



# 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:

$$[12] \quad \Delta s_{\max} = d_{G\max} - 2 \cdot s_{3\min} - d_{W\min}$$

$$[13] \quad \Delta s_{\min} = d_{G\min} - 2 \cdot s_{3\max} - d_{W\max}$$

- $\Delta s_{\max}$  [mm] Maximum bearing clearance
- $\Delta s_{\min}$  [mm] Minimum bearing clearance
- $d_{G\max}$  [mm] Maximum diameter of housing bore
- $d_{G\min}$  [mm] Minimum diameter of housing bore
- $d_{W\max}$  [mm] Maximum shaft diameter
- $d_{W\min}$  [mm] Minimum shaft diameter
- $s_{3\max}$  [mm] Maximum wall thickness
- $s_{3\min}$  [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  $D_o$  are stated in Table 2.

\* On request

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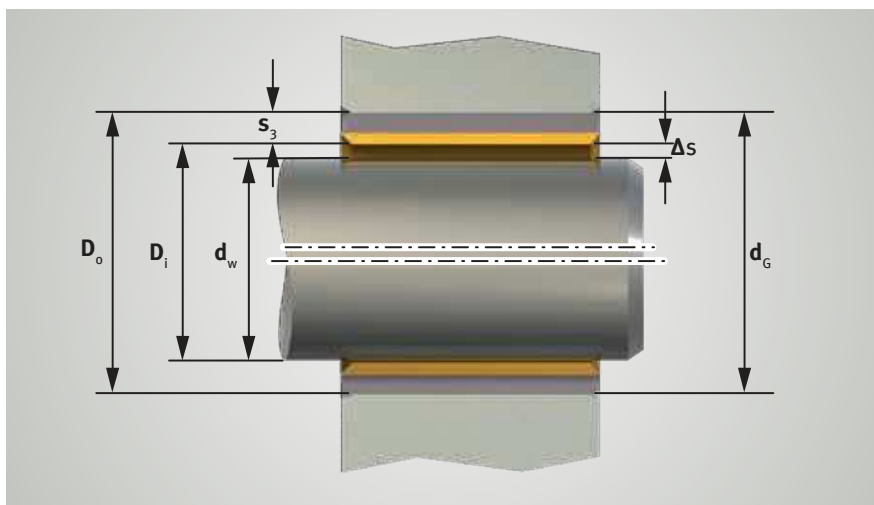


Fig. 1: Theoretical bearing clearance  $\Delta s$

## 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  $d_w < 80$  (P11) must be verified using equations [12] for  $\Delta s_{\max}$  and [13] for  $\Delta s_{\min}$ .

| Diameter range      | KS PERMAGLIDE®  |     |           |
|---------------------|-----------------|-----|-----------|
|                     | P10, P14, P147* | P11 | P20, P200 |
| <b>Shaft</b>        |                 |     |           |
| $d_w < 5$           | h6              | f7  | h8        |
| $5 \leq d_w < 80$   | f7              | f7  | h8        |
| $80 \leq d_w$       | h8              | h8  | h8        |
| <b>Housing bore</b> |                 |     |           |
| $d_G \leq 5.5$      | H6              | –   | –         |
| $5.5 < d_G$         | H7              | H7  | H7        |

Tab. 1: Recommended fitting tolerances



| Outside diameter of bush<br>$D_o$ | 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  $D_o$

| Inside diameter of bush<br>$D_i$ | Wall thickness<br>$s_3$ | 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  $s_3$  for P1 bushes and flange bushes

| Inside diameter<br>$D_i$ | Wall thickness<br>$s_3$ | 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  $s_3$  for bushes made from KS PERMAGLIDE® P20/P200

| Wall thickness<br>$s_3$ | Outside bevel, without cutting<br>$C_o$ | Inside bevel<br>$C_i$ |      |
|-------------------------|---|-----------------------|------|
|                         |   | Min.                  | Max. |
| 0.75                    | $0.5 \pm 0.3$                           | 0.1                   | 0.4  |
| 1                       | $0.6 \pm 0.4$                           | 0.1                   | 0.5  |
| 1.5                     | $0.6 \pm 0.4$                           | 0.1                   | 0.7  |
| 2                       | $1.0 \pm 0.4$                           | 0.1                   | 0.7  |
| 2.5                     | $1.2 \pm 0.4$                           | 0.2                   | 1.0  |

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

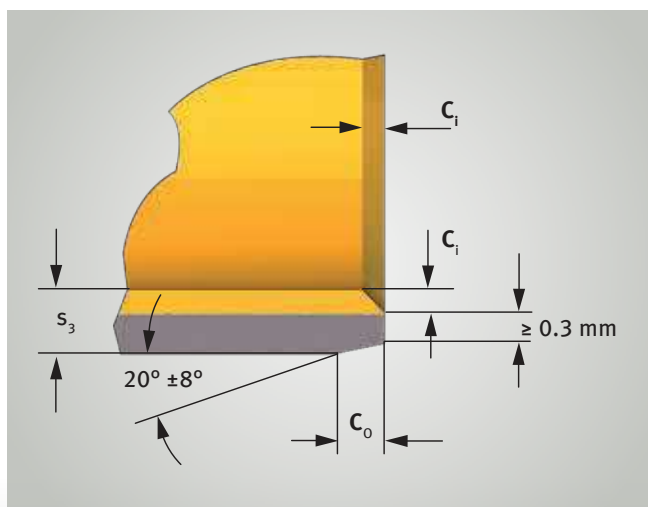
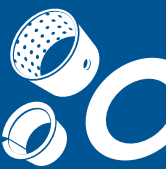


Fig. 2: Outside bevel  $C_o$  and inside bevel  $C_i$  with metric dimensions

\* On request

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**Theoretical bearing clearance**

| Bush diameter |               | Bearing clearance $\Delta s$ |                          |                          |                          |
|---------------|---------------|------------------------------|--------------------------|--------------------------|--------------------------|
| $D_i$<br>(mm) | $D_o$<br>(mm) | P10, P11, P14, P147*         |                          | P20, P200                |                          |
|               |               | $\Delta s_{min}$<br>(mm)     | $\Delta s_{max}$<br>(mm) | $\Delta s_{min}$<br>(mm) | $\Delta s_{max}$<br>(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 $\Delta s$ |                          |                          |                          |
|---------------|---------------|------------------------------|--------------------------|--------------------------|--------------------------|
| $D_i$<br>(mm) | $D_o$<br>(mm) | P10, P 11, P14, P147*        |                          | P20, P200                |                          |
|               |               | $\Delta s_{min}$<br>(mm)     | $\Delta s_{max}$<br>(mm) | $\Delta s_{min}$<br>(mm) | $\Delta s_{max}$<br>(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

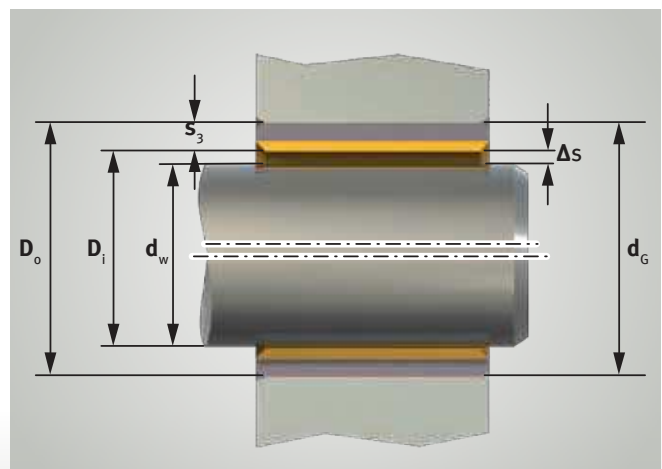
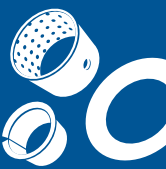


Fig. 3: Theoretical bearing clearance  $\Delta s$

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### Press fit and bearing clearance

| Design and environmental influences                         | Consequence  | Measure   | Note   |
|---|--|---|--|
| Alloy or thin-walled housing                                | Extensive widening<br>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<br>Insufficient clearance | Enlarge housing bore $d_g$<br>Example:<br>Layer thickness $0.015 \pm 0.003$ 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