

# Deviations of Shaft Centre Distances and Shaft Position Tolerances of Casings for Cylindrical Gears

# DIN 3964

Achsstabstandsabweichung und Achslagetoleranzen von Gehäusen für Stirnradgetriebe

## 1 Field of application

The data in this Standard apply to the deviations defined in DIN 3960, viz.:

- Shaft centre distance deviation  $A_a$   
A distinction is made between the upper deviation  $A_{ae}$  (+) and the lower deviation  $A_{al}$  (–).
- Shaft centre distance tolerance  $T_a$
- Shaft inclination  $f_{\Sigma\delta}$
- Shaft skew  $f_{\Sigma\beta}$  } see also note 3.

## 2 Other relevant standards

- DIN 3960            Definitions and parameters for cylindrical gears and cylindrical gear pairs with involute teeth  
 DIN 3962 Part 2    Tolerances for cylindrical gear teeth; tolerances for tooth trace deviations  
 DIN 3967            System of gear fits; backlash, tooth thickness deviations and tooth thickness tolerances; bases

## 3 Shaft centre distance deviations

The ISO tolerance zones js 5 to js 11 in accordance with ISO/R 286 – 1962 are used for the shaft centre distance deviations. They are, therefore, dependent on the nominal dimension of the shaft centre distance. In addition, the accuracy class of the shaft position is correlated, see Section 4.

Table 1. Shaft centre distance deviations  $A_{ae}$  and  $A_{al}$  in  $\mu\text{m}$

		Accuracy class of shaft position 1 to 3							
		Accuracy class of shaft position 4 to 6				Accuracy class of shaft position 7 to 9			
		Accuracy class of shaft position 10 to 12							
		ISO-Tolerance zone							
		js							
		5	6	7	8	9	10	11	
Shaft centre distance $a$ (nominal dimension) in mm	over 10	+ 4	+ 5,5	+ 9	+ 13,5	+ 21,5	+ 35	+ 55	
	up to 18	- 4	- 5,5	- 9	- 13,5	- 21,5	- 35	- 55	
	over 18	+ 4,5	+ 6,5	+ 10,5	+ 16,5	+ 26	+ 42	+ 65	
	up to 30	- 4,5	- 6,5	- 10,5	- 16,5	- 26	- 42	- 65	
	over 30	+ 5,5	+ 8	+ 12,5	+ 19,5	+ 31	+ 50	+ 80	
	up to 50	- 5,5	- 8	- 12,5	- 19,5	- 31	- 50	- 80	
	over 50	+ 6,5	+ 9,5	+ 15	+ 23	+ 37	+ 60	+ 95	
	up to 80	- 6,5	- 9,5	- 15	- 23	- 37	- 60	- 95	
	over 80	+ 7,5	+ 11	+ 17,5	+ 27	+ 43,5	+ 70	+ 110	
	up to 120	- 7,5	- 11	- 17,5	- 27	- 43,5	- 70	- 110	
	over 120	+ 9	+ 12,5	+ 20	+ 31,5	+ 50	+ 80	+ 125	
	up to 180	- 9	- 12,5	- 20	- 31,5	- 50	- 80	- 125	
	over 180	+ 10	+ 14,5	+ 23	+ 36	+ 57,5	+ 92,5	+ 145	
	up to 250	- 10	- 14,5	- 23	- 36	- 57,5	- 92,5	- 145	
	over 250	+ 11,5	+ 16	+ 26	+ 40,5	+ 65	+ 105	+ 160	
	up to 315	- 11,5	- 16	- 26	- 40,5	- 65	- 105	- 160	
	over 315	+ 12,5	+ 18	+ 28,5	+ 44,5	+ 70	+ 115	+ 180	
	up to 400	- 12,5	- 18	- 28,5	- 44,5	- 70	- 115	- 180	
	over 400	+ 13,5	+ 20	+ 31,5	+ 48,5	+ 77,5	+ 125	+ 200	
	up to 500	- 13,5	- 20	- 31,5	- 48,5	- 77,5	- 125	- 200	
	over 500	+ 14	+ 22	+ 35	+ 55	+ 87	+ 140	+ 220	
	up to 630	- 14	- 22	- 35	- 55	- 87	- 140	- 220	
	over 630	+ 16	+ 25	+ 40	+ 62	+ 100	+ 160	+ 250	
	up to 800	- 16	- 25	- 40	- 62	- 100	- 160	- 250	
	over 800	+ 18	+ 28	+ 45	+ 70	+ 115	+ 180	+ 280	
	up to 1000	- 18	- 28	- 45	- 70	- 115	- 180	- 280	
	over 1000	+ 21	+ 33	+ 52	+ 82	+ 130	+ 210	+ 330	
	up to 1250	- 21	- 33	- 52	- 82	- 130	- 210	- 330	
	over 1250	+ 25	+ 39	+ 62	+ 97	+ 155	+ 250	+ 390	
	up to 1600	- 25	- 39	- 62	- 97	- 155	- 250	- 390	
over 1600	+ 30	+ 46	+ 75	+ 115	+ 185	+ 300	+ 460		
up to 2000	- 30	- 46	- 75	- 115	- 185	- 300	- 460		
over 2000	+ 35	+ 55	+ 87	+ 140	+ 220	+ 350	+ 550		
up to 2500	- 35	- 55	- 87	- 140	- 220	- 350	- 550		
over 2500	+ 43	+ 67	+ 105	+ 165	+ 270	+ 430	+ 675		
up to 3150	- 43	- 67	- 105	- 165	- 270	- 430	- 675		

Continued on pages 2 to 4

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On the drawing, the shaft centre distance deviations may be entered both with their ISO tolerance zone and also with their numerical value. The ISO tolerance zone may in addition be entered in the gear tooth tables of the gears appertaining to the drawings.

In the case of gear transmissions in which one gear drives several other gears (or vice versa) e.g. in the case of epicyclic gear transmissions with several planet gears or in the case of transfer gearboxes or power take-off gears, it may become necessary to restrict the shaft centre distance deviations additionally by means of a permissible shaft centre distance fluctuation. This represents the range within which the shaft centre distances may differ within the tolerancing of a gear-box casing (or of a planet carrier). Permissible shaft centre distance fluctuations must be specified on the drawing or mutually agreed between manufacturer and purchaser.

The criterion for the minimum backlash of the gear teeth is the minimum dimension of the shaft centre distance in the case of external gear pairs, and the maximum dimension of shaft centre distance in the case of internal gear pairs.

See DIN 3960, July 1980 edition, Section 9 and DIN 3967 for the effect of the shaft centre distance deviations on the backlash. The larger shaft centre distance deviations should preferably be allocated to the larger amounts of backlash, and the smaller deviations to the smaller amounts of backlash.

#### 4 Shaft position tolerances

The shaft position tolerances are graded according to the R 10 preferred number series, with a differentiation according to the accuracy classes 1 to 12. They are dependent on the magnitude of the bearing centre distance  $L_G$ . The shaft position accuracy class takes account of the gear tooth quality, but does not necessarily have to agree with it.

Table 2. Tolerances for shaft skew  $f_{\Sigma\beta}$  and for shaft inclination  $f_{\Sigma\delta}$  (shaft position tolerances) in  $\mu\text{m}$

		Shaft position accuracy class											
		1	2	3	4	5	6	7	8	9	10	11	12
Bearing centre distance $L_G$ (nominal dimension) in mm	up to 50	5	6	8	10	12	16	20	25	32	40	50	63
	over 50 up to 125	6	8	10	12	16	20	25	32	40	50	63	80
	over 125 up to 280	8	10	12	16	20	25	32	40	50	63	80	100
	over 280 up to 560	10	12	16	20	25	32	40	50	63	80	100	125
	over 560 up to 1000	12	16	20	25	32	40	50	63	80	100	125	160
	over 1000 up to 1600	16	20	25	32	40	50	63	80	100	125	160	200
	over 1600 up to 2500	20	25	32	40	50	63	80	100	125	160	200	250
	over 2500 up to 3150	25	32	40	50	63	80	100	125	160	200	250	320

The shaft inclination in respect of the casing seating surface or of the casing reference surface is not tolerated by way of  $f_{\Sigma\beta}$  or  $f_{\Sigma\delta}$ . It should however not be disregarded in cases where precise alignment with the shafts of motors or machines to be coupled to the gearbox is required. Unless something to the contrary has been mutually agreed, an amount equal to five times the permissible shaft skew or shaft inclination applies.

“Shaft skew  $f_{\Sigma\beta}$  and shaft inclination  $f_{\Sigma\delta}$ ” shall be entered on the drawing of the casing in the manner indicated in the example of entering the particulars on the drawing. The added words “in accordance with DIN 3964” in the middle box of the tolerance frame indicate that the position tolerances (deviating from DIN 7184) apply to the common axis formed by the two bores designated by indicating arrowheads.

**Entry on the drawing**

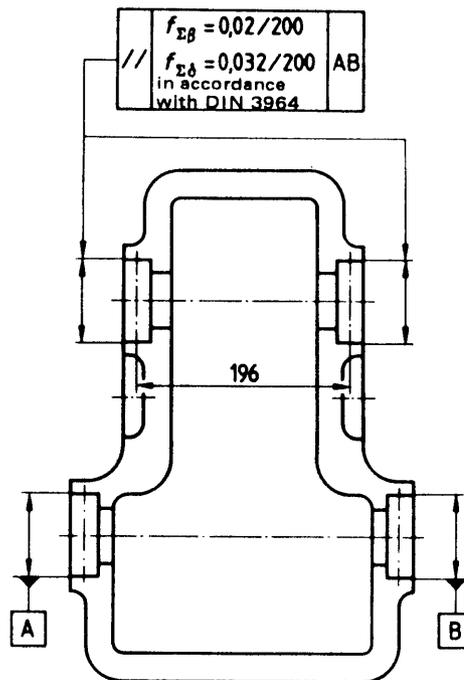
Example of entry of shaft position tolerances on a casing with:

Bearing centre distance: 196 mm

Shaft skew  $f_{\Sigma\beta}$  in accordance with shaft position accuracy class 5 (in accordance with Table 2):  $20\ \mu\text{m} = 0.02\ \text{mm}$

Shaft inclination  $f_{\Sigma\delta}$  in accordance with shaft position accuracy class 7 (in accordance with Table 2):  $32\ \mu\text{m} = 0.032\ \text{mm}$   
(refer to use of tolerance families in accordance with DIN 3961)

Reference length  $L_G$  to be entered (numerical value of bearing centre distance, rounded up): 200 mm



*Note 1:* The shaft position tolerances selected for the casing (shaft position accuracy class and numerical values for  $f_{\Sigma\beta}$  and  $f_{\Sigma\delta}$ ) may also be indicated in the drawings of the associated gears or in the table of the toothing data.

*Note 2:* The shaft skew and the shaft inclination act upon the effective flank line angular deviation  $f_{H\beta}$  in accordance with DIN 3962 Part 2 in accordance with the following equations:

$$\Delta f_{H\beta(\beta)} = \frac{b}{L_G} \cdot f_{\Sigma\beta} \cdot \cos \alpha_{wt}$$

$$\Delta f_{H\beta(\delta)} = \frac{b}{L_G} \cdot f_{\Sigma\delta} \cdot \sin \alpha_{wt}$$

Wherein:

$\Delta f_{H\beta(\beta)}$  or  $\Delta f_{H\beta(\delta)}$  Alteration of the effective flank line angular deviation  $f_{H\beta}$  by virtue of the influence of the shaft skew or of the shaft inclination

$b$  Width of tooth face

$L_G$  Bearing centre distance

$f_{\Sigma\beta}$  Shaft skew

$f_{\Sigma\delta}$  Shaft inclination

$\alpha_{wt}$  Working pressure angle

Additional amounts of skew can arise in gear trains as a result of the deformation of component parts and as a result of displacement in the case of overhung gears.

In principle, the specified shaft position tolerances should only be utilized to the extent that the shaft centre distance tolerances resulting therefrom are not exceeded and vice versa.

Note 3: In accordance with DIN 3960, the following applies:

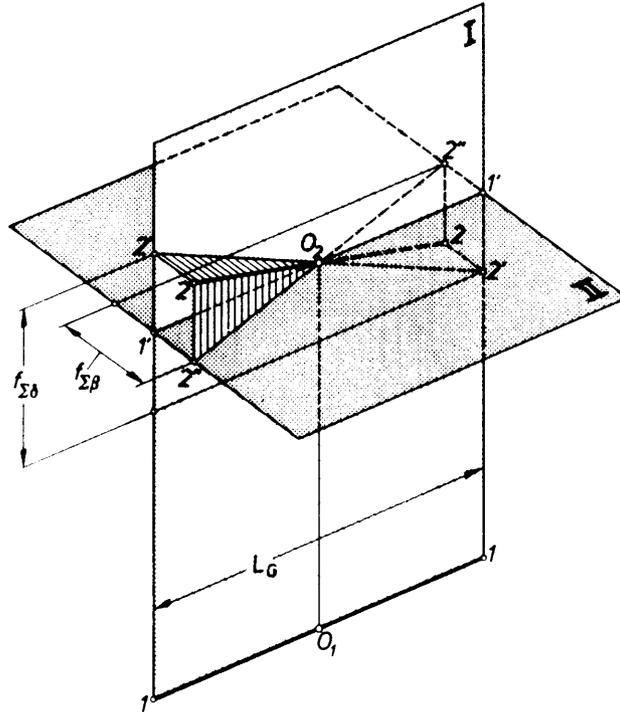
**Re shaft inclination  $f_{\Sigma\delta}$**

The shaft inclination is the deviation of the wheel shaft 2 from absolute parallelism to wheel shaft 1 in the centre plane I. In Fig. 1 it is given in plane I as the perpendicular distance  $f_{\Sigma\delta}$  to the intersection line 1'-1' of the bearing centre points of wheel shaft 2 projected in the centre plane.

**Re shaft skew  $f_{\Sigma\beta}$**

The shaft skew is the deviation of the wheel shaft 2 from absolute parallelism to wheel shaft 1 in the plane II which is perpendicular to the centre plane.

In Fig. 1 it is given in plane II as the perpendicular distance  $f_{\Sigma\beta}$  to the intersection line 1'-1' of the bearing centre points of wheel shaft 2 projected in plane II.



- 1-1 Wheel shaft 1
- 2-2 Wheel shaft 2
- O<sub>2</sub> Midpoint of wheel shaft 2
- O<sub>1</sub> Foot of the perpendicular from O<sub>2</sub> onto wheel shaft 1
- I Centre plane of wheel shafts
- II Plane perpendicular to the centre plane, and parallel to 1-1
- 1'-1' Intersection line of planes I and II
- 2'-2' Projection of 2-2 in the plane I
- 2''-2'' Projection of 2-2 in the plane II

Figure 1. Deviations from parallelism of the shaft positions

**Further standards**

- DIN 3961 Tolerances for cylindrical gear teeth; bases
- DIN 3962 Part 1 Tolerances for cylindrical gear teeth; tolerances for deviations of individual parameters
- DIN 3962 Part 3 Tolerances for cylindrical gear teeth; tolerances for pitch-span deviations
- DIN 3963 Tolerances for cylindrical gear teeth; tolerances for hobbing deviations
- DIN 3999 Symbols for gear tooth systems