

Tolerancing of bevel gears

Basic concepts

DIN
3965
 Part 1

Toleranzen für Kegelradverzahnungen; Grundlagen

Supersedes September 1981 edition.

In keeping with current practice in standards published by the International Organization for Standardization (ISO), a comma has been used throughout as the decimal marker.

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1 Field of application

This standard specifies tolerances for straight, skew and spiral bevel gears with and without axial offset, of modules 1 mm to 50 mm and with reference diameters up to 2500 mm.

2 Scope

To ensure compliance with all the functional requirements to be met by bevel gears, relating to smooth running, load bearing capacity, uniform angular transmission and operating life, it is essential that the errors of certain parameters of the tooth system be kept within given limits.

The sizes of the tolerances have been developed on principles similar to those applying to the tolerancing of circular fits. Thus, as for circular fits, tolerance classes have also been specified to a fineness which cannot be technically realized at present, but which is likely to represent the fineness possible in the future.

3 Symbols and quantities

a	dimension of tooth contact pattern, axial offset
c	dimension of tooth contact pattern
d	reference diameter; dimension of tooth contact pattern
d_m	mean reference diameter
d_B	test flange diameter
d_R	reference surface diameter
e	dimension of tooth contact pattern
f	individual error; dimension for tooth contact pattern
f_a	axes intersection point error
f_i	tangential tooth-to-tooth composite error

f'_k	short-wave component of tangential composite error
f'_l	long-wave component of tangential composite error
f_p	adjacent pitch error
f_u	difference between adjacent pitches
f_Σ	shaft angle error
m	module
m_{mn}	normal module at mean cone distance
t_B	apex to back distance
t_E	tip distance
t_H	auxiliary plane distance
u	gear ratio
B	bore diameter
F	composite and cumulative errors
F_i	working deviation
F'_i	tangential composite error
F_p	cumulative pitch error
F_r	radial run-out
F_{rd}	radial run-out of test flange of diameter d_B , relative to gear axis
F_{rs}	axial run-out of reference face F_1 , relative to gear axis
F_1, F_2	reference faces
K_1 to K_9	auxiliary quantities
R_m	mean cone distance
δ	reference cone angle
δ_a	tip angle
ϵ_α	transverse contact ratio
ϵ_β	overlap ratio
ϵ_γ	total contact ratio
φ	tolerance increment
Σ	shaft angle

Continued on pages 2 to 4

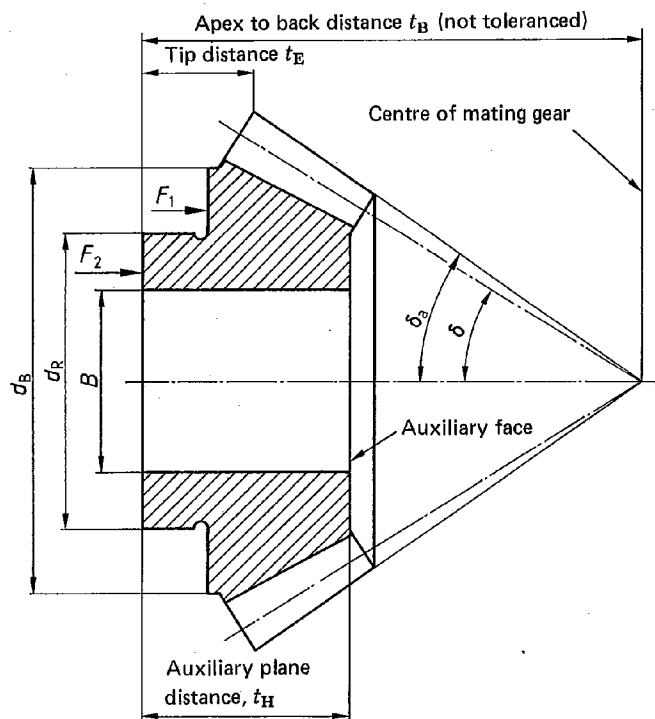


Figure 1. Gear blank and mounting tolerances (see also DIN 3971 for definitions)

4 Tolerances on gear blank dimensions (applying to gear blank prior to cutting)

The tolerance requirements for the test faces and test diameters necessary for gauging, manufacture and assembly shall also be met.

The principal dimensions of a bevel gear are indicated in figure 1. In particular cases, further dimensions may be toleranced.

The use of the following formula is recommended for tolerancing the radial run-out and axial run-out:

$$F_{rd} = F_{rs} = 0,2 \cdot F_r$$

This applies by analogy to all cases in which a test flange is refinished after heat treatment.

Limit deviations of tip angle, δ_a :

for tolerance classes up to 6:	$\begin{matrix} + 6' \\ 0 \end{matrix}$
for tolerance classes 7 to 9:	$\begin{matrix} + 8' \\ 0 \end{matrix}$
for tolerance classes 10 and upwards:	$\begin{matrix} + 10' \\ 0 \end{matrix}$

Tolerance on bore diameter or shank diameter, B :

for tolerance classes 5 and 6:	IT 5;
for tolerance classes 7 to 9:	IT 6;
for tolerance classes 10 and upwards:	IT 7.

5 Structure of the gear tolerance system

5.1 Relationship between tolerances

The tolerance system for bevel gears is similar to that developed for cylindrical gears (see DIN 3961). An attempt has been made to ensure that a particular gear quality roughly covers the average values of all errors and

deviations from the target manufacturing quality. However, it frequently happens that differences in requirements and manufacturing processes cause changes in the relationship between individual errors (see clause 6).

The tolerances given in DIN 3965 Parts 2 to 4 have been specified as far as possible on the basis of existing manufacturing experience.

For the single flank working test, tolerances have been given for f'_i and f'_k , as alternatives to those given for F'_i and f'_i (see DIN 3965 Part 3). To avoid inconsistency, the tolerances for F'_i and f'_i on the one hand, and for f'_i and f'_k on the other hand, shall not be applied simultaneously.

5.2 Errors and deviations of parameters

For the purposes of this standard, individual errors, f , are deviations of individual parameters of the tooth system (such as pitch) from the desired values, whilst composite and cumulative errors, F , allow for the effect of several individual errors.

See DIN 3971 for definitions of parameters.

Some of the possible errors or deviations (see DIN 3971) cannot be determined with sufficient accuracy at the present time. Others, such as radial composite errors should not be used for assessment purposes, since the measurement of these errors has to be carried out under conditions involving a displacement of the tooth contact pattern. The measurement may only be used for determining the radial run-out.

5.3 Tolerance classes for bevel gears

The tolerance system for bevel gears as specified in this standard covers 12 tolerance classes. In present-day manufacturing practice it is not possible to achieve the finer tolerance classes. They are included only for the

sake of completeness. The tolerances are multiplied by an increment, φ , at each step. Values of φ are given in subclause 5.4.

The limit values of the reference diameter and normal module ranges have been taken from the R 20 preferred number series specified in DIN 323 Part 1.

5.4 Calculation of tolerances

Formulae are stated below for calculating the tolerances for which numerical values have been given in DIN 3965 Parts 2 and 3, taking tolerance class 4 as the basis.

Values of m_{mn} and d_m are given in mm, tolerances, in μm .

The reference circle and normal module are each related to the mean reference cone distance.

When calculating the tolerances from the formulae, the geometrical means of the corresponding range limits shall be substituted for the actual values of m_{mn} and d_m . For figures smaller than 10, the tolerances so calculated shall be rounded to the nearest value that gives an integer when divided by 0,5, whilst figures greater than 10 shall be rounded to the nearest integer.

a) Adjacent pitch error:

$$f_p = 4 + 0,315 (m_{mn} + 0,25 \sqrt{d_m})$$

with $\varphi = 1,4$ up to tolerance class 8 and
 $\varphi = 1,6$ from tolerance class 8.

b) Difference between adjacent pitches:

$$f_u = 5 + 0,4 (m_{mn} + 0,25 \sqrt{d_m})$$

with $\varphi = 1,4$ up to tolerance class 8 and
 $\varphi = 1,6$ from tolerance class 8.

c) Cumulative pitch error:

$$F_p = 7,25 \cdot m_{mn}^{1/7} \cdot d_m^{4/21}$$

with $\varphi = 1,4$ up to tolerance class 8 and
 $\varphi = 1,6$ from tolerance class 8.

d) Radial run-out:

$$F_r = 1,68 + 2,18 \sqrt{m_{mn}} + (2,3 + 1,2 \log m_{mn}) \cdot d_m^{1/4}$$

with $\varphi = 1,4$ up to tolerance class 12.

e) Tangential composite error 1):

$$F_t' = 0,8 \cdot (K_1 + K_2)$$

$$K_1 = 7,25 \cdot m_{mn}^{1/7} \cdot d_m^{4/21}$$

$$K_2 = \sqrt{K_3^2 + K_4^2}$$

$$K_3 = 2,5 + 0,25 (m_{mn} + 3 \sqrt{m_{mn}})$$

$$K_4 = 1,5 + 0,25 (m_{mn} + 9 \sqrt{m_{mn}})$$

with $\varphi = 1,4$ up to tolerance class 8 and
 $\varphi = 1,6$ from tolerance class 8.

f) Tangential tooth-to-tooth composite error 1):

$$f_t' = 0,7 \cdot (K_5 + K_2)$$

$$K_5 = 4 + 0,315 (m_{mn} + 0,25 \sqrt{d_m})$$

(see under item e) for K_2)

with $\varphi = 1,4$ up to tolerance class 8 and
 $\varphi = 1,6$ from tolerance class 8.

g) Long-wave component of tangential composite error 1):

$$f_l' = 10 + 1,13 \sqrt{d_m}$$

with $\varphi = 1,4$ up to tolerance class 8 and
 $\varphi = 1,6$ from tolerance class 8.

h) Short-wave component of tangential composite error 1):

$$f_k' = K_6 \cdot (K_7 + 0,2 f_p)$$

$$K_6 = 1/\varepsilon_\gamma \text{ for } \varepsilon_\gamma = \varepsilon_\alpha + \varepsilon_\beta < 2$$

$$K_6 = 1/2 \text{ for } \varepsilon_\gamma = \varepsilon_\alpha + \varepsilon_\beta \geq 2$$

$$K_7 = \sqrt{K_8^2 + K_9^2}$$

$$K_8 = 2 + 2,5 \sqrt{m_{mn}} + 0,15 \sqrt{d_m}$$

$$K_9 = 1,5 + 2 \sqrt{m_{mn}} + 0,12 \sqrt{d_m}$$

(see under item a) for f_p)

with $\varphi = 1,4$ up to tolerance class 8 and

$\varphi = 1,6$ from tolerance class 8.

6 Tolerancing

When selecting the tolerances, both functional and production requirements shall be taken into account. The tolerances selected shall apply to the whole gauging area, which, unless otherwise specified, is identical with the theoretical zone of contact.

Bevel gears are often manufactured, gauged and installed pairwise. In such cases, larger errors are permitted for parameters such as pressure angle, helix angle and tooth thickness than are permitted for single bevel gears.

Apart from specifying a particular tolerance class involving a specific allocation of tolerances, individual errors derived from different tolerance classes may be grouped together to make up a requirement.

7 Additional gauging methods

Gauging shall be carried out on the lines of DIN 3961. For some errors, adequate gauging methods are not as yet available.

7.1 Radial run-out

The radial run-out shall be measured perpendicular to the reference cone envelope.

Unless otherwise agreed, the radial run-out shall be measured at mid-facewidth, recommended contact with the gauging device being made at mid-depth of tooth.

7.2 Pitch error

Measurement of the pitch error is to be made preferentially at mid-facewidth and approximately at mid-depth of tooth.

7.3 Tangential composite error

Measurement of the tangential composite error is to be made on the right-hand and left-hand flanks respectively.

The formulae given under items g) and h) above apply for the gauging of a bevel gear with the aid of a master bevel gear. In most cases, however, gauging is made with the gear paired with its mating gear. Taking the quadratic error propagation theorem as the basis, the following tolerance is found for the working deviation of the bevel gear pair:

$$F_1 = \sqrt{F_{t1}^2 + F_{t2}^2}$$

This formulae also applies to the tangential composite error, the tangential tooth-to-tooth composite error and the short-wave component of the tangential composite error.

Assuming a gear ratio, u , of 1, the long-wave component of the tangential composite error can be taken as $f_l' = f_{l1}' = f_{l2}'$ if, by appropriate pairing and marking of the bevel gears, the errors for the individual gears are so

1) See subclause 7.3.

disposed that, in absolute terms, their sum is less than or equal to the biggest long-wave component of the tangential composite error for the individual gear 2).

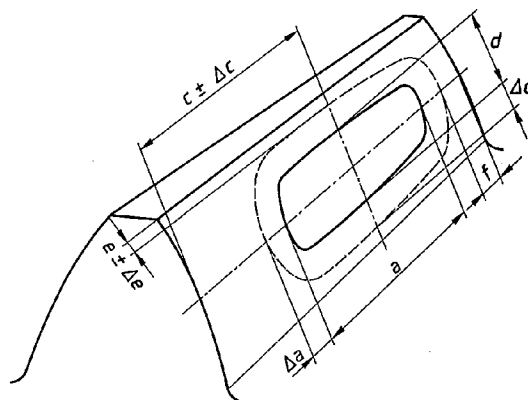
The expression $f'_1 = \sqrt{f_{11}^2 + f_{12}^2}$ shall apply to gear ratios unequal to 1. For calculating the tolerances for a particular bevel gear pair, the rounded values of the individual gears shall be used.

8 Tooth contact pattern

The tooth contact pattern shall be determined with the gears at their as installed distance, running under light test load and with approximately $5\text{ }\mu\text{m}$ film thickness of test medium (such as spotting lacquer or paste) applied. During the contact pattern test it is also possible to check the displacement capability of crowned teeth by deliberate vertical and horizontal shifting of the axes. Figure 2 shows an example of dimensioning the tooth contact pattern in terms of position and size. DIN 3971 gives examples of types of tooth contact pattern usually obtained.

Apart from the tooth contact pattern under test conditions, the pattern obtained with the gears in their

as installed condition shall also be considered for given load increments.



Tooth end

Figure 2. Dimensioning of tooth contact patterns of bevel gears (all dimensions applying to the projected tooth flank).

Standards referred to

DIN 323 Part 1	Preferred number and series of preferred numbers; basic values, calculated values, rounded values
DIN 3961	Tolerances for cylindrical gear teeth; bases
DIN 3965 Part 2	Tolerancing of bevel gears; tolerances for individual parameters
DIN 3965 Part 3	Tolerancing of bevel gears; tolerances for composite and cumulative errors
DIN 3965 Part 4	Tolerancing of bevel gears; tolerances for shaft angle errors and axes intersection point deviation
DIN 3971	Terminology and parameters for bevel gears and bevel gear pairs

Previous editions

DIN 3965 Part 1: 09.81.

Amendments

The following amendments have been made in comparison with the September 1981 edition.

- The status of the standard is no longer that of a preliminary standard.
- The symbols denoting the components of the tangential composite errors, f'_p and F'_p , have been altered to f'_k and f'_l respectively.
- The standard has been editorially revised.

Explanatory notes

DIN 3965 Parts 1 to 4 only provide information on the gear blank and on errors that can be measured by conventional means.

The finer tolerances cannot yet be measured under production conditions. Nevertheless, the tables shown in DIN 3965 Parts 2 and 3 cover all diameter ranges, the fields crossed out indicating that for these diameter ranges no tolerances can currently be specified.

In future, more advanced gauging and calculation methods may allow errors to be dealt with, which have not as yet been specified, such as profile errors, and more information to be provided regarding the accuracy of bevel gears.

The parameters (see clause 3) have been defined in DIN 3971, the aim of which was to include as many quantities as possible without regard for the current feasibility or difficulty of their measurement.

The structure of the tolerance system for bevel gears has been brought into line with that for cylindrical gears. The relationship between the parameters are the same, except for an overall shift in the tolerance system by one tolerance class. The tolerance system proposed may thus serve as an adequate basis for international discussion.

International Patent Classification

F 16 H 55/08

F 16 H 55/17

2) This is caused by the generally periodic behaviour of the long-wave component of the tangential composite error associated with one revolution of the gear.

Tolerancing of bevel gears

Tolerances for individual parameters

DIN
3965
 Part 2

Toleranzen für Kegelradverzahnungen;
 Toleranzen für Abweichungen einzelner Bestimmungsgrößen

Supersedes September 1981 edition.

In keeping with current practice in standards published by the International Organization for Standardization (ISO), a comma has been used throughout as the decimal marker.

1 Scope and field of application

The parameters for which tolerances have been given in this standard are defined in DIN 3971. The tolerances specified apply for straight, skew and spiral bevel gears with and without axial offset. See also DIN 3965 Part 1.

2 Tolerances

This standard specifies tolerances for the following parameters:

- adjacent pitch error, f_p ;
- difference between adjacent pitches, f_u ;
- cumulative pitch error, F_p ;
- deviation from radial run-out, F_r .

Continued on pages 2 to 16

Normal module, m_{mn} : 1 mm to 2 mmTolerances in μm

Mean reference diameter, d_m , in mm	Error f_p for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10	1,5	2,5	3,5	4,5	6,5	9,0	13	18	28	45	72	115
Over 10 up to 50	2,0	2,5	3,5	5,0	6,5	9,5	13	19	30	47	76	121
Over 50 up to 125	2,0	2,5	3,5	5,0	7,0	10	14	20	32	51	91	130
Over 125 up to 280	2,0	3,0	4,0	5,5	7,5	11	15	21	34	54	87	139
Over 280 up to 560												
Over 560 up to 1000												
Over 1000 up to 1600												
Over 1600 up to 2500												

Mean reference diameter, d_m , in mm	Error f_u for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10	2,0	3,0	4,0	5,5	8,0	11	16	22	35	56	90	145
Over 10 up to 50	2,0	3,0	4,5	6,0	8,5	12	17	23	37	59	95	152
Over 50 up to 125	2,5	3,5	4,5	6,5	9,0	13	18	25	40	63	102	163
Over 125 up to 280	2,5	3,5	5,0	7,0	9,5	14	19	27	43	68	109	175
Over 280 up to 560												
Over 560 up to 1000												
Over 1000 up to 1600												
Over 1600 up to 2500												

Normal module, m_{mn} : 1 mm to 2 mmTolerances in μm

Mean reference diameter, d_m , in mm	Error F_p for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10	3,5	5,0	7,0	9,5	13	19	26	36	58	93	149	239
Over 10 up to 50	5,0	7,0	10	14	19	27	38	53	85	135	217	347
Over 50 up to 125	6,5	9,0	13	18	25	34	48	67	108	172	276	441
Over 125 up to 280	7,5	11	15	21	29	40	57	79	127	203	325	520
Over 280 up to 560												
Over 560 up to 1000												
Over 1000 up to 1600												
Over 1600 up to 2500												

Mean reference diameter, d_m , in mm	Error F_r for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10	3,0	4,0	5,5	7,5	11	15	21	29	41	57	80	112
Over 10 up to 50	3,5	5,0	7,0	9,5	14	19	27	37	52	73	102	143
Over 50 up to 125	4,5	6,0	8,5	12	16	23	32	45	63	88	123	172
Over 125 up to 280	5,0	7,0	9,5	13	19	26	37	52	72	101	142	198
Over 280 up to 560												
Over 560 up to 1000												
Over 1000 up to 1600												
Over 1600 up to 2500												

Normal module, m_{mn} : over 2 mm up to and including 3,55 mmTolerances in μm

Mean reference diameter, d_m , in mm	Error f_p for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10												
Over 10 up to 50	2,0	2,5	3,5	5,0	7,5	10	14	20	32	51	82	131
Over 50 up to 125	2,0	3,0	4,0	5,5	8,0	11	15	21	34	54	87	139
Over 125 up to 280	2,0	3,0	4,0	6,0	8,5	12	16	23	36	58	93	149
Over 280 up to 560	2,5	3,5	4,5	6,5	9,0	13	18	25	39	63	101	161
Over 560 up to 1000												
Over 1000 up to 1600												
Over 1600 up to 2500												

Mean reference diameter, d_m , in mm	Error f_u for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10												
Over 10 up to 50	2,5	3,5	4,5	6,5	9,0	13	18	25	40	64	103	165
Over 50 up to 125	2,5	3,5	5,0	7,0	9,5	14	19	27	43	68	109	175
Over 125 up to 280	2,5	4,0	5,5	7,5	10	15	20	29	46	73	117	187
Over 280 up to 560	3,0	4,0	6,0	8,0	11	16	22	31	50	79	127	203
Over 560 up to 1000												
Over 1000 up to 1600												
Over 1600 up to 2500												

Normal module, m_{mn} : over 2 mm up to and including 3,55 mmTolerances in μm

Mean reference diameter, d_m , in mm	Error F_p for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10												
Over 10 up to 50	5,5	7,5	11	15	21	30	41	58	93	148	237	379
Over 50 up to 125	7,0	10	14	19	27	38	53	74	118	189	302	483
Over 125 up to 280	8,0	12	16	23	32	44	62	87	139	222	355	569
Over 280 up to 560	9,5	13	19	26	36	51	72	100	160	256	410	656
Over 560 up to 1000												
Over 1000 up to 1600												
Over 1600 up to 2500												

Mean reference diameter, d_m , in mm	Error F_r for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10												
Over 10 up to 50	4,0	6,0	8,0	11	16	22	31	44	61	85	120	168
Over 50 up to 125	5,0	7,0	9,5	14	19	27	37	52	73	103	144	201
Over 125 up to 280	5,5	8,0	11	16	22	31	43	60	84	118	165	231
Over 280 up to 560	6,5	9,0	13	18	25	35	49	68	96	134	187	262
Over 560 up to 1000												
Over 1000 up to 1600												
Over 1600 up to 2500												

Normal module, m_{mn} : over 3,55 mm up to and including 6 mmTolerances in μm

Mean reference diameter, d_m , in mm	Error f_p for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10												
Over 10 up to 50	2,0	3,0	4,0	6,0	8,0	11	16	22	36	57	92	147
Over 50 up to 125	2,0	3,0	4,5	6,0	8,5	12	17	24	38	61	97	155
Over 125 up to 280	2,5	3,5	4,5	6,5	9,0	13	18	25	40	64	103	164
Over 280 up to 560	2,5	3,5	5,0	7,0	10	14	19	27	43	69	110	177
Over 560 up to 1000	3,0	4,0	5,5	7,5	11	15	21	29	47	75	120	192
Over 1000 up to 1600	3,0	4,0	6,0	8,5	12	16	23	32	51	81	130	208
Over 1600 up to 2500												

Mean reference diameter, d_m , in mm	Error f_u for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10												
Over 10 up to 50	2,5	3,5	5,0	7,5	10	14	20	28	45	72	115	184
Over 50 up to 125	3,0	4,0	5,5	7,5	11	15	21	30	48	76	122	195
Over 125 up to 280	3,0	4,0	6,0	8,0	11	16	23	32	50	81	129	207
Over 280 up to 560	3,0	4,5	6,5	9,0	12	17	24	34	54	87	139	222
Over 560 up to 1000	3,5	5,0	7,0	9,5	13	19	26	37	59	94	151	241
Over 1000 up to 1600	4,0	5,5	7,5	10	15	20	29	40	64	102	164	262
Over 1600 up to 2500												

Normal module, m_{mn} : over 3,55 mm up to and including 6 mmTolerances in μm

Mean reference diameter, d_m , in mm	Error F_p for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10												
Over 10 up to 50	6,0	8,5	12	16	23	32	45	63	100	160	257	410
Over 50 up to 125	7,5	11	15	21	29	41	57	80	127	204	326	522
Over 125 up to 280	9,0	12	17	24	34	48	67	94	150	240	384	615
Over 280 up to 560	10	14	20	28	39	55	77	108	173	277	443	710
Over 560 up to 1000	12	16	23	32	45	62	87	122	196	313	501	801
Over 1000 up to 1600	13	18	25	35	49	69	96	135	216	346	553	885
Over 1600 up to 2500												

Mean reference diameter, d_m , in mm	Error F_t for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10												
Over 10 up to 50	5,5	6,5	9,5	13	18	26	36	50	70	99	138	193
Over 50 up to 125	5,5	8,0	11	16	22	31	43	60	84	117	164	230
Over 125 up to 280	6,5	9,0	13	18	25	35	49	68	96	134	188	263
Over 280 up to 560	7,5	10	14	20	28	40	55	78	109	152	213	298
Over 560 up to 1000	8,0	12	16	23	32	44	62	87	121	170	238	333
Over 1000 up to 1600	9,0	13	18	25	35	49	68	95	134	187	262	366
Over 1600 up to 2500												

Normal module, m_{mn} : over 6 mm up to and including 10 mmTolerances in μm

Mean reference diameter, d_m , in mm	Error f_p for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10												
Over 10 up to 50	2,5	3,5	5,0	7,0	9,5	13	19	26	42	67	107	172
Over 50 up to 125	2,5	3,5	5,0	7,0	10	14	20	27	44	70	112	180
Over 125 up to 280	2,5	4,0	5,5	7,5	11	15	21	29	46	74	118	189
Over 280 up to 560	3,0	4,0	5,5	8,0	11	16	22	31	49	79	126	202
Over 560 up to 1000	3,0	4,5	6,0	8,5	12	17	24	33	53	85	135	216
Over 1000 up to 1600	3,5	4,5	6,5	9,0	13	18	25	35	57	91	145	233
Over 1600 up to 2500	3,5	5,0	7,0	10	14	20	27	38	61	98	157	251

Mean reference diameter, d_m , in mm	Error f_a for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10												
Over 10 up to 50	3,0	4,5	6,0	8,5	12	17	24	33	53	84	135	216
Over 50 up to 125	3,5	4,5	6,5	9,0	13	18	25	35	55	88	141	226
Over 125 up to 280	3,5	5,0	7,0	9,5	13	19	26	36	58	93	149	238
Over 280 up to 560	3,5	5,0	7,0	10	14	20	28	39	62	99	159	254
Over 560 up to 1000	4,0	5,5	7,5	11	15	21	30	42	67	107	170	273
Over 1000 up to 1600	4,0	6,0	8,5	12	16	23	32	45	72	115	183	293
Over 1600 up to 2500	4,5	6,5	9,0	13	18	25	34	48	77	124	198	316

Normal module, m_{mn} : over 6 mm up to and including 10 mmTolerances in μm

Mean reference diameter, d_m , in mm	Error F_p for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10												
Over 10 up to 50	6,5	9,0	13	18	25	34	48	67	108	173	276	442
Over 50 up to 125	8,0	11	16	22	31	44	61	86	137	220	351	562
Over 125 up to 280	9,5	13	19	26	37	52	72	101	162	259	414	662
Over 280 up to 560	11	15	22	30	42	59	83	117	187	298	478	764
Over 560 up to 1000	12	17	24	34	48	67	94	132	211	337	539	863
Over 1000 up to 1600	14	19	27	38	53	74	104	145	233	372	596	953
Over 1600 up to 2500	15	21	30	41	58	81	113	159	254	406	650	1040

Mean reference diameter, d_m , in mm	Error F_r for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10												
Over 10 up to 50	5,5	7,5	11	15	21	30	41	58	81	113	159	222
Over 50 up to 125	6,5	9,0	13	18	25	35	49	68	96	134	187	262
Over 125 up to 280	7,5	10	14	20	28	40	55	78	109	152	213	298
Over 280 up to 560	8,5	12	16	23	32	45	62	87	122	171	240	336
Over 560 up to 1000	9,0	13	18	25	35	50	70	97	136	191	267	374
Over 1000 up to 1600	10	14	20	28	39	55	76	107	150	210	293	411
Over 1600 up to 2500	11	15	22	30	42	59	83	116	163	228	319	447

Normal module, m_{mn} : over 10 mm up to and including 16 mmTolerances in μm

Mean reference diameter, d_m , in mm	Error f_p for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10												
Over 10 up to 50												
Over 50 up to 125	3,0	4,5	6,0	8,5	12	17	24	33	53	85	137	219
Over 125 up to 280	3,5	4,5	6,5	9,0	13	18	25	35	56	89	143	228
Over 280 up to 560	3,5	5,0	7,0	9,5	13	19	26	37	59	94	150	240
Over 560 up to 1000	3,5	5,0	7,0	10	14	20	28	39	62	100	160	255
Over 1000 up to 1600	4,0	5,5	7,5	11	15	21	30	41	66	106	170	272
Over 1600 up to 2500	4,0	6,0	8,0	12	16	23	32	44	71	113	181	290

Mean reference diameter, d_m , in mm	Error f_a for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10												
Over 10 up to 50												
Over 50 up to 125	4,0	5,5	8,0	11	15	21	30	42	67	108	172	276
Over 125 up to 280	4,0	6,0	8,0	11	16	22	31	44	70	112	180	288
Over 280 up to 560	4,5	6,0	8,5	12	17	24	33	46	74	119	190	303
Over 560 up to 1000	4,5	6,5	9,0	13	18	25	35	49	79	126	201	322
Over 1000 up to 1600	5,0	7,0	9,5	14	19	27	37	52	84	134	214	343
Over 1600 up to 2500	5,5	7,5	10	15	20	28	40	56	89	143	229	366

Normal module, m_{mn} : over 10 mm up to and including 16 mmTolerances in μm

Mean reference diameter, d_m , in mm	Error F_p for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10												
Over 10 up to 50												
Over 50 up to 125	8,5	12	17	24	34	47	66	92	147	236	377	603
Over 125 up to 280	10	14	20	28	40	55	77	108	173	278	444	710
Over 280 up to 560	12	17	23	33	46	64	89	125	200	320	512	820
Over 560 up to 1000	13	19	26	37	51	72	101	141	226	361	578	925
Over 1000 up to 1600	15	21	29	41	57	80	111	156	250	399	639	1022
Over 1600 up to 2500	16	23	32	44	62	87	122	170	272	436	697	1116

Mean reference diameter, d_m , in mm	Error F_r for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10												
Over 10 up to 50												
Over 50 up to 125	7,5	10	14	20	28	40	56	78	109	152	213	299
Over 125 up to 280	8,5	12	16	23	32	45	63	88	123	172	241	337
Over 280 up to 560	9,5	13	18	26	36	50	70	98	138	193	270	378
Over 560 up to 1000	10	14	20	28	40	56	78	109	153	214	299	419
Over 1000 up to 1600	11	16	22	31	43	61	85	119	167	234	327	458
Over 1600 up to 2500	12	17	24	34	47	66	92	129	181	253	355	497

Normal module, m_{mn} : over 16 mm up to and including 25 mmTolerances in μm

Mean reference diameter, d_m , in mm	Error f_p for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10												
Over 10 up to 50												
Over 50 up to 125	4,0	5,5	8,0	11	15	22	30	42	68	108	173	277
Over 125 up to 280	4,0	6,0	8,0	11	16	22	31	44	70	112	179	286
Over 280 up to 560	4,5	6,0	8,5	12	17	23	33	46	73	117	187	299
Over 560 up to 1000	4,5	6,5	9,0	12	17	24	34	48	77	122	196	314
Over 1000 up to 1600	5,0	6,5	9,5	13	18	26	36	50	81	129	206	330
Over 1600 up to 2500	5,0	7,0	10	14	19	27	38	53	85	136	217	348

Mean reference diameter, d_m , in mm	Error f_u for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10												
Over 10 up to 50												
Over 50 up to 125	5,0	7,0	10	14	19	27	38	53	85	137	219	350
Over 125 up to 280	5,0	7,5	10	14	20	28	39	55	88	141	226	362
Over 280 up to 560	5,5	7,5	11	15	21	29	41	58	92	147	236	377
Over 560 up to 1000	5,5	8,0	11	16	22	31	43	60	97	155	248	396
Over 1000 up to 1600	6,0	8,5	12	17	23	32	45	64	102	163	261	417
Over 1600 up to 2500	6,5	9,0	12	17	24	34	48	67	107	172	275	440

Normal module, m_{mn} : over 16 mm up to and including 25 mmTolerances in μm

Mean reference diameter, d_m , in mm	Error F_p for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10												
Over 10 up to 50												
Over 50 up to 125	9,5	13	18	26	36	50	70	98	157	251	402	644
Over 125 up to 280	11	15	22	30	42	59	83	116	185	296	474	759
Over 280 up to 560	13	18	25	35	49	68	95	134	214	342	547	875
Over 560 up to 1000	14	20	28	39	55	77	108	151	241	386	617	988
Over 1000 up to 1600	16	22	31	43	61	85	119	167	267	426	682	1092
Over 1600 up to 2500	17	24	34	47	66	93	130	182	291	465	744	1191

Mean reference diameter, d_m , in mm	Error F_r for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10												
Over 10 up to 50												
Over 50 up to 125	8,5	12	16	23	32	45	63	88	123	173	242	339
Over 125 up to 280	9,5	13	18	26	36	50	71	99	138	194	271	379
Over 280 up to 560	10	15	20	29	40	56	79	110	154	216	302	423
Over 560 up to 1000	12	16	23	32	44	62	87	121	170	238	333	467
Over 1000 up to 1600	13	18	25	34	48	68	95	132	185	259	363	509
Over 1600 up to 2500	14	19	27	37	52	73	102	143	200	280	393	550

Normal module, m_{mn} : over 25 mm up to and including 50 mmTolerances in μm

Mean reference diameter, d_m , in mm	Error f_p for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10												
Over 10 up to 50												
Over 50 up to 125												
Over 125 up to 280	6,0	8,5	12	16	23	32	44	62	100	159	255	408
Over 280 up to 560	6,0	8,5	12	17	23	33	46	64	103	164	263	421
Over 560 up to 1000	6,5	9,0	12	17	24	34	47	66	106	170	272	435
Over 1000 up to 1600	6,5	9,0	13	18	25	35	49	69	110	176	282	452
Over 1600 up to 2500	7,0	9,5	13	19	26	37	51	72	115	183	294	470

Mean reference diameter, d_m , in mm	Error f_u for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10												
Over 10 up to 50												
Over 50 up to 125												
Over 125 up to 280	7,5	10	15	21	29	40	56	79	126	202	323	516
Over 280 up to 560	7,5	11	15	21	30	41	58	81	130	208	333	532
Over 560 up to 1000	8,0	11	16	22	31	43	60	84	134	215	344	551
Over 1000 up to 1600	8,5	12	16	23	32	44	62	87	140	223	357	571
Over 1600 up to 2500	8,5	12	17	24	33	46	65	91	145	232	372	595

Normal module, m_{mn} : over 25 mm up to and including 50 mmTolerances in μm

Mean reference diameter, d_m , in mm	Error F_p for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10												
Over 10 up to 50												
Over 50 up to 125												
Over 125 up to 280	12	17	23	33	46	64	90	126	201	321	514	823
Over 280 up to 560	14	19	27	38	53	74	103	145	232	371	593	949
Over 560 up to 1000	16	22	30	43	60	83	117	163	262	419	670	1071
Over 1000 up to 1600	17	24	34	47	66	92	129	181	289	463	740	1184
Over 1600 up to 2500	19	26	37	51	72	101	141	197	315	505	808	1292

Mean reference diameter, d_m , in mm	Error F_r for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10												
Over 10 up to 50												
Over 50 up to 125												
Over 125 up to 280	11	15	21	30	42	59	82	115	161	226	316	443
Over 280 up to 560	12	17	24	33	46	65	91	128	179	250	350	490
Over 560 up to 1000	13	19	26	36	51	71	100	140	196	274	384	537
Over 1000 up to 1600	14	20	28	39	55	77	108	152	212	297	416	582
Over 1600 up to 2500	15	22	30	42	59	83	116	163	228	320	447	626

Standards referred to

DIN 3965 Part 1 Tolerancing of bevel gears; basic concepts

DIN 3971 Terminology and parameters for bevel gears and bevel gear pairs

Previous editions

DIN 3965 Part 2: 09.81.

Amendments

The following amendments have been made in comparison with the September 1981 edition.

- a) The status of the standard is no longer that of a preliminary standard.
- b) The standard has been editorially revised.

Explanatory notes

DIN 3965 Parts 1 to 4 provide only information on the gear blank and on errors that can be measured by conventional means.

The finer tolerances cannot yet be measured under production conditions. Nevertheless, the tables shown in DIN 3965 Parts 2 and 3 cover all diameter ranges, the fields crossed out indicating that for these diameter ranges no tolerances can currently be specified.

In futurè, more advanced gauging and calculation methods may allow errors to be dealt with, which have not as yet been specified, such as profile errors, and more information to be provided regarding the accuracy of bevel gears.

The parameters (see clause 3) have been defined in DIN 3971, the aim of which was to include as many quantities as possible without regard for the current feasibility or difficulty of their measurement.

The structure of the tolerance system for bevel gears has been brought into line with that for cylindrical gears. The relationship between the parameters are the same, except for an overall shift in the tolerance system by one tolerance class. The tolerance system proposed may thus serve as an adequate basis for international discussion.

International Patent Classification

F 16 H 55/08

F 16 H 55/17

Tolerancing of bevel gears

Tolerances for tangential composite errors

DIN
3965
Part 3

Toleranzen für Kegelradverzahnungen;
Toleranzen für Wälzabweichungen

Supersedes September 1981 edition.

In keeping with current practice in standards published by the International Organization for Standardization (ISO), a comma has been used throughout as the decimal marker.

1 Scope and field of application

The parameters for which tolerances have been given in this standard are defined in DIN 3971. The tolerances specified apply for straight, skew and spiral bevel gears with and without axial offset. See also DIN 3965 Part 1.

2 Tolerances

This standard specifies tolerances for the following parameters:

- tangential composite error, F_i' ;
- tangential tooth-to-tooth composite error, f_i' ;
- long-wave component of tangential composite error, f_{li}' ;
- short-wave component of tangential composite error, f_{sk}' .

f_{sk}' is obtained by multiplying the relevant tabulated value by K_6 , which is a function of the total overlap, ε_γ , and is given by

$$K_6 = \frac{1}{\varepsilon_\gamma} \text{ for } \varepsilon_\gamma \text{ less than 2 and}$$

$$K_6 = 0,5 \text{ for } \varepsilon_\gamma \text{ not less than 2.}$$

Continued on pages 2 to 16

Normal module, m_{mn} : 1 mm to 2 mmTolerances in μm

Mean reference diameter, d_m , in mm	Error F'_i for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10	4,5	6,5	9,0	12	17	24	34	47	76	121	193	309
Over 10 up to 50	5,5	8,0	11	16	22	31	43	60	97	155	247	396
Over 50 up to 125	7,0	9,5	13	19	26	37	51	72	115	184	294	471
Over 125 up to 280	7,5	11	15	21	30	42	58	81	130	209	334	534
Over 280 up to 560												
Over 560 up to 1000												
Over 1000 up to 1600												
Over 1600 up to 2500												

Mean reference diameter, d_m , in mm	Error f'_i for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10	2,5	3,5	5,0	7,5	10	14	20	28	45	72	115	184
Over 10 up to 50	2,5	4,0	5,5	7,5	10	15	21	29	46	74	118	188
Over 50 up to 125	3,0	4,0	5,5	7,5	11	15	21	30	47	76	121	194
Over 125 up to 280	3,0	4,0	5,5	8,0	11	16	22	31	49	78	126	201
Over 280 up to 560												
Over 560 up to 1000												
Over 1000 up to 1600												
Over 1600 up to 2500												

Normal module, m_{mn} : 1 mm to 2 mmTolerances in μm

Mean reference diameter, d_m , in mm	Error f'_k/K_6 for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10	3,0	4,0	5,5	7,5	11	15	21	29	47	74	119	190
Over 10 up to 50	3,0	4,0	6,0	8,0	11	16	22	31	50	80	129	206
Over 50 up to 125	3,5	4,5	6,5	9,0	13	18	25	35	56	89	142	228
Over 125 up to 280	3,5	5,0	7,0	10	14	20	28	39	62	99	158	253
Over 280 up to 560												
Over 560 up to 1000												
Over 1000 up to 1600												
Over 1600 up to 2500												

Mean reference diameter, d_m , in mm	Error f'_1 *) for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10	4,5	6,0	8,5	12	17	24	33	46	74	118	189	302
Over 10 up to 50	5,5	8,0	11	15	21	30	42	59	94	151	241	386
Over 50 up to 125	7,5	10	14	20	28	39	55	77	123	197	315	505
Over 125 up to 280	9,5	13	18	25	36	50	70	98	156	250	401	641
Over 280 up to 560	12	17	23	32	45	64	89	125	200	319	511	818
Over 560 up to 1000	15	21	29	41	57	80	112	157	251	402	644	1030
Over 1000 up to 1600	18	26	36	50	70	98	138	193	308	494	790	1264
Over 1600 up to 2500	22	31	43	61	85	119	166	233	372	595	953	1524
*) Applies to all modules.												

Normal module, m_{mn} : over 2 mm to up and including 3,55 mmTolerances in μm

Mean reference diameter, d_m , in mm	Error F'_i for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10												
Over 10 up to 50	6,5	9,0	13	18	25	35	49	69	110	176	282	451
Over 50 up to 125	7,5	11	15	21	30	42	58	81	130	208	333	533
Over 125 up to 280	8,5	12	17	24	33	47	66	92	147	235	376	602
Over 280 up to 560	9,5	14	19	27	37	52	73	103	164	262	420	672
Over 560 up to 1000												
Over 1000 up to 1600												
Over 1600 up to 2500												

Mean reference diameter, d_m , in mm	Error f'_i for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10												
Over 10 up to 50	3,0	4,5	6,5	9,0	12	17	24	34	54	86	138	221
Over 50 up to 125	3,5	4,5	6,5	9,0	13	18	25	35	55	88	141	226
Over 125 up to 280	3,5	4,5	6,5	9,5	13	18	25	36	57	91	146	233
Over 280 up to 560	3,5	5,0	7,0	9,5	13	19	26	37	59	94	151	242
Over 560 up to 1000												
Over 1000 up to 1600												
Over 1600 up to 2500												

Normal module, m_{nn} : over 2 mm up to and including 3,55 mm

Tolerances in μm

Mean reference diameter, d_m , in mm	Error f'_k/K_6 for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10												
Over 10 up to 50	3,5	5,0	7,0	9,5	14	19	27	37	59	95	152	244
Over 50 up to 125	4,0	5,5	7,5	11	15	21	29	40	65	104	166	265
Over 125 up to 280	4,0	6,0	8,0	12	16	23	32	44	71	113	182	290
Over 280 up to 560	4,5	6,5	9,0	13	18	25	35	49	79	126	202	323
Over 560 up to 1000												
Over 1000 up to 1600												
Over 1600 up to 2500												

Normal module, m_{mn} : over 3,55 mm up to and including 6 mmTolerances in μm

Mean reference diameter, d_m , in mm	Error F'_i for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10												
Over 10 up to 50	7,5	10	15	20	29	40	56	78	125	200	320	513
Over 50 up to 125	8,5	12	17	24	33	47	66	92	147	235	376	602
Over 125 up to 280	10	14	19	27	38	53	74	103	165	264	423	676
Over 280 up to 560	11	15	21	30	42	59	82	115	184	294	470	752
Over 560 up to 1000	12	17	23	33	46	64	90	126	201	322	516	825
Over 1000 up to 1600	13	18	25	35	50	69	97	136	218	349	558	893
Over 1600 up to 2500												

Mean reference diameter, d_m , in mm	Error f'_i for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10												
Over 10 up to 50	4,0	5,5	7,5	10	15	21	29	40	64	103	165	264
Over 50 up to 125	4,0	5,5	7,5	11	15	21	29	41	66	105	169	270
Over 125 up to 280	4,0	5,5	8,0	11	15	22	30	42	67	108	173	276
Over 280 up to 560	4,0	6,0	8,0	11	16	22	31	43	70	111	178	285
Over 560 up to 1000	4,5	6,0	8,5	12	16	23	32	45	72	115	185	295
Over 1000 up to 1600	4,5	6,0	8,5	12	17	24	33	47	75	120	192	307
Over 1600 up to 2500												

Normal module, m_{mn} : over 3,55 mm up to and including 6 mm

Tolerances in μm

Mean reference diameter, d_m , in mm	Error f'_k/K_6 for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10												
Over 10 up to 50	4,0	6,0	8,0	11	16	22	31	44	70	113	180	288
Over 50 up to 125	4,5	6,5	9,0	12	17	24	34	47	76	121	194	310
Over 125 up to 280	5,0	7,0	9,5	13	19	26	37	51	82	131	209	335
Over 280 up to 560	5,5	7,5	10	15	20	29	40	56	90	144	230	368
Over 560 up to 1000	6,0	8,0	12	16	23	32	44	62	99	159	254	407
Over 1000 up to 1600	6,5	9,0	13	18	25	35	49	69	110	176	281	450
Over 1600 up to 2500												

Normal module, m_{mn} : over 6 mm up to and including 10 mmTolerances in μm

Mean reference diameter, d_m , in mm	Error F'_i for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10												
Over 10 up to 50	8,5	12	17	23	33	46	64	90	144	230	368	589
Over 50 up to 125	10	14	19	27	38	53	75	105	167	268	428	685
Over 125 up to 280	11	16	22	30	43	60	83	117	187	299	478	765
Over 280 up to 560	12	17	24	34	47	66	92	129	207	331	529	847
Over 560 up to 1000	13	19	26	37	51	72	101	141	226	362	578	925
Over 1000 up to 1600	14	20	28	40	55	78	109	152	244	390	624	998
Over 1600 up to 2500	15	22	30	42	59	83	116	163	261	417	667	1068

Mean reference diameter, d_m , in mm	Error f'_i for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10												
Over 10 up to 50	4,5	6,5	9,5	13	18	25	36	50	80	127	204	326
Over 50 up to 125	5,0	6,5	9,5	13	18	26	36	51	81	130	207	332
Over 125 up to 280	5,0	7,0	9,5	13	19	26	37	52	83	132	212	338
Over 280 up to 560	5,0	7,0	10	14	19	27	38	53	85	136	217	347
Over 560 up to 1000	5,0	7,0	10	14	20	28	39	55	87	140	223	357
Over 1000 up to 1600	5,5	7,5	10	15	21	29	40	56	90	144	231	369
Over 1600 up to 2500	5,5	7,5	11	15	21	30	42	58	93	149	238	382

Normal module, m_{mn} : over 6 mm up to and including 10 mm

Tolerances in μm

Mean reference diameter, d_m , in mm	Error f'_k/K_6 for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10												
Over 10 up to 50	5,0	7,0	10	14	19	27	38	53	84	135	215	344
Over 50 up to 125	5,5	7,5	10	15	20	29	40	56	89	143	229	366
Over 125 up to 280	5,5	8,0	11	16	22	30	43	60	96	153	245	391
Over 280 up to 560	6,0	8,5	12	17	24	33	46	65	103	166	265	424
Over 560 up to 1000	6,5	9,5	13	18	26	36	50	71	113	181	289	463
Over 1000 up to 1600	7,5	10	14	20	28	39	55	77	123	198	316	506
Over 1600 up to 2500	8,5	11	16	22	31	43	60	84	135	216	346	554

Normal module, m_{mn} : over 10 mm up to and including 16 mmTolerances in μm

Mean reference diameter, d_m , in mm	Error F'_i for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10												
Over 10 up to 50												
Over 50 up to 125	11	16	22	31	44	61	86	120	192	308	492	788
Over 125 up to 280	13	18	25	35	49	68	95	133	213	341	546	874
Over 280 up to 560	14	19	27	38	53	75	105	147	235	375	601	961
Over 560 up to 1000	15	21	30	42	58	81	114	160	255	408	653	1045
Over 1000 up to 1600	16	23	32	45	62	87	122	171	274	439	702	1123
Over 1600 up to 2500	17	24	34	48	67	93	131	183	292	468	749	1198

Mean reference diameter, d_m , in mm	Error f'_i for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10												
Over 10 up to 50												
Over 50 up to 125	6,0	8,5	12	17	23	33	46	64	103	164	263	420
Over 125 up to 280	6,0	8,5	12	17	24	33	47	65	104	167	267	427
Over 280 up to 560	6,5	9,0	12	17	24	34	47	66	106	170	272	435
Over 560 up to 1000	6,5	9,0	13	18	25	35	49	68	109	174	279	446
Over 1000 up to 1600	6,5	9,5	13	18	25	36	50	70	112	179	286	457
Over 1600 up to 2500	7,0	9,5	13	19	26	37	51	72	115	184	294	470

Normal module, m_{mn} : over 10 mm up to and including 16 mm

Tolerances in μm

Mean reference diameter, d_m , in mm	Error f'_k/K_6 for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10												
Over 10 up to 50												
Over 50 up to 125	6,5	9,0	12	17	24	34	48	67	107	170	273	436
Over 125 up to 280	6,5	9,5	13	18	26	36	50	70	113	180	288	461
Over 280 up to 560	7,0	10	14	20	27	38	54	75	121	193	309	494
Over 560 up to 1000	7,5	11	15	21	30	41	58	81	130	208	333	533
Over 1000 up to 1600	8,5	12	16	23	32	45	63	88	141	225	360	576
Over 1600 up to 2500	9,0	13	18	25	35	49	68	95	152	244	390	624

Normal module, m_{mn} : over 16 mm up to and including 25 mmTolerances in μm

Mean reference diameter, d_m , in mm	Error f'_i for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10												
Over 10 up to 50												
Over 50 up to 125	13	19	26	36	51	71	100	139	223	357	571	914
Over 125 up to 280	15	20	29	40	56	78	110	153	246	393	629	1006
Over 280 up to 560	16	22	31	44	61	86	120	168	268	429	687	1099
Over 560 up to 1000	17	24	34	47	66	93	130	181	290	464	743	1189
Over 1000 up to 1600	18	26	36	51	71	99	139	194	311	497	795	1272
Over 1600 up to 2500	20	27	38	54	75	105	147	206	330	528	845	1352

Mean reference diameter, d_m , in mm	Error f'_i for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10												
Over 10 up to 50												
Over 50 up to 125	8,0	11	15	22	30	42	59	83	133	212	339	543
Over 125 up to 280	8,0	11	16	22	31	43	60	84	134	215	343	549
Over 280 up to 560	8,0	11	16	22	31	43	61	85	136	218	349	558
Over 560 up to 1000	8,0	12	16	23	32	44	62	87	139	222	355	568
Over 1000 up to 1600	8,5	12	16	23	32	45	63	88	142	227	362	580
Over 1600 up to 2500	8,5	12	17	24	33	46	65	90	145	231	370	593

Normal module, m_{mn} : over 16 mm up to and including 25 mm

Tolerances in μm

Mean reference diameter, d_m , in mm	Error f'_k/K_6 for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10												
Over 10 up to 50												
Over 50 up to 125	7,5	11	15	21	29	41	57	80	127	204	326	522
Over 125 up to 280	8,0	11	16	22	30	43	60	83	134	214	342	547
Over 280 up to 560	8,5	12	16	23	32	45	63	88	141	226	362	579
Over 560 up to 1000	9,0	13	18	25	34	48	67	94	151	242	386	618
Over 1000 up to 1600	9,5	13	19	26	37	51	72	101	161	258	413	661
Over 1600 up to 2500	10	14	20	28	39	55	77	108	173	277	443	709

Normal module, m_{mn} : over 25 mm up to and including 50 mmTolerances in μm

Mean reference diameter, d_m , in mm	Error F'_1 for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10												
Over 10 up to 50												
Over 50 up to 125												
Over 125 up to 280	18	25	35	49	69	96	134	188	301	481	770	1232
Over 280 up to 560	19	27	38	53	74	104	145	203	326	521	833	1333
Over 560 up to 1000	21	29	41	57	80	111	156	218	349	559	894	1431
Over 1000 up to 1600	22	31	43	60	85	118	166	232	371	594	951	1521
Over 1600 up to 2500	23	33	46	64	89	125	175	245	392	628	1005	1608

Mean reference diameter, d_m , in mm	Error f'_1 for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10												
Over 10 up to 50												
Over 50 up to 125												
Over 125 up to 280	11	16	22	31	44	61	86	120	192	308	492	788
Over 280 up to 560	12	16	23	32	44	62	87	122	194	311	498	797
Over 560 up to 1000	12	16	23	32	45	63	88	123	197	315	504	807
Over 1000 up to 1600	12	17	23	33	46	64	89	125	200	320	511	818
Over 1600 up to 2500	12	17	24	33	46	65	91	127	203	325	519	831

Normal module, m_{mn} : over 25 mm up to and including 50 mm

Tolerances in μm

Mean reference diameter, d_m , in mm	Error f'_k/K_6 for tolerance class											
	1	2	3	4	5	6	7	8	9	10	11	12
Over 1 up to 10												
Over 10 up to 50												
Over 50 up to 125												
Over 125 up to 280	10	14	20	27	38	54	75	105	168	270	431	690
Over 280 up to 560	10	15	20	29	40	56	79	110	176	282	452	723
Over 560 up to 1000	11	15	22	30	42	59	83	116	186	297	476	762
Over 1000 up to 1600	12	16	23	32	45	63	88	123	196	314	503	805
Over 1600 up to 2500	12	17	24	34	47	66	93	130	208	333	533	852

Standards referred to

DIN 3965 Part 1 Tolerancing of bevel gears; basic concepts

DIN 3971 Terminology and parameters for bevel gears and bevel gear pairs

Previous editions

DIN 3965 Part 3: 09.81.

Amendments

The following amendments have been made in comparison with the September 1981 edition.

- a) The status of the standard is no longer that of a preliminary standard.
- b) The standard has been editorially revised.

Explanatory notes

DIN 3965 Parts 1 to 4 provide only information on the gear blank and on errors that can be measured by conventional means.

The finer tolerances cannot yet be measured under production conditions. Nevertheless, the tables shown in DIN 3965 Parts 2 and 3 cover all diameter ranges, the fields crossed out indicating that for these diameter ranges no tolerances can currently be specified.

In future, more advanced gauging and calculation methods may allow errors to be dealt with, which have not as yet been specified, such as profile errors, and more information to be provided regarding the accuracy of bevel gears.

The parameters (see clause 3) have been defined in DIN 3971, the aim of which was to include as many quantities as possible without regard for the current feasibility or difficulty of their measurement.

The structure of the tolerance system for bevel gears has been brought into line with that for cylindrical gears. The relationship between the parameters are the same, except for an overall shift in the tolerance system by one tolerance class. The tolerance system proposed may thus serve as an adequate basis for international discussion.

International Patent Classification

F 16 H 55/08

F 16 H 55/17

Tolerancing of bevel gears

Tolerances for shaft angle errors
and axes intersection point deviations

DIN
3965
Part 4

Toleranzen für Kegelradverzahnungen;
Toleranzen für Achsenwinkelabweichungen
und Achsenschnittpunktabweichungen

Supersedes September 1981 edition.

The accuracy of the bevel gear transmission housing is a major factor influencing the working load limit and running quality of the gearing. For the deviations of the housing parameters (position of gear axes), 12 accuracy grades for the axial position have been specified. These accuracy grades are not expected to correspond with the tolerance classes specified for bevel gears.

The permissible axes intersection point deviations (axial offset deviations) are also a function of the diameter of the larger gear of the pair.

Backlash has to be taken into account when specifying the tolerances. Deformation of the housing under load may greatly modify the deviations.

1 Scope and field of application

This standard specifies values for straight, skew and spiral bevel gears with and without axial offset, and with reference diameters up to 2500 mm.

The tolerances for the parameters specified in this standard are defined in DIN 3971, the values given in tables 1 and 2 applying to the gear pair. See also DIN 3965 Part 1.

Continued on pages 2 and 3

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2 Tolerances

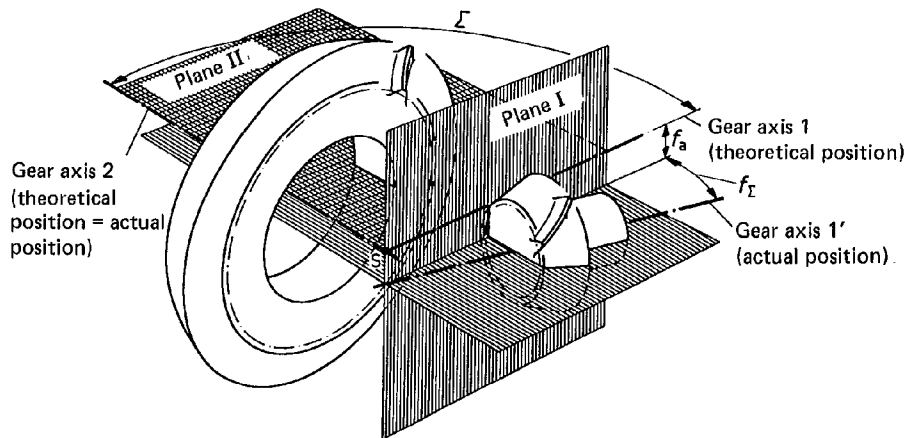


Figure 1. Deviations of position of bevel gear axes

Table 1. Permissible shaft angle errors, f_{Σ} , in angular seconds

Accuracy grade for axial position	1	2	3	4	5	6	7	8	9	10	11	12
f_{Σ}	—	—	—	± 16	± 20	± 25	± 32	± 40	± 50	± 63	± 80	± 100

Table 2. Permissible axes intersection point deviations axial, f_a , in μm

Accuracy grade for axial position		1	2	3	4	5	6	7	8	9	10	11	12
Mean reference diameter of gear, d_m , in mm	Up to 50	—	—	—	± 6	± 8	± 10	± 12	± 16	± 20	± 25	± 32	± 40
	Over 50 up to 125	—	—	—	± 8	± 10	± 12	± 16	± 20	± 25	± 32	± 40	± 50
	Over 125 up to 280	—	—	—	± 10	± 12	± 16	± 20	± 25	± 32	± 40	± 50	± 63
	Over 280 up to 560	—	—	—	± 12	± 16	± 20	± 25	± 32	± 40	± 50	± 63	± 80
	Over 560 up to 1000	—	—	—	± 16	± 20	± 25	± 32	± 40	± 50	± 63	± 80	± 100
	Over 1000 up to 1600	—	—	—	± 20	± 25	± 32	± 40	± 50	± 63	± 80	± 100	± 125
	Over 1600 up to 2500	—	—	—	± 25	± 32	± 40	± 50	± 63	± 80	± 100	± 125	± 160

Standards referred to

DIN 3965 Part 1 Tolerancing of bevel gears; basic concepts
DIN 3971 Terminology and parameters for bevel gears and bevel gear pairs

Previous editions

DIN 3965 Part 4: 09.81.

Amendments

The following amendments have been made in comparison with the September 1981 edition.

- a) The status of the standard is no longer that of a preliminary standard.
- b) The standard has been editorially revised.

Explanatory notes

The housing tolerances given in this standard have been specified to a fineness which cannot be technically realized at present, but which is likely to represent the fineness possible in future.

The concepts of axes intersection point, axial offset and shaft angle (see DIN 868) and of axes intersection point deviation and shaft angle error (see DIN 3971) have been established as follows.

Axial offset

The axial offset, a , of a hypoid gear pair is the distance between the two non-intersecting gear axes.
For a bevel gear pair a is equal to zero.

Shaft angle

The shaft angle, Σ , of a bevel gear pair is that angle between the two axes that faces the tooth engagement.
The shaft angle, Σ , of a hypoid gear pair is that angle between the non-intersecting gear axes that faces the tooth engagement.

Shaft angle error

The shaft angle error, f_{Σ} , is the difference between the shaft angle of the two gear shafts in their actual positions and the theoretical value of this angle.

Axes intersection point deviation

The axes intersection point deviation, f_a , of a bevel gear pair is the distance between the two non-intersecting gear axes in their actual positions.

The axes intersection point deviation, f_a , of a hypoid gear pair is the difference between the distance separating the two non-intersecting gear axes in their actual positions compared with the theoretical distance.

The permissible values of f_a given in this standard correspond to the axial position tolerances of cylindrical gear transmissions as specified in DIN 3964, but the f_a values are shifted by one accuracy grade towards larger deviations, and reduced by half. The tolerance system proposed for bevel gears is also intended to serve as a basis for international discussion.

International Patent Classification

F 16 H 55/08
F 16 H 55/17