Second edition
2013-09-01

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

Reference number
ISO 1328-1:2013(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.

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*[1)]

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).

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:

$5 \leq z \leq 1\,000$

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

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

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

$\beta \leq 45°$

where

d is the reference diameter;

m_n is the normal module;

b is the facewidth (axial);

z is the number of teeth;

β 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	µm
Adjacent pitch difference tolerance	f_{uT}	µm
Adjacent pitch difference, individual	f_{ui}	µm
Amount of root relief	$C_{\alpha f}$	µm
Amount of tip relief	$C_{\alpha a}$	µm
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}	µm
Cumulative pitch deviation (index deviation), total	F_{p}	µm
Cumulative pitch (index) tolerance, total	F_{pT}	µm
Facewidth (axial)	b	mm
Flank tolerance class	A	–
Helix angle	β	deg
Helix deviation, total	F_{β}	µm
Helix evaluation length	L_{β}	mm
Helix form deviation	$f_{f\beta}$	µm
Helix form filter cutoff	λ_{β}	mm
Helix form tolerance	$f_{f\beta T}$	µm
Helix slope deviation	$f_{H\beta}$	µm
Helix slope tolerance	$f_{H\beta T}$	µm
Helix tolerance, total	$F_{\beta T}$	µm
Individual radial measurement	r_{i}	µm
Length of path of contact	g_{α}	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}	µm
Profile control diameter	d_{Cf}	mm
Profile deviation, total	F_{α}	µm
Profile evaluation length	L_{α}	mm
Profile form deviation	$f_{f\alpha}$	µm
Profile form filter cutoff	λ_{α}	mm
Profile form tolerance	$f_{f\alpha T}$	µm
Profile slope deviation	$f_{H\alpha}$	µm
Profile slope tolerance	$f_{H\alpha T}$	µm
Profile tolerance, total	$F_{\alpha T}$	µm
Radial composite deviation, tooth-to-tooth[a]	f_{i}''	µm
Radial composite deviation, total[a]	F_{i}''	µm

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	µm
Sector pitch deviation	F_{pk}	µm
Sector pitch tolerance	F_{pkT}	µm
Single flank composite deviation, total	F_{is}	µm
Single flank composite tolerance, total	F_{isT}	µm
Single flank composite deviation, tooth-to-tooth	f_{is}	µm
Single flank composite tolerance, tooth-to-tooth	f_{isT}	µm
Single pitch deviation	f_p	µm
Single pitch deviation (individual)	f_{pi}	µm
Single pitch tolerance	f_{pT}	µm
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	α_{wt}	deg
[a] 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	µm
$C_{\alpha f}$	Amount of root relief	µm
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[a]	µm
F_{is}	Single flank composite deviation, total	µm
F_{isT}	Single flank composite tolerance, total	µm
F_p	Cumulative pitch deviation (index deviation), total	µm
F_{pi}	Cumulative pitch deviation (index deviation), individual	µm
F_{pk}	Sector pitch deviation	µm
F_{pkT}	Sector pitch tolerance	µm
F_{pT}	Cumulative pitch (index) tolerance, total	µm
F_{pSk}	Pitch span deviation	µm
F_r	Runout	µm
F_α	Profile deviation, total	µm
$F_{\alpha T}$	Profile tolerance, total	µm
F_β	Helix deviation, total	µm
$F_{\beta T}$	Helix tolerance, total	µm
$f_{f\alpha}$	Profile form deviation	µm
$f_{f\alpha T}$	Profile form tolerance	µm
$f_{f\beta}$	Helix form deviation	µm
$f_{f\beta T}$	Helix form tolerance	µm
$f_{H\alpha}$	Profile slope deviation	µm
$f_{H\alpha T}$	Profile slope tolerance	µm
$f_{H\beta}$	Helix slope deviation	µm
$f_{H\beta T}$	Helix slope tolerance	µm
f_i''	Radial composite deviation, tooth-to-tooth[a]	µm
f_{is}	Single flank composite deviation, tooth-to-tooth	µm
f_{isT}	Single flank composite tolerance, tooth-to-tooth	µm
f_p	Single pitch deviation	µm
f_{pi}	Single pitch deviation (individual)	µm
f_{pT}	Single pitch tolerance	µm
f_u	Adjacent pitch difference	µm
f_{ui}	Adjacent pitch difference, individual	µm
f_{uT}	Adjacent pitch difference tolerance	µm
g_α	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_{α}	Profile evaluation length	mm
L_{β}	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	µm
s	Tooth thickness	mm
T	Contact point at tangent at base circle	–
z	Number of teeth	–
α_{wt}	Working transverse pressure angle	deg
β	Helix angle	deg
λ_{α}	Profile form filter cutoff	mm
λ_{β}	Helix form filter cutoff	mm

[a] 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
λ_α
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
λ_β
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.

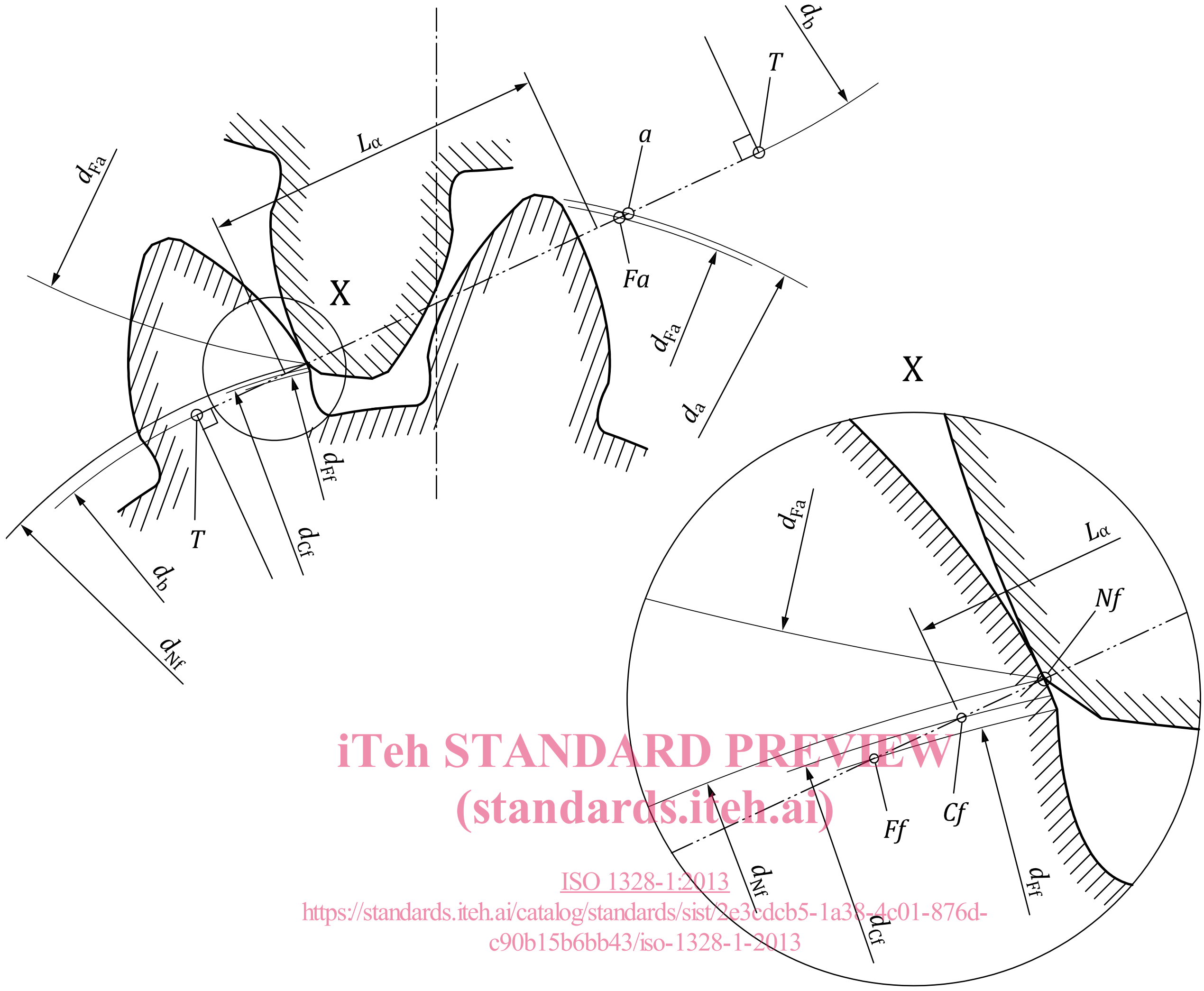
Note 2 to entry: See Figure 1 and ISO 21771:2007, 4.3.8.

3.2.6
length of path of contact
g_α
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.



Key

L_α evaluation length

Points on line of action

a tip

Cf profile control

Fa tip form

Ff root form

Nf start of active profile

T tangency to base circle

—··——··— line of action

Diameters

d_a tip

d_b base

d_{Cf} profile control

d_{Fa} tip form, where tip break starts

d_{Ff} root form, where involute starts

d_{Nf} start of active profile

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

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

3.3 Pitch deviations

3.3.1
individual single pitch deviation

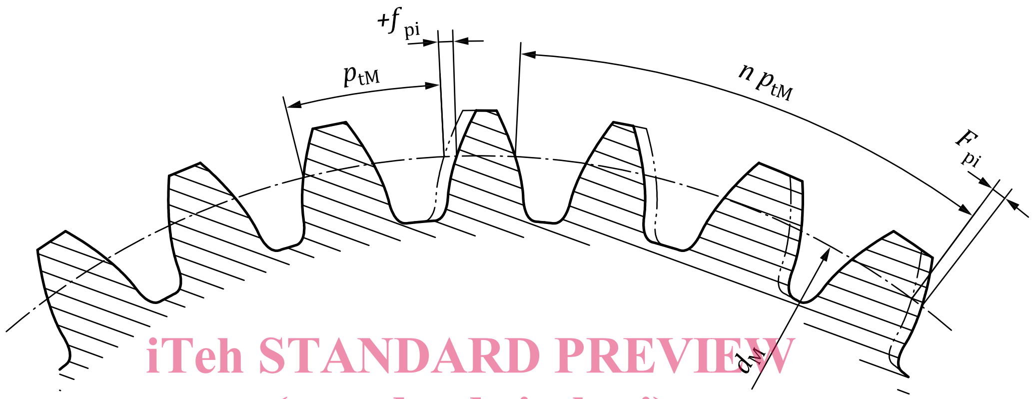
f_{pi}

algebraic difference between the actual pitch and the corresponding theoretical pitch in the transverse plane on the measurement circle of the gear

Note 1 to entry: It corresponds to the displacement of any tooth flank from its theoretical position relative to the corresponding flank of an adjacent tooth.

Note 2 to entry: For the left flanks, as well as for the right flanks, there are as many values of f_{pi} as there are teeth.

Note 3 to entry: See Figure 2.



Key

—··——··— theoretical

———— actual

NOTE $p_{tM} = \pi\ d_M/z$.

Figure 2 — Pitch deviations

3.3.2
single pitch deviation

f_p

maximum absolute value of all the *individual single pitch deviations* (3.3.1) observed

Note 1 to entry: $f_p = \max |f_{pi}|$.

3.3.3
individual cumulative pitch deviation

individual index deviation

F_{pi}

algebraic difference, over a sector of n adjacent pitches, between the length and the theoretical length of the relevant arc

Note 1 to entry: n varies from 1 to z; for the left flanks, as well as the right flanks, there are as many values of F_{pi} as there are teeth.

Note 2 to entry: In theory, it is equal to the algebraic sum of the individual single pitch deviations (3.3.1) of the same n pitches. It corresponds to the displacement of any tooth flank from its theoretical position, relative to a datum tooth flank.

Note 3 to entry: See Figure 2 and Annex D.