Design and layout of bearing assembly: bearing clearance, press fit

Theoretical bearing clearance

Bushes made from KS PERMAGLIDE® P1 and P2 are pressed into the housing and fixed in place radially and axially.
No further measures are required. For rigid housings and shafts, the fitting tolerances from Table 1 result in the following:

- The press fit
- The bearing clearance as per Table 6

The theoretical bearing clearance is calculated as follows:

[12] $$\Delta s_{max} = d_{Gmax} - 2 \cdot s_{3min} - d_{Wmin}$$

[13] $$\Delta s_{min} = d_{Gmin} - 2 \cdot s_{3max} - d_{Wmax}$$

Δs_{max}	[mm]	Maximum bearing clearance
Δs_{min}	[mm]	Minimum bearing clearance
d_{Gmax}	[mm]	Maximum diameter of housing bore
d_{Gmin}	[mm]	Minimum diameter of housing bore
d_{Wmax}	[mm]	Maximum shaft diameter
d_{Wmin}	[mm]	Minimum shaft diameter
s_{3max}	[mm]	Maximum wall thickness
s_{3min}	[mm]	Minimum wall thickness (see Tab. 4)

Attention:
Widening the housing bore is not taken into consideration in the bearing clearance calculation.

For calculating the press-fit U, the tolerances of the housing bore are stated in Table 1 and the dimensions of the bush outside diameter D_0 are stated in Table 2.

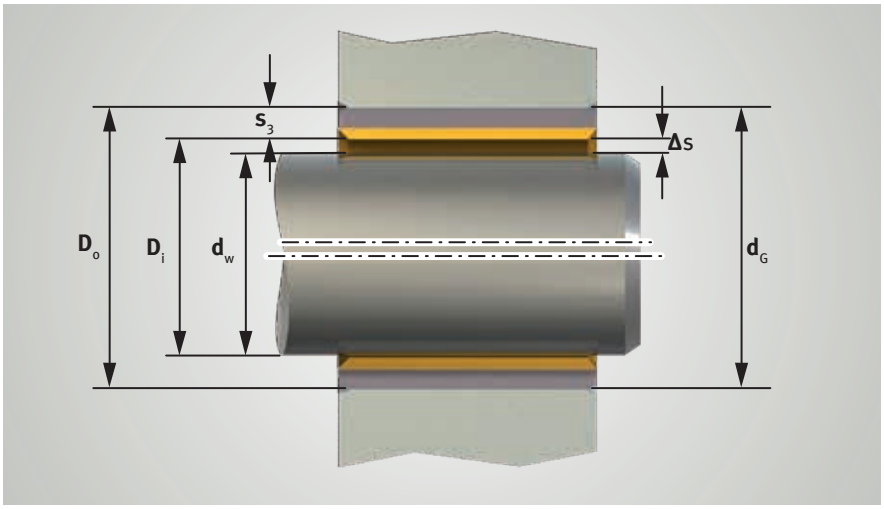

Fig. 1: Theoretical bearing clearance Δs

Press fit and bearing clearance

The bearing clearance and press fit can be influenced by the measures shown in Tab. 7:

- At high ambient temperatures
- Depending on the housing material
- Depending on the housing wall thickness.

Smaller clearance tolerances require narrower tolerances for the shaft and bore.

Attention:
When using shafts with tolerance zone position h, the bearing clearance for $5 \leq d_W < 80$ (P10, P14, P147) and $d_W < 80$ (P 11) must be verified using equations [12] for Δs_{max} and [13] for Δs_{min}.

Diameter range	KS PERMAGLIDE®		
	P10, P14, P147*	P11	P20, P200
Shaft			
d_W < 5	h6	f7	h8
5 ≤ d_W < 80	f7	f7	h8
80 ≤ d_W	h8	h8	h8
Housing bore			
d_G ≤ 5.5	H6	–	–
5.5 < d_G	H7	H7	H7

Tab. 1: Recommended fitting tolerances

* On request

Outside diameter of bush D_o			Dimensions (test A to DIN ISO 3547-2)			
			P10, P14, P147*, P20, P200		P 11	
			Upper	Lower	Upper	Lower
	$D_o \leq$	10	+0.055	+0.025	+0.075	+0.045
10	$< D_o \leq$	18	+0.065	+0.030	+0.080	+0.050
18	$< D_o \leq$	30	+0.075	+0.035	+0.095	+0.055
30	$< D_o \leq$	50	+0.085	+0.045	+0.110	+0.065
50	$< D_o \leq$	80	+0.100	+0.055	+0.125	+0.075
80	$< D_o \leq$	120	+0.120	+0.070	+0.140	+0.090
120	$< D_o \leq$	180	+0.170	+0.100	+0.190	+0.120
180	$< D_o \leq$	250	+0.210	+0.130	+0.230	+0.150
250	$< D_o \leq$	305	+0.260	+0.170	+0.280	+0.190

Tab. 2: Dimensions for outside diameter Do

Inside diameter D_i			Wall thickness s_3	Dimensions to DIN ISO 3 547-1, Table 3, row D, P20, P200	
				Upper	Lower
8	$\leq D_i <$	20	1	-0.020	-0.045
20	$\leq D_i <$	28	1.5	-0.025	-0.055
28	$\leq D_i <$	45	2	-0.030	-0.065
45	$\leq D_i <$	80	2.5	-0.040	-0.085
80	$\leq D_i$		2.5	-0.050	-0.115

Tab. 4: Wall thickness s3 for bushes made from KS PERMAGLIDE® P20/P200

Inside diameter of bush D_i			Wall thickness s_3	Dimensions to DIN ISO 3 547-1, Table 3, row B			
				P10, P14, P147*		P 11	
				Upper	Lower	Upper	Lower
	$D_i <$	5	0.75	0	-0.020	-	-
			1	-	-	+0.005	-0.020
5	$\leq D_i <$	20	1	+0.005	-0.020	+0.005	-0.020
20	$\leq D_i <$	28	1.5	+0.005	-0.025	+0.005	-0.025
28	$\leq D_i <$	45	2	+0.005	-0.030	+0.005	-0.030
45	$\leq D_i <$	80	2.5	+0.005	-0.040	+0.005	-0.040
80	$\leq D_i <$	120	2.5	-0.010	-0.060	-0.010	-0.060
120	$\leq D_i$		2.5	-0.035	-0.085	-0.035	-0.085

Tab. 3: Wall thickness s3 for P1 bushes and flange bushes

Wall thickness s_3	Outside bevel, without cutting C_o	Inside bevel C_i	
		Min.	Max.
0.75	0.5±0.3	0.1	0.4
1	0.6±0.4	0.1	0.5
1.5	0.6±0.4	0.1	0.7
2	1.0±0.4	0.1	0.7
2.5	1.2±0.4	0.2	1.0

Tab. 5: Outside bevel Co and inside bevel Ci (Fig. 2) for bushes with metric dimensions to DIN ISO 3 547-1, Table 2

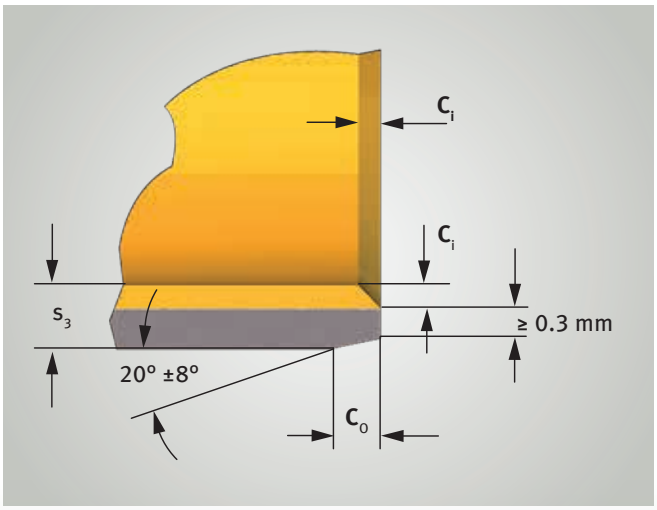

Fig. 2: Outside bevel Co and inside bevel Ci with metric dimensions

* On request

Theoretical bearing clearance

Bush diameter		Bearing clearance Δs			
		P10, P11, P14, P147*		P20, P200	
D_i (mm)	D_o (mm)	Δs_{min} (mm)	Δs_{max} (mm)	Δs_{min} (mm)	Δs_{max} (mm)
2	3.5	0	0.054	-	-
3	4.5	0	0.054	-	-
4	5.5	0	0.056	-	-
5	7	0	0.077	-	-
6	8	0	0.077	-	-
7	9	0.003	0.083	-	-
8	10	0.003	0.083	0.040	0.127
10	12	0.003	0.086	0.040	0.130
12	14	0.006	0.092	0.040	0.135
13	15	0.006	0.092	-	-
14	16	0.006	0.092	0.040	0.135
15	17	0.006	0.092	0.040	0.135
16	18	0.006	0.092	0.040	0.135
18	20	0.006	0.095	0.040	0.138
20	23	0.010	0.112	0.050	0.164
22	25	0.010	0.112	0.050	0.164
24	27	0.010	0.112	0.050	0.164
25	28	0.010	0.112	0.050	0.164
28	32	0.010	0.126	0.060	0.188
30	34	0.010	0.126	0.060	0.188
32	36	0.015	0.135	0.060	0.194
35	39	0.015	0.135	0.060	0.194
40	44	0.015	0.135	0.060	0.194
45	50	0.015	0.155	0.080	0.234
50	55	0.015	0.160	0.080	0.239
55	60	0.020	0.170	0.080	0.246
60	65	0.020	0.170	0.080	0.246
65	70	0.020	0.170	-	-
70	75	0.020	0.170	0.080	0.246
75	80	0.020	0.170	0.080	0.246
80	85	0.020	0.201	0.100	0.311
85	90	0.020	0.209	-	-
90	95	0.020	0.209	0.100	0.319
95	100	0.020	0.209	-	-
100	105	0.020	0.209	0.100	0.319
105	110	0.020	0.209	-	-
110	115	0.020	0.209	-	-
115	120	0.020	0.209	-	-

Bush diameter		Bearing clearance Δs			
		P10, P 11, P14, P147*		P20, P200	
D_i (mm)	D_o (mm)	Δs_{min} (mm)	Δs_{max} (mm)	Δs_{min} (mm)	Δs_{max} (mm)
120	125	0.070	0.264	-	-
125	130	0.070	0.273	-	-
130	135	0.070	0.273	-	-
135	140	0.070	0.273	-	-
140	145	0.070	0.273	-	-
150	155	0.070	0.273	-	-
160	165	0.070	0.273	-	-
180	185	0.070	0.279	-	-
200	205	0.070	0.288	-	-
220	225	0.070	0.288	-	-
250	255	0.070	0.294	-	-
300	305	0.070	0.303	-	-

Tab. 6: Theoretical bearing clearance after press-fitting bushes or flange bushes with metric dimensions, without consideration of possible widening of the bore

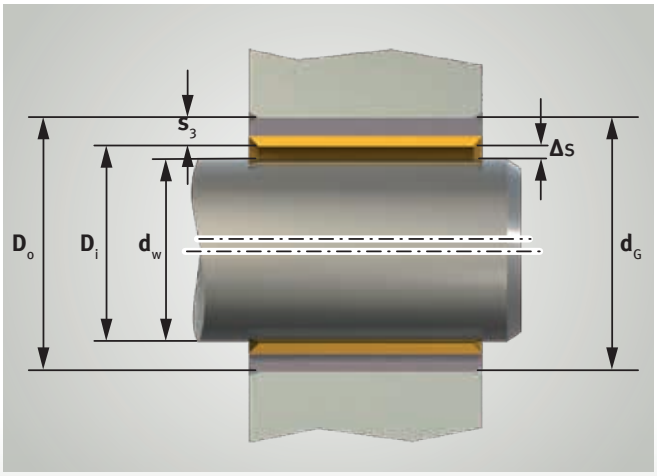

Fig. 3: Theoretical bearing clearance Δs

* On request

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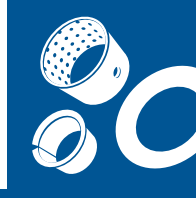

Press fit and bearing clearance

Design and environmental influences	Consequence	Measure	Note
Alloy or thin-walled housing	Extensive widening Excessive clearance	Reduce housing bore d_G	The housing is under greater strain; the permitted housing tension must not be exceeded.
Steel or cast iron housing at high ambient temperatures	Smaller clearance	Reduce shaft diameter d_W by 0.008 mm per 100°C above room temperature	
Bronze or copper alloy housing at high ambient temperatures	Poor press fit	Reduce housing bore d_G, recommended change to diameter per 100°C above room temperature: d_G -0.05%	Reduce shaft diameter d_W by the same value, in order to retain the same bearing clearance.
Aluminium alloy housing at high ambient temperatures	Poor press fit	Reduce housing bore d_G, recommended change to diameter per 100°C above room temperature: d_G -0.1%	Reduce shaft diameter d_W by the same value, in order to retain the same bearing clearance. The housing is under greater strain at temperatures below 0°C; the permitted housing tension must not be exceeded.
Bushes with thicker layer of corrosion protection	Outside diameter D_o too large Insufficient clearance	Enlarge housing bore d_G Example: Layer thickness 0.015±0.003 mm producing d_G +0.03 mm	The bush and housing are subject to greater strain unless appropriate measures are taken.

Tab. 7: Errors, consequences and measures in relation to press fit and bearing clearance at high ambient temperatures, with special housing materials or housing wall thicknesses

Information on the design and layout of the bearing assembly and the housing is available in Service Information SI 1425

KSPG Automotive

* On request

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