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ISO 1328-2

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Cylindrical gears — ISO system of accuracy —

Part 2:
Definitions and allowable values of deviations relevant to radial composite deviations and runout information

Engrenages cylindriques — Système ISO de précision —

Partie 2: Définitions et valeurs admissibles des écarts composés radiaux et information sur le faux-rond

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Contents

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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.

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.

International Standard ISO 1328-2 was prepared by Technical Committee ISO/TC 60, *Gears*.

ISO 1328 consists of the following parts, under the general title *Cylindrical gears - ISO system of accuracy*:

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

— *Part 2: Definitions and allowable values of deviations relevant to radial composite deviations and runout information*

Annexes A, B and C of this part of ISO 1328 are for information only.

Introduction

Together with definitions and allowable values of gear element deviations, ISO 1328:1975 also provided advice on appropriate inspection methods.

In the course of revising ISO 1328:1975 and taking into account several important aspects, it was agreed that the description and advice on gear inspection methods would be published separately, and that, together with parts 1 and 2 of ISO 1328, a system of standards and technical reports (listed in clause 2 and annex C) should be established.

Cylindrical gears — ISO system of accuracy —

Part 2:
Definitions and allowable values of deviations relevant to radial composite deviations and runout information

1 Scope

This part of ISO 1328 establishes a system of accuracy relevant to radial composite deviations of individual cylindrical involute gears. It specifies the appropriate definitions of gear tooth accuracy terms, the structure of the gear accuracy system and the allowable values of the above mentioned deviations.

The radial measurement accuracy system has different grade ranges than elemental ranges in ISO 1328-1. The diameter and module ranges for radial composite deviations and runout are also different.

The radial composite accuracy system comprises 9 accuracy grades for F_i'' or f_i'' of which grade 4 is the highest and grade 12 is the lowest. The module range extends from 0,2 mm to 10 mm and the diameter range from 5,0 mm to 1 000 mm, see clauses 6 and 7. Annex A gives tables based on the formulae in clause 7.

Runout is defined in annex B and values are not given in the standard for determining accuracy grade 5. Annex B provides information on runout for use if agreed upon between purchaser and manufacturer.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions, of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 701:1976, *International gear notation — Symbols for geometrical data.*

ISO 1122-1:1983, *Glossary of gear terms — Part 1: Geometrical definitions.*

ISO 1328-1:1995, *Cylindrical gears — ISO System of accuracy — Part 1: Definitions and allowable values of deviations relevant to corresponding flanks of gear teeth.*

ISO/TR 10064-2:1996, *Cylindrical gears — Code of inspection practice — Part 2: Inspection related to radial composite deviations, runout, tooth thickness and backlash.*

3 Definitions

For the purposes of this part of ISO 1328, the definitions given in ISO 1122-1 apply.

4 Symbols, quantities and units

Symbols are based on those given in ISO 701. Only symbols for quantities used in this part of ISO 1328 are given in table 1.

Table 1 - Symbols used within ISO 1328-2

Symbol	Quantity	Unit
d	reference diameter	mm
m_n	normal module	mm
ε_β	overlap ratio	-
f_i''	tooth-to-tooth radial composite deviation	µm
F_i''	total radial composite deviation	µm
L_{AE}	active length	mm
Q	accuracy grade number	-
z	number of teeth	-
F_r	runout	µm

5 Gear tooth accuracy terms relevant to radial composite deviations

5.1 Product gear

The "product gear" is the gear which is being measured or evaluated.

5.2 Radial composite deviations

Measured values of radial composite deviations are affected by the accuracy of the master gear and the total contact ratio of the product gear with the master gear (refer to ISO/TR 10064-2).

5.3 Total radial composite deviation, F_i''

Total radial composite deviation is the difference between the maximum and minimum values of centre distance which occur during a radial (double-flank) composite test, when the product gear with its right and left flank simultaneously in contact with those of the master gear, is turned through one complete revolution. Figure 1 shows an example of a relevant diagram.

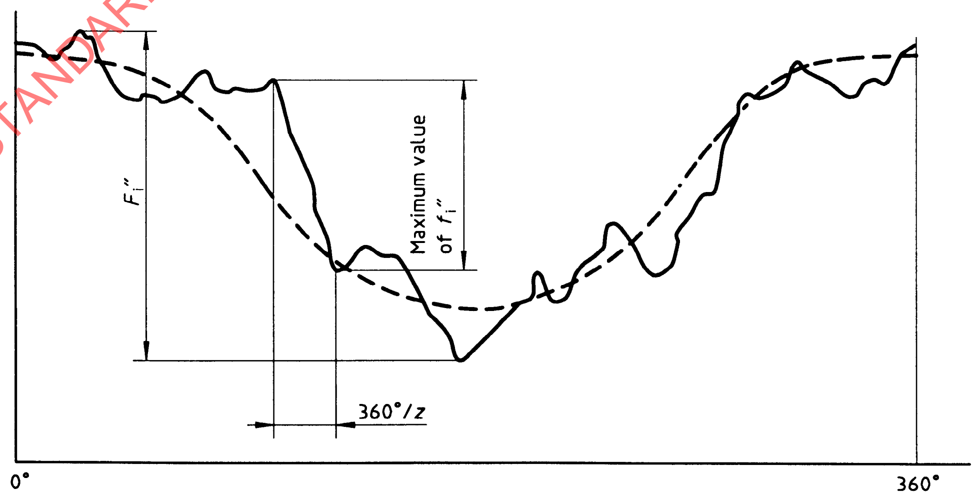

Figure 1 - Radial composite deviation diagram

5.4 Tooth-to-tooth radial composite deviation, f_i''

Tooth-to-tooth radial composite deviation is the value of the radial composite deviation corresponding to one pitch, 360°/z, during the complete cycle of engagement of all the product gear teeth. The maximum value f_i'' of all the product gear teeth should not exceed the specified allowable value (see figure 1).

5.5 Master gear

The master gear for a radial composite test should engage the product gear over the "active length", L_{AE}, as defined in ISO 1328-1.

The tolerances have been established for spur gears and can be used to determine an accuracy grade. Since the overlap ratio, ε_β, may influence the results of radial composite measurements of helical gears, the master gear used shall be subject to agreement between purchaser and manufacturer. When used for helical gears, the master gear facewidth should be such that ε_β is less than or equal to 0,5 with the product gear.

6 Structure of the gear accuracy system

Determination of the accuracy grade by measurement of radial composite deviations in accordance with this part of ISO 1328 does not imply that the elemental deviations (e.g. pitch, profile, lead, etc. from ISO 1328-1) will conform to the same grade. Statements in documents concerning required accuracy shall include reference to the relevant standard, ISO 1328-1 or ISO 1328-2, as appropriate.

The tolerances for radial composite deviation apply only to the inspection of a gear running with a master gear. They do not apply to the measurement of two product gears running together.

6.1 Gear accuracy

Gear accuracy is evaluated by comparing measured deviations against the numerical values determined according to clause 7. The values calculated using the formulae apply to accuracy grade 5. The step factor between two consecutive grades is equal to $\sqrt{2}$; i.e., values of each next higher (lower) grade are determined by multiplying (dividing) by $\sqrt{2}$. The required value for any accuracy grade can be determined by multiplying the un-rounded calculated value for accuracy grade 5 by 2 to exponent [0,5 (Q - 5)], where Q is the accuracy grade of the required value.

When gear geometry is not within the specified ranges of clause 1, use of the formulae shall be agreed upon between purchaser and manufacturer.

6.2 Validity of radial composite deviation

When tolerance values are small, particularly when less than 5 µm, the measuring apparatus including the master gear shall be of sufficiently high precision as to ensure that values can be measured and repeated with the required accuracy.

The tolerances have been established for spur gears and can be used to determine an accuracy grade. However, subject to agreement between purchaser and manufacturer they can similarly be used for helical gears. See also 5.5.

7 Formulae for grade 5 accuracy tolerances for radial composite deviations

Use the actual values of module and diameter in the following formulae.

a) Total radial composite deviation, F_i''

$$F_i'' = 3{,}2m_n + 1{,}01\sqrt{d} + 6{,}4$$

b) Tooth-to-tooth radial composite deviation, f_i''

$$f_i'' = 2{,}96m_n + 0{,}01\sqrt{d} + 0{,}8$$

The formulae with the system of accuracy presented in clause 6 are used if no other agreement is specified. The values for the tables in annex A were determined using the relevant mean values as stated in A.2. The tables of tolerances should only be used with agreement between purchaser and manufacturer.

Annex A
(informative)
Tables of allowable values of radial composite deviations

A.1 Purpose

This annex gives a method for applying the formulae of clause 7 and subclause 6.1 to develop tables of tolerances:

$$F_i'' = (F_r + f_i'')(2^{[0,5(Q-5)]}) = (3{,}2m_n + 1{,}01\sqrt{d} + 6{,}4)(2^{[0,5(Q-5)]})$$

A.2 Ranges of parameters

The recommended lower and upper range limits for applying the formulae to tables are:

a) for the reference diameter, d

composite: 5 / 20 / 50 / 125 / 280 / 560 / 1 000 mm

b) for the normal module, m_n

composite: 0,2 / 0,5 / 0,8 / 1,0 / 1,5 / 2,5 / 4 / 6 / 10 mm

When applying the formulae of clause 7 for tables of tolerances, the parameters m_n and d can be introduced as the geometrical mean values of the relevant range limits. If the actual module is 7, for example, the range limits are normally $m_n = 6$ and $m_n = 10$ and the table value calculated with $m_n = \sqrt{(6 \times 10)} = 7{,}746$.

A.3 Rounding rules

The tolerance values are rounded versions of values calculated using the formulae in clause 7 and subclause 6.1. If values are greater than 10 µm, they are rounded to the nearest integer. If less than 10 µm, they are rounded to the nearest 0,5 µm value or integer.

A.4 Validity

When procurement documents state the required gear accuracy grade with reference to ISO 1328-2, but without other indication, that accuracy grade applies only to deviations of all elements according to clauses 6 and 7. However, by agreement, different tolerance limits may be specified using tables for any quantity.

A.5 Tables of radial deviation tolerances

The tabulated values in this annex are based on values calculated using the formulae in clause 7 with the criteria of A.2 and A.3. Total radial composite tolerance values are shown in table A.1 and tooth-to-tooth radial composite tolerance values in table A.2.

Table A.1 - Total radial composite tolerance, F_i''

Reference diameter d mm	Normal module m_n mm	Accuracy grade								
		4	5	6	7	8	9	10	11	12
		F_i'' µm								
$5 \le d \le 20$	$0,2 \le m_n \le 0,5$	7,5	11	15	21	30	42	60	85	120
	$0,5 < m_n \le 0,8$	8,0	12	16	23	33	46	66	93	131
	$0,8 < m_n \le 1,0$	9,0	12	18	25	35	50	70	100	141
	$1,0 < m_n \le 1,5$	10	14	19	27	38	54	76	108	153
	$1,5 < m_n \le 2,5$	11	16	22	32	45	63	89	126	179
	$2,5 < m_n \le 4,0$	14	20	28	39	56	79	112	158	223
$20 < d \le 50$	$0,2 \le m_n \le 0,5$	9,0	13	19	26	37	52	74	105	148
	$0,5 < m_n \le 0,8$	10	14	20	28	40	56	80	113	160
	$0,8 < m_n \le 1,0$	11	15	21	30	42	60	85	120	169
	$1,0 < m_n \le 1,5$	11	16	23	32	45	64	91	128	181
	$1,5 < m_n \le 2,5$	13	18	26	37	52	73	103	146	207
	$2,5 < m_n \le 4,0$	16	22	31	44	63	89	126	178	251
	$4,0 < m_n \le 6,0$	20	28	39	56	79	111	157	222	314
	$6,0 < m_n \le 10$	26	37	52	74	104	147	209	295	417
$50 < d \le 125$	$0,2 \le m_n \le 0,5$	12	16	23	33	46	66	93	131	185
	$0,5 < m_n \le 0,8$	12	17	25	35	49	70	98	139	197
	$0,8 < m_n \le 1,0$	13	18	26	36	52	73	103	146	206
	$1,0 < m_n \le 1,5$	14	19	27	39	55	77	109	154	218
	$1,5 < m_n \le 2,5$	15	22	31	43	61	86	122	173	244
	$2,5 < m_n \le 4,0$	18	25	36	51	72	102	144	204	288
	$4,0 < m_n \le 6,0$	22	31	44	62	88	124	176	248	351
	$6,0 < m_n \le 10$	28	40	57	80	114	161	227	321	454
$125 < d \le 280$	$0,2 \le m_n \le 0,5$	15	21	30	42	60	85	120	170	240
	$0,5 < m_n \le 0,8$	16	22	31	44	63	89	126	178	252
	$0,8 < m_n \le 1,0$	16	23	33	46	65	92	131	185	261
	$1,0 < m_n \le 1,5$	17	24	34	48	68	97	137	193	273
	$1,5 < m_n \le 2,5$	19	26	37	53	75	106	149	211	299
	$2,5 < m_n \le 4,0$	21	30	43	61	86	121	172	243	343
	$4,0 < m_n \le 6,0$	25	36	51	72	102	144	203	287	406
	$6,0 < m_n \le 10$	32	45	64	90	127	180	255	360	509
$280 < d \le 560$	$0,2 \le m_n \le 0,5$	19	28	39	55	78	110	156	220	311
	$0,5 < m_n \le 0,8$	20	29	40	57	81	114	161	228	323
	$0,8 < m_n \le 1,0$	21	29	42	59	83	117	166	235	332
	$1,0 < m_n \le 1,5$	22	30	43	61	86	122	172	243	344
	$1,5 < m_n \le 2,5$	23	33	46	65	92	131	185	262	370
	$2,5 < m_n \le 4,0$	26	37	52	73	104	146	207	293	414
	$4,0 < m_n \le 6,0$	30	42	60	84	119	169	239	337	477
	$6,0 < m_n \le 10$	36	51	73	103	145	205	290	410	580
$560 < d \le 1\,000$	$0,2 \le m_n \le 0,5$	25	35	50	70	99	140	198	280	396
	$0,5 < m_n \le 0,8$	25	36	51	72	102	144	204	288	408
	$0,8 < m_n \le 1,0$	26	37	52	74	104	148	209	295	417
	$1,0 < m_n \le 1,5$	27	38	54	76	107	152	215	304	429
	$1,5 < m_n \le 2,5$	28	40	57	80	114	161	228	322	455
	$2,5 < m_n \le 4,0$	31	44	62	88	125	177	250	353	499
	$4,0 < m_n \le 6,0$	35	50	70	99	141	199	281	398	562
	$6,0 < m_n \le 10$	42	59	83	118	166	235	333	471	665

Table A.2 - Tooth-to-tooth radial composite tolerance, f_i''

Reference diameter d mm	Normal module m_n mm	Accuracy grade								
		4	5	6	7	8	9	10	11	12
		F_i'' µm								
$5 \le d \le 20$	$0,2 \le m_n \le 0,5$	1,0	2,0	2,5	3,5	5,0	7,0	10	14	20
	$0,5 < m_n \le 0,8$	2,0	2,5	4,0	5,5	7,5	11	15	22	31
	$0,8 < m_n \le 1,0$	2,5	3,5	5,0	7,0	10	14	20	28	39
	$1,0 < m_n \le 1,5$	3,0	4,5	6,5	9,0	13	18	25	36	50
	$1,5 < m_n \le 2,5$	4,5	6,5	9,5	13	19	26	37	53	74
	$2,5 < m_n \le 4,0$	7,0	10	14	20	29	41	58	82	115
$20 < d \le 50$	$0,2 \le m_n \le 0,5$	1,5	2,0	2,5	3,5	5,0	7,0	10	14	20
	$0,5 < m_n \le 0,8$	2,0	2,5	4,0	5,5	7,5	11	15	22	31
	$0,8 < m_n \le 1,0$	2,5	3,5	5,0	7,0	10	14	20	28	40
	$1,0 < m_n \le 1,5$	3,0	4,5	6,5	9,0	13	18	25	36	51
	$1,5 < m_n \le 2,5$	4,5	6,5	9,5	13	19	26	37	53	75
	$2,5 < m_n \le 4,0$	7,0	10	14	20	29	41	58	82	116
	$4,0 < m_n \le 6,0$	11	15	22	31	43	61	87	123	174
	$6,0 < m_n \le 10$	17	24	34	48	67	95	135	190	269
$50 < d \le 125$	$0,2 \le m_n \le 0,5$	1,5	2,0	2,5	3,5	5,0	7,5	10	15	21
	$0,5 < m_n \le 0,8$	2,0	3,0	4,0	5,5	8,0	11	16	22	31
	$0,8 < m_n \le 1,0$	2,5	3,5	5,0	7,0	10	14	20	28	40
	$1,0 < m_n \le 1,5$	3,0	4,5	6,5	9,0	13	18	26	36	51
	$1,5 < m_n \le 2,5$	4,5	6,5	9,5	13	19	26	37	53	75
	$2,5 < m_n \le 4,0$	7,0	10	14	20	29	41	58	82	116
	$4,0 < m_n \le 6,0$	11	15	22	31	44	62	87	123	174
	$6,0 < m_n \le 10$	17	24	34	48	67	95	135	191	269
$125 < d \le 280$	$0,2 \le m_n \le 0,5$	1,5	2,0	2,5	3,5	5,5	7,5	11	15	21
	$0,5 < m_n \le 0,8$	2,0	3,0	4,0	5,5	8,0	11	16	22	32
	$0,8 < m_n \le 1,0$	2,5	3,5	5,0	7,0	10	14	20	29	41
	$1,0 < m_n \le 1,5$	3,0	4,5	6,5	9,0	13	18	26	36	52
	$1,5 < m_n \le 2,5$	4,5	6,5	9,5	13	19	27	38	53	75
	$2,5 < m_n \le 4,0$	7,5	10	15	21	29	41	58	82	116
	$4,0 < m_n \le 6,0$	11	15	22	31	44	62	87	124	175
	$6,0 < m_n \le 10$	17	24	34	48	67	95	135	191	270
$280 < d \le 560$	$0,2 \le m_n \le 0,5$	1,5	2,0	2,5	4,0	5,5	7,5	11	15	22
	$0,5 < m_n \le 0,8$	2,0	3,0	4,0	5,5	8,0	11	16	23	32
	$0,8 < m_n \le 1,0$	2,5	3,5	5,0	7,5	10	15	21	29	41
	$1,0 < m_n \le 1,5$	3,5	4,5	6,5	9,0	13	18	26	37	52
	$1,5 < m_n \le 2,5$	5,0	6,5	9,5	13	19	27	38	54	76
	$2,5 < m_n \le 4,0$	7,5	10	15	21	29	41	59	83	117
	$4,0 < m_n \le 6,0$	11	15	22	31	44	62	88	124	175
	$6,0 < m_n \le 10$	17	24	34	48	68	96	135	191	271
$560 < d \le 1\,000$	$0,2 \le m_n \le 0,5$	1,5	2,0	3,0	4,0	5,5	8,0	11	16	23
	$0,5 < m_n \le 0,8$	2,0	3,0	4,0	6,0	8,5	12	17	24	33
	$0,8 < m_n \le 1,0$	2,5	3,5	5,5	7,5	11	15	21	30	42
	$1,0 < m_n \le 1,5$	3,5	4,5	6,5	9,5	13	19	27	38	53
	$1,5 < m_n \le 2,5$	5,0	7,0	9,5	14	19	27	38	54	77
	$2,5 < m_n \le 4,0$	7,5	10	15	21	30	42	59	83	118
	$4,0 < m_n \le 6,0$	11	16	22	31	44	62	88	125	176
	$6,0 < m_n \le 10$	17	24	34	48	68	96	136	192	272

Annex B
(informative)
Allowable values of runout with tolerance tables

B.1 Purpose

This annex gives informative values and a method for applying the runout formula to develop tables of recommended limits.

B.2 Runout, F_r

The value of the runout, F_r, of the gear is the difference between the maximum and the minimum radial distance from the gear axis, of a probe (ball, cylinder, anvil) which is placed successively in each tooth space. During each check, the probe contacts both the right and left flanks at approximately mid tooth-depth. Figure B.1 shows an example of a runout diagram, in which the eccentricity is a portion of the runout (see ISO/TR 10064-2).

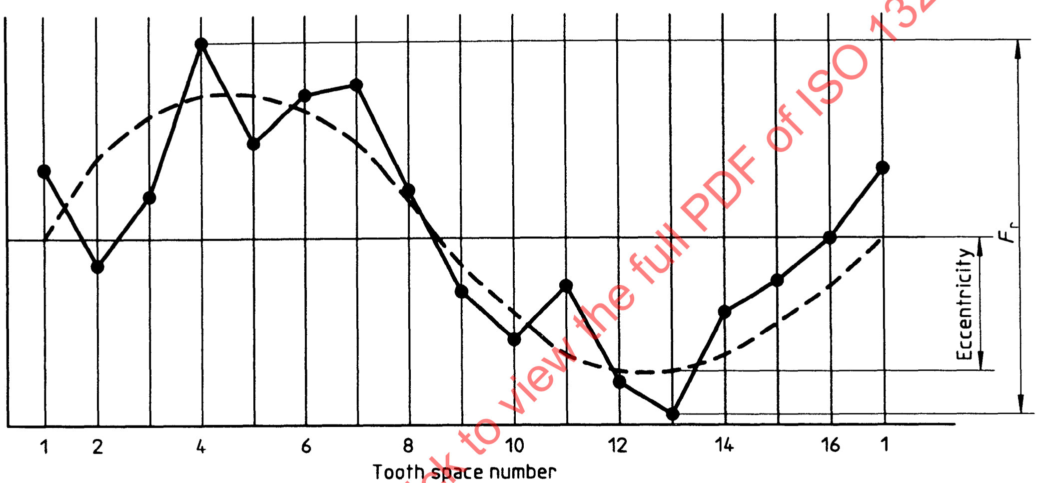

Figure B.1 - Runout diagram of a gear with 16 teeth

B.3 Recommended formula for runout tolerances, F_r, for accuracy grade 5

Use the actual values of module and diameter in the following formula.

$$F_r = 0{,}8\,F_p = 0{,}24\,m_n + 1{,}0\sqrt{d} + 5{,}6$$

The system of accuracy is the same as that for radial composite deviations. See 6.1.

B.4 Ranges of parameters

The recommended lower and upper range limits for applying the formula are:

a) For the reference diameter, d
5 / 20 / 50 / 125 / 280 / 560 / 1000 / 1600 / 2500 / 4000 / 6000 / 8000 / 10 000 mm

b) For the normal module, m_n
0,5 / 2,0 / 3,5 / 6 / 10 / 16 / 25 / 40 / 70 mm

When applying the formula of B.3 for a table of tolerances, the parameters m_n and d can be introduced as the geometrical mean values of the relevant range limits. If the actual module is 7, for example, the range limits are normally $m_n = 6$ and $m_n = 10$ and the table value calculated with $m_n = \sqrt{(6 \times 10)} = 7{,}746$.