SLOVENSKI STANDARD

SIST ISO/TR 10064-2:1998

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Valjasti zobniki - Smernice za meritve - 2. del: Meritve odstopkov pri radialnem preskuġanju, odstopki kroģnega teka, debeline zob in boļ nega razstopa

Cylindrical gears - Code of inspection practice -- Part 2: Inspection related to radial composite deviations, runout, tooth thickness and backlash

Code pratique de réception -- Partie 2: Contrôle relatif aux écarts composés radiaux, au faux-rond, à l'épaisseur de dent et au jeu entre dents

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TECHNICAL REPORT

ISO TR 10064-2

First edition
1996-03-01

Cylindrical gears — Code of inspection practice —

Part 2:
Inspection related to radial composite deviations, runout, tooth thickness and backlash

Engrenages cylindriques — Code pratique de réception —
Partie 2: Contrôle relatif aux écarts composés radiaux, au faux-rond, à l'épaisseur de dent et au jeu entre dents

Reference number
ISO/TR 10064-2:1996(E)

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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 main task of technical committees is to prepare International Standards, but in exceptional circumstances a technical committee may propose the publication of a Technical Report of one of the following types:

— type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;

— type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;

— type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/TR 10064-2, which is a Technical Report of type 3, was prepared by Technical Committee ISO/TC 60, *Gears*.

Together with definitions and values allowed for gear element deviations, the International Standard ISO 1328:1975 also provided advice on appropriate inspection methods.

In the course of revising ISO 1328:1975, it was agreed that the description and advice on gear inspection methods should be brought up to date. Because of necessary enlargement and other considerations, the Technical Committee decided that the relevant sections should be published under separate cover as a Technical Report, type 3. It was decided that, together with this Technical Report, a system of documents as listed in clause 2 (References) and annex B (Bibliography) should be established for definitive information.

ISO/TR 10064 consists of the following parts, under the general title *Cylindrical gears — Code of inspection practice*:

— *Part 1: Inspection of corresponding blanks of gear teeth*

— *Part 2: Inspection related to radial composite deviations, runout, tooth thickness and backlash*

— *Part 3: Recommendations relative to blanks, shaft centre distance and parallelism of axes*

— *Part 4: Recommendations relative to surface roughness and tooth contact pattern checking*

Cylindrical gears — Code of inspection practice —

Part 2:
Inspection related to radial composite deviations, runout, tooth thickness and backlash

1 Scope

This part of the Technical Report constitutes a code of practice dealing with inspection relevant to radial composite deviations, runout, tooth thickness and backlash of cylindrical involute gears; i.e., with measurements referred to double flank contact.

In providing advice on gear checking methods and the analysis of measurement results, it supplements the standard ISO 1328-2. Most of the terms used are defined in ISO 1328-2.

Annex A provides a method to select gear tooth thickness tolerances and minimum backlash of a gear mesh. Suggested values for minimum backlash are included.

2 References

ISO 53: 1974 Cylindrical gears for general and heavy engineering - Basic rack;

ISO 54: 1977 Cylindrical gears - Modules and diametral pitches of cylindrical gears for general and heavy engineering;

ISO 1328-1:1995 Cylindrical gears - Definitions and allowable values of deviations relevant to corresponding flanks of gear teeth;

ISO 1328-2: Cylindrical gears - Definitions and allowable values of deviations relevant to radial composite deviations and runout information *(in the state of preparation)*;

ISO/TR 10064-1: 1992 Cylindrical gears - Code of inspection practice - Inspection of corresponding flanks of gear teeth;

ISO/TR 10064-3: Cylindrical gears - Recommendations relative to blanks, shaft center distance and parallelism of axes *(in the state of preparation)*.

3 Symbols, corresponding terms and definitions

3.1 Lower case symbols

a	center distance	mm
b	facewidth	mm
d	reference diameter	mm
d_b	base diameter	mm
d_a	tip diameter	mm
f_e	eccentricity	mm
f_i''	tooth-to-tooth radial composite deviation	µm
h_a	addendum	mm
h_c	reference chordal height	mm
m_n	normal module	-
s_n	normal tooth thickness	mm
s_{nc}	normal chordal tooth thickness	mm
x	profile shift coefficient	-
z	number of teeth	-

3.2 Upper case symbols

D_M	diameter of ball or cylinder used for measurement	mm
E_{sni}	lower tooth thickness allowance	mm
E_{sns}	upper tooth thickness allowance	mm
F_i''	total radial composite deviation	µm
F_r	runout	µm
F_r''	runout by composite test	µm
M_d	dimension over balls or cylinders (pins)	mm
W_k	base tangent length	mm

3.3 Greek symbols

α_{Mt}	pressure angle in transverse plane	°
α_n	normal pressure angle	°
β	helix angle	°
δ	prism (anvil) half angle	°
ε_β	overlap ratio	-
η	tooth space half angle	°
ψ	tooth thickness half angle	°

3.4 Subscript symbols

0	tool	b	base
1	pinion	t	transverse
2	wheel (gear)	w	working
3	master gear	y	any (specified) diameter

3.5 Definitions

3.5.1 Definitions with regard to composite deviation

The **reference axis** of a component is defined by means of datum surfaces. In most cases the axis of the bore can be adequately represented by the axis of the mating work arbor (see ISO/TR 10064-3).

The **geometric axis of the teeth** for radial composite deviation is that axis which, if used for the measurement, would give the minimum root mean square (rms) total composite deviation over a complete revolution.

3.5.2 Definitions with regard to tooth thickness

Nominal tooth thickness, s_n, on the reference cylinder in a normal plane is equal to the theoretical value for meshing without backlash with a mating gear, which also has the theoretical tooth thickness, on the basic center distance. The nominal tooth thickness is calculated using the following equations:
for external gears,

$$s_n = m_n \left(\frac{\pi}{2} + 2 \tan \alpha_n x \right) \quad ...(1)$$

for internal gears,

$$s_n = m_n \left(\frac{\pi}{2} - 2 \tan \alpha_n x \right) \quad ...(2)$$

For helical gears, the value of s_n is measured in the normal plane.

Maximum and minimum limits of tooth thickness, s_{ns} and s_{ni}, are the two extreme permissible sizes of tooth thickness between which the actual size should lie, the limits of size being included. See figure 1.

The upper and lower (E_{sns} and E_{sni}) **tooth thickness allowances** define the limits of gear tooth thickness. See equations 3 and 4 and figure 1.

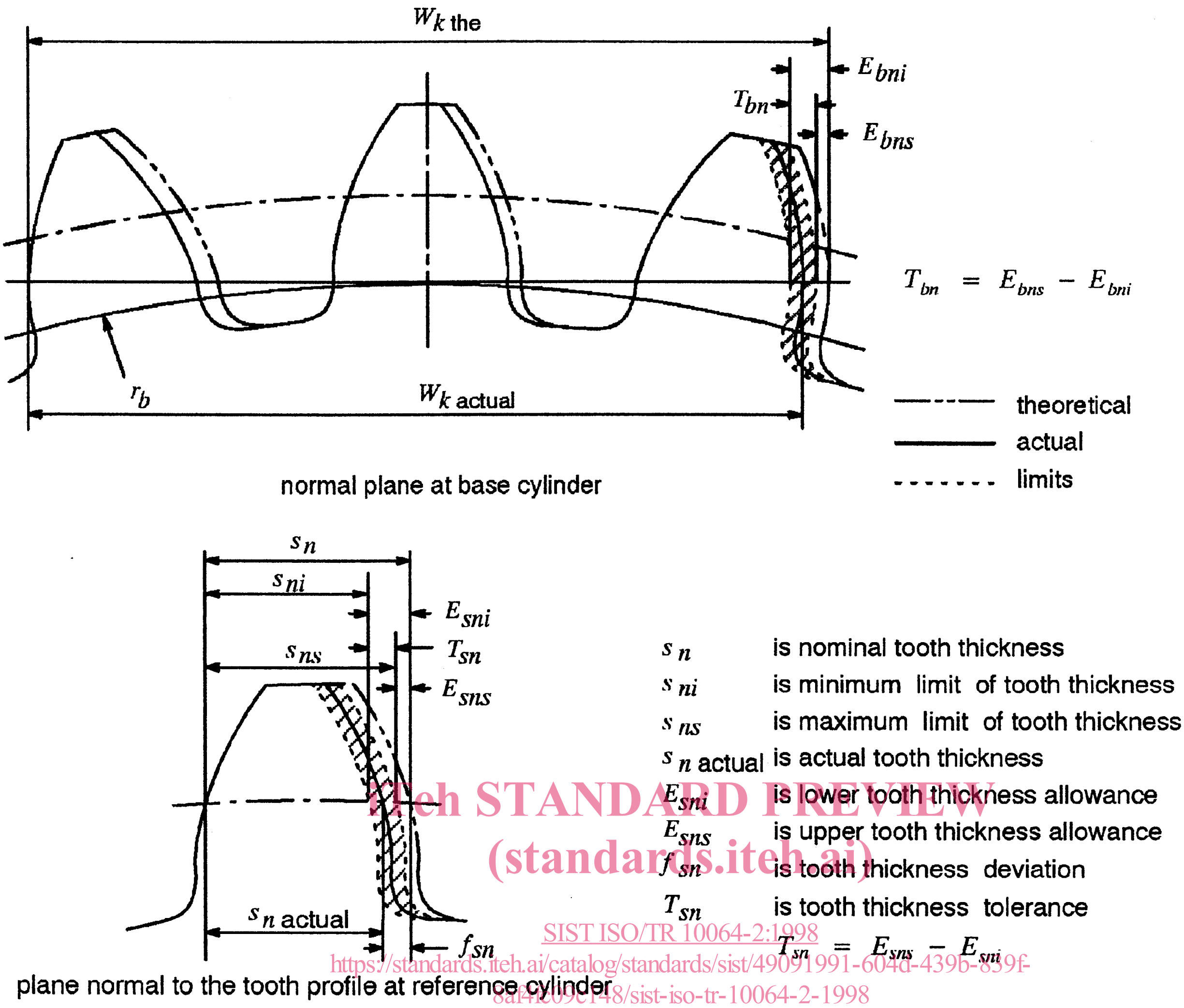


Figure 1 - Span and tooth thickness allowances

$$E_{sns} = s_{ns} - s_n \qquad ...(3)$$

$$E_{sni} = s_{ni} - s_n \qquad ...(4)$$

Tooth thickness tolerance, T_{sn}, is the difference between the upper and the lower tooth thickness allowance.

$$T_{sn} = E_{sns} - E_{sni} \qquad ...(5)$$

The design values of tooth thickness are usually established from engineering considerations of gear geometry, gear tooth strength, mounting and considerations of backlash. The methods for establishing design tooth thicknesses for given applications are beyond the scope of this document.

Actual tooth thickness, $s_{n\ actual}$, is the tooth thickness determined by measurement.

Functional tooth thickness, s_{func}, is the maximum tooth thickness value obtained on a radial composite action test (double flank) by means of a calibrated master gear.

It is a measurement which encompasses the effects of element deviations in profile, helix, pitch, etc., similar to the concept of maximum material condition, see 6.5. It should never exceed the design tooth thickness.

The **Effective tooth thickness** of a gear will be different than the measured tooth thickness by an amount equal to all the combined effects of the tooth element deviations and mounting, similar to functional tooth thickness.

It is the final envelope condition which encompasses all the effects which must be considered to determine the maximum material condition.

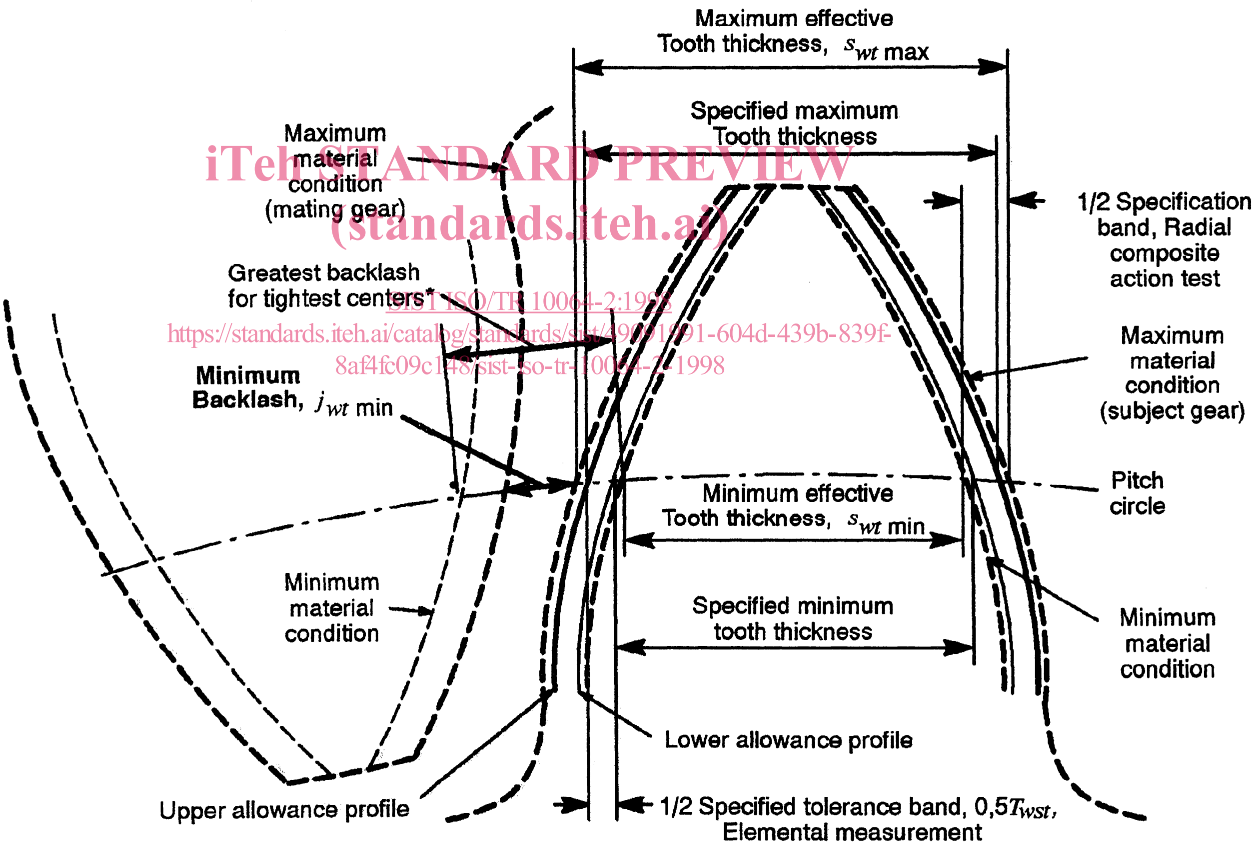
The tooth element deviations of mating gears may have an additive effect or may cancel each other at various angular positions within a given mesh. It is not possible to segregate the individual tooth element deviations from the effective tooth thickness.

3.5.3 Definitions with regard to backlash

Backlash is the clearance between the non-working flanks of two mating gears when their working flanks are in contact, as shown in figure 2.

> **Note:** Figure 2 is drawn at the position of tightest center distance; if center distance is increased backlash will increase. The maximum effective tooth thickness (minimum backlash) will be different than the measured tooth thickness by an amount equal to all the combined effects of the tooth element deviations, and mounting, similar to functional tooth thickness. It is the final envelope condition which encompasses all the effects which must be considered to determine the maximum material condition.

Usually the backlash under stabilized working conditions (working backlash) is different from (smaller than) the backlash which is measured when the gears are mounted in the housing under static conditions (assembly backlash).



* THIS FIGURE IS DRAWN AT THE POSITION OF TIGHTEST CENTER DISTANCE; if center distance is increased backlash will increase.

Figure 2 - Tooth thickness, transverse plane

Circumferential backlash, j_{wt}, (figure 3) is the maximum length of arc of the pitch circle through which a gear can be rotated when the mating gear is fixed.

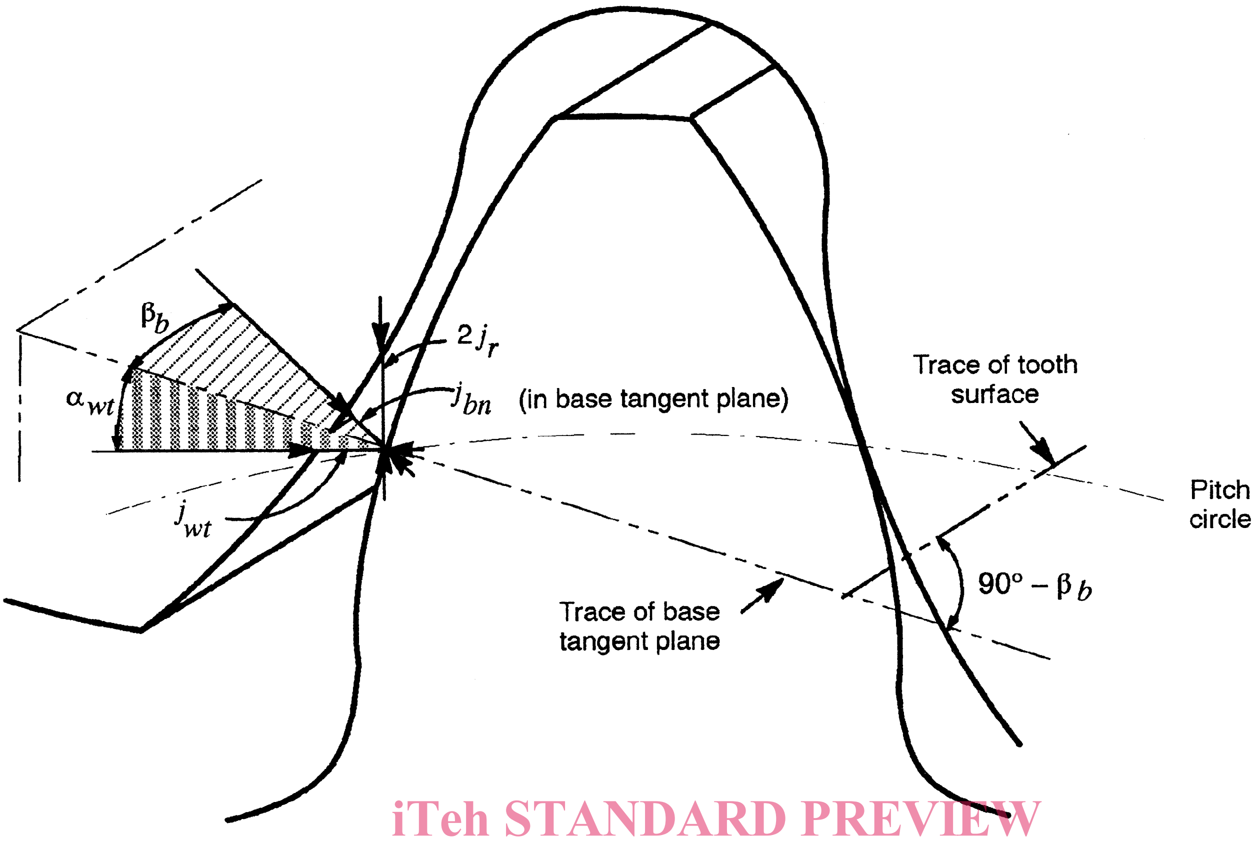


Figure 3 - Relationship between circumferential j_{wt}, normal j_{bn}, and radial j_r backlash

Normal backlash, j_{bn}, (figure 3) is the shortest distance between non-working flanks of two gears when the working flanks are in contact. The relationship with the circumferential backlash, j_{wt}, is in accordance with the following equation:

$$j_{bn} = j_{wt} \cos \alpha_{wt} \cos \beta_b \quad \ldots(6)$$

Radial backlash, j_r, (figure 3) is the amount by which the center distance has to be diminished till the position in which left and right flanks of mating gears are in contact.

$$j_r = \frac{j_{wt}}{2 \tan \alpha_{wt}} \quad \ldots(7)$$

Minimum backlash, $j_{wt\,min}$, is the minimum circumferential backlash on the pitch circle when the gear tooth with the greatest allowable effective tooth thickness is in mesh with the mating gear tooth having its greatest allowable effective tooth thickness, at the tightest allowable center distance, under static conditions (figure 2).

The tightest center distance is the minimum working center distance for external gears and the maximum working center distance for internal gears.

Maximum backlash, $j_{wt\,max}$, is the maximum circumferential backlash on the pitch circle when the gear tooth with the smallest allowable effective tooth thickness is in mesh with the mating gear tooth having its smallest allowable effective tooth thickness at the largest allowable center distance under static conditions (figure 2).

4 Measurement of radial composite deviations

4.1 Checking principle

Radial composite deviations are checked on a device on which pairs of gears are assembled with one gear on a fixed spindle, the other on a spindle carried on a slide provided with a spring arrangement enabling the