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Cylindrical gears — ISO system of flank tolerance classification —

Part 2: Definitions and allowable values of double flank radial composite deviations

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

Partie 2: Définitions et valeurs admissibles des écarts composés radiaux

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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*.

This second edition cancels and replaces the first edition (ISO 1328-2:1997), which has been technically revised. The main changes compared to the previous edition are as follows:

— the document title of this part has been revised to correspond to that of part 1 and better reflect the contents of this part;

— the scope of applicability has been expanded to include sector gears;

— revisions have been made to the formulae which define the double flank radial composite tolerances, and the range of classification numbers has been changed to clarify the independence of this classification system from that given in part 1;

— the change in tolerance value between consecutive tolerance classes has been reduced, so two steps in the new system results in the same change as one step of the old system, but approximately the same global range of tolerance values is maintained with additional steps;

— annexes have been added to describe complementary information and examples;

— evaluation of runout, previously handled in this document, has been moved to ISO 1328-1:2013;

— advice on appropriate inspection methods has been removed; the information can be found in ISO/TR 10064-2.

A list of all parts in the ISO 1328 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.

Cylindrical gears — ISO system of flank tolerance classification —

Part 2: **Definitions and allowable values of double flank radial composite deviations**

1 Scope

This document establishes a gear tooth classification system relevant to double flank radial composite deviations of individual cylindrical involute gears and sector gears. It specifies the appropriate definitions of gear tooth deviations, the structure of the gear tooth flank classification system, and the allowable values of the gear tooth deviations. It provides formulae to calculate tolerances for individual product gears when mated in double flank contact with a master gear. Tolerance tables are not included.

This document is applicable to gears with three or more teeth that have reference diameters of up to 600 mm.

This document does not provide guidance on gear design nor does it recommend tolerances.

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

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

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 701 and ISO 1122-1 and the following apply.

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

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

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

3.1.1
double flank test
test where a *master gear* (3.1.4) and a *product gear* (3.1.5) are rotated in tight mesh contact, i.e. held together by a spring load so there is no backlash, while measuring the changes in center distance

3.1.2
elemental deviation
deviation, such as profile and helix deviation on individual teeth or pitch deviation between teeth, generally using a single point of contact probe

3.1.3
elemental method
method to measure *elemental deviations* (3.1.2)

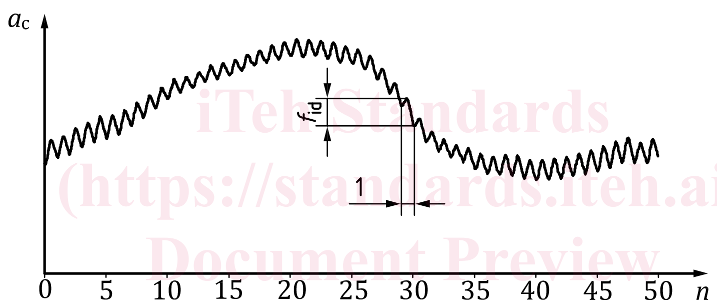
Note 1 to entry: ISO 1328-1 describes elemental methods and deviations.

3.1.4
master gear
gear with the required precision that is designed to measure double flank radial composite deviation in a double flank contact test with a *product gear* (3.1.5)

3.1.5
product gear
gear that is being measured or evaluated

3.1.6
tooth-to-tooth radial composite deviation
f_{id}
value of the greatest change in center distance within any one pitch, found after evaluating all the teeth of a *product gear* (3.1.5) in a *double flank test* (3.1.1) with a *master gear* (3.1.4)

Note 1 to entry: See Figure 1.



Key

1 single tooth pitch

n tooth number

a_c tight mesh center distance

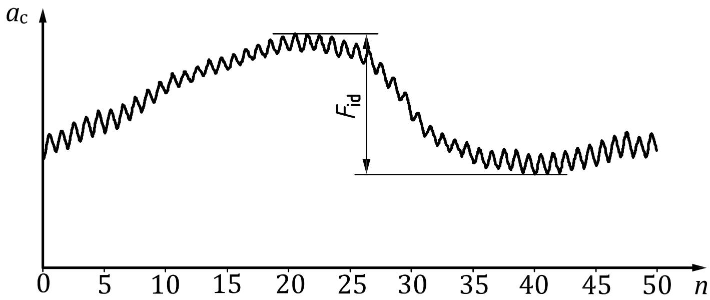
Figure 1 — Tooth-to-tooth radial composite deviation

3.1.7
tooth-to-tooth radial composite tolerance
f_{idT}
maximum *tooth-to-tooth radial composite deviation* (3.1.6) allowable by specification

3.1.8
total radial composite deviation
F_{id}
difference between the maximum and minimum values of center distance found after evaluating all the teeth of a *product gear* (3.1.5) in a *double flank test* (3.1.1) with a *master gear* (3.1.4)

Note 1 to entry: See Figure 2.

3.1.9
total radial composite tolerance
F_{idT}
maximum *total radial composite deviation* (3.1.8) allowable by specification



Key

n tooth number

a_c tight mesh center distance

Figure 2 — Total radial composite deviation

3.2 Symbols

For the purposes of this document, the symbols given in Table 1 apply. The symbols are based on those given in ISO 701.

Table 1 — Symbols

Symbol	Term	Units	First used
a_c	Tight mesh center distance	mm	3.1.6
F_{id}	Total radial composite deviation	µm	3.1.8
f_{id}	Tooth-to-tooth radial composite deviation	µm	3.1.6
F_{idk}	Radial composite deviation over k teeth	µm	B.3
F_{idkT}	Radial composite tolerance over k teeth	µm	B.4
F_{idT}	Total radial composite tolerance	µm	3.1.9
f_{idT}	Tooth-to-tooth radial composite tolerance	µm	3.1.7
k_{max}	Maximum number of tooth pitches in measurement segment	—	B.4
m_n	Normal module	mm	5.3
n	Tooth number	—	3.1.6
R	Tolerance class number	—	5.3
R_x	Tolerance class modifier based on number of teeth	—	5.3
z	Number of teeth	—	5.2.1
z_c	Number of teeth for calculation	—	5.3
z_k	Number of teeth in the sector	—	5.4.2
β	Helix angle	°	5.3

4 Application of the ISO double flank radial composite tolerance classification system

4.1 General

This document provides classification tolerances and measuring methods for unassembled gears.

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

With agreement between the purchaser and manufacturer, the tolerances may be applied to other types of gears such as cylindrical worms, worm gears, racks, and bevel gears. However, in these cases, modified procedures and associated measurement processes should be considered since this standard only describes procedures for parallel axis gears. See ISO/TR 10064-2 for additional information.

Some design and application considerations may warrant measurements or documentation not normally included in standard manufacturing processes. Specific requirements shall be stated in the contractual documents.

Additional information on double flank testing is given in ISO/TR 10064-2.

NOTE 1 Tolerances for a specified class are calculated according to the formulae in Clause 5. To aid in visualizing how the tolerances change with the number of gear teeth, graphs are provided in Annex A showing tolerance values for 3 tolerance classes.

NOTE 2 There is no correlation or interrelation between the classes specified in this document and other parts or standards such as ISO 1328-1. This document uses a unique set of tolerance classes (i.e., R30 to R50) to reinforce that no correlation to other elemental or radial composite standards exists (see Annex C). However, while there is no general correlation to other standards, for a specific gear it is possible to find a tolerance class or classes according to this document that will give similar tolerances to those that were originally specified for the gear, see Annex D.

NOTE 3 The specific methods of measurement, documentation of the results, inspection frequency, and use of statistical methods are items that normally are mutually agreed upon between the manufacturer and the purchaser.

4.2 Gear tooth tolerance class

In this document, the double flank radial composite tolerance class is determined by measurement of total radial composite deviation, F_{id}, and tooth-to-tooth radial composite deviation, f_{id}. A gear that is specified to a single ISO double flank radial composite tolerance class shall meet both individual tolerance requirements.

In addition to the total and tooth-to-tooth tolerances, Annex B provides an optional specification for composite tolerance over a selected number of teeth, k.

NOTE 1 Specifying a class or measurement criteria that require more precise tolerances than required by the application can unnecessarily increase the cost.

NOTE 2 Double flank measurements, such as tight mesh center distance, can be used for control of tooth thickness and total radial composite effects simultaneously.

This document allows for the specification of separate classes for total radial composite deviation, F_{id}, and tooth-to-tooth radial composite deviation, f_{id}.

The assessment of the gear's double flank radial composite tolerance class shall be performed after the final manufacturing process. Double flank composite checks may also be performed at any step in the manufacturing process.

This document is for classes R30 to R50. It may be convenient in a specific application to use the formulae in this document by extrapolating them below R30 or beyond R50. When this is done, individual tolerances should be used on these applications as opposed to defining a class outside of the R30 to R50 range.

4.3 Specification of datum surfaces

Specification of radial composite tolerances requires the definition of datum surfaces to be used for double flank inspection. See ISO/TR 10064-3.

4.4 Application of the ISO flank classification standard

4.4.1 Measurement equipment and master gears

When measurement according to this document is specified, the double flank equipment for the gears being measured is to be calibrated and appropriate. Unless otherwise agreed upon, the manufacturer may select the double flank equipment to be used.

A master gear shall be used for double flank radial composite tests. The design of the teeth, including specified tolerances, of a master gear shall be agreed upon between the manufacturer and purchaser of the product gear. Master gears are subject to wear and damage during use and should be periodically calibrated and traceable to national standards, with a stated measurement uncertainty.

NOTE Master gear deviations can increase or decrease the measured deviations in the test gear. Therefore, parts requiring higher levels of precision normally require more precise master gears. The use of lower quality masters will increase the risk of false acceptance or rejection of a product gear.

There shall be no gear mesh interference between the product gear and the master gear. Interference between the tips and fillets at the minimum center distance during measurement should be checked. Minimum total contact ratio should be checked, and its value should be greater than 1,02 with all tolerances applied.

4.4.2 Equipment verification and uncertainty

The equipment used for the measurement of gears should be verified periodically.

The uncertainty of the measuring process should be determined, see ISO 14253-1.

4.4.3 Filtering and data density

Tooth-to-tooth radial composite deviation can be greatly influenced by runout, especially on gears with low numbers of teeth. Some double flank equipment may have the option of using filtering techniques to report tooth-to-tooth radial composite deviations after removing the effect of eccentricity. The tolerance values in this document shall be applied without the use of filtering that removes the effects of eccentricity.

Other filtering can occur due to the mechanical dynamic frequency response of the moving pieces of the tester including the effects from the mass of the gear itself, mass of the moving head, frictional resistance of the measuring system, and the spring. Slower rotation during testing reduces the effect of this filtering due to mechanical dynamic response.

When an electronic measuring device is used, a minimum of 30 data samples per tooth pitch should be taken.

4.5 Acceptance criteria

The double flank radial composite tolerance class of a gear is determined by the larger class number measured for the tolerance parameters specified for the gear by this document.

The tolerances for double flank radial composite deviations apply to the inspection of a gear meshing with a master gear. Use of double flank radial composite tolerances on two product gears meshing together should be agreed upon between the manufacturer and the purchaser.

4.6 Correlation of double flank radial composite and element deviations

The tolerance class determined for a gear measured with the double flank radial composite methods of this document does not correlate to the class determined for that gear by the elemental methods covered in ISO 1328-1. Users are cautioned that specification to this document alone may not properly control deviations of index or total cumulative pitch that can occur without radial deviations. See ISO/TR 10064-1 and ISO/TR 10064-2 for more information on index deviation.

4.7 Designation of the double flank radial composite tolerance class or tolerances

Designation/specification of a double flank radial composite tolerance class in accordance with this document shall be as follows:

ISO 1328-2:2020, class Rxx

where xx designates the design double flank radial composite tolerance class.

NOTE If the year of publication is not listed and previous standard qualifier class is not listed, the latest version of ISO 1328-2 applies.

5 Tolerance values

5.1 General

The tolerance values are calculated by the formulae given in 5.3 and 5.4. In addition, the formula in B.4 may be used to calculate the optional double flank radial composite deviation over segments of k teeth.

NOTE Annex E provides tolerance calculation examples.

When the gear diameter or number of teeth is not within the specified range listed in Clause 1, use of the tolerance formulae shall be agreed upon between manufacturer and purchaser.

The double flank radial composite classification system is comprised of 21 tolerance classes for total and tooth-to-tooth radial composite deviations of which class R30 is the most accurate and class R50 is the least accurate.

5.2 Use of formulae

5.2.1 Number of teeth used to calculate tolerances

For gears with more than 200 teeth, except for sector gears, a default value of 200 shall be used for the number of teeth.

For sector gears, z is the equivalent number of teeth based on extending the sector to cover 360° around the gear's axis of rotation.

5.2.2 Rounding rules

Values calculated from Formulae (1), (4), and (5) shall be rounded to the nearest micron. If the fractional result is equal to 0,5, the value is rounded up to the next integer.

If the measuring instrument reads in inches, values calculated from Formulae (1), (4), and (5) shall be converted to ten thousandths of an inch prior to rounding and then rounded to the nearest 0,5 ten thousandths of an inch. For example, a value of 11,74 tenths would be rounded to 11,5 tenths while 11,75 tenths would be rounded to 12,0 tenths.

