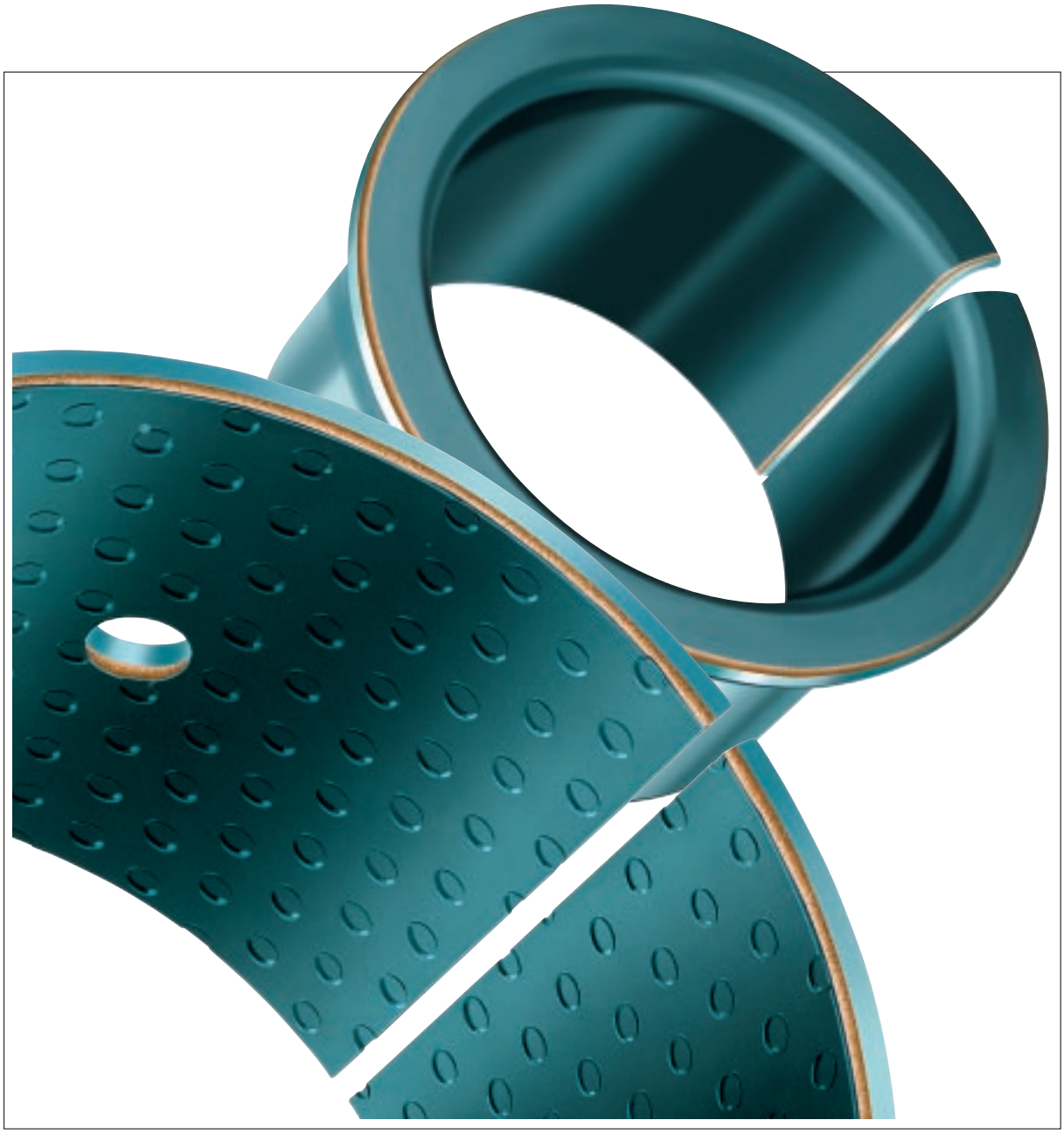


Permaglide®
plain bearings

Catalogue 706

This technical publication has been produced with a great deal of care and attention and all data have been checked for their accuracy. However, no liability can be assumed for any incorrect or incomplete data.

Product pictures are for illustrative purposes only and must not be used for design work.

Designs must only be prepared in accordance with the technical information, dimension tables and dimension drawings!

Due to constant development of the product range, we reserve the right to make modifications.

The sales and delivery conditions in force are those which form the basis of the invoices and contracts.

Produced by:

INA Bearing Company Ltd
Forge Lane, Minworth
Sutton Coldfield
West Midlands · B76 1AP

www.ina.co.uk

Printed in Germany by
Frankendruck GmbH, 90025 Nürnberg

706 Permaglide® plain bearings

With its new structure and pictograms, Catalogue 706 “Permaglide® Plain Bearings” will quickly guide you to the information you require.

It is subdivided into three main sections:

- Technical principles:
  - How is the rating life calculated?
  - How is a bearing arrangement designed?
  - How are Permaglide® plain bearings installed?
    The section on “Technical principles” will provide the answers.
- Materials: This section contains information about the design, behaviour and areas of application of the Permaglide® materials.
- Designs and dimension tables:
  - This section contains the description and dimensions of the bearings offered in this catalogue.

The new structure is matched to the different stages involved in designing a bearing arrangement. Pictograms direct you to additional information.

This catalogue contains the standard Permaglide® range.
The main dimensions conform to DIN ISO 3547 “Plain bearings. Wrapped bushes. Dimensions”.

Catalogue 706 has been completely revised and updated. It replaces Catalogue 705. Any information in earlier publications that does not agree with Catalogue 706 is therefore invalid.

If you would like to know more:
Using the CD-ROM “**medias**® *professional*” or the INA website at www.ina.com, you can for example calculate the rating life for Permaglide® plain bearings.

The publication ABP “Application Examples for Permaglide® Plain Bearings” shows exemplary design solutions.

Furthermore, our experts from the application engineering function and the INA engineering service are available to provide in-depth advice and prepare installation proposals.

INA-Schaeffler KG
Herzogenaurach

Maintenance-free plain bearing material
primarily for dry running

Permaglide® P1

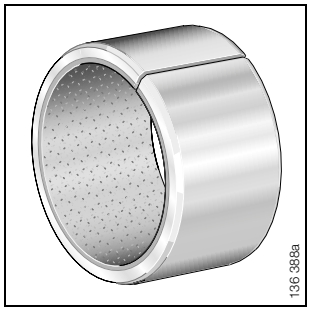
pv_{max} = 1,8 N/mm² · m/s
pv_{temp} = 3,6 N/mm² · m/s
$p_{max\ stat.}$ = 250 N/mm²
$p_{max\ dyn.}$ = 56 N/mm²
v_{max} = 2 m/s
ϑ = –200 °C to +280 °C

Low-maintenance plain bearing material
lubrication required

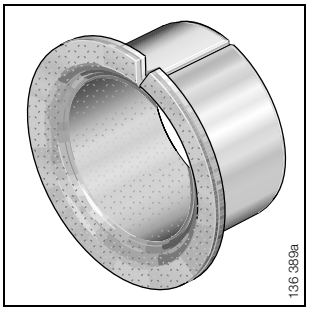
Permaglide® P2

pv_{max} = 3 N/mm² · m/s
$p_{max\ stat.}$ = 250 N/mm²
$p_{max\ dyn.}$ = 70 N/mm²
v_{max} = 3 m/s
ϑ = –40 °C to +110 °C
ϑ_{max} = up to +140 °C for short periods

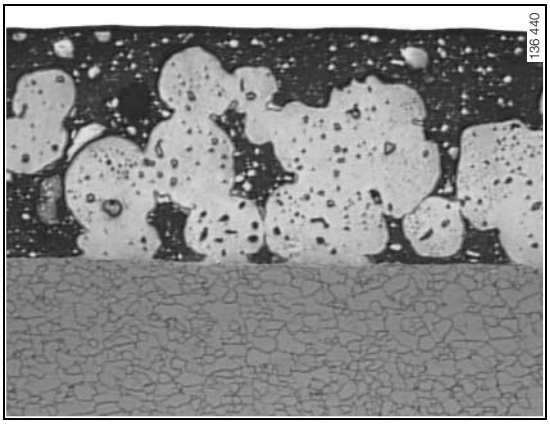
Bushes
maintenance-free:
PAP..P10
PAP..P11
low-maintenance:
PAP..P20



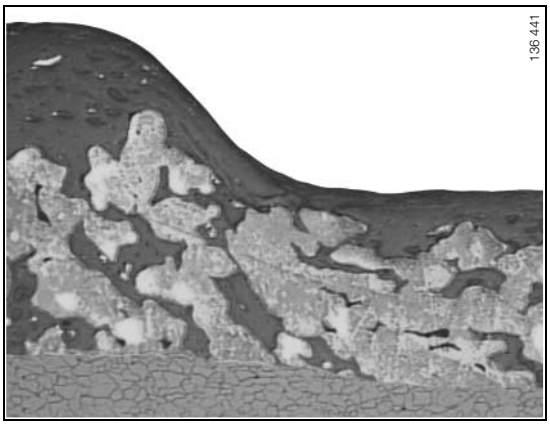
Flanged bushes
maintenance-free:
PAF..P10
PAF..P11



Permaglide® P1



Permaglide® P2

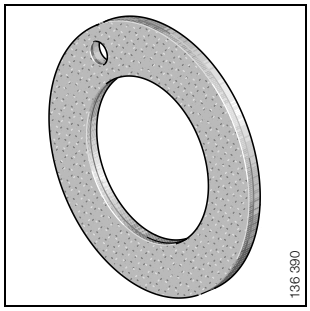


Designs

Thrust washers PAW

maintenance-free:
PAW..P10

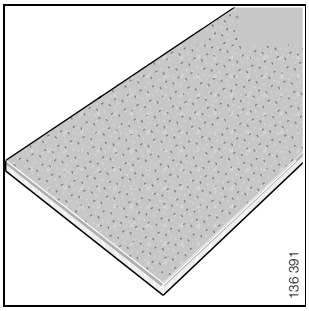
low-maintenance:
PAW..P20



Strips PAS

maintenance-free:
PAS..P10
PAS..P11

low-maintenance:
PAS..P20



Dimension tables

Appendix
Index
Addresses

Contents

Page	
6	**US conversion factors**
7	**Symbols and units**
10	**Rating life**
10	Operating life
10	Calculation of rating life
11	Range
12	Basic rating life
14	Correction factors
17	Calculation example Bush PAP..P10
18	Calculation example Thrust washer PAW..P20
19	**Design of bearing arrangements**
19	Housing
20	Location of thrust washers
21	Shaft
21	Mating surface
22	Seals
22	Heat dissipation
22	Machining of bearing elements
23	Alignment
24	**Internal clearance and mounting tolerances**
24	Metric sizes
24	Theoretical internal clearance
24	Interference fit and internal clearance
25	Conversion to DIN ISO 3547
25	Deviations for the outside diameter
25	Wall thicknesses with tolerances
25	Chamfers and chamfer tolerances
28	Inch sizes
30	**Pressing in of bushes**
30	Recommendations
32	Calculation of press-in force
34	Calculation example
35	**Delivered condition, storage**
35	**Environmental considerations, health and safety at work**

Page

36 **Materials**
36 Permaglide® P1, maintenance-free plain bearing material
37 Technical data
38 Friction
38 Chemical resistance and corrosion protection
39 Fretting corrosion
39 Electrochemical contact corrosion
39 Electrical conductivity
39 Lubrication
40 Hydrodynamic properties
40 High temperature operation
40 Operating behaviour
42 Sizing
43 Special designs
44 **Materials**
44 Permaglide® P2, low-maintenance plain bearing material
45 Technical data
46 Friction
46 Chemical resistance and corrosion protection
46 Fretting corrosion
46 Electrochemical contact corrosion
46 Lubrication
47 Hydrodynamic properties
47 Machining of the sliding layer
48 Special designs
50 **Designs**
50 Maintenance-free Permaglide® plain bearings P1
50 Low-maintenance Permaglide® plain bearings P2
52 Ordering examples
53 **Dimension tables**
53 Bushes PAP..P10
56 Bushes PAPZ..P10, inch sizes
59 Bushes PAP..P11
60 Flanged bushes PAF..P10, PAF..P11
61 Thrust washers PAW..P10
62 Strips PAS..P10, PAS..P11
63 Bushes PAP..P20
64 Thrust washers PAW..P20
65 Strips PAS..P20, PAS..P21, PAS..P22
66 **Special designs, linear plain bearings**
68 **Subject index**
72 **Sales company/Engineering service**

US conversion factors
Surface roughness
ISO tolerances

Conversion factors

Dimensions	1 mm	0,039 in
	1 in	25,4 mm
	0,001 mm	0,00004 in
	0,001 in	0,025 mm
Mass	1 g	0,0022 lbs
	1 lb	453,6 g
Force	1 N	0,225 lbf
	1 lbf	4,45 N
Temperature	$°F = \frac{9 \times °C}{5} + 32$	$°C = \frac{5}{9}(°F - 32)$
	–200 ° C	–328 °F
	–40 ° C	–40 °F
	+110 ° C	+230 °F
	+140 ° C	+284 °F
	+280 ° C	+536 °F
Speed	1 m/s	196,848 fpm = 3,281 ft/s
	2 m/s	394 fpm
	3 m/s	590 fpm
	1 ft/s	0,3048 m/s
Torque	1 Nmm	0,009 in · lbf
	1 in · lbf	113 Nmm
	1 Nm	8,85 in · lbf
	1 in · lbf	0,113 Nm
Pressure	1 N/mm^2 = 1 MPa	145 psi
	250 N/mm^2	36 258 psi
	1 psi	0,007 N/mm^2 = 0,007 MPa
pv value	1,8 N/mm^2 · m/s	51 390 psi · fpm
	3 N/mm^2 · m/s	85 650 psi · fpm
	3,6 N/mm^2 · m/s	102 780 psi · fpm

Surface roughness

R_a µm	AA and CLA µinch	R_t µm	R_z µm	RMS µinch	Surface symbols
0,2	8	1	1	8,96	∇∇∇∇
0,25	10	–	–	11,2	
0,3	12	1,5	1,6	13,44	
0,32	13	–	–	14,56	
0,4	16	2	2	17,92	∇∇∇
0,5	20	2,5	2,5	22,4	
0,63	25	3	3	28	
0,8	32	4	4	35,84	
1	40	–	–	44,8	∇∇
1,2	48	6,3	6,3	53,76	

ISO tolerances for shafts

Designation	Nominal devi.	Nominal dimension range in mm									
		over 3 incl. 6	6 10	10 18	18 30	30 50	50 80	80 120	120 180	180 250	250 315
		Deviations in µm									
f 7	upper	–10	–13	–16	–20	–25	–30	–36	–43	–50	– 56
	lower	–22	–28	–34	–41	–50	–60	–71	–83	–96	–108
h 6	upper	0	0	0	0	0	0	0	0	0	0
	lower	– 8	– 9	–11	–13	–16	–19	–22	–25	–29	– 32
h 7	upper	0	0	0	0	0	0	0	0	0	0
	lower	–12	–15	–18	–21	–25	–30	–35	–40	–46	– 52
h 8	upper	0	0	0	0	0	0	0	0	0	0
	lower	–18	–22	–27	–33	–39	–46	–54	–63	–72	– 81

ISO tolerances for holes

Designation	Nominal devi.	Nominal dimension range in mm									
		over 3 incl. 6	6 10	10 18	18 30	30 50	50 80	80 120	120 180	180 250	250 315
		Deviations in µm									
G 7	upper	+16	+20	+24	+28	+34	+40	+47	+54	+61	+69
	lower	+ 4	+ 5	+ 6	+ 7	+ 9	+10	+12	+14	+15	+17
H 6	upper	+ 8	+ 9	+11	+13	+16	+19	+22	+25	+29	+32
	lower	0	0	0	0	0	0	0	0	0	0
H 7	upper	+12	+15	+18	+21	+25	+30	+35	+40	+46	+52
	lower	0	0	0	0	0	0	0	0	0	0
H 8	upper	+18	+22	+27	+33	+39	+46	+54	+63	+72	+81
	lower	0	0	0	0	0	0	0	0	0	0
J 7	upper	+ 6	+ 8	+10	+12	+14	+18	+22	+26	+30	+36
	lower	– 6	– 7	– 8	– 9	–11	–12	–13	–14	–16	–16

Symbols and units

Unless stated otherwise in the text, the values used in this catalogue have the following symbols, units and definitions.

A	mm^2	Outside surface area of bush
B	mm	Width of bush, total width of strip
B_1	mm	Usable width of strip
C_i	mm	Inner edge break
C_o	mm	Outer chamfer
D_{FL}	mm	Flange diameter
D_i	mm	Inside diameter of bush Inside diameter of thrust washer
D_{iE}	mm	Inside diameter of bush after pressing in
D_o	mm	Outside diameter of bush Outside diameter of thrust washer
d_1	mm	Diameter of fixing hole in thrust washer
d_{6a}	mm	Diameter of housing recess for thrust washers
d_G	mm	Diameter of housing bore
d_H	mm	Inside diameter of auxiliary ring
d_K	mm	Diameter of burnishing tool
d_L	mm	Diameter of lubrication hole in PAP..P20 bush
d_W	mm	Shaft diameter
E_G	N/mm^2	Modulus of elasticity of housing
E_L	N/mm^2	Modulus of elasticity of bearing
F	N	Bearing load, press-in force
f_G	mm	Chamfer width on housing
f_A	–	Correction factor for loading
f_L	–	Correction factor for linear movement
f_p	–	Correction factor for load
f_R	–	Correction factor for roughness depth
f_v	–	Correction factor for sliding speed
f_W	–	Correction factor for material
f_ϑ	–	Correction factor for temperature
H	mm	Stroke length for linear movement

J	mm	Pitch circle diameter of thrust washer
L	mm	Length of strip
L_h	h	Basic rating life
m	g	Mass
n	min^{-1}	Speed
n_{osc}	min^{-1}	Oscillation frequency of to and fro movement
p	N/mm^2	Specific bearing load
p_1	N/mm^2	Joint pressure
pv	$N/mm^2 \cdot m/s$	pv value: product of the specific bearing load and the sliding speed
R	mm	Radius
R_{rel}	$\Omega \cdot cm^2$	Relative electrical resistance
R_z	µm	Roughness depth
$R_{z\,G}$	µm	Roughness depth of housing bore
$R_{z\,L}$	µm	Roughness depth of bush backing material
s_1	mm	Thickness of steel or bronze backing
s_3	mm	Wall thickness of bush
s_{FL}	mm	Thickness of flange
s_G	mm	Wall thickness of housing
s_{Mat}	mm	Material removal during running-in
s_4	mm	Machining allowance
t_a	mm	Depth of the housing recess
v	m/s	Sliding speed
U	mm	Interference

α_{Bz}	K^{-1}	Coefficient of thermal expansion for bronze
α_{St}	K^{-1}	Coefficient of thermal expansion for steel
Δs	mm	Theoretical internal clearance
ϑ	°C, K	Operating temperature
λ_{Bz}	W/(m · K)	Coefficient of thermal conductivity for bronze
λ_{St}	W/(m · K)	Coefficient of thermal conductivity for steel
μ	–	Coefficient of friction
μ_L	–	Coefficient of friction between bush backing and housing bore
ν_G	–	Transversal contraction of housing
ν_L	–	Transversal contraction of bearing
φ	°	Oscillation angle

Rating life

Operating life

The operating life is the life actually achieved by a plain bearing. This can deviate substantially from the calculated basic rating life.

Calculation of rating life

Calculation of the basic rating life applies to plain bearings with

- rotary movement
- oscillating movement
- linear movement
  - – please consult the INA engineering service for Permaglide® P2.

The basic rating life is essentially dependent on

- the pv value
  - – specific bearing load
  - – sliding speed
- mating surface
  - – material
  - – roughness depth
  - – surface structure
- operating temperature.

It is not possible to quantify the following in mathematical terms:

- corrosion – in dry running of Permaglide® P1
- lubricant ageing – in grease lubrication of Permaglide® P2
- contamination.

Calculated rating life – guide value

For the reasons stated above, the calculated basic rating life can serve only as a guide value.

Unrealistic guide values will result under the following conditions:

- very low bearing loads or
- very low sliding speeds.

⚠ The range (Table 1) only indicates the limits within which it is realistic to carry out life calculation.

The Permaglide® plain bearing material can be loaded up to the values given in Table 2.

The rating life may be shortened or extended by special operating conditions: guide values are given in Table 3.

Range

Table 1 · Range of the life calculation

Range for		Permaglide® **P1**	Permaglide® **P2**
pv value			
pv	N/mm² · m/s	0,03 ≤ pv ≤ 1,8	0,2≤ pv ≤ 3
Specific load			
p	N/mm²	p ≤56	p ≤70
Sliding speed			
v	m/s	v ≤ 2	v ≤ 3

Table 2 · Permissible loads

Permissible loads		Permaglide® **P1**	Permaglide® **P2**
pv value			
pv_{max}	N/mm² · m/s	1,8	3
pv[1)]	N/mm² · m/s	3,6	–
Specific load p			
$p_{max\ stat.}$	N/mm²	250	250
p_{max}[2)]	N/mm²	140	140
$p_{max\ dyn.}$	N/mm²	56	70
Sliding speed v			
v_{max}	m/s	2	3
Operating temperature ϑ			
ϑ	°C	–200 to +280	–40 to +110
$ϑ_{max}$[1)]	°C	–	to +140

1) For short periods.

2) Very low sliding speed.

Table 3 · Guide values for the rating life of **P1** under special operating conditions

Operating conditions	Rating life
Dry running, intermittent	200% L_h
Alternating between dry running and running in water	20% L_h
Running in water	200% L_h
Continuous operation in fluid lubricants	300% L_h
Continuous operation in lubricating greases	50% to 150% L_h

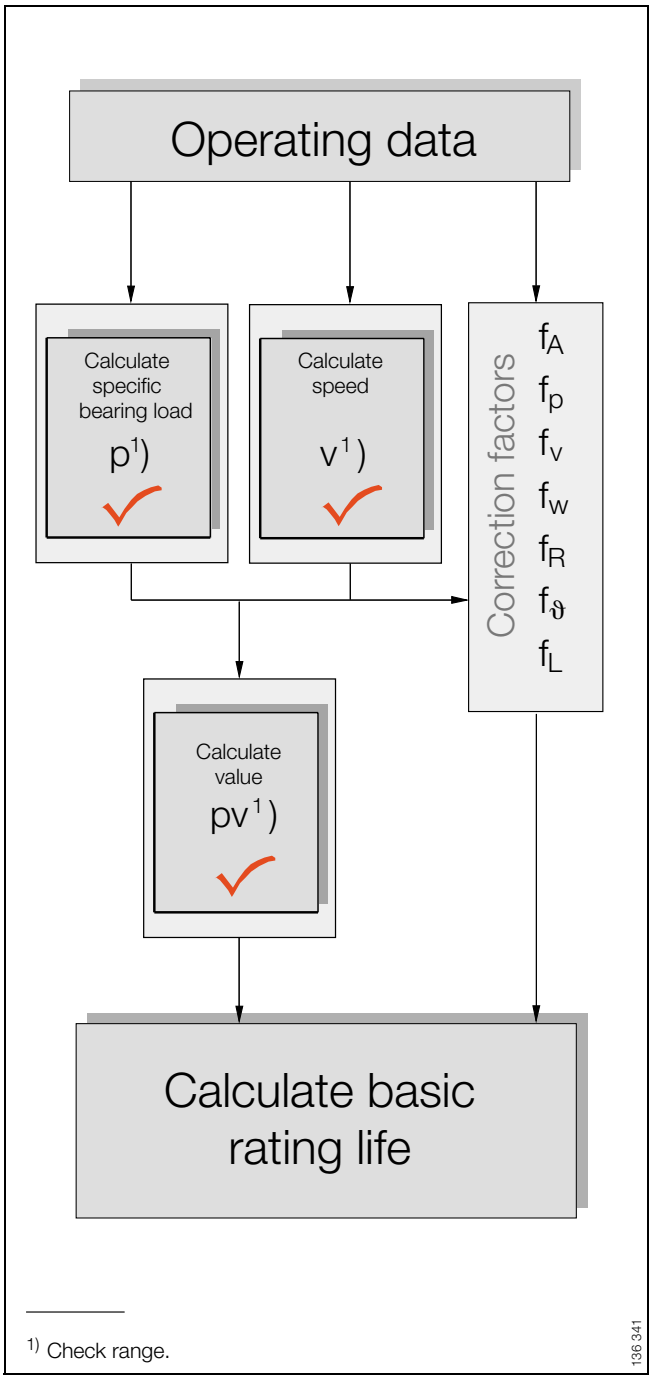


Figure 1 · Life calculation diagram

Basic rating life

Maintenance-free Permaglide® **P1**

Rotary movement

$$L_h = \frac{400}{(pv)^{1,2}} \cdot f_A \cdot f_p \cdot f_v \cdot f_\vartheta \cdot f_W \cdot f_R \quad (1)$$

Linear movement

$$L_h = \frac{400}{(pv)^{1,2}} \cdot f_A \cdot f_p \cdot f_v \cdot f_\vartheta \cdot f_W \cdot f_R \cdot f_L \quad (2)$$

Low-maintenance Permaglide® **P2**

Rotary movement

$$L_h = \frac{2\,000}{(pv)^{1,5}} \cdot f_A \cdot f_p \cdot f_v \cdot f_\vartheta \cdot f_W \cdot f_R \quad (3)$$

Specific bearing load

Bush

$$p = \frac{F}{D_i \cdot B} \quad (4)$$

Thrust washer

$$p = \frac{4 \cdot F}{(D_o^{\,2} - D_i^{\,2}) \cdot \pi} \quad (5)$$

Sliding speed

Bush, rotary movement

$$v = \frac{D_i \cdot \pi \cdot n}{60 \cdot 10^3} \quad (6)$$

Bush, oscillating movement

$$v = \frac{D_i \cdot \pi}{60 \cdot 10^3} \cdot \frac{2\varphi \cdot n_{osc}}{360°} \quad (7)$$

Thrust washer, rotary movement

$$v = \frac{D_o \cdot \pi \cdot n}{60 \cdot 10^3} \quad (8)$$

Thrust washer, oscillating movement

$$v = \frac{D_o \cdot \pi}{60 \cdot 10^3} \cdot \frac{2\varphi \cdot n_{osc}}{360°} \quad (9)$$

⚠ Check whether p, v and pv are within range – see Table 1, page 11.

B mm
Width of bush, see *dimension tables*

D_i mm
Inside diameter of bush, see *dimension tables*
Inside diameter of thrust washer, see *dimension tables*

D_o mm
Outside diameter of thrust washer, see *dimension tables*

F N
Bearing load

f_A –
Correction factor for loading, Figure 3, page 14

f_D –
Correction factor for load, Figure 4, page 15

f_v –
Correction factor for sliding speed, Figure 5, page 15

f_ϑ –
Correction factor for temperature, Figure 6, page 15

f_W –
Correction factor for material, Table 4, page 14

f_R –
Correction factor for roughness depth, Figure 7, page 15

f_L –
Correction factor for linear movement, see page 16

L_h h
Basic rating life

n min^{-1}
Speed

n_{osc} min^{-1}
Oscillation frequency, Figure 2

p N/mm^2
Specific bearing load

v m/s
Sliding speed

φ °
Oscillation angle, Figure 2.

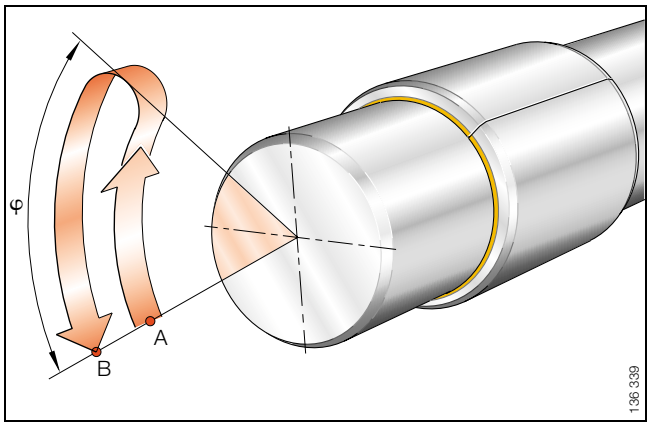


Figure 2 · Oscillation angle φ
The oscillation frequency n_{osc} is the number of movements from A to B per minute

Correction factors

- Correction factor for loading f_A, Figure 3
  - Point load $f_A = 1$
    Rotating shaft, stationary bush
  - Circumferential load $f_A = 2$
    Stationary shaft, rotating bush
  - Thrust washer $f_A = 1$
  - Linear movement $f_A = 1$
- Correction factor for load f_p, Figure 4, page 15
- Correction factor for sliding speed f_v, Figure 5, page 15
- Correction factor for temperature f_ϑ, Figure 6, page 15
- Correction factor for material f_W, Table 4, page 14
- Correction factor for roughness depth f_R, Figure 7, page 15
- Correction factor for linear movement f_L, page 16.

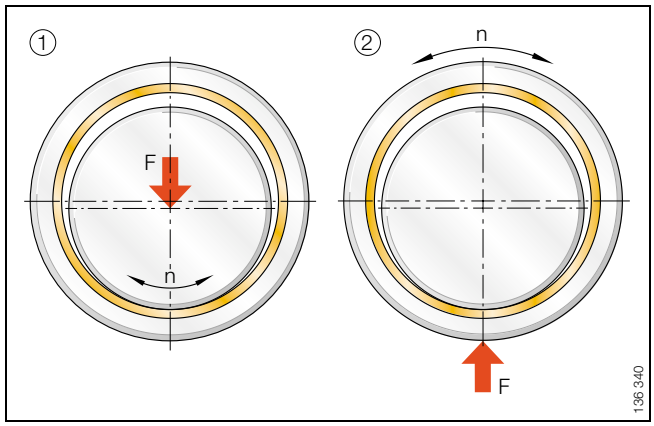


Figure 3 · Correction factor for loading f_A
① Point load $f_A = 1$
② Circumferential load $f_A = 2$

Table 4 · Correction factor for material f_W with roughness depth R_z2 to R_z3 of the mating surface for Permaglide® P1 and P2

Mating surface material	f_W
Steel	1
Nitrided steel	1
Corrosion-resistant steel	2
Hard-chromium plated steel (layer thickness min. 0,013 mm)	2
Zinc-plated steel (layer thickness min. 0,013 mm)	0,2
Phosphated steel (layer thickness min. 0,013 mm)	0,2
Cast iron R_z2	1
Anodized aluminium	0,4
Hard anodized aluminium (hardness 450 +50 HV; 0,025 mm thick)	2
Copper-based alloys	0,1 to 0,4
Nickel	0,2

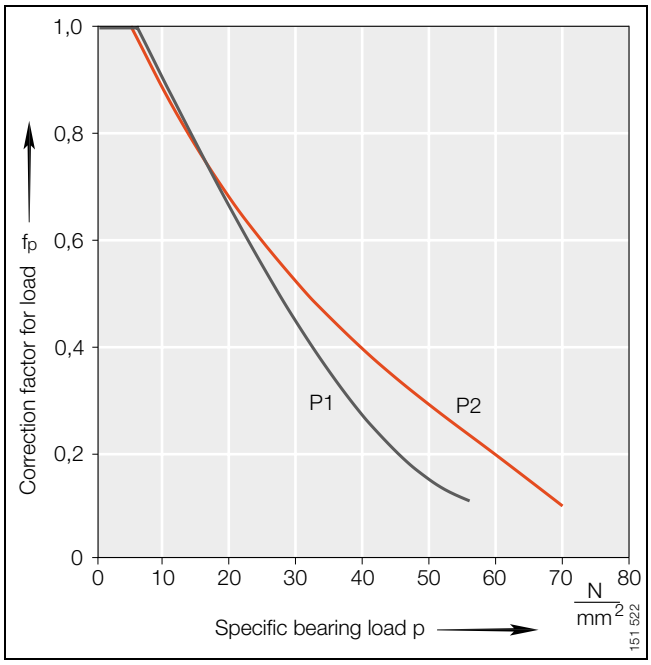


Figure 4 · Correction factor for load f_p, Permaglide® P1, P2

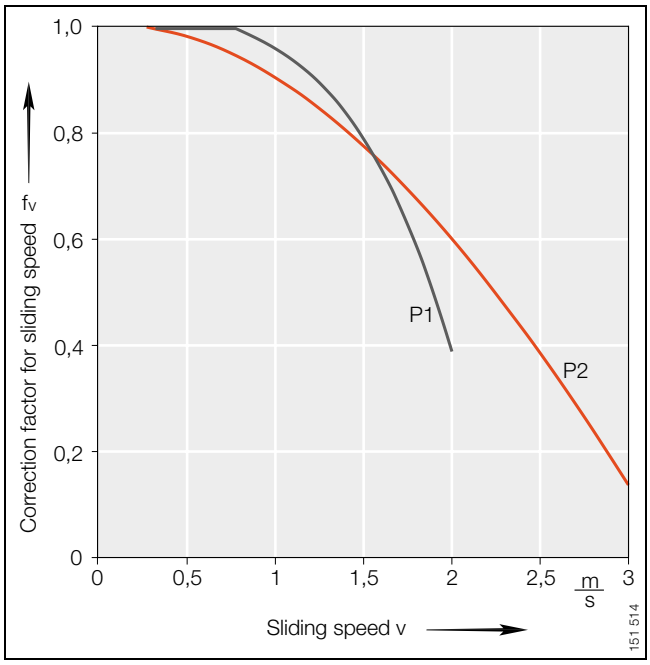


Figure 5 · Correction factor for sliding speed f_v, Permaglide® P1, P2

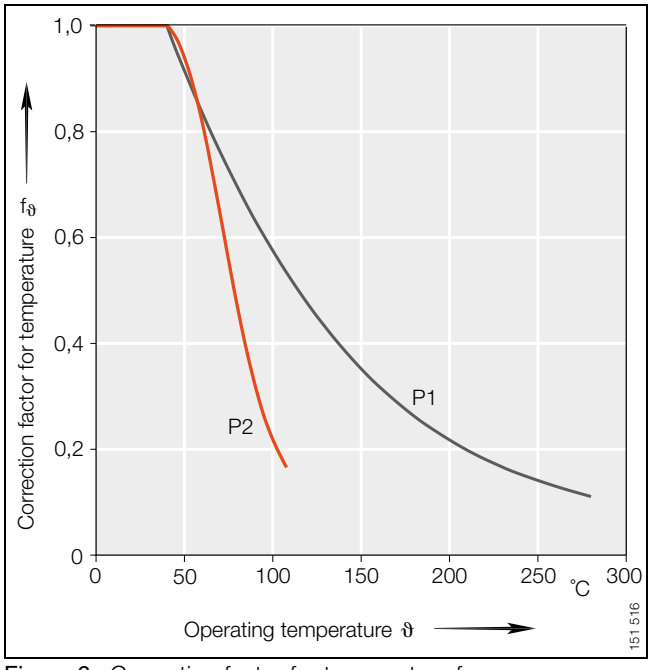


Figure 6 · Correction factor for temperature f_ϑ, Permaglide® P1, P2

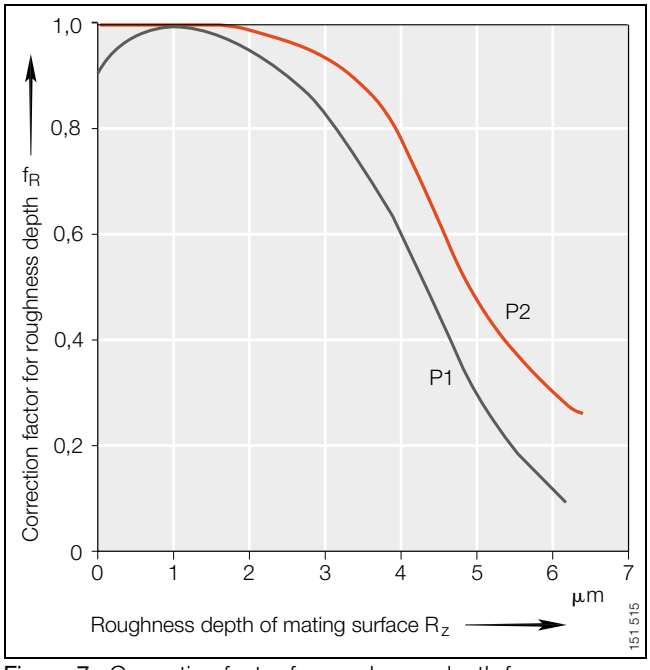


Figure 7 · Correction factor for roughness depth f_R, Permaglide® P1, P2

Calculation of correction factor f_L for Permaglide® P1:

$$f_L = 0{,}65 \cdot \frac{B}{H + B} \quad (10)$$

f_L –
Correction factor for linear movement

B mm
Width of bush, see *dimension tables*

H mm
Stroke length.

Stroke length for linear movement, Figure 8:

⚠ Limit value: $H_{max} = 2{,}5 \times B$.

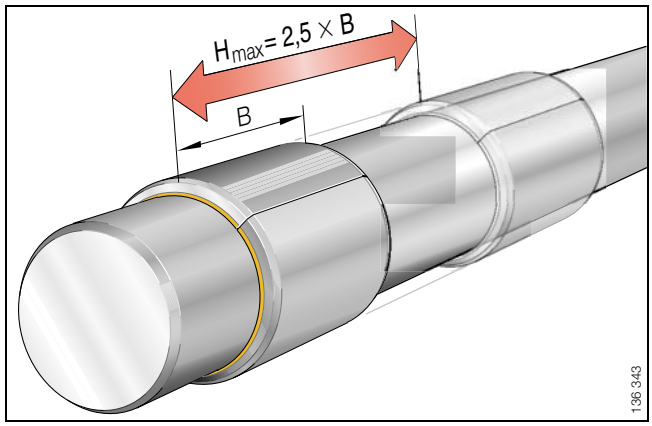


Figure 8 · Linear movement, stroke length H_{max}

A bearing with a rating life of 1000 h under point load is required for a steel shaft of 20 mm diameter

Bush PAP 2015 P10 / Operating data / Required	Inside diameter of bush D_i = 20 mm	Width of bush B = 15 mm	Bearing load F = 300 N	Speed n = 500 min^{-1}	Correction factors
Specific bearing load p *Check range!*	$p = \frac{F}{D_i \cdot B} = \frac{300}{20 \cdot 5}$ N/mm^2		$p = 1$ N/mm^2		
Sliding speed v *Check range!*	$v = \frac{D_i \cdot \pi \cdot n}{60 \cdot 10^3} = \frac{20 \cdot \pi \cdot 500}{60 \cdot 10^3}$ m/s		$v = 0{,}52$ m/s		
pv value *Check range!*	$pv = p \cdot v = 1 \cdot 0{,}52$ N/mm^2 · m/s		$pv = 0{,}52$ N/mm^2 · m/s		
Correction factor for loading f_A	$f_A = 1$	Point load	Figure 3, page 14		
Correction factor for load f	$f_p = 1$		Figure 4, page 15		
Correction factor for sliding speed f_v	$f_v = 1$		Figure 5, page 15		
Correction factor for temperature f_ϑ	$f_\vartheta = 1$	ϑ = +35 °C	Figure 6, page 15		
Correction factor for material f_W	$f_W = 1$	Steel	Table 4, page 14		
Correction factor for roughness depth f_R	$f_R = 0{,}96$	$R_z = 2$	Figure 7, page 15		
Basic rating life L_h	$L_h = \frac{100}{(pv)^{1,2}} \cdot f_A \cdot f_p \cdot f_v \cdot f_\vartheta \cdot f_W \cdot f_R = \frac{400}{0{,}52^{1,2}} \cdot 1 \cdot 1 \cdot 1 \cdot 1 \cdot 1 \cdot 0{,}96$ h				
	L_h = 842 h <1000 h = $L_{h\ required}$		**Condition not fulfilled**		

New calculation with wider bush PAP 2020 P10

Bush PAP 2020 P10 / Operating data / Required	Inside diameter of bush D_i = 20 mm	Width of bush B = 20 mm	Bearing load F = 300 N	Speed n = 500 min^{-1}	Correction factors
Specific bearing load p *Check range!*	$p = \frac{F}{D_i \cdot B} = \frac{300}{20 \cdot 20}$ N/mm^2		$p = 0{,}75$ N/mm^2		
Sliding speed v *Check range!*	$v = \frac{D_i \cdot \pi \cdot n}{60 \cdot 10^3} = \frac{20 \cdot \pi \cdot 500}{60 \cdot 10^3}$ m/s		$v = 0{,}52$ m/s		
pv value *Check range!*	$pv = p \cdot v = 0{,}75 \cdot 0{,}52$ N/mm^2 · m/s		$pv = 0{,}39$ N/mm^2 · m/s		
Correction factor for loading f_A	$f_A = 1$	Point load	Figure 3, page 14		
Correction factor for load f_p	$f_p = 1$		Figure 4, page 15		
Correction factor for sliding speed f_v	$f_v = 1$		Figure 5, page 15		
Correction factor for temperature f_ϑ	$f_\vartheta = 1$	ϑ = +35 °C	Figure 6, page 15		
Correction factor for material f_W	$f_W = 1$	Steel	Table 4, page 14		
Correction factor for roughness depth f_R	$f_R = 0{,}96$	$R_z = 2$	Figure 7, page 15		
Basic rating life L_h	$L_h = \frac{100}{(pv)^{1,2}} \cdot f_A \cdot f_p \cdot f_v \cdot f_\vartheta \cdot f_W \cdot f_R = \frac{400}{0{,}39^{1,2}} \cdot 1 \cdot 1 \cdot 1 \cdot 1 \cdot 1 \cdot 0{,}96$ h				
	L_h = 1189 h >1000 h = $L_{h\ required}$		**Selected: Bush PAP 2020 P10**		

Rating life

Calculation example
Thrust washer PAW..P20

A rating life of 4 000 h is required for a thrust washer under an axial load of 1500 N

Thrust washer PAW 28 P20 / Operating data / Required	Inside diameter of thrust washer D_i = 28 mm	Outside diameter of thrust washer D_o = 48 mm	Bearing load F = 1500 N	Speed n = 200 min^{-1}	Correction factors
Specific bearing load p *Check range!*	$p = \frac{4 \cdot F}{(D_o^2 - D_i^2) \cdot \pi} = \frac{4 \cdot 1500}{(48^2 - 28^2) \cdot \pi}$		$p = 1{,}26$ N/mm^2		
Sliding speed v *Check range!*	$v = \frac{D_o \cdot \pi \cdot n}{60 \cdot 10^3} = \frac{48 \cdot \pi \cdot 200}{60 \cdot 10^3}$ m/s		$v = 0{,}5$ m/s		
pv value *Check range!*	$pv = p \cdot v = 1{,}26 \cdot 0{,}5$ N/mm$^2 \cdot$ m/s		$pv = 0{,}63$ N/mm$^2 \cdot$ m/s		
Correction factor for loading f_A	$f_A = 1$	Axial load	Figure 3, page 14		
Correction factor for load f_p	$f_p = 1$		Figure 4, page 15		
Correction factor for sliding speed f_v	$f_v = 0{,}98$		Figure 5, page 15		
Correction factor for temperature f_ϑ	$f_\vartheta = 1$	ϑ = +20 °C	Figure 6, page 15		
Correction factor for material f_W	$f_W = 1$	Steel	Table 4, page 14		
Correction factor for roughness depth f_R	$f_R = 0{,}98$	$R_z = 2$	Figure 7, page 15		
Basic rating life L_h	$L_h = \frac{2000}{(pv)^{1,5}} \cdot f_A \cdot f_p \cdot f_v \cdot f_\vartheta \cdot f_W \cdot f_R = \frac{2000}{0{,}63^{1,5}} \cdot 1 \cdot 1 \cdot 0{,}98 \cdot 1 \cdot 1 \cdot 0{,}98$ h				
	L_h = 3841 h <4000 h = $L_{h\ required}$		**Condition not fulfilled**		

New calculation with larger thrust washer PAW 32 P20

Thrust washer PAW 32 P20 / Operating data / Required	Inside diameter of thrust washer D_i = 32 mm	Outside diameter of thrust washer D_o = 54 mm	Bearing load F = 1500 N	Speed n = 200 min^{-1}	Correction factors
Specific bearing load p *Check range!*	$p = \frac{4 \cdot F}{(D_o^2 - D_i^2) \cdot \pi} = \frac{4 \cdot 1500}{(54^2 - 32^2) \cdot \pi}$		$p = 1{,}01$ N/mm^2		
Sliding speed v *Check range!*	$v = \frac{D_o \cdot \pi \cdot n}{60 \cdot 10^3} = \frac{54 \cdot \pi \cdot 200}{60 \cdot 10^3}$ m/s		$v = 0{,}57$ m/s		
pv value *Check range!*	$pv = p \cdot v = 1{,}01 \cdot 0{,}57$ N/mm$^2 \cdot$ m/s		$pv = 0{,}58$ N/mm$^2 \cdot$ m/s		
Correction factor for loading f_A	$f_A = 1$	Axial load	Figure 3, page 14		
Correction factor for load f_p	$f_p = 1$		Figure 4, page 15		
Correction factor for sliding speed f_v	$f_v = 0{,}97$		Figure 5, page 15		
Correction factor for temperature f_ϑ	$f_\vartheta = 1$	ϑ = +20 °C	Figure 6, page 15		
Correction factor for material f_W	$f_W = 1$	Steel	Table 4, page 14		
Correction factor for roughness depth f_R	$f_R = 0{,}98$	$R_z = 2$	Figure 7, page 15		
Basic rating life L_h	$L_h = \frac{2000}{(pv)^{1,5}} \cdot f_A \cdot f_p \cdot f_v \cdot f_\vartheta \cdot f_W \cdot f_R = \frac{2000}{0{,}58^{1,5}} \cdot 1 \cdot 1 \cdot 0{,}97 \cdot 1 \cdot 1 \cdot 0{,}98$ h				
	L_h = 4304 h >4000 h = $L_{h\ required}$		**Selected: Thrust washer PAW 32 P20**		

Housing

Bushes

Permaglide® bushes are pressed into the housing.

This provides both axial and radial location. No further means of fixing are required.

The following are recommended for the housing bore:

- roughness depth R_z10
- chamfer $f_G \times 20° \pm 5°$ (Figure 9, Table 5). This chamfer makes it easier to press the bush into the housing.

Table 5 · Chamfer width f_G on the housing bore for bushes (Figure 9)

Bore diameter d_G	Chamfer width f_G
$d_G \leqq 30$	$0{,}8_{\pm 0{,}3}$
$30 < d_G \leqq 80$	$1{,}2_{\pm 0{,}4}$
$80 < d_G \leqq 180$	$1{,}8_{\pm 0{,}8}$
$180 < d_G$	$2{,}5_{\pm 1{,}0}$

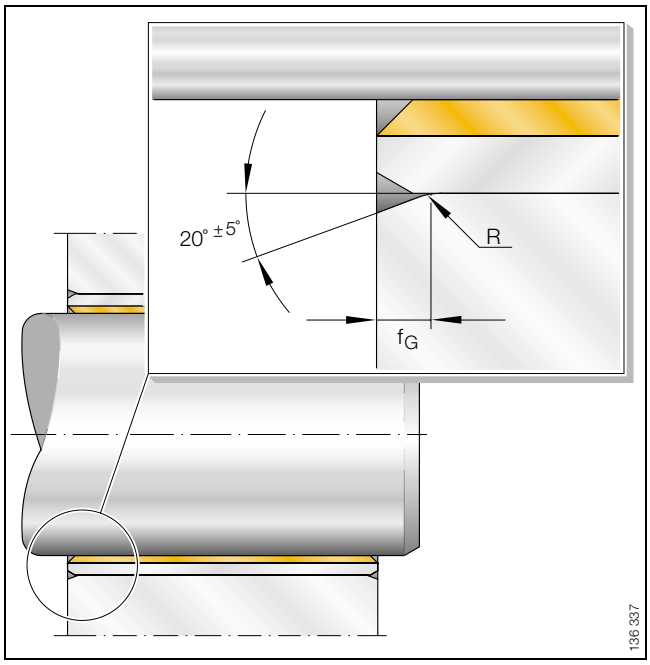


Figure 9 · Chamfer on housing for bush PAP

Flanged bushes

The radius at the transition from the radial to the axial component must be taken into consideration for flanged bushes (Figure 10, Table 6).

- the flanged bush must not be in contact in the area of the radius
- in applications with axial loads, the flange must be adequately supported.

Table 6 · Chamfer width f_G on the housing bore for flanged bushes (Figure 10)

Bore diameter d_G	Chamfer width f_G
$d_G \leqq 10$	$1{,}2_{\pm 0{,}2}$
$10 < d_G$	$1{,}7_{\pm 0{,}2}$

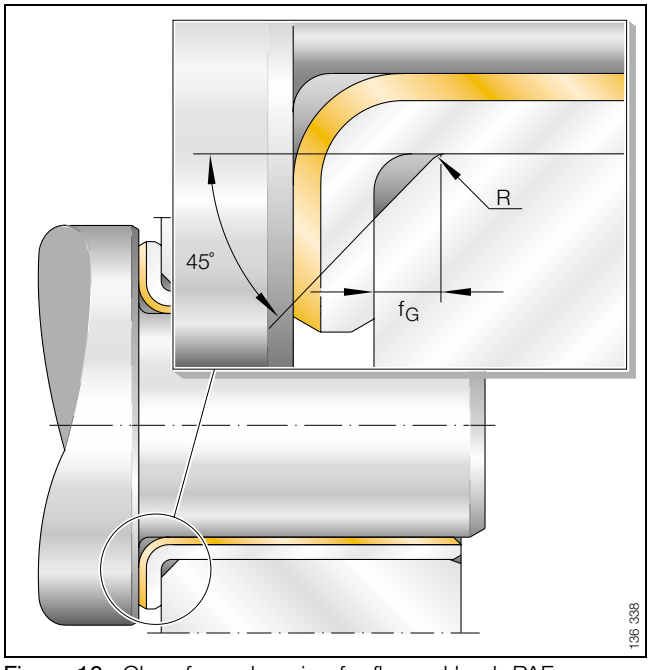


Figure 10 · Chamfer on housing for flanged bush PAF

Location of thrust washers

It is recommended that:

- concentric seating is ensured by means of recesses in the housing (Figure 11)
  - diameters and depths of the recesses: see *dimension tables*
- unintentional rotation is prevented by means of a dowel pin or countersunk head screw (Figures 11 and 12)
  - the screw head or dowel pin must be recessed by at least 0,25 mm with respect to the running surface (Figures 11 and 12)
  - size and arrangement of the holes, see *dimension tables*.

If recesses are not possible in the housing,

- location must be provided by means of several dowel pins or screws (Figure 12)
- other location methods should be used.

It is not always necessary to secure thrust washers against rotation. In some cases, the friction between the bearing backing and the housing will be sufficient.

Strips can be located in the same way as thrust washers.

Other location methods

If the interference fit of the bush is inadequate or if it is uneconomical to use dowel pins or screws, there are economical alternative methods for location:

- laser welding
- soft soldering
- adhesive fastening: see “Further information”.

The temperature of the running-in or sliding surface must not exceed +280 °C for Permaglide® P1 and +140 °C for Permaglide® P2.

The running-in or sliding surface must always be kept free of adhesives.

Recommendation: The adhesive manufacturer should be consulted for information about adhesive fastening, particularly on adhesive selection, preparation of the surface, hardening, strength, temperature range and elongation behaviour.

Further information on adhesive fastening of Permaglide® plain bearing materials:
INA Technical Product Information “Adhesive bonding of Permaglide®, TPI 50”

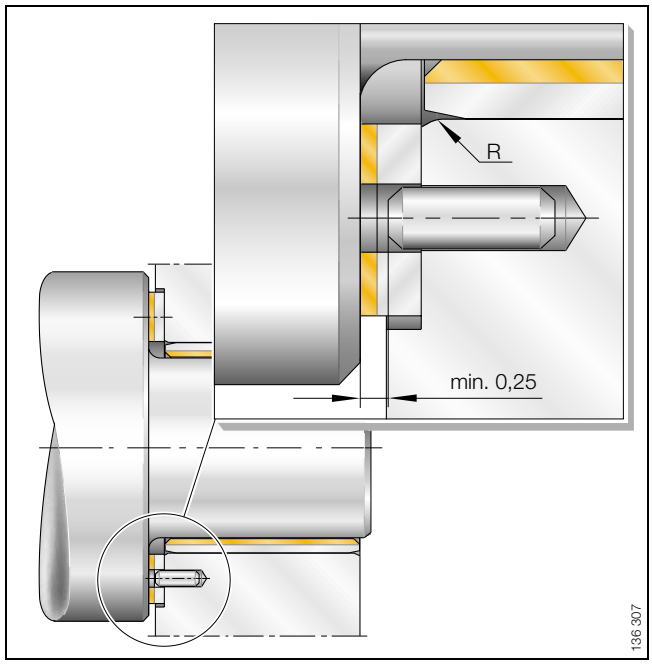


Figure 11 · Location of a PAW thrust washer in a recess in the housing

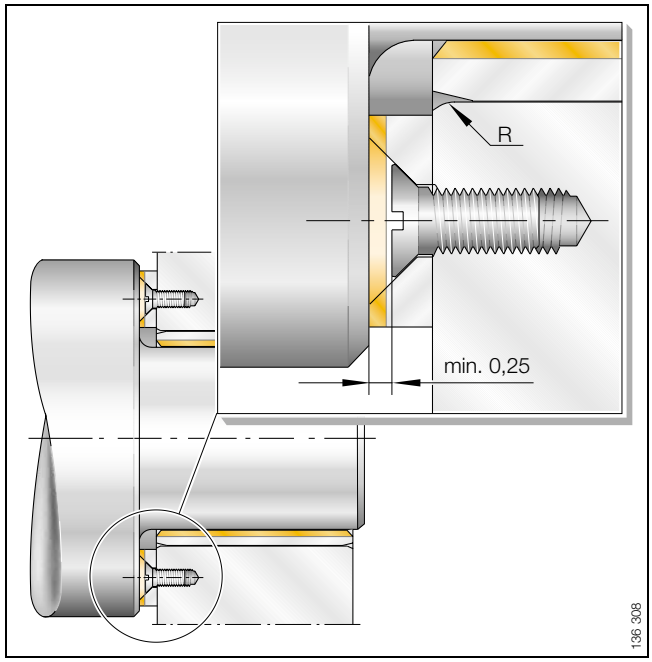


Figure 12 · Location of a PAW thrust washer without a recess in the housing

Shaft

Shafts should be chamfered and all sharp edges rounded:

- this makes fitting easier
- it prevents damage to the sliding layer of the bush.

Mating surface

Optimum operating life

- The optimum operating life will be achieved with a roughness depth of the mating surface of max. R_z2 to R_z3
  - for dry running of Permaglide® P1
  - with lubrication of Permaglide® P2.

⚠ Very small roughness depth values do not have a beneficial effect on the operating life. However, larger roughness depth values do significantly reduce the operating life.

- With Permaglide® P1 and P2, corrosion of the mating surface can be prevented by:
  - sealing
  - the use of corrosion-resistant steel
  - applying a suitable surface treatment.

With Permaglide® P2, the lubricant gives additional protection against corrosion.

- The mating surface should be wider than the bearing to prevent the formation of steps in the sliding layer.

Surface roughness

- Ground or drawn surfaces are preferable
- Even with a surface roughness of R_z2 to R_z3, precision turned or precision turned and rolled surfaces can cause greater wear due to the spiral grooves produced during precision turning
- Spheroidal graphite cast iron (GGG) has an open surface structure and should therefore be ground to a surface roughness of R_z2 or better.
  - The direction of rotation of cast shafts in the application should be the same as that of the grinding wheel during machining, since increased wear should be anticipated if rotation is in the opposing direction (Figure 13).

Hydrodynamic operation

For hydrodynamic operation, the roughness depth R_z of the mating surface should be less than the smallest lubricant film thickness for fluid friction.

INA offers calculation of hydrodynamic operation as a service.

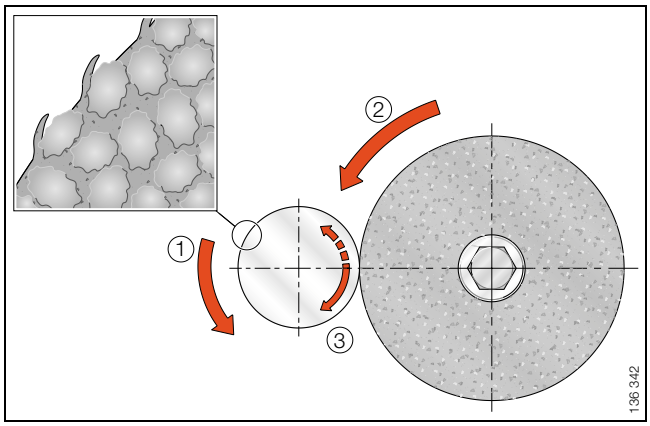


Figure 13 · Grinding of a cast shaft
① Direction of shaft rotation in the application
② Direction of grinding wheel rotation
③ Direction of shaft rotation during grinding

Seals

If increased levels of contamination occur or if the bearing is used in an aggressive environment, the bearing arrangement should be protected by (Figure 14):

- the adjacent construction ①
- a gap seal ②
- a shaft seal ③
- a grease collar.

Heat dissipation

Correct and sufficient heat dissipation must be provided.

- If the bearing operates under hydrodynamic conditions, the heat is largely dissipated by the fluid lubricant
- In the case of maintenance-free and low-maintenance plain bearings, the heat can be dissipated through the housing and the shaft.

Machining of bearing elements

- Permaglide® plain bearings can be machined by either cutting or non-cutting methods, such as shortening, drilling or bending
- Permaglide® should be cut starting from the PTFE side, since the cutting process would otherwise leave a burr on the running surface
- The bearing elements must subsequently be cleaned
- Bright steel surfaces (cut edges) must be protected against corrosion by means of:
  - oil or
  - electroplated protective coatings.
    If high current densities or long coating times are used, the sliding layers should be masked to prevent deposits.

⚠ Exceeding the following temperature limits during machining constitutes a health hazard:
+280 °C for Permaglide® P1
+140 °C for Permaglide® P2

The swarf produced may contain lead.

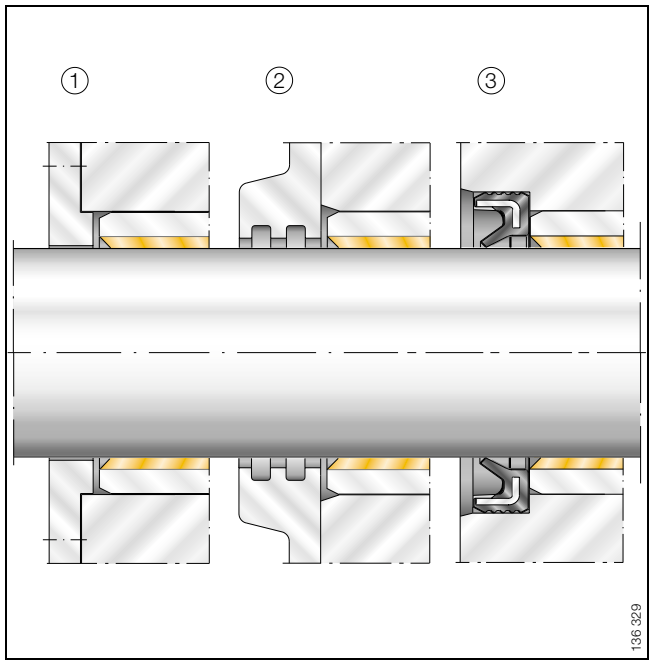


Figure 14 · Seals

Alignment

Accurate alignment is important for radial and axial plain bearings. This applies particularly to dry plain bearings because there is no lubricant film to distribute the load.

The angular misalignment across the entire bush width must not exceed 0,02 mm (Figure 15). This value also applies across the whole width for bushes arranged in pairs as well as to thrust washers.

If the bushes are arranged one behind the other, it may be advisable to use bushes of the same width and the butt joints should be aligned.

High edge loads can be reduced by design measures.

Design measures (Figure 16):

- chamfers
- increased bore diameter in edge area
- bushes projecting beyond the edge of the bore.

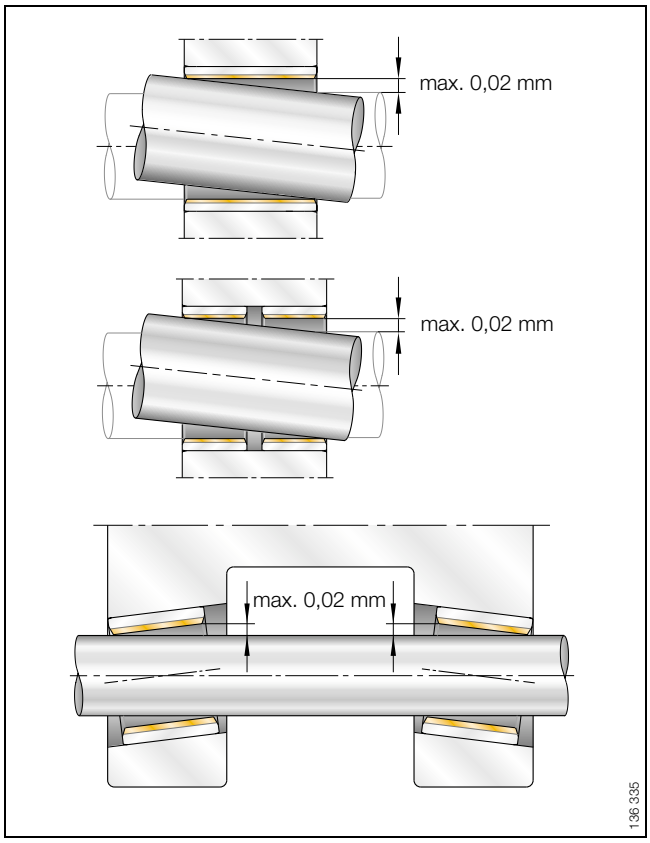


Figure 15 · Permissible angular misalignment

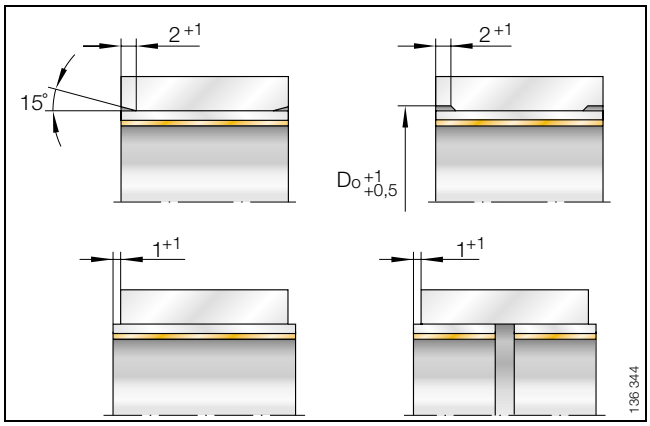


Figure 16 · Reduction of peak stresses at edges

Internal clearance and mounting tolerances

Metric sizes

Theoretical internal clearance

Permaglide® P1 and P2 bushes are pressed into the housing. This provides axial and radial location.

No additional means of location are required.

If the mounting tolerances in Table 7 are used, rigid housings and shafts will have:

- interference fit
- internal clearance according to Table 12, page 26.

The theoretical internal clearance is calculated as follows:

$$\Delta s_{max} = d_{G\,max} - 2 \cdot s_{3\,min} - d_{W\,min} \quad (11)$$

$$\Delta s_{min} = d_{G\,min} - 2 \cdot s_{3\,max} - d_{W\,max} \quad (12)$$

Δs_{max}, Δs_{min} mm
Maximum internal clearance, minimum internal clearance

$d_{G\,max}$, $d_{G\,min}$ mm
Maximum housing bore diameter, minimum housing bore diameter

$d_{W\,max}$, $d_{W\,min}$ mm
Maximum shaft diameter, minimum shaft diameter

$s_{3\,max}$, $s_{3\,min}$ mm
Maximum wall thickness, minimum wall thickness, see Table 10, page 25.

⚠ Expansion of the housing bore is not taken into account in calculation of the internal clearance.

The interference U is calculated using the tolerances for the housing bore specified in Table 7 and the deviations of the bush outside diameter D_o in Table 8, page 25.

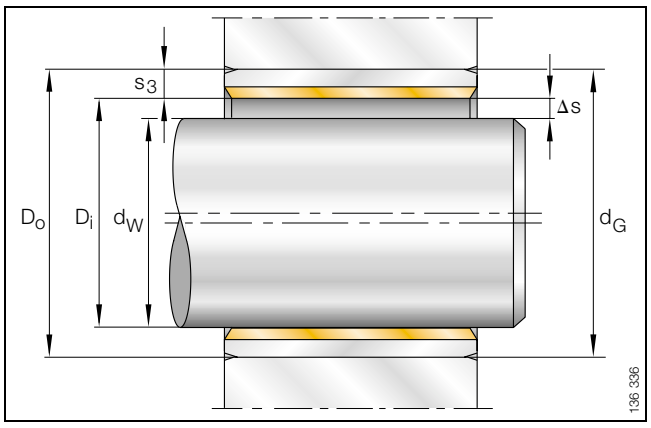


Figure 17 · Theoretical internal clearance Δs

Interference fit and internal clearance

Table 13 on page 27 shows measures that can be taken to influence the internal clearance and interference fit:

- at high ambient temperatures
- depending on housing material
- depending on housing wall thickness.

Reduced tolerances

Reduced clearance tolerances require tighter tolerances for the shaft and the bore.

Table 7 · Recommended mounting tolerances

Diameter range	Permaglide®		
	P10	**P11**	**P20**
Shaft			
$d_W < 5$	h6	f7	h8
$5 \leq d_W < 80$	f7	f7	h8
$80 \leq d_W$	h8	h8	h8
Housing bore			
$d_G \leq 5{,}5$	H6	–	–
$5{,}5 < d_G$	H7	H7	H7

⚠ If shafts in tolerance zone h are used, the internal clearance must be checked for $5 \leq d_W < 80$ (P10) and $d_W < 80$ (P11) in accordance with the equations (11) for Δs_{max} and (12) for Δs_{min}.

Further information

	Page
Inch sizes	28
Internal clearance and mounting tolerances	28
Shaft and bore dimensions	28
Chamfers	29

Conversion to DIN ISO 3 547

DIN 1 494, which has been applicable up to now, specifies the deviations for outside diameters up to $D_o \leqq 180$ mm, and DIN ISO 3 547 additionally specifies them for $D_o > 180$ mm.

The deviations for the outside diameters D_o therefore correspond to the specifications in Table 8 or to DIN ISO 3 547 for the transitional period.

Deviations for the outside diameter

Table 8 · Deviations for outside diameter D_o

Outside diameter of bush[1]	Deviations (Test A to DIN ISO 3 547-2)			
	P10, P20		**P11**	
D_o	upper	lower	upper	lower
$D_o \leqq 10$	+0,055	+0,025	+0,075	+0,045
$10 < D_o \leqq 18$	+0,065	+0,030	+0,080	+0,050
$18 < D_o \leqq 30$	+0,075	+0,035	+0,095	+0,055
$30 < D_o \leqq 50$	+0,085	+0,045	+0,110	+0,065
$50 < D_o \leqq 80$	+0,100	+0,055	+0,125	+0,075
$80 < D_o \leqq 120$	+0,120	+0,070	+0,140	+0,090
$120 < D_o \leqq 180$	+0,170	+0,100	+0,190	+0,120
$180 < D_o \leqq 250$	+0,210	+0,130	+0,230	+0,150
$250 < D_o \leqq 305$	+0,260	+0,170	+0,280	+0,190

[1] Deviations to DIN ISO 3 547-1, Table 6.

Wall thicknesses with tolerances

Table 9 · Wall thickness s_3 for bushes and flanged bushes **P1**

Inside diameter	Wall thickness	Deviations to DIN ISO 3 547-1, Table 3, series B			
		P10[1]		**P11**	
D_i	s_3	upper	lower	upper	lower
$D_i < 5$	0,75	0	–0,020	–	–
	1	–	–	+0,005	–0,020
$5 \leqq D_i < 20$	1	+0,005	–0,020	+0,005	–0,020
$20 \leqq D_i < 28$	1,5	+0,005	–0,025	+0,005	–0,025
$28 \leqq D_i < 45$	2	+0,005	–0,030	+0,005	–0,030
$45 \leqq D_i < 80$	2,5	+0,005	–0,040	+0,005	–0,040
$80 \leqq D_i < 120$	2,5	–0,010	–0,060	–0,010	–0,060
$120 \leqq D_i$	2,5	–0,035	–0,085	–0,035	–0,085

[1] Permaglide® P10 is also available with a wall thickness of 0,5 mm; please consult the INA engineering service.

Table 10 · Wall thickness s_3 for Permaglide® **P20** bushes

Inside diameter	Wall thickness	Deviations to DIN ISO 3 547-1, Table 3, series D, **P20**	
D_i	s_3	upper	lower
$8 \leqq D_i < 20$	1	–0,020	–0,045
$20 \leqq D_i < 28$	1,5	–0,025	–0,055
$28 \leqq D_i < 45$	2	–0,030	–0,065
$45 \leqq D_i < 80$	2,5	–0,040	–0,085
$80 \leqq D_i$	2,5	–0,050	–0,115

Chamfers and chamfer tolerances

Table 11 · Outer chamfer C_o and inner edge break C_i (Figure 18) for bushes in metric sizes, to DIN ISO 3 547-1, Table 2

Wall thickness	Outer chamfer, machined without cutting[1]	Inner edge break C_i	
s_3	C_o	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

C_o should be correspondingly larger for bushes with a bearing bore that must be machined to size. Chamfer deformation due to round bending is permissible.

[1] For a transitional period, bushes with differing chamfers can be supplied for wall thicknesses 2 mm and 2,5 mm.

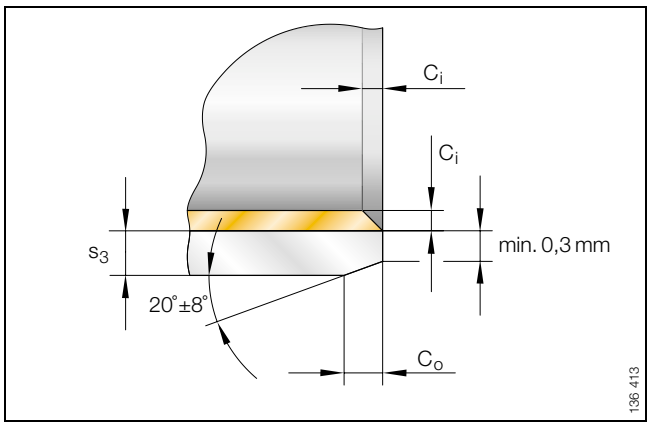


Figure 18 · Outer chamfer C_o and inner edge break C_i for metric sizes

Table 12 · Theoretical internal clearance after pressing in of bushes or flanged bushes of metric sizes, disregarding possible expansion of the bore. Equations: page 24

Bush diameter		Internal clearance Δs			
		P10, P11		**P20**	
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	–	–
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	–	–

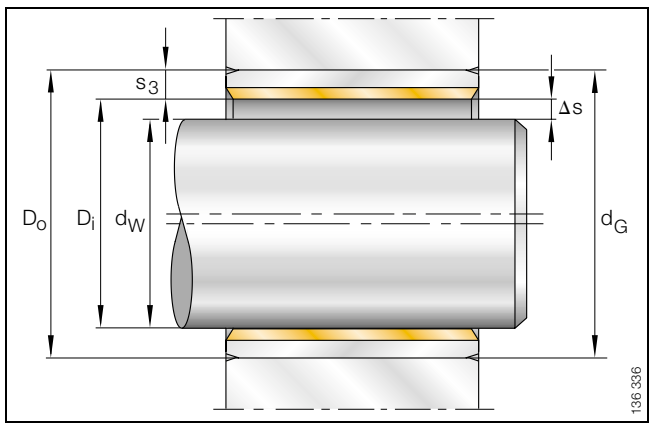


Figure 19 · Theoretical internal clearance Δs

Table 13 · Consequences and measures for interference fit and internal clearance in case of high ambient temperatures, special housing materials or special wall thicknesses

Design and environmental influences	Consequence	Measure	Note
Light metal or thin-walled housings	Large expansion, excessive clearance	Reduce housing bore d_G	Housing is more highly stressed; the permissible stress on the housing must not be exceeded.
Steel or cast iron housings *at high ambient temperatures*	Reduced clearance	Reduce shaft diameter d_W by 0,008 mm for each increment of 100 °C above room temperature	
Bronze or copper alloy housings *at high ambient temperatures*	Impaired interference fit	Reduce housing bore d_G; recommended diameter change for each increment of 100 °C above room temperature: d_G –0,05%	Reduce shaft diameter d_W by the same value to maintain the internal clearance.
Aluminium alloy housings *at high ambient temperatures*	Impaired interference fit	Reduce housing bore d_G; recommended diameter change for each increment of 100 °C above room temperature: d_G –0,1%	Reduce shaft diameter d_W by the same value to maintain the internal clearance. The housing is more highly stressed at temperatures below 0 °C; the permissible stress on the housing must not be exceeded.
Bushes with thicker corrosion protection layer	Outer diameter D_o too large, insufficient clearance	Increase housing bore d_G Example: Layer thickness $0{,}015_{\pm 0{,}003}$ mm Consequently: d_G +0,03 mm	Bush and housing will be more highly stressed if appropriate measures are not taken.

Table 14 · Theoretical internal clearance (Figure 20, page 29) after pressing in of PAPZ bushes – disregarding possible expansion of the housing bore – and shaft and bore dimensions

Shaft diameter	Designation	Bush diameter *Inch*/mm		Wall thickness *Inch*/mm		Shaft dimensions *Inch*/mm		Bore dimensions *Inch*/mm		Internal clearance *Inch*/mm	
		D_i	D_o	$s_{3\ min}$	$s_{3\ max}$	$d_{W\ min}$	$d_{W\ max}$	$d_{G\ min}$	$d_{G\ max}$	Δs_{min}	$\Delta s_{\ max}$
3/16	**PAPZ 03**	*0,1875*	*0,25*	*0,0307*	*0,0315*	*0,1858*	*0,1865*	*0,2497*	*0,2503*	*0,0002*	*0,0031*
		4,763	6,35	0,780	0,800	4,719	4,737	6,342	6,358	0,005	0,079
1/4	**PAPZ 04**	*0,25*	*0,3125*	*0,0307*	*0,0315*	*0,2481*	*0,2490*	*0,3122*	*0,3128*	*0,0002*	*0,0033*
		6,35	7,938	0,780	0,800	6,302	6,325	7,930	7,945	0,005	0,083
5/16	**PAPZ 05**	*0,3125*	*0,375*	*0,0307*	*0,0315*	*0,3106*	*0,3115*	*0,3747*	*0,3753*	*0,0002*	*0,0033*
		7,938	9,525	0,780	0,800	7,889	7,912	9,517	9,533	0,005	0,083
3/8	**PAPZ 06**	*0,375*	*0,4688*	*0,0461*	*0,0471*	*0,3731*	*0,3740*	*0,4684*	*0,4691*	*0,0002*	*0,0038*
		9,525	11,906	1,171	1,196	9,477	9,500	11,897	11,915	0,005	0,096
7/16	**PAPZ 07**	*0,4375*	*0,5312*	*0,0461*	*0,0471*	*0,4355*	*0,4365*	*0,5309*	*0,5316*	*0,0002*	*0,0039*
		11,113	13,494	1,171	1,196	11,062	11,087	13,485	13,503	0,006	0,099
1/2	**PAPZ 08**	*0,5*	*0,5938*	*0,0461*	*0,0471*	*0,4980*	*0,4990*	*0,5934*	*0,5941*	*0,0002*	*0,0039*
		12,7	15,081	1,171	1,196	12,649	12,675	15,072	15,090	0,005	0,099
9/16	**PAPZ 09**	*0,5625*	*0,6563*	*0,0461*	*0,0471*	*0,5605*	*0,5615*	*0,6559*	*0,6566*	*0,0002*	*0,0039*
		14,288	16,669	1,171	1,196	14,237	14,262	16,660	16,678	0,006	0,099
5/8	**PAPZ 10**	*0,625*	*0,7188*	*0,0461*	*0,0471*	*0,6230*	*0,6240*	*0,7184*	*0,7192*	*0,0002*	*0,0040*
		15,875	18,256	1,171	1,196	15,824	15,850	18,247	18,268	0,005	0,102
11/16	**PAPZ 11**	*0,6875*	*0,7813*	*0,0461*	*0,0471*	*0,6855*	*0,6865*	*0,7809*	*0,7817*	*0,0002*	*0,0040*
		17,463	19,844	1,171	1,196	17,412	17,437	19,835	19,855	0,006	0,101
3/4	**PAPZ 12**	*0,75*	*0,875*	*0,0615*	*0,0627*	*0,7479*	*0,7491*	*0,8747*	*0,8755*	*0,0002*	*0,0046*
		19,050	22,225	1,562	1,593	18,997	19,027	22,217	22,238	0,004	0,117
7/8	**PAPZ 14**	*0,875*	*1*	*0,0615*	*0,0627*	*0,8729*	*0,8741*	*0,9997*	*1,0005*	*0,0002*	*0,0046*
		22,225	25,4	1,562	1,593	22,172	22,202	25,392	25,413	0,004	0,117
1	**PAPZ 16**	*1*	*1,125*	*0,0615*	*0,0627*	*0,9979*	*0,9991*	*1,1247*	*1,1255*	*0,0002*	*0,0046*
		25,4	28,575	1,562	1,593	25,347	25,377	28,567	28,588	0,004	0,117
1 1/8	**PAPZ 18**	*1,125*	*1,2813*	*0,0770*	*0,0784*	*1,1226*	*1,1238*	*1,2808*	*1,2818*	*0,0002*	*0,0052*
		28,575	32,544	1,956	1,991	28,514	28,545	32,532	32,558	0,005	0,132
1 1/4	**PAPZ 20**	*1,25*	*1,4063*	*0,0770*	*0,0784*	*1,2472*	*1,2488*	*1,4058*	*1,4068*	*0,0002*	*0,0056*
		31,75	35,719	1,956	1,991	31,679	31,720	35,707	35,733	0,005	0,142
1 3/8	**PAPZ 22**	*1,375*	*1,5313*	*0,0770*	*0,0784*	*1,3722*	*1,3738*	*1,5308*	*1,5318*	*0,0002*	*0,0056*
		34,925	38,894	1,956	1,991	34,854	34,895	38,882	38,908	0,005	0,142
1 1/2	**PAPZ 24**	*1,5*	*1,6563*	*0,0770*	*0,0784*	*1,4972*	*1,4988*	*1,6558*	*1,6568*	*0,0002*	*0,0056*
		38,1	42,069	1,956	1,991	38,029	38,070	42,057	42,083	0,005	0,142
1 5/8	**PAPZ 26**	*1,625*	*1,7813*	*0,0770*	*0,0784*	*1,6222*	*1,6238*	*1,7808*	*1,7818*	*0,0002*	*0,0056*
		41,275	45,244	1,956	1,991	41,204	41,245	45,232	45,258	0,005	0,142
1 3/4	**PAPZ 28**	*1,75*	*1,9375*	*0,0923*	*0,0941*	*1,7471*	*1,7487*	*1,9371*	*1,9381*	*0,0002*	*0,0065*
		44,45	49,213	2,344	2,390	44,376	44,417	49,202	49,228	0,005	0,164
2	**PAPZ 32**	*2*	*2,1875*	*0,0923*	*0,0941*	*1,9969*	*1,9987*	*2,1871*	*2,1883*	*0,0002*	*0,0069*
		50,8	55,563	2,344	2,390	50,721	50,767	55,552	55,583	0,005	0,174

Table 15 · Outer chamfer C_o and inner edge break C_i (Figure 21) for bushes in inch sizes

	Wall thickness *Inch*/mm s_3		Outer chamfer *Inch*/mm C_o		Inner edge break *Inch*/mm C_i	
	min.	max.	min.	max.	min.	max.
Inch	*0,0307*	*0,0315*	*0,008*	*0,032*	*0,0040*	*0,016*
mm	0,780	0,800	0,2	0,8	0,1	0,4
Inch	*0,0461*	*0,0471*	*0,008*	*0,040*	*0,0040*	*0,020*
mm	1,171	1,196	0,2	1,0	0,1	0,5
Inch	*0,0615*	*0,0627*	*0,008*	*0,040*	*0,0040*	*0,028*
mm	1,562	1,593	0,2	1,0	0,1	0,7
Inch	*0,0770*	*0,0784*	*0,024*	*0,055*	*0,0040*	*0,028*
mm	1,956	1,991	0,6	1,4	0,1	0,7
Inch	*0,0923*	*0,0941*	*0,032*	*0,063*	*0,0080*	*0,040*
mm	2,344	2,390	0,8	1,6	0,2	1,0

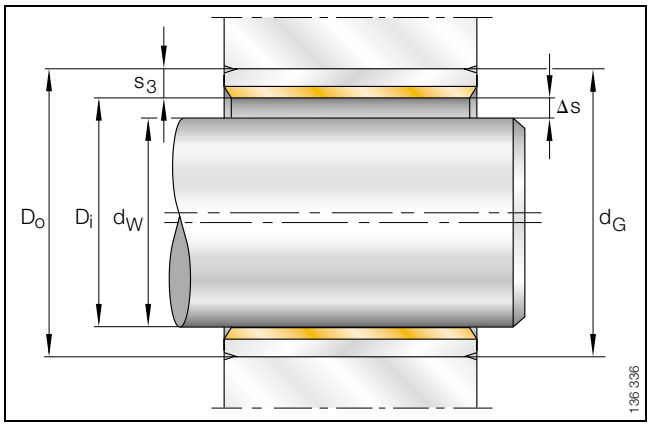


Figure 20 · Theoretical internal clearance Δs

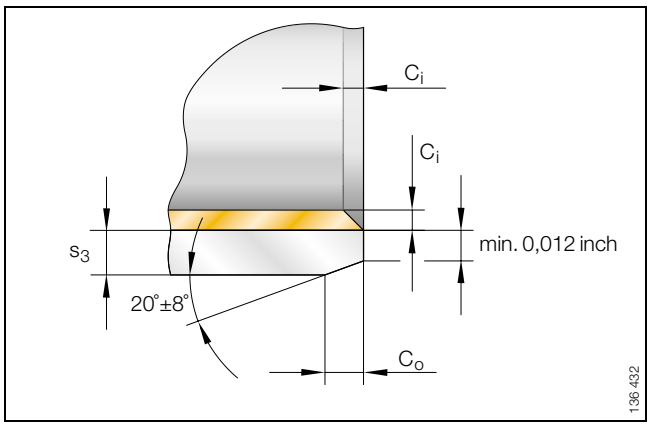


Figure 21 · Outer chamfer C_o and inner edge break C_i for inch sizes

Pressing in of bushes

Permaglide® bushes can be easily pressed into the housing bore

- The bushes can be pressed in more easily if the bush backing or housing bore is lightly oiled.

Recommendations

Outside diameter D_o up to approx. 55 mm:

- press in flush using arbor without auxiliary ring according to Figure 22
- press in recessed using arbor without auxiliary ring according to Figure 23.

Outside diameter greater than approx. 55 mm:

- press in using arbor with auxiliary ring according to Figure 24, page 31.

⚠ Ensure that assembly is carried out in clean conditions.
Contamination will reduce the operating life of the bearing arrangement.
Ensure that the sliding layer is not damaged.
If a mounting position is specified, this must be observed.

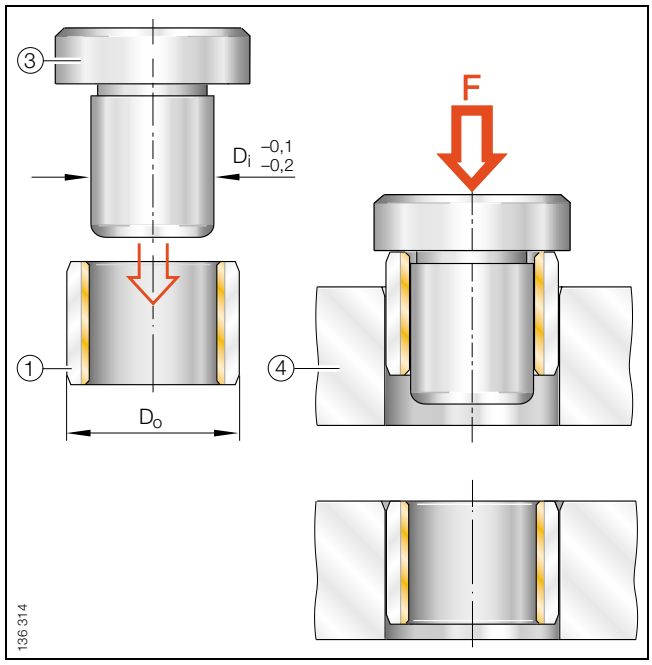


Figure 22 · Pressing in flush, $D_o \lesssim 55$ mm
Legend: see page 31

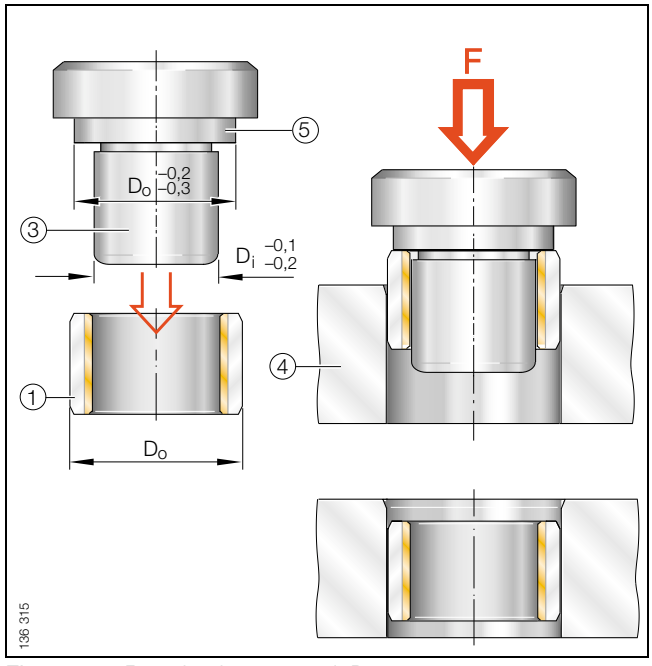


Figure 23 · Pressing in recessed, $D_o \gtrsim 55$ mm
Legend: see page 31

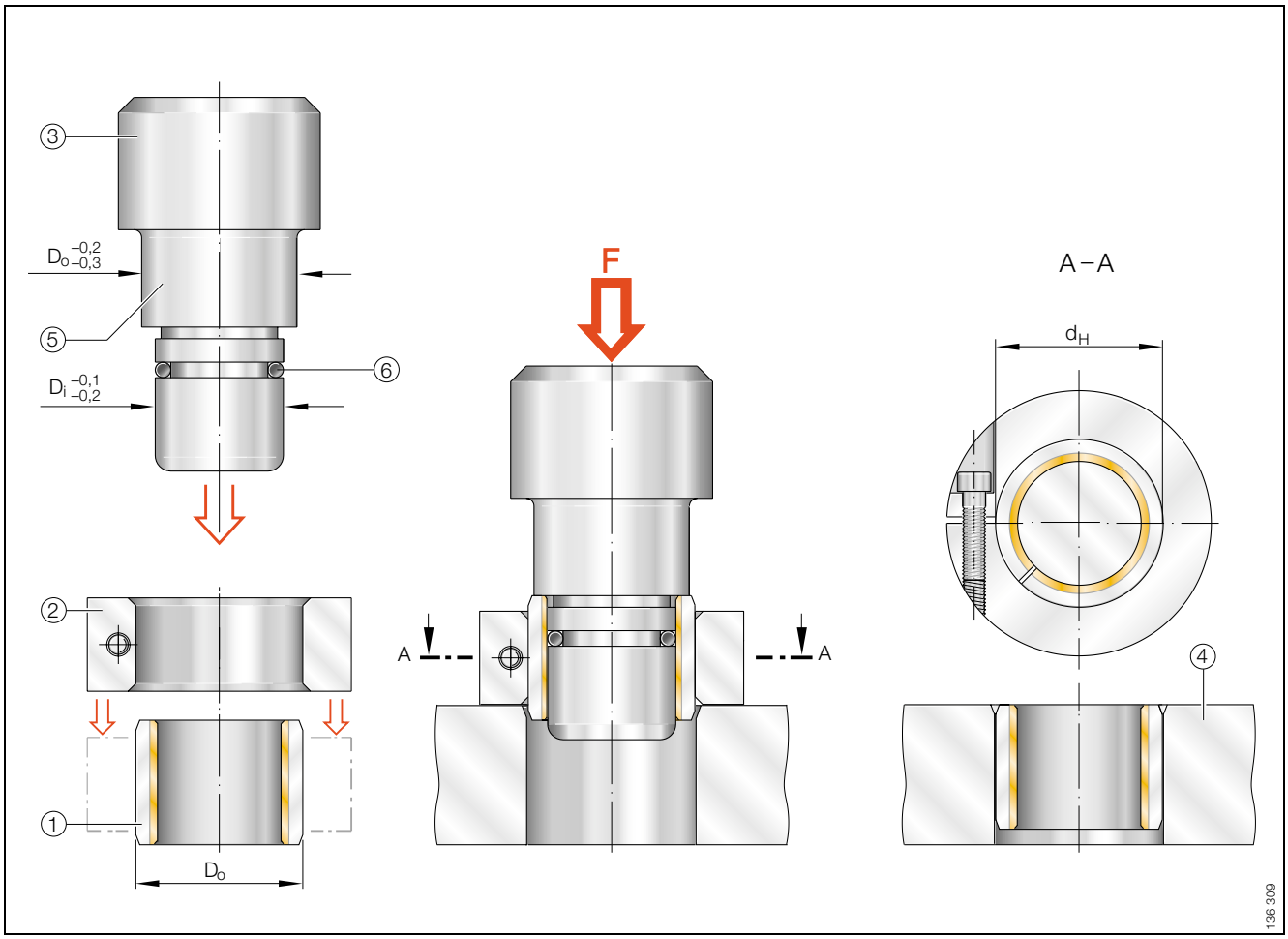


Figure 24 · Pressing in of bushes, $D_o \geq 55$ mm, with auxiliary ring

① Bush
② Auxiliary ring
③ Press-in arbor
④ Housing
⑤ Shoulder diameter
⑥ O ring

Table 16 · Inside diameter d_H of auxiliary ring for outside diameter D_o

D_o mm	d_H mm
$55 \leq D_o \leq 100$	$D_{o\,+0,25}^{+0,28}$
$100 < D_o \leq 200$	$D_{o\,+0,36}^{+0,40}$
$200 < D_o \leq 305$	$D_{o\,+0,46}^{+0,50}$

Calculation of press-in force

- The press-in force is dependent on many factors that are difficult to assess accurately, e.g.:
  - actual interference
  - coefficient of friction
  - scoring
  - press-in speed.
- Simplifications are therefore permissible in the calculation, e.g. for the interference:
  - only the thickness of the steel or bronze backing s_1 is taken into account.

⚠ The calculated press-in force is only a guide value.
Considerably higher forces sometimes occur in practice!
In critical cases, the press-in force must be determined by means of tests.

INA offers calculation of the press-in force as a service.

Table 17 · Modulus of elasticity, transversal contraction

Material	Modulus of elasticity E N/mm²	Transversal contraction ν
Steel	210 000	0,30
Cast steel	210 000	0,30
GGG	170 000	0,28
Aluminium	70 000	0,33
Bronze	85 000	0,35

Table 18 · Guide values for the coefficients of friction μ_R between bush backing and housing bore

Housing material	Coefficient of friction μ_L			
	Steel backing, tin plated		Bronze backing	
	dry	lubricated	dry	lubricated
Steel	0,12	0,10	0,10	0,08
Cast steel, GGG	0,12	0,10	0,10	0,08
Aluminium	0,10	0,08	0,10[1)]	0,08[1)]

[1)] ⚠ **Caution: Electrochemical contact corrosion!**

Calculation steps for determining the press-in force

Press-in force:

$$F = p_1 \cdot \mu_L \cdot A \qquad (13)$$

Joint pressure:

$$p_1 = \frac{U}{d_G} \cdot \frac{E_G}{KG + \frac{E_G}{E_L} \cdot KL} \qquad (14)$$

$$p_1 = \frac{\frac{U}{d_G} \cdot E_G}{\left[\frac{\left(1 + 2\frac{s_G}{d_G}\right)^2 + 1}{\left(1 + 2\frac{s_G}{d_G}\right)^2 - 1} + \nu_G\right] + \frac{E_G}{E_L}\left[\frac{1 + \left(1 - 2\frac{s_1}{D_o}\right)^2}{1 - \left(1 - 2\frac{s_1}{D_o}\right)^2} - \nu_L\right]} \qquad (15)$$

Outside surface area of bush:

$$A = D_o \cdot \pi \cdot B \qquad (16)$$

Calculation of individual expressions

Interference for F_{max}

$$U_{max} = D_{o\,max} - d_{G\,min} - 0{,}8 \cdot (R_{z\,G} + R_{z\,L}) \quad (17)$$

Interference for F_{min}

$$U_{min} = D_{o\,min} - d_{G\,max} - 0{,}8 \cdot (R_{z\,G} + R_{z\,L}) \quad (18)$$

Thickness of steel or bronze backing

$$s_1 = s_3 - 0{,}3\ mm \quad (19)$$

"Round brackets"

$$\left(1 + 2\frac{s_G}{d_G}\right) = RG \quad (20)$$

$$\left(1 - 2\frac{s_1}{D_o}\right) = RL \quad (21)$$

"Square brackets"

$$\left[\frac{RG^2 + 1}{RG^2 - 1} + \nu_G\right] = KG \quad (22)$$

$$\left[\frac{1 + RL^2}{1 - RL^2} - \nu_L\right] = KL \quad (23)$$

A — mm^2
Outside surface area

B — mm
Width of bush, see *dimension tables*

D_o — mm
Outside diameter of bush (nominal dimension), see *dimension tables*

$d_G = D_o$ — mm
Diameter of housing bore (nominal dimension)

$d_{W\,max}$, $d_{W\,min}$ — mm
Minimum and maximum dimensions of bush;
see page 25 for deviations

$d_{G\,min}$, $d_{G\,max}$ — mm
Minimum and maximum dimensions of bush;
see page 24 for tolerances

E_L, E_G — N/mm^2
Modulus of elasticity, Table 17, page 32

F — N
Press-in force

p_1 — N/mm^2
Joint pressure

$R_{z\,G}$ — mm
Roughness depth of housing bore

$R_{z\,L}$ — mm
Roughness depth of bush backing

s_1 — mm
Thickness of steel or bronze backing

s_3 — mm
Wall thickness of bush, Table 9, page 25

s_G — mm
Wall thickness of housing

U — mm
Interference

μ_L — –
Coefficient of friction, Table 18, page 32

ν_L, ν_G — –
Transversal contraction, Table 17, page 32.

Calculation example

Bush PAP 2010 P10 (steel backing)
Aluminium housing, wall thickness 30 mm
pressed in dry

- Required:
  – press-in force F_{max} in kN
- Given:

Outside diameter of bush	D_o	23	mm
Width of bush	B	10	mm
Diameter of housing bore	d_G	23	mm
Wall thickness of housing	s_G	30	mm
Roughness depth of bush backing	$R_{z\,L}$	0,006	mm
Minimum dimension of housing bore	$d_{G\,min}$	23,000	mm
Maximum dimension of bush	$D_{o\,max}$	23,075	mm
Wall thickness of bush	s_3	1,5	mm
Modulus of elasticity of bearing	E_L	210 000	N/mm²
Modulus of elasticity of housing	E_G	70 000	N/mm²
Transversal contraction of bearing	ν_L	0,30	
Transversal contraction of housing	ν_G	0,33	
Roughness depth of housing bore	$R_{z\,G}$	0,010	mm
Coefficient of friction	μ_R	0,10	

Calculation according to steps on page 32

Interference for F_{max}

$$U_{max} = 23{,}075\ \text{mm} - 23{,}0\ \text{mm} - 0{,}8 \cdot (0{,}010 + 0{,}006)\ \text{mm}$$

$$U_{max} = 0{,}062\ \text{mm}$$

Thickness of steel backing

$$s_1 = 1{,}5\ \text{mm} - 0{,}3\ \text{mm} = 1{,}2\ \text{mm}$$

“Round brackets”

$$\left(1 + 2 \cdot \frac{30\ \text{mm}}{23\ \text{mm}}\right) = RG = 3{,}609$$

$$\left(1 - 2 \cdot \frac{1{,}2\ \text{mm}}{23\ \text{mm}}\right) = RL = 0{,}896$$

“Square brackets”

$$\left[\frac{3{,}609^2 + 1}{3{,}609^2 - 1} + 0{,}33\right] = KG = 1{,}496$$

$$\left[\frac{1 + 0{,}896^2}{1 - 0{,}896^2} - 0{,}30\right] = KL = 8{,}843$$

Joint pressure

$$p_{1\,max} = \frac{0{,}062}{23} \cdot \frac{70\,000}{1{,}496 + \frac{70\,000}{210\,000} \cdot 8{,}843}\ \text{N/mm}^2$$

$$p_{1\,max} = 42{,}5\ \text{N/mm}^2$$

Outside surface area of bush

$$A = 23\ \text{mm} \cdot \pi \cdot 10\ \text{mm} = 723\ \text{mm}^2$$

Press-in force

$$F_{max} = 42{,}5\ \text{N/mm}^2 \cdot 0{,}10 \cdot 723\ \text{mm}^2$$

$$F_{max} = 3\,073\ \text{N}$$

$$F_{max} \approx 3\ \text{kN}$$

Delivered condition
Storage

Delivered condition

- packed in cartons or
- packed in bags in cartons.

Storage

Permaglide® plain bearings should be stored in:

- clean, dry areas
- at as constant a temperature as possible
- at a relative humidity of 65%.

⚠ Keep packaging closed as far as possible.
Permaglide® plain bearings should not be removed from their original packaging until immediately before fitting.

Environmental considerations
Health and safety at work

Environmental considerations, health and safety at work

In the interests of the user, the applicable legal regulations and other directives relating to

- environmental protection
- health and safety at work

and similar issues should be observed.

Materials

Permaglide® P1
Maintenance-free plain bearing material

Page

Features 36

Design and safety information 38

Special designs 43

Features

Permaglide® plain bearing material P1

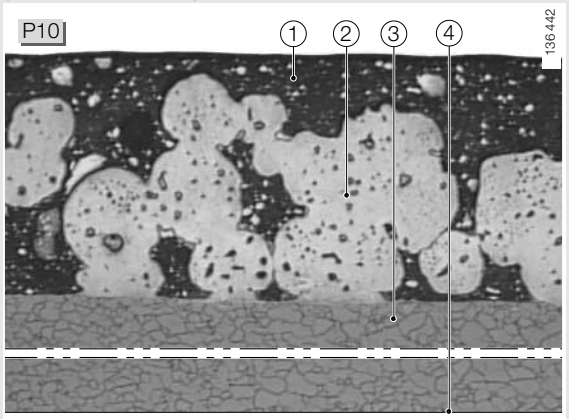
- maintenance-free
- suitable for
  - dry running
  - rotary movement
  - oscillating movement and
  - linear movement with short stroke lengths (page 16)
- good sliding characteristics – no stick-slip
- low coefficient of friction
- low wear
- high chemical resistance
- does not tend to weld to metal
- largely resistant to swelling
  - see information on chemical resistance (page 38)
  - does not absorb water
- hydrodynamic operation possible.

Variants

- P10 with steel backing
- P11 with bronze backing, therefore
  - largely corrosion-resistant
  - very good thermal conductivity
  - antimagnetic.

⚠ Permaglide® P10 and P11 contain lead (Pb). Therefore, contact with foodstuffs or pharmaceutical products should be avoided.

Permaglide® plain bearing material, maintenance-free



- Running-in layer ①: polytetrafluoroethylene (PTFE) and lead (Pb), 0,01 mm to 0,03 mm thick
- Sliding layer ②: porous bronze layer filled with PTFE/Pb, 0,20 mm to 0,35 mm thick
- Steel backing ③
- Surface protection for steel backing, end faces and butt joint faces ④: tin, approx. 0,002 mm thick

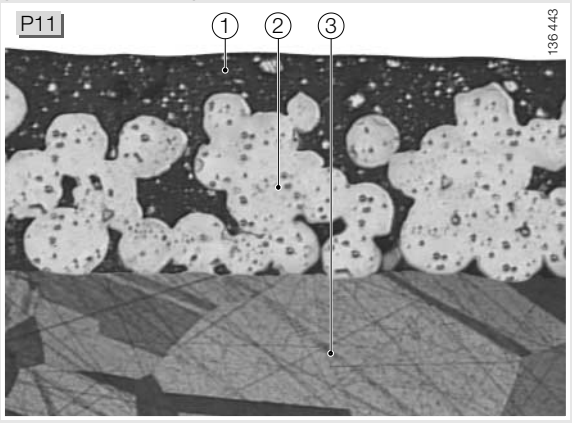
Page

Features 50

Ordering example and ordering designation 52

Dimension table 53

Permaglide® plain bearing material, maintenance-free



- Running-in layer ①: polytetrafluoroethylene (PTFE) and lead (Pb), 0,01 mm to 0,03 mm thick
- Sliding layer ②: porous bronze layer filled with PTFE/Pb, 0,20 mm to 0,35 mm thick
- Bronze backing ③

Technical data

Maximum pv value for dry running	continuous operation	pv	1,8	$N/mm^2 \cdot m/s$
	for short periods	pv	3,6	$N/mm^2 \cdot m/s$
Permissible specific bearing load	static	p_{max}	250	N/mm^2
	very low sliding speed	p_{max}	140	N/mm^2
	rotating, oscillating	p_{max}	56	N/mm^2
Permissible sliding speed	dry running	v_{max}	2	m/s
	hydrodynamic operation	v_{max}	> 2	m/s
Permissible operating temperature	–	ϑ	– 200 to +280	°C
Coefficient of thermal expansion	steel backing	α_{St}	$11 \cdot 10^{-6}$	K^{-1}
	bronze backing	α_{Bz}	$17 \cdot 10^{-6}$	K^{-1}
Coefficient of thermal conductivity	steel backing	λ_{St}	> 42	$W (m \cdot K)^{-1}$
	bronze backing	λ_{Bz}	> 70	$W (m \cdot K)^{-1}$
Relative electrical resistance after running-in		$R_{rel\,min}$	> 1	$\Omega \cdot cm^2$

Design and safety information

Friction

Sliding movements are free from stick-slip.

The friction is dependent on:

- the roughness depth of the mating surface
- the mating surface material
- the specific bearing load
- the sliding speed
- the operating temperature
  - – up to approx. +100 °C, the coefficient of friction is slightly less than the value at room temperature
  - – over +100 °C, the coefficient of friction can be up to 50% higher than the value at room temperature.

The coefficient of friction is more favourable at high specific bearing load and low sliding speed (Table 19).

Table 19 · Coefficient of friction at room temperature (steel mating surface, roughness depth R_z2 to R_z3)

Specific bearing load p N/mm²		Sliding speed v m/s		Coefficient of friction μ	
250 to 140	high	to 0,001	low	0,03	low
140 to 60	↑	0,001 to 0,005	↓	0,04 to 0,07	↓
60 to 10	p	0,005 to 0,05	v	0,07 to 0,1	μ
10 to 1	↑	0,05 to 0,5	↓	0,1 to 0,15	↓
to 1	low	0,5 to 2	high	0,15 to 0,25	high

Chemical resistance and corrosion protection

The resistance of Permaglide® P1 depends on the chemical characteristics of the individual layers.

In general:

- Permaglide® P1 is resistant to water, alcohols, glycols and many mineral oils.
- With Permaglide® P10, the tin-plated steel surface is adequate protection against corrosion in most cases
  - – special designs (page 43).
- With Permaglide® P11, the bronze backing is additionally resistant to steam, seawater and various saline solutions.

Special operating conditions

- The running-in layer and sliding layer swells in the presence of some mineral oils at temperatures above +100 °C.
  Remedy:
  - – increase the internal clearance
  - – use special design Permaglide® P14.
- Permaglide® P10 is not resistant to acidic (pH <5) and alkaline media (pH >9).
- The bronze backing of Permaglide® P11 is not resistant to oxidizing acids and gases such as halides, ammonia or hydrogen sulphide, especially if these gases have a high moisture content.

Fretting corrosion

Permaglide® P1 is designed for dry running, i.e. there is no lubricant to protect the mating surface.

If there is a risk of corrosion on the mating surface, the following materials are advisable:

- corrosion-resistant steels
- hard-chromium plated steels
- hard-anodized aluminium.

Corrosion-resistant surfaces of this type also decrease the wear.

Rust cannot form between the sliding material and mating surface due to the running-in layer or sliding surface comprising PTFE and Pb.

Fretting corrosion occurs only infrequently between the steel backing of Permaglide® P10 and the housing. Electroplated protective layers delay corrosion in such cases.

Electrochemical contact corrosion

In unfavourable conditions, local elements can form which reduce the operating life.

Remedy:

- note this factor at the design stage
- clarify by means of tests if necessary.

Electrical conductivity

The electrical conductivity of new bearings may be lower because the running-in layer is still present. The bronze layer is partially exposed after the running-in process, thus improving the electrical conductivity.

The electrical resistance is dependent on the size of the contact surface area.

Lubrication

Permaglide® P1 contains dry lubricants and therefore does not need lubrication.

Permaglide® P1 can be used in fluid media in certain applications. The improved heat dissipation in this case can significantly increase the operating life.

The compatibility of the media with Permaglide® P1 must be checked.

One-off lubrication is not permissible.

Oil and grease lubrication, even in very small quantities, impairs material transfer during running-in.

Paste formation

Over time, grease mixes with abraded particles from the bearing to form a paste that promotes wear. Solid lubricants such as zinc sulphide, molybdenum disulphide or similar grease additives promote this paste formation. For this reason, they are not permissible.

Exceptions

If grease lubrication is unavoidable in exceptional cases, the bearing should be relubricated regularly in order to counteract paste formation.

Examples:

- corrosion protection of the mating surface
- simple sealing against contamination.

However, a corrosion-protected mating surface (page 21) or a different seal type for the bearing (page 22) is nevertheless more advantageous in such cases.

Hydrodynamic properties

Permaglide® plain bearings P1 can be operated under hydrodynamic conditions.

Advantages:

- higher circumferential speeds permissible than with dry running
- wear-free operation, since only fluid friction is present once the transition speed is reached
- self-lubricating action of Permaglide® P1 in mixed friction conditions (below the transition speed).

INA offers the calculation of hydrodynamic operating conditions for Permaglide® bearings as a service.

The following data must be provided:

- load
- speed
- housing bore diameter d_G with tolerance
- shaft diameter d_W with tolerance
- bush width B
- viscosity of the fluid at operating temperature.

High temperature operation

⚠ Permaglide® P1 swells in some mineral oils if the temperature exceeds +100 °C.

It is sufficient to increase the internal clearance in this case, since other characteristics of Permaglide® P1 are not affected.

Operating behaviour

Running-in process

During the running-in process, part of the running-in layer is transferred to the mating surface, Figure 25 to Figure 27:

- this compensates uneven areas
- a mating surface with a low coefficient of friction is formed, which acts favourably on the operating behaviour
- after running in, some of the porous bronze layer is visible on the sliding layer as individual areas of differing sizes.
  This shows:
  – that the bearing is running correctly.

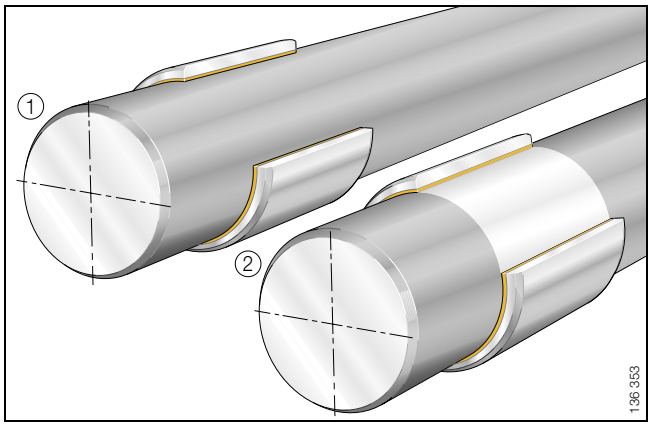


Figure 25 · Material transfer during running-in

① Before running-in
② After running-in

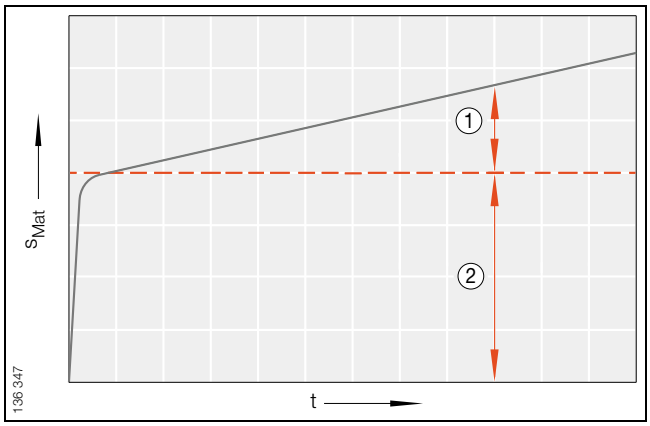


Figure 26 · Typical operating behaviour, material wear s_{Mat} during operating life t

① Wear during operation
② Material transfer during running-in

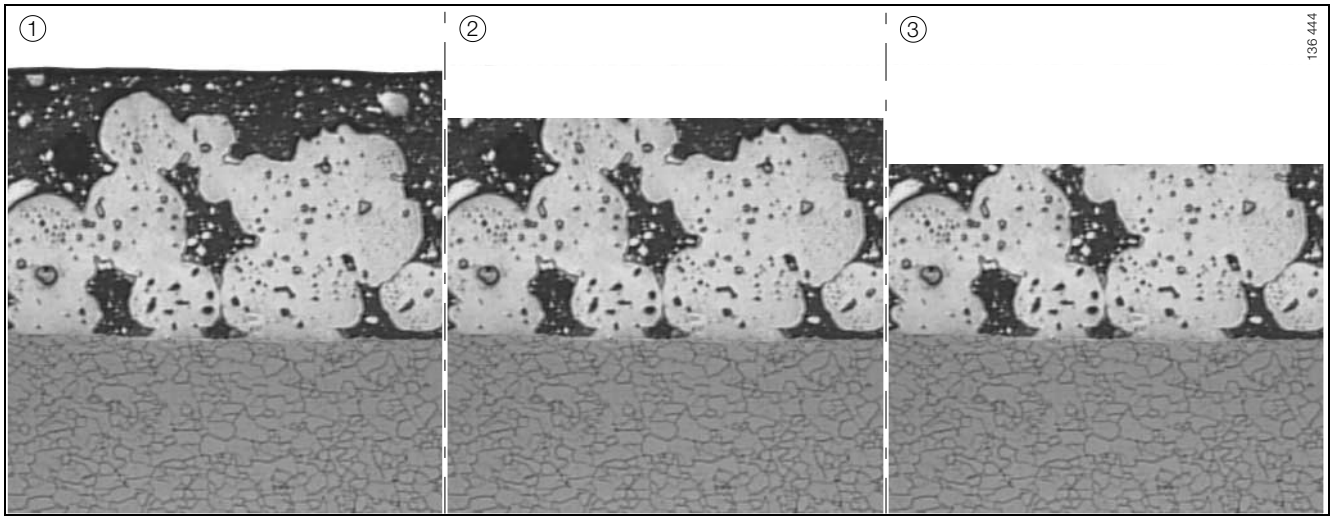


Figure 27 · Permaglide® P10

① Before running-in
② After running-in
③ After long operating life

Sizing

Permaglide® plain bearings are supplied ready-to-fit.

Permaglide® bushings should be sized only if there is no other way to achieve a reduced tolerance for the internal clearance.

⚠ Sizing significantly shortens the rating life of Permaglide® bushes P1 (Table 20).

- Figure 28 shows sizing using an arbor
- Table 20 contains guide values for the diameter of the burnishing tool d_K
- Exact values can only be determined by means of tests.

Preferable methods

The internal clearance tolerance can also be reduced using measures that do not shorten the rating life:

- tighter housing bore tolerances
- tighter shaft tolerances.

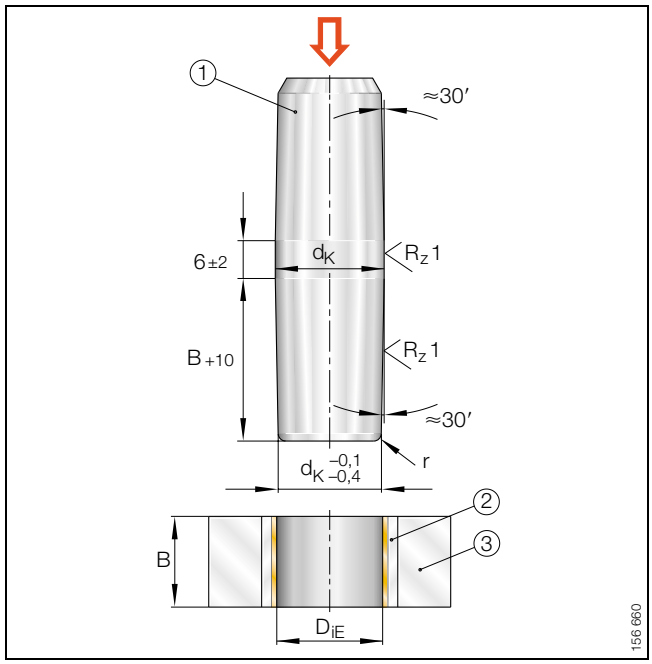


Figure 28 · Sizing

① Burnishing tool, case depth Eht >0,6, HRC 56 to 64
② Permaglide® bush PAP..P10
③ Housing
B Width of bush
D_{iE} Diameter of the bush after pressing-in
d_K Diameter of burnishing tool
r Rounded edge

Table 20 · Guide values for diameter of burnishing tool and reduction in rating life

Required inside diameter of bush	Diameter of burnishing tool[1] d_K	Rating life[2]
D_{iE}	–	100% L_h
D_{iE} +0,02	D_{iE} +0,06	80% L_h
D_{iE} +0,03	D_{iE} +0,08	60% L_h
D_{iE} +0,04	D_{iE} +0,10	30% L_h

D_{iE} Inside diameter of bush after pressing-in.

[1] Guide value related to steel housing.

[2] Guide value for dry running.

Special designs

Special designs

Available by agreement:

- Permaglide® P14
  - *lead-free*
  - running-in layer and sliding layer resistant to swelling
  - operating temperature range –200 °C to +280 °C
  - identical in design to P10, but with lead-free bronze and zinc sulphide in the running-in layer and sliding layer instead of lead
- Permaglide® P16
  - particularly good wear resistance
  - operating temperature range –40 °C to +160 °C
  - identical in design to P10, but with polyvinylidene fluoride (PVDF) in the running-in layer and sliding layer
- Permaglide® P18
  - particularly good wear resistance
  - preferred for axial movements
  - operating temperature range –200 °C to +280 °C
  - only for use with oil
  - identical in design to P10, but carbon fibres in the running-in layer and sliding layer
- all maintenance-free Permaglide® materials P1 (except for P11) with increased corrosion protection.

Further information

	Page
Technical principles	10
Rating life	10
Design of bearing arrangements	19
Internal clearance and mounting tolerances	24
Pressing in of bushes	30
Calculation of press-in force	32

Materials

Permaglide® P2
Low-maintenance plain bearing material

Page

Features 44

Design and safety information 46

Special designs 48

Features

Permaglide® plain bearing material P2

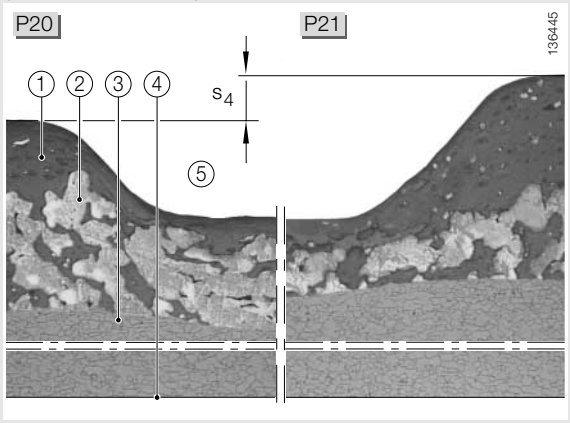
- low maintenance
- suitable for
  - rotating and
  - oscillating movements
- long relubrication intervals
- low wear
- good resistance to edge stress
- good damping behaviour
- good resistance to shock loads.

Variants

- P20
  - with lubrication pockets
  - ready-to-fit
- P21, available by agreement
  - with lubrication pockets
  - with machining allowance.
    The sliding layer is on average 0,15 mm thicker than in the case of P20. It can therefore be machined subsequently. Misalignment inaccuracies can therefore be compensated or internal clearances with tighter tolerances can be achieved
- P22, available by agreement
  - without lubrication pockets
  - with machining allowance.
    The sliding layer is on average 0,15 mm thicker than in the case of P20. It can therefore be machined subsequently. Misalignment inaccuracies can therefore be compensated or internal clearances with tighter tolerances can be achieved
- P23, available by agreement
  - without lubrication pockets
  - ready-to-fit.

⚠ Permaglide® P20 to P23 contain lead (Pb). Therefore, contact with foodstuffs or pharmaceutical products should be avoided.

Permaglide® plain bearing material, low maintenance



- Sliding layer ①: polyvinylidenefluoride (PVDF), polytetrafluoroethylene (PTFE) and lead (Pb), 0,05 mm to 0,10 mm thick
- Bronze intermediate layer ②: 0,20 mm to 0,35 mm thick
- Steel backing ③
- Surface protection ④: tin, approx. 0,002 mm thick
- P20 and P21 with lubrication pockets ⑤
- P21 with machining allowance s_4 of approx. 0,15 mm

Designs

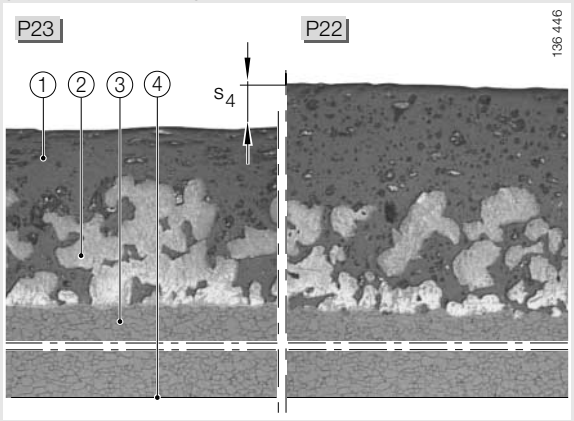
Page

Features 50

Ordering example and ordering designation 52

Dimension table 63

Permaglide® plain bearing material, low maintenance



- Sliding layer (1): polyvinylidenefluoride (PVDF), polytetrafluoroethylene (PTFE) and lead (Pb), 0,05 mm to 0,10 mm thick
- Bronze intermediate layer (2): 0,20 mm to 0,35 mm thick
- Steel backing (3)
- Surface protection (4): tin, approx. 0,002 mm thick
- P22 and P23 without lubrication pockets
- P22 with machining allowance s_4 of approx. 0,15 mm

Technical data

Maximum pv value		pv	3	$N/mm^2 \cdot m/s$
Permissible specific bearing load	static	p_{max}	250	N/mm^2
	very low sliding speed	p_{max}	140	N/mm^2
	rotating, oscillating	p_{max}	70	N/mm^2
Permissible sliding speed		v_{max}	3	m/s
	hydrodynamic operation	v_{max}	> 3	m/s
Permissible operating temperature	continuous operation	ϑ	– 40 to +110	°C
	for short periods	ϑ_{max}	+ 140	°C
Coefficient of thermal expansion	steel backing	α_{St}	$11 \cdot 10^{-6}$	K^{-1}
Coefficient of thermal conductivity	steel backing	λ_{St}	< 4	$W (m \cdot K)^{-1}$
Coefficient of friction		μ	0,02 to 0,2	

Design and safety information

Friction

The friction is dependent on:

- the lubricant
- the roughness depth of the mating surface
- the specific bearing load
- the sliding speed
- the operating temperature
- the wear conditions.

Coefficient of friction

$0{,}02 < \mu < 0{,}2$

Chemical resistance and corrosion protection

The resistance of Permaglide® P2 depends on the chemical characteristics of the individual layers.

In general:

- Permaglide® P2 is resistant to water, alcohols, glycols and many mineral oils.
- With Permaglide® P2, the tin-plated steel surface is adequate protection against corrosion in most cases.
  – special designs, page 48.

Special operating conditions

- Permaglide® P2 is not resistant to acidic (pH <5) and alkaline (pH >9) media.

Fretting corrosion

Rust cannot form between the sliding material and the mating surface due to the sliding layer comprising PVDF, PTFE, Pb and the lubricant.

Fretting corrossion occurs only infrequently between the steel backing of Permaglide® P2 and the housing.
Electroplated protective layers delay corrosion in such cases.

Electrochemical contact corrosion

In unfavourable conditions, local elements can form which reduce the operating life.

Remedy:

- note this factor at the design stage
- clarify by means of tests if necessary.

Lubrication

Low-maintenance Permaglide® P2 must be lubricated with grease or fluid.

Permaglide® P20 and P21 have lubrication pockets that retain the lubricant. The initial lubrication is therefore adequate in most cases.

The operating life increases if relubrication is carried out regularly.

The lubricant also protects the bearing arrangement against corrosion.

Lubricating greases

- Lithium soap greases with a mineral oil base are highly suitable
- Grease additives such as molybdenum disulphide and zinc sulphide are unfavourable since they increase wear:
  – greases may contain max. 5% MoS_2.

Hydrodynamic properties

Permaglide® plain bearings P22 and P23 (without lubrication pockets) can be operated under hydrodynamic conditions.

Advantages:

- higher circumferential speeds permissible than with dry running
- wear-free operation:
  - only fluid friction is present once the transition speed is reached.

INA offers the calculation of hydrodynamic operating conditions for Permaglide® bearings as a service.

The following data must be provided:

- load
- speed
- housing bore diameter d_G with tolerance
- shaft diameter d_W with tolerance
- bush width B
- viscosity of the fluid at operating temperature.

Machining of the sliding layer

The sliding layers of Permaglide® P21 and P22 have a machining allowance of approx. 0,15 mm suitable for

- turning, drilling or reaming, in order to
  - achieve narrower clearance tolerances
  - compensate for misalignment inaccuracies.
- the following have proven effective for turning and drilling:
  - dry cutting
  - cutting speed 100 m/min to 150 m/min
  - feed 0,05 mm
  - maximum cutting depth 0,1 mm
  - hard metal cutting tools (Figure 29).

⚠ Removing a substantial amount of material reduces the operating life and the lubrication pocket volume.

Incorrect machining will have a detrimental effect on the operating life and the load carrying capacity.

Parts must be cleaned after machining.

During machining, burrs can form in the area of the lubrication pockets (Permaglide® P21).

Exceeding a temperature of +140 °C during machining constitutes a health hazard.

The swarf produced may contain lead.

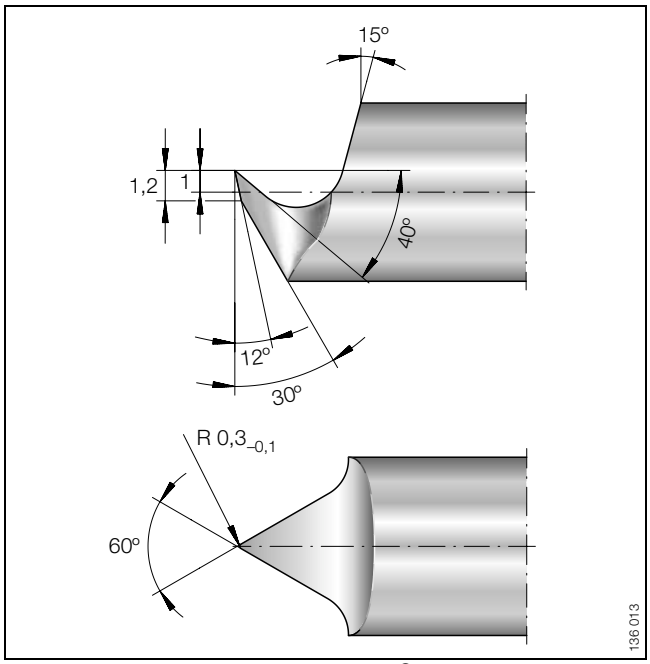


Figure 29 · Cutting tool for Permaglide® P21 and P22

Special designs

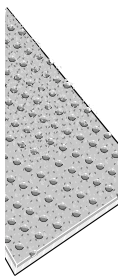
Special designs

Available by agreement:

- Permaglide® P25
  - with lubrication pockets
  - ready-to-fit
  - with bronze backing, therefore substantially corrosion-resistant
- all low-maintenance Permaglide® materials P2 (except for P25) with increased corrosion protection.

Further information

	Page
Technical principles	10
Rating life	10
Design of bearing arrangements	19
Internal clearance and mounting tolerances	24
Pressing in of bushes	30
Calculation of press-in force	32



Designs

Maintenance-free Permaglide® plain bearings P1
Low-maintenance Permaglide® plain bearings P2

Page

Features 50

Ordering example and ordering designation 52

Dimension table 53

Features

Maintenance-free Permaglide® plain bearings P1

- Suitable primarily for dry running
- Technical data, page 37
  - pv_{max} = 1,8 N/mm² · m/s
  - pv_{temp} = 3,6 N/mm² · m/s
  - $p_{max\ stat.}$ = 250 N/mm²
  - $p_{max\ dyn.}$ = 56 N/mm²
  - v_{max} = 2 m/s
  - ϑ = –200 °C to +280 °C
- Permaglide® P10 with steel backing
- Permaglide® P10 with bronze backing.

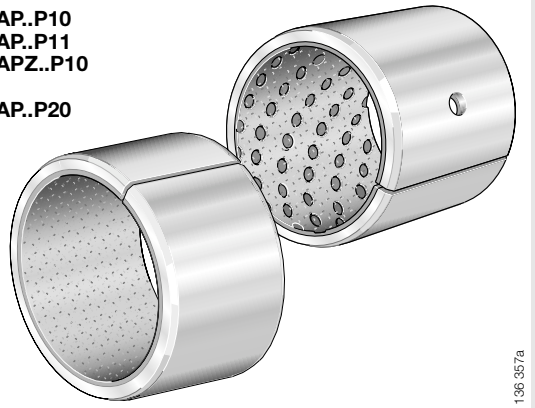
Low-maintenance Permaglide® plain bearings P2

- Lubrication required
- Technical data, page 45
  - pv_{max} = 3 N/mm² · m/s
  - $p_{max\ stat.}$ = 250 N/mm²
  - $p_{max\ dyn.}$ = 70 N/mm²
  - v_{max} = –3 m/s
  - ϑ = –40 °C to +110 °C
  - ϑ_{max} = up to +140 °C for short periods
- Permaglide® P20 with lubrication pockets.

Bushes PAP

PAP..P10
PAP..P11
PAPZ..P10

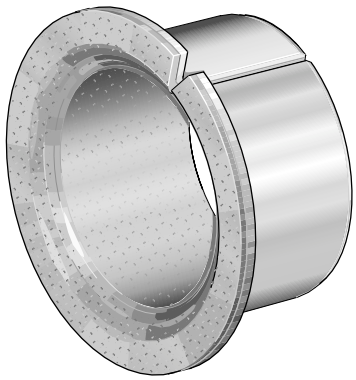
PAP..P20



- PAP..P10 for shafts from 2 mm to 300 mm
- PAP..P11 for shafts from 4 mm to 100 mm
- PAPZ..P10 for shafts from 3/16″ to 2″, inch sizes
- PAP..P20 for shafts from 8 mm to 100 mm

Flanged bushes PAF

PAF..P10
PAF..P11



- PAF..P10 for shafts from 6 mm to 40 mm
- PAF..P11 for shafts from 6 mm to 40 mm

Materials

Page

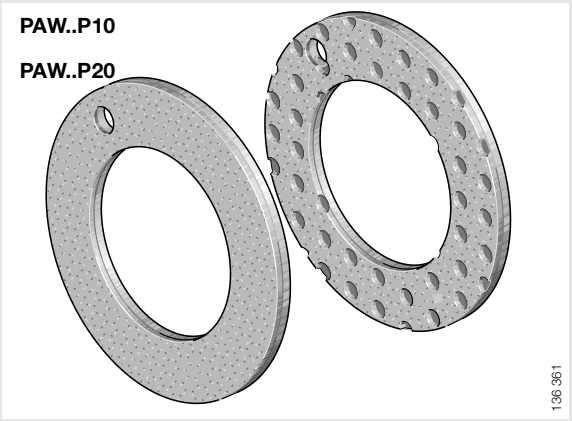
P1 Permaglide®P1 36

P2 Permaglide®P2 44

Thrust washers PAW

PAW..P10

PAW..P20

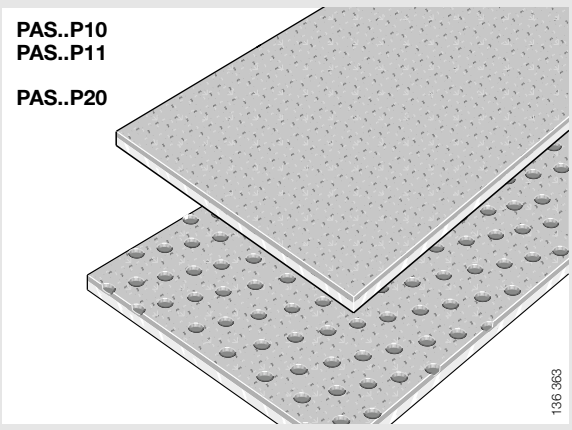


- PAW..P10 with inside diameter from 10 mm to 62 mm
- PAW..P11 available by agreement
- PAW..P20 with inside diameter from 12 mm to 52 mm

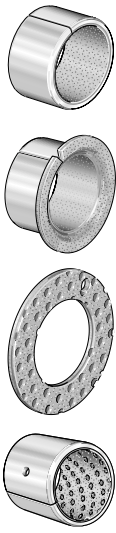
Strips PAS

PAS..P10
PAS..P11

PAS..P20



- PAS..P10, PAS..P11
  - Length 500 mm
  - Widths, see *dimension tables* page 62
  - Wall thicknesses, see *dimension tables* page 62
- PAS..P20
  - Length 500 mm
  - Width 180 mm
  - Wall thicknesses, see *dimension tables* page 65



Ordering example and ordering designation

Bush, Permaglide® P10
with steel backing:
Inside diameter 16 mm
Width 25 mm

Ordering designation: **PAP 1625 P10**

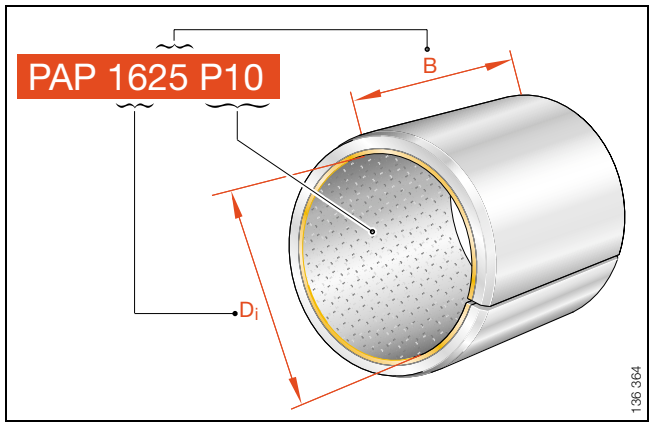


Figure 30 · Ordering example, bush P10

Strip, Permaglide® P20:
Length 500 mm
Width 180 mm
Wall thickness 1 mm (ordering data: $s_3 \times 10$)

Ordering designation: **PAS 10180 P20**

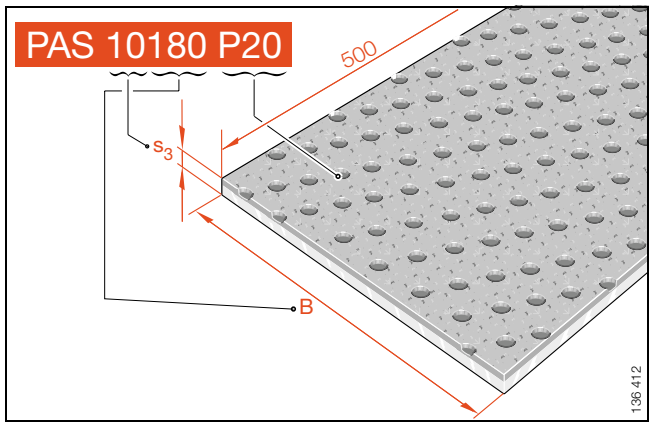


Figure 31 · Ordering example, strip P20

Thrust washers, Permaglide® P20:
Inside diameter 12 mm

Ordering designation: **PAW 12 P20**

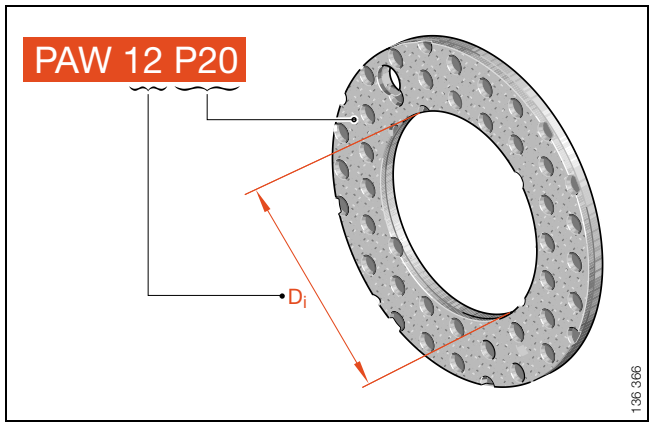


Figure 32 · Ordering example, thrust washer P20

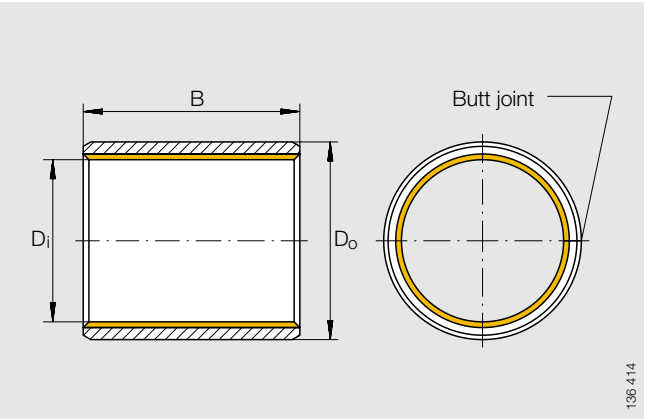
Dimension tables

Permaglide®

Bushes

Maintenance-free, with steel backing

Series PAP..P10



PAP

Dimension table · Dimensions in mm

Shaft diameter	Designation	Mass	Dimensions		
		g	D_i	D_o	B ±0,25
2	**PAP 0203 P10**	0,15	2	3,5	3
	PAP 0205 P10	0,25	2	3,5	5
3	**PAP 0303 P10**	0,2	3	4,5	3
	PAP 0304 P10	0,25	3	4,5	4
	PAP 0305 P10	0,3	3	4,5	5
	PAP 0306 P10	0,4	3	4,5	6
4	**PAP 0403 P10**	0,2	4	5,5	3
	PAP 0404 P10	0,3	4	5,5	4
	PAP 0406 P10	0,6	4	5,5	6
	PAP 0410 P10	0,8	4	5,5	10
5	**PAP 0505 P10**	0,7	5	7	5
	PAP 0508 P10	1,1	5	7	8
	PAP 0510 P10	1,4	5	7	10
6	**PAP 0606 P10**	0,9	6	8	6
	PAP 0608 P10	1,4	6	8	8
	PAP 0610 P10	1,7	6	8	10
7	**PAP 0710 P10**	1,8	7	9	10
8	**PAP 0808 P10**	1,7	8	10	8
	PAP 0810 P10	2,1	8	10	10
	PAP 0812 P10	2,5	8	10	12
10	**PAP 1008 P10**	2	10	12	8
	PAP 1010 P10	2,5	10	12	10
	PAP 1012 P10	2,9	10	12	12
	PAP 1015 P10	3,8	10	12	15
	PAP 1020 P10	5,3	10	12	20

Recommended mounting tolerance:

Shaft		Housing	
d_W	< 5: h6	d_G	≦5,5: H6
5 ≦ d_W	<80: f7	5,5 < d_G:	H7
80 ≦ d_W:	h8		

Internal clearances, wall thicknesses and chamfer tolerances: see page 25ff.
Bushes in special sizes are available by agreement.

Dimension table (continued) · Dimensions in mm

Shaft diameter	Designation	Mass	Dimensions		
		g	D_i	D_o	B ±0,25
12	**PAP 1208 P10**	2	12	14	8
	PAP 1210 P10	3	12	14	10
	PAP 1212 P10	3,7	12	14	12
	PAP 1215 P10	4,7	12	14	15
	PAP 1220 P10	6,1	12	14	20
	PAP 1225 P10	7,6	12	14	25
13	**PAP 1310 P10**	3,2	13	15	10
14	**PAP 1410 P10**	3,5	14	16	10
	PAP 1412 P10	4,3	14	16	12
	PAP 1415 P10	5,4	14	16	15
	PAP 1420 P10	7,1	14	16	20
	PAP 1425 P10	8,8	14	16	25
15	**PAP 1510 P10**	3,7	15	17	10
	PAP 1512 P10	4,5	15	17	12
	PAP 1515 P10	5,7	15	17	15
	PAP 1520 P10	7,6	15	17	20
	PAP 1525 P10	9,4	15	17	25
16	**PAP 1610 P10**	4	16	18	10
	PAP 1612 P10	4,8	16	18	12
	PAP 1615 P10	6,1	16	18	15
	PAP 1620 P10	8,1	16	18	20
	PAP 1625 P10	10,1	16	18	25
18	**PAP 1810 P10**	4,5	18	20	10
	PAP 1815 P10	6,7	18	20	15
	PAP 1820 P10	8,9	18	20	20
	PAP 1825 P10	11,1	18	20	25

Bushes

Maintenance-free, with steel backing

Series PAP..P10

Dimension table (continued) · Dimensions in mm

Shaft diameter	Designation	Mass	Dimensions		
		g	D_i	D_o	B ±0,25
20	**PAP 2010 P10**	7,7	20	23	10
	PAP 2015 P10	11,1	20	23	15
	PAP 2020 P10	15,1	20	23	20
	PAP 2025 P10	19,1	20	23	25
	PAP 2030 P10	23	20	23	30
22	**PAP 2215 P10**	12,7	22	25	15
	PAP 2220 P10	16,6	22	25	20
	PAP 2225 P10	21,1	22	25	25
	PAP 2230 P10	25,2	22	25	30
24	**PAP 2415 P10**	13,5	24	27	15
	PAP 2420 P10	17,9	24	27	20
	PAP 2425 P10	22,8	24	27	25
	PAP 2430 P10	27,1	24	27	30
25	**PAP 2510 P10**	9,6	25	28	10
	PAP 2515 P10	14,2	25	28	15
	PAP 2520 P10	19	25	28	20
	PAP 2525 P10	23,9	25	28	25
	PAP 2530 P10	28,4	25	28	30
	PAP 2540 P10	38	25	28	40
	PAP 2550 P10	47,7	25	28	50
28	**PAP 2820 P10**	28,8	28	32	20
	PAP 2830 P10	44	28	32	30

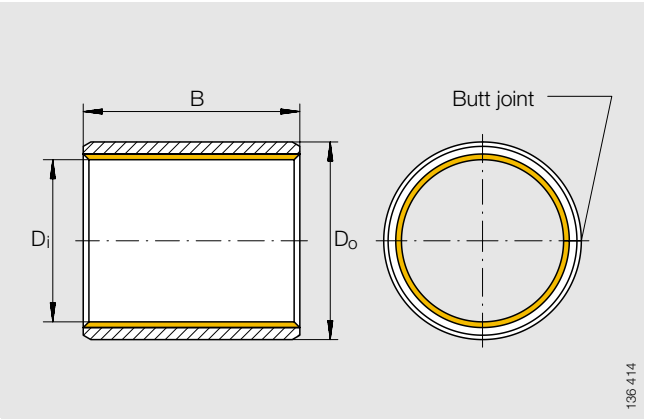
Recommended mounting tolerance:

Shaft		Housing	
d_W	< 5: h6	d_G	≦5,5: H6
5 ≦ d_W	<80: f7	5,5 < d_G:	H7
80 ≦ d_W:	h8		

Internal clearances, wall thicknesses and chamfer tolerances:
see page 25ff.
Bushes in special sizes are available by agreement.

Dimension table (continued) · Dimensions in mm

Shaft diameter	Designation	Mass	Dimensions		
		g	D_i	D_o	B ±0,25
30	**PAP 3015 P10**	22,9	30	34	15
	PAP 3020 P10	30,9	30	34	20
	PAP 3025 P10	38,5	30	34	25
	PAP 3030 P10	46,1	30	34	30
	PAP 3040 P10	63	30	34	40
32	**PAP 3230 P10**	49	32	36	30
	PAP 3240 P10	65	32	36	40
35	**PAP 3520 P10**	35	35	39	20
	PAP 3530 P10	53	35	39	30
	PAP 3540 P10	71	35	39	40
	PAP 3550 P10	89	35	39	50
40	**PAP 4020 P10**	40	40	44	20
	PAP 4030 P10	60	40	44	30
	PAP 4040 P10	81	40	44	40
	PAP 4050 P10	101	40	44	50
45	**PAP 4530 P10**	86	45	50	30
	PAP 4540 P10	113	45	50	40
	PAP 4550 P10	144	45	50	50
50	**PAP 5020 P10**	63	50	55	20
	PAP 5030 P10	95	50	55	30
	PAP 5040 P10	127	50	55	40
	PAP 5060 P10	188	50	55	60
55	**PAP 5540 P10**	138	55	60	40
	PAP 5560 P10	207	55	60	60
60	**PAP 6030 P10**	113	60	65	30
	PAP 6040 P10	150	60	65	40
	PAP 6060 P10	226	60	65	60
	PAP 6070 P10	265	60	65	70
65	**PAP 6530 P10**	123	65	70	30
	PAP 6540 P10	164	65	70	40
	PAP 6550 P10	204	65	70	50
	PAP 6560 P10	244	65	70	60
	PAP 6570 P10	284	65	70	70



PAP

Dimension table (continued) · Dimensions in mm

Shaft diameter	Designation	Mass	Dimensions		
		g	D_i	D_o	B ±0,25
70	**PAP 7040 P10**	174	70	75	40
	PAP 7050 P10	218	70	75	50
	PAP 7070 P10	305	70	75	70
75	**PAP 7540 P10**	187	75	80	40
	PAP 7550 P10	233	75	80	50
	PAP 7560 P10	280	75	80	60
	PAP 7580 P10	374	75	80	80
80	**PAP 8040 P10**	197	80	85	40
	PAP 8060 P10	297	80	85	60
	PAP 8080 P10	395	80	85	80
	PAP 80100 P10	493	80	85	100
85	**PAP 8560 P10**	313	85	90	60
	PAP 85100 P10	525	85	90	100
90	**PAP 9050 P10**	277	90	95	50
	PAP 9060 P10	333	90	95	60
	PAP 90100 P10	551	90	95	100
95	**PAP 9560 P10**	351	95	100	60
	PAP 95100 P10	583	95	100	100
100	**PAP 10050 P10**	312	100	105	50
	PAP 10060 P10	388	100	105	60
	PAP 100115 P10	742	100	105	115
105	**PAP 10560 P10**	370	105	110	60
	PAP 105115 P10	712	105	110	115
110	**PAP 11060 P10**	410	110	115	60
	PAP 110115 P10	775	110	115	115
115	**PAP 11550 P10**	350	115	120	50
	PAP 11560 P10	400	115	120	60
	PAP 11570 P10	450	115	120	70

Recommended mounting tolerance:

Shaft		Housing	
d_W	< 5: h6	d_G	≦5,5: H6
5 ≦ d_W	<80: f7	5,5 < d_G:	H7
80 ≦ d_W:	h8		

Internal clearances, wall thicknesses and chamfer tolerances:
see page 25ff.
Bushes in special sizes are available by agreement.

Dimension table (continued) · Dimensions in mm

Shaft diameter	Designation	Mass	Dimensions		
		g	D_i	D_o	B ±0,25
120	**PAP 12060 P10**	435	120	125	60
	PAP 120100 P10	730	120	125	100
125	**PAP 125100 P10**	760	125	130	100
130	**PAP 13060 P10**	470	130	135	60
	PAP 130100 P10	795	130	135	100
135	**PAP 13560 P10**	490	135	140	60
	PAP 13580 P10	652	135	140	80
140	**PAP 14060 P10**	515	140	145	60
	PAP 140100 P10	855	140	145	100
150	**PAP 15060 P10**	550	150	155	60
	PAP 15080 P10	730	150	155	80
	PAP 150100 P10	915	150	155	100
160	**PAP 16080 P10**	776	160	165	80
	PAP 160100 P10	970	160	165	100
180	**PAP 180100 P10**	1100	180	185	100
200	**PAP 200100 P10**	1220	200	205	100
220	**PAP 220100 P10**	1320	220	225	100
250	**PAP 250100 P10**	1495	250	255	100
300	**PAP 300100 P10**	1760	300	305	100

Permaglide®

Bushes

Maintenance-free, with steel backing
Inch sizes

Series PAPZ..P10

Dimension table · Dimensions in *inch*/mm

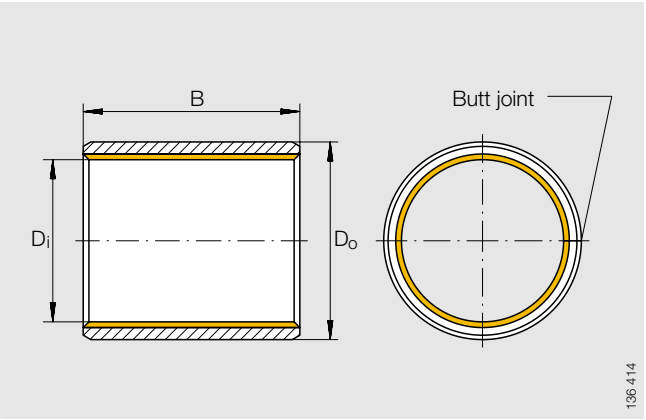
Shaft diameter	Designation	Mass	Dimensions		
			D_i	D_o	B
		g			
3/16 **4,763**	**PAPZ 0303 P10**	0,5	3/16	1/4	3/16
			4,763	6,35	4,76±0,25
	PAPZ 0304 P10	0,7	3/16	1/4	1/4
			4,763	6,35	6,35±0,25
	PAPZ 0306 P10	1	3/16	1/4	3/8
			4,763	6,35	9,53±0,25
1/4 **6,35**	**PAPZ 0404 P10**	0,8	1/4	5/16	1/4
			6,35	7,938	6,35±0,25
	PAPZ 0406 P10	1,3	1/4	5/16	3/8
			6,35	7,938	9,53±0,25
	PAPZ 0408 P10	1,7	1/4	5/16	1/2
			6,35	7,938	12,7±0,25
5/16 **7,938**	**PAPZ 0504 P10**	1	5/16	3/8	1/4
			7,938	9,525	6,35±0,25
	PAPZ 0506 P10	1,6	5/16	3/8	3/8
			7,938	9,525	9,53±0,25
3/8 **9,525**	**PAPZ 0603 P10**	1,4	3/8	15/32	3/16
			9,525	11,906	4,76±0,25
	PAPZ 0604 P10	1,9	3/8	15/32	1/4
			9,525	11,906	6,35±0,25
	PAPZ 0606 P10	2,9	3/8	15/32	3/8
			9,525	11,906	9,53±0,25
	PAPZ 0608 P10	3,8	3/8	15/32	1/2
			9,525	11,906	12,70±0,25
	PAPZ 0610 P10	4,8	3/8	15/32	5/8
			9,525	11,906	15,88±0,25
	PAPZ 0612 P10	5,8	3/8	15/32	3/4
			9,525	11,906	19,05±0,25

Recommended mounting tolerances, wall thicknesses, internal clearances and chamfer tolerances: see page 28ff.

Bushes in special sizes are available by agreement.

Dimension table (continued) · Dimensions in *inch*/mm

Shaft diameter	Designation	Mass	Dimensions		
			D_i	D_o	B
		g			
7/16 **11,113**	**PAPZ 0706 P10**	3,3	7/16	17/32	3/8
			11,113	13,494	9,53±0,25
	PAPZ 0708 P10	4,4	7/16	17/32	1/2
			11,113	13,494	12,70±0,25
	PAPZ 0710 P10	5,5	7/16	17/32	5/8
			11,113	13,494	15,88±0,25
	PAPZ 0712 P10	6,6	7/16	17/32	3/4
			11,113	13,494	19,05±0,25
1/2 **12,7**	**PAPZ 0804 P10**	2,5	1/2	19/32	1/4
			12,7	15,081	6,35±0,25
	PAPZ 0806 P10	3,7	1/2	19/32	3/8
			12,7	15,081	9,53±0,25
	PAPZ 0808 P10	5	1/2	19/32	1/2
			12,7	15,081	12,70±0,25
	PAPZ 0810 P10	6,2	1/2	19/32	5/8
			12,7	15,081	15,88±0,25
	PAPZ 0812 P10	7,5	1/2	19/32	3/4
			12,7	15,081	19,05±0,25
	PAPZ 0814 P10	8,7	1/2	19/32	7/8
			12,7	15,081	22,23±0,25
9/16 **14,288**	**PAPZ 0906 P10**	4	9/16	21/32	3/8
			14,288	16,669	9,53±0,25
	PAPZ 0908 P10	5,5	9/16	21/32	1/2
			14,288	16,669	12,70±0,25
	PAPZ 0912 P10	8,3	9/16	21/32	3/4
			14,288	16,669	19,05±0,25
5/8 **15,875**	**PAPZ 1004 P10**	3	5/8	23/32	1/4
			15,875	18,256	6,35±0,25
	PAPZ 1008 P10	6,1	5/8	23/32	1/2
			15,875	18,256	12,70±0,25
	PAPZ 1010 P10	7,6	5/8	23/32	5/8
			15,875	18,256	15,88±0,25
	PAPZ 1012 P10	9,2	5/8	23/32	3/4
			15,875	18,256	19,05±0,25
	PAPZ 1014 P10	10,7	5/8	23/32	7/8
			15,875	18,256	22,23±0,25



PAPZ

Dimension table (continued) · Dimensions in *inch*/mm

Shaft diameter	Designation	Mass	Dimensions		
			D_i	D_o	B
		g			
11/16 **17,463**	**PAPZ 1112 P10**	10	*11/16*	*25/32*	*3/4*
			17,463	19,844	19,05±0,25
3/4 **19,05**	**PAPZ 1204 P10**	4,9	*3/4*	*7/8*	*1/4*
			19,05	22,225	6,35±0,25
	PAPZ 1206 P10	7,4	*3/4*	*7/8*	*3/8*
			19,05	22,225	9,53±0,25
	PAPZ 1208 P10	9,9	*3/4*	*7/8*	*1/2*
			19,05	22,225	12,70±0,25
	PAPZ 1210 P10	12,3	*3/4*	*7/8*	*5/8*
			19,05	22,225	15,88±0,25
	PAPZ 1212 P10	14,8	*3/4*	*7/8*	*3/4*
			19,05	22,225	19,05±0,25
	PAPZ 1216 P10	19,7	*3/4*	*7/8*	*1*
			19,05	22,225	25,40±0,25
7/8 **22,225**	**PAPZ 1412 P10**	17,1	*7/8*	*1*	*3/4*
			22,225	25,4	19,05±0,25
	PAPZ 1416 P10	22,8	*7/8*	*1*	*1*
			22,225	25,4	25,40±0,25
1 **25,4**	**PAPZ 1606 P10**	9,7	*1*	*1 1/8*	*3/8*
			25,4	28,575	9,53±0,25
	PAPZ 1608 P10	12,9	*1*	*1 1/8*	*1/2*
			25,4	28,575	12,70±0,25
	PAPZ 1612 P10	19,3	*1*	*1 1/8*	*3/4*
			25,4	28,575	19,05±0,25
	PAPZ 1614 P10	22,6	*1*	*1 1/8*	*7/8*
			25,4	28,575	22,23±0,25
	PAPZ 1616 P10	25,8	*1*	*1 1/8*	*1*
			25,4	28,575	25,40±0,25
	PAPZ 1620 P10	32,2	*1*	*1 1/8*	*1 1/4*
			25,4	28,575	31,75±0,25
	PAPZ 1624 P10	38,7	*1*	*1 1/8*	*1 1/2*
			25,4	28,575	38,10±0,25

Recommended mounting tolerances, wall thicknesses, internal clearances and chamfer tolerances: see page 28ff.

Bushes in special sizes are available by agreement.

Dimension table (continued) · Dimensions in *inch*/mm

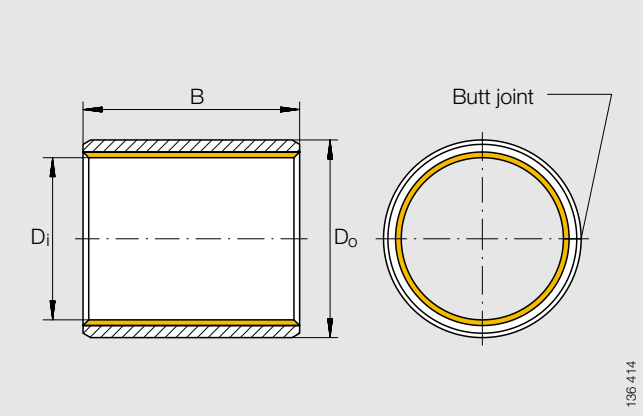
Shaft diameter	Designation	Mass	Dimensions		
			D_i	D_o	B
		g			
1 1/8 **28,575**	**PAPZ 1808 P10**	18,3	*1 1/8*	*1 9/32*	*1/2*
			28,575	32,544	12,70±0,25
	PAPZ 1812 P10	27,4	*1 1/8*	*1 9/32*	*3/4*
			28,575	32,544	19,05±0,25
	PAPZ 1816 P10	36,5	*1 1/8*	*1 9/32*	*1*
			28,575	32,544	25,40±0,25
1 1/4 **31,75**	**PAPZ 2006 P10**	15,1	*1 1/4*	*1 13/32*	*3/8*
			31,75	35,719	9,53±0,25
	PAPZ 2012 P10	30,2	*1 1/4*	*1 13/32*	*3/4*
			31,75	35,719	19,05±0,25
	PAPZ 2016 P10	40,3	*1 1/4*	*1 13/32*	*1*
			31,75	35,719	25,40±0,25
	PAPZ 2020 P10	50,4	*1 1/4*	*1 13/32*	*1 1/4*
			31,75	35,719	31,75±0,25
1 3/8 **34,925**	**PAPZ 2206 P10**	16,5	*1 3/8*	*1 17/32*	*3/8*
			34,925	38,894	9,53±0,25
	PAPZ 2208 P10	22,1	*1 3/8*	*1 17/32*	*1/2*
			34,925	38,894	12,70±0,25
	PAPZ 2210 P10	27,6	*1 3/8*	*1 17/32*	*5/8*
			34,925	38,894	15,88±0,25
	PAPZ 2212 P10	33	*1 3/8*	*1 17/32*	*3/4*
			34,925	38,894	19,05±0,25
	PAPZ 2216 P10	44,1	*1 3/8*	*1 17/32*	*1*
			34,925	38,894	25,40±0,25
	PAPZ 2224 P10	66	*1 3/8*	*1 17/32*	*1 1/2*
			34,925	38,894	38,10±0,25
	PAPZ 2228 P10	77	*1 3/8*	*1 17/32*	*1 3/4*
			34,925	38,894	44,45±0,25

Permaglide®

Bushes

Maintenance-free, with steel backing
Inch sizes

Series PAPZ..P10



PAPZ

Dimension table (continued) · Dimensions in *inch*/mm

Shaft diameter	Designation	Mass	Dimensions		
		g	D_i	D_o	B
1 1/2 **38,1**	**PAPZ 2408 P10**	23,9	*1 1/2*	*1 21/32*	*1/2*
			38,1	42,069	12,70±0,25
	PAPZ 2416 P10	48	*1 1/2*	*1 21/32*	*1*
			38,1	42,069	25,40±0,25
	PAPZ 2420 P10	60	*1 1/2*	*1 21/32*	*1 1/4*
			38,1	42,069	31,75±0,25
	PAPZ 2424 P10	72	*1 1/2*	*1 21/32*	*1 1/2*
			38,1	42,069	38,10±0,25
	PAPZ 2432 P10	96	*1 1/2*	*1 21/32*	*2*
			38,1	42,069	50,80±0,25
1 5/8 **41,275**	**PAPZ 2616 P10**	52	*1 5/8*	*1 25/32*	*1*
			41,275	45,244	25,40±0,25
	PAPZ 2624 P10	78	*1 5/8*	*1 25/32*	*1 1/2*
			41,275	45,244	38,10±0,25
1 3/4 **44,45**	**PAPZ 2816 P10**	67	*1 3/4*	*1 15/16*	*1*
			44,45	49,213	25,40±0,25
	PAPZ 2824 P10	101	*1 3/4*	*1 15/16*	*1 1/2*
			44,45	49,213	38,10±0,25
	PAPZ 2832 P10	134	*1 3/4*	*1 15/16*	*2*
			44,45	49,213	50,80±0,25

Recommended mounting tolerances, wall thicknesses, internal clearances and chamfer tolerances: see page 28ff.

Bushes in special sizes are available by agreement.

Dimension table (continued) · Dimensions in *inch*/mm

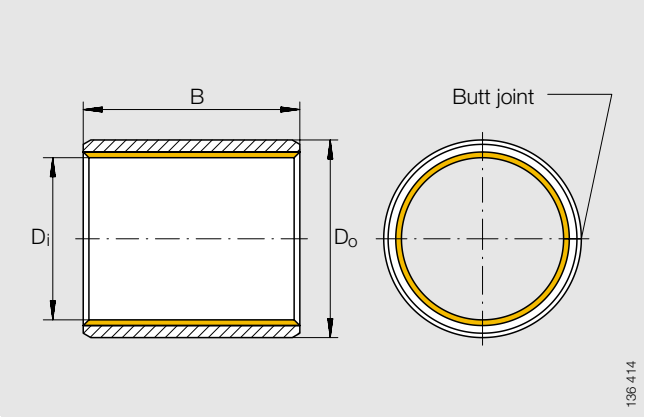
Shaft diameter	Designation	Mass	Dimensions		
		g	D_i	D_o	B
2 **50,8**	**PAPZ 3216 P10**	76	*2*	*2 3/16*	*1*
			50,8	55,563	25,4±0,25
	PAPZ 3224 P10	114	*2*	*2 3/16*	*1 1/2*
			50,8	55,563	38,1±0,25
	PAPZ 3232 P10	153	*2*	*2 3/16*	*2*
			50,8	55,563	50,8±0,25
	PAPZ 3240 P10	191	*2*	*2 3/16*	*2 1/2*
			50,8	55,563	63,5±0,25

Permaglide®

Bushes

Maintenance-free, with bronze backing

Series PAP..P11



PAP

Dimension table · Dimensions in mm

Shaft diameter	Designation	Mass	Dimensions		
		g	D_i	D_o	B ±0,25
4	**PAP 0406 P11**	0,8	4	6	6
5	**PAP 0505 P11**	0,8	5	7	5
6	**PAP 0606 P11**	1,1	6	8	6
	PAP 0610 P11	1,9	6	8	10
8	**PAP 0808 P11**	1,8	8	10	8
	PAP 0810 P11	2,2	8	10	10
	PAP 0812 P11	2,7	8	10	12
10	**PAP 1005 P11**	1,4	10	12	5
	PAP 1010 P11	2,7	10	12	10
	PAP 1015 P11	4,2	10	12	15
	PAP 1020 P11	5,6	10	12	20
12	**PAP 1210 P11**	3,3	12	14	10
	PAP 1212 P11	4,1	12	14	12
	PAP 1215 P11	5,2	12	14	15
	PAP 1220 P11	6,9	12	14	20
	PAP 1225 P11	8,7	12	14	25
14	**PAP 1415 P11**	6	14	16	15
15	**PAP 1515 P11**	6,8	15	17	15
	PAP 1525 P11	10,3	15	17	25
16	**PAP 1615 P11**	6,7	16	18	15
	PAP 1625 P11	11	16	18	25
18	**PAP 1815 P11**	7,4	18	20	15
	PAP 1825 P11	12,2	18	20	25

Recommended mounting tolerance:

Shaft	Housing bore
d_W <80: f7	H7
d_W ≥80: h8	

Internal clearances, wall thicknesses and chamfer tolerances: see page 25ff.

Bushes in special sizes are available by agreement.

Dimension table (continued) · Dimensions in mm

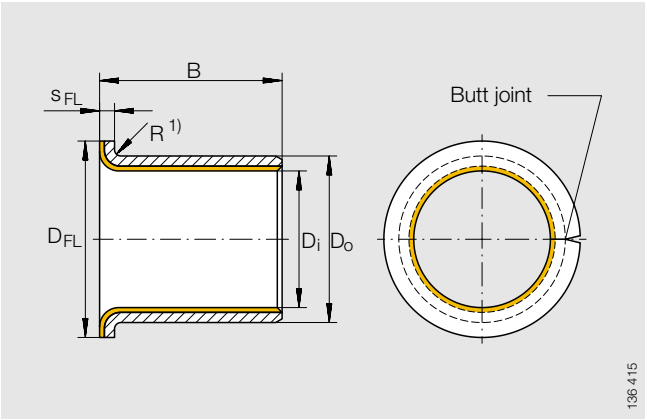
Shaft diameter	Designation	Mass	Dimensions		
		g	D_i	D_o	B ±0,25
20	**PAP 2015 P11**	13,3	20	23	15
	PAP 2020 P11	17	20	23	20
	PAP 2025 P11	21,3	20	23	25
	PAP 2030 P11	25,5	20	23	30
22	**PAP 2215 P11**	15,7	22	25	15
	PAP 2220 P11	20,9	22	25	20
	PAP 2225 P11	26,5	22	25	25
24	**PAP 2430 P11**	34,1	24	27	30
25	**PAP 2525 P11**	29,4	25	28	25
	PAP 2530 P11	35,3	25	28	30
28	**PAP 2830 P11**	46	28	32	30
30	**PAP 3020 P11**	36,8	30	34	20
	PAP 3030 P11	55	30	34	30
	PAP 3040 P11	74	30	34	40
35	**PAP 3520 P11**	44	35	39	20
	PAP 3530 P11	66	35	39	30
40	**PAP 4050 P11**	119	40	44	50
45	**PAP 4550 P11**	186	45	50	50
50	**PAP 5030 P11**	134	50	55	30
	PAP 5040 P11	179	50	55	40
	PAP 5060 P11	269	50	55	60
55	**PAP 5540 P11**	155	55	60	40
60	**PAP 6040 P11**	168	60	65	40
	PAP 6050 P11	211	60	65	50
	PAP 6060 P11	253	60	65	60
	PAP 6070 P11	295	60	65	70
70	**PAP 7050 P11**	245	70	75	50
	PAP 7070 P11	342	70	75	70
80	**PAP 8060 P11**	332	80	85	60
	PAP 80100 P11	554	80	85	100
90	**PAP 9060 P11**	353	90	95	60
	PAP 90100 P11	588	90	95	100
95	**PAP 9560 P11**	430	95	100	60
100	**PAP 10060 P11**	412	100	105	60
	PAP 100115 P11	790	100	105	115

Permaglide®

Flanged bushes

Maintenance-free, with steel backing
Series PAF..P10

Maintenance-free, with bronze backing
Series PAF..P11



PAF

Dimension table · Dimensions in mm

Shaft diameter	Designation **PAF..P10**	Mass	Dimensions				
			D_i	D_o	D_{FL}	B	s_{FL}
		g			±0,5	±0,25	–0,2
6	**PAF 06040 P10**	0,9	6	8	12	4	1
	PAF 06070 P10	1,6	6	8	12	7	1
	PAF 06080 P10	1,7	6	8	12	8	1
8	**PAF 08055 P10**	1,7	8	10	15	5,5	1
	PAF 08075 P10	2,1	8	10	15	7,5	1
	PAF 08095 P10	2,5	8	10	15	9,5	1
10	**PAF 10070 P10**	2,5	10	12	18	7	1
	PAF 10090 P10	2,9	10	12	18	9	1
	PAF 10120 P10	3,8	10	12	18	12	1
	PAF 10170 P10	5,4	10	12	18	17	1
12	**PAF 12070 P10**	3	12	14	20	7	1
	PAF 12090 P10	3,7	12	14	20	9	1
	PAF 12120 P10	4,7	12	14	20	12	1
	PAF 12170 P10	6,1	12	14	20	17	1
14	**PAF 14120 P10**	5,4	14	16	22	12	1
	PAF 14170 P10	7,1	14	16	22	17	1
15	**PAF 15090 P10**	4,4	15	17	23	9	1
	PAF 15120 P10	5,7	15	17	23	12	1
	PAF 15170 P10	7,7	15	17	23	17	1
16	**PAF 16120 P10**	6	16	18	24	12	1
	PAF 16170 P10	8,3	16	18	24	17	1
18	**PAF 18120 P10**	6,7	18	20	26	12	1
	PAF 18170 P10	8,9	18	20	26	17	1
	PAF 18220 P10	11,1	18	20	26	22	1
20	**PAF 20115 P10**	11,6	20	23	30	11,5	1,5
	PAF 20165 P10	15,1	20	23	30	16,5	1,5
	PAF 20215 P10	19,1	20	23	30	21,5	1,5
25	**PAF 25115 P10**	14,2	25	28	35	11,5	1,5
	PAF 25165 P10	19	25	28	35	16,5	1,5
	PAF 25215 P10	23,9	25	28	35	21,5	1,5
30	**PAF 30160 P10**	30,9	30	34	42	16	2
	PAF 30260 P10	46,1	30	34	42	26	2
35	**PAF 35160 P10**	35,4	35	39	47	16	2
	PAF 35260 P10	52,7	35	39	47	26	2
40	**PAF 40260 P10**	60	40	44	53	26	2

Dimension table · Dimensions in mm

Shaft diameter	Designation **PAF..P11**	Mass	Dimensions				
			D_i	D_o	D_{FL}	B	s_{FL}
		g			±0,5	±0,25	–0,2
6	**PAF 06080 P11**	1,7	6	8	12	8	1
8	**PAF 08055 P11**	1,7	8	10	15	5,5	1
	PAF 08095 P11	2,5	8	10	15	9,5	1
10	**PAF 10070 P11**	2,5	10	12	18	7	1
	PAF 10120 P11	3,8	10	12	18	12	1
	PAF 10170 P11	5,4	10	12	18	17	1
12	**PAF 12070 P11**	3	12	14	20	7	1
	PAF 12090 P11	3,7	12	14	20	9	1
	PAF 12120 P11	4,7	12	14	20	12	1
15	**PAF 15120 P11**	5,7	15	17	23	12	1
	PAF 15170 P11	7,7	15	17	23	17	1
16	**PAF 16120 P11**	6	16	18	24	12	1
18	**PAF 18100 P11**	5	18	20	26	10	1
	PAF 18220 P11	11,1	18	20	26	22	1
20	**PAF 20115 P11**	11,6	20	23	30	11,5	1,5
	PAF 20165 P11	15,1	20	23	30	16,5	1,5
25	**PAF 25215 P11**	23,9	25	28	35	21,5	1,5
30	**PAF 30160 P11**	30,9	30	34	42	16	2
	PAF 30260 P11	46,1	30	34	42	26	2
35	**PAF 35260 P11**	52,7	35	39	47	26	2
40	**PAF 40260 P11**	59	40	44	53	26	2

Recommended mounting tolerance:

Shaft	Housing bore
f7	H7

Internal clearances, wall thicknesses and chamfer tolerances:
see page 25ff.
Bushes in special sizes are available by agreement.

1) $\overline{\text{Inside diameter}}$ Radius

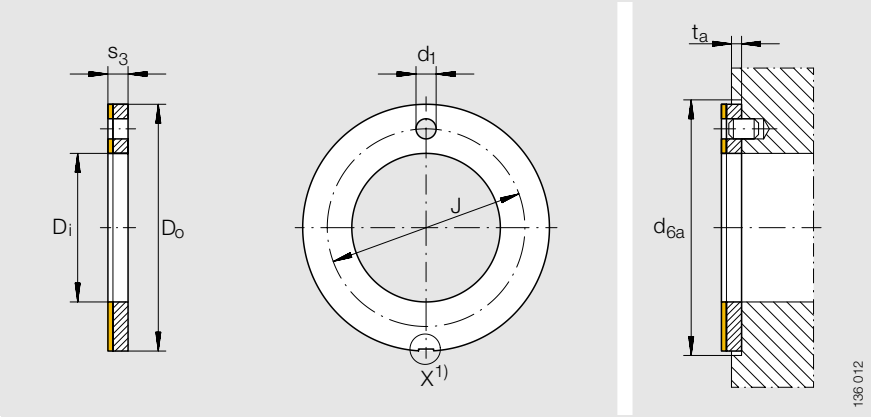
D_i ≦8:	R1–0,5
D_i >8:	R1±0,5

Permaglide®

Thrust washers

Maintenance-free,
with steel backing

Series PAW..P10



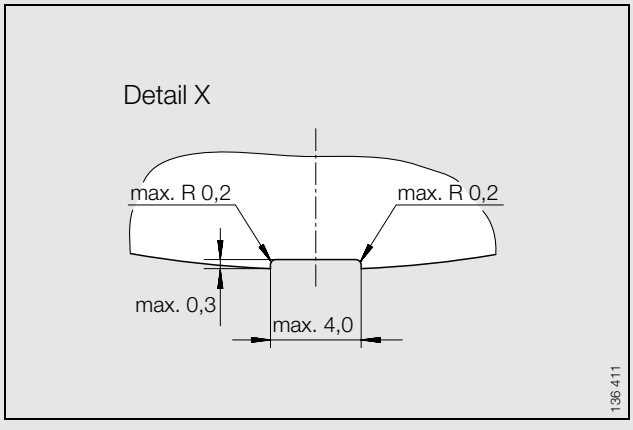
PAW

Dimension table · Dimensions in mm

Designation	Mass	Dimensions					Mounting dimensions	
		D_i	D_o	s_3	J	d_1 +0,4	t_a	d_{6a}
	g	+0,25	–0,25	–0,05	±0,12	+0,1	±0,2	+0,12
PAW 10 P10	2,6	10	20	1,5	15	1,5	1	20
PAW 12 P10	3,8	12	24	1,5	18	1,5	1	24
PAW 14 P10	4,3	14	26	1,5	20	2	1	26
PAW 16 P10	5,5	16	30	1,5	22	2	1	30
PAW 18 P10	6	18	32	1,5	25	2	1	32
PAW 20 P10	8	20	36	1,5	28	3	1	36
PAW 22 P10	8,5	22	38	1,5	30	3	1	38
PAW 26 P10	11,1	26	44	1,5	35	3	1	44
PAW 28 P10	13,3	28	48	1,5	38	4	1	48
PAW 32 P10	16,3	32	54	1,5	43	4	1	54
PAW 38 P10	21	38	62	1,5	50	4	1	62
PAW 42 P10	23,5	42	66	1,5	54	4	1	66
PAW 48 P10	36,8	48	74	2	61	4	1,5	74
PAW 52 P10	38,8	52	78	2	65	4	1,5	78
PAW 62 P10	48,8	62	90	2	76	4	1,5	90

Thrust washers in special sizes are available by agreement.
Thrust washers PAW..P11 are available by agreement.

1) A maximum of 4 cutouts are permissible on the outside diameter in any position.



Permaglide®

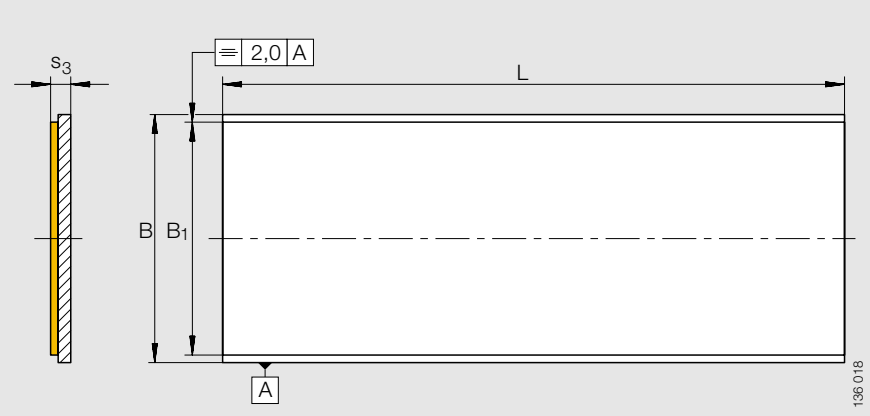
Strips

Maintenance-free,
with steel backing

Series PAS..P10

Maintenance free,
with bronze backing

Series PAS..P11



PAS..P10, PAS..P11

Dimension table · Dimensions in mm

Designation **PAS..P10**	Mass	Dimensions			
		s_3	B	B_1	L
	g	–0,04	+1,5		+3
PAS 05180 P10	330	0,5	180	168	500
PAS 07180 P10[1)]	506	0,75	180	168	500
PAS 07250 P10[2)]	703	0,75	250	238	500
PAS 10250 P10	939	1	250	238	500
PAS 15250 P10	1 421	1,5	250	238	500
PAS 20250 P10	1 914	2	250	238	500
PAS 25250 P10	2 392	2,5	250	238	500
PAS 30250 P10	2 940	3,06	250	238	500

Strips in special sizes are available by agreement.

B = Total width
B_1 = Usable width

1) Type to be discontinued; conversion to PAS 07250 P10 after existing supplies have been sold off.

2) Available only once stocks of PAS 07180 P10 have been sold off.

Dimension table · Dimensions in mm

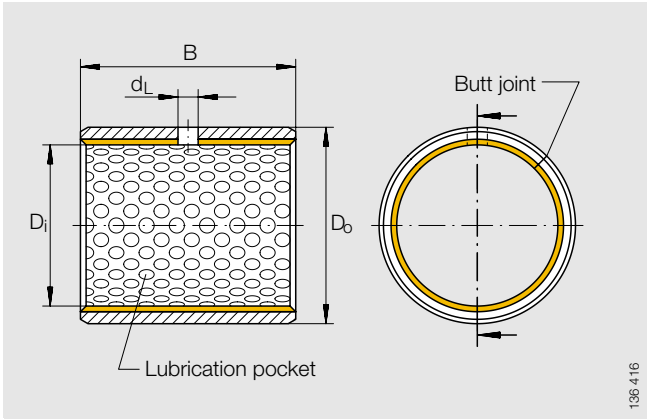
Designation **PAS..P11**	Mass	Dimensions			
		s_3	B	B_1	L
	g	–0,04	+1,5		+3
PAS 10160 P11	663	1	160	148	500
PAS 15180 P11	1 131	1,5	180	168	500
PAS 20180 P11	1 523	2	180	168	500
PAS 25180 P11	1 915	2,5	180	168	500

Permaglide®

Bushes

Low-maintenance

Series PAP..P20



PAP

Dimension table · Dimensions in mm

Shaft diameter	Designation	Mass	Dimensions			
		g	D_i	D_o	B ±0,25	d_L
8	**PAP 0808 P20**	1,6	8	10	8	–[1]
	PAP 0810 P20	2	8	10	10	–[1]
	PAP 0812 P20	2,4	8	10	12	–[1]
10	**PAP 1008 P20**	1,8	10	12	8	–[1]
	PAP 1010 P20	2,3	10	12	10	3
	PAP 1015 P20	3,5	10	12	15	3
12	**PAP 1210 P20**	3	12	14	10	3
	PAP 1212 P20	3,5	12	14	12	3
	PAP 1215 P20	4,4	12	14	15	3
	PAP 1220 P20	6	12	14	20	3
14	**PAP 1420 P20**	6,7	14	16	20	3
15	**PAP 1510 P20**	3,5	15	17	10	3
	PAP 1515 P20	5,3	15	17	15	3
	PAP 1525 P20	8,8	15	17	25	3
16	**PAP 1612 P20**	4,5	16	18	12	3
	PAP 1615 P20	5,6	16	18	15	3
	PAP 1620 P20	7,5	16	18	20	3
18	**PAP 1815 P20**	6,3	18	20	15	3
	PAP 1820 P20	8,5	18	20	20	3
20	**PAP 2015 P20**	10,5	20	23	15	3
	PAP 2020 P20	14	20	23	20	3
	PAP 2025 P20	17,5	20	23	25	3
	PAP 2030 P20	23	20	23	30	3
22	**PAP 2220 P20**	15,4	22	25	20	3
25	**PAP 2515 P20**	14,2	25	28	15	4
	PAP 2520 P20	19	25	28	20	4
	PAP 2525 P20	22	25	28	25	4
	PAP 2530 P20	26,4	25	28	30	4
28	**PAP 2830 P20**	40	28	32	30	4
30	**PAP 3020 P20**	28,6	30	34	20	4
	PAP 3025 P20	35,8	30	34	25	4
	PAP 3030 P20	42,9	30	34	30	4
	PAP 3040 P20	57	30	34	40	4
32	**PAP 3230 P20**	48	32	36	30	4

Dimension table (continued) · Dimensions in mm

Shaft diameter	Designation	Mass	Dimensions			
		g	D_i	D_o	B ±0,25	d_L
35	**PAP 3520 P20**	33	35	39	20	4
	PAP 3530 P20	49	35	39	30	4
	PAP 3550 P20	88	35	39	50	4
40	**PAP 4020 P20**	37	40	44	20	4
	PAP 4030 P20	56	40	44	30	4
	PAP 4040 P20	75	40	44	40	4
	PAP 4050 P20	93	40	44	50	4
45	**PAP 4540 P20**	113	45	50	40	5
	PAP 4550 P20	133	45	50	50	5
50	**PAP 5025 P20**	78	50	55	25	5
	PAP 5040 P20	118	50	55	40	5
	PAP 5060 P20	176	50	55	60	5
55	**PAP 5540 P20**	137	55	60	40	5
60	**PAP 6030 P20**	104	60	65	30	6
	PAP 6040 P20	139	60	65	40	6
	PAP 6060 P20	209	60	65	60	6
70	**PAP 7040 P20**	173	70	75	40	6
	PAP 7050 P20	202	70	75	50	6
	PAP 7070 P20	303	70	75	70	6
75	**PAP 7540 P20**	184	75	80	40	6
	PAP 7580 P20	370	75	80	80	6
80	**PAP 8040 P20**	184	80	85	40	6
	PAP 8055 P20	271	80	85	55	6
	PAP 8060 P20	276	80	85	60	6
	PAP 8080 P20	394	80	85	80	6
90	**PAP 9060 P20**	310	90	95	60	6
100	**PAP 10050 P20**	285	100	105	50	8
	PAP 10060 P20	343	100	105	60	8

Recommended mounting tolerance:

Shaft	Housing bore
h8	H7

Internal clearances, wall thicknesses and chamfer tolerances: see page 25ff.
Deformation of lubrication hole due to round bending is permissible.
Bushes in special sizes are available by agreement.

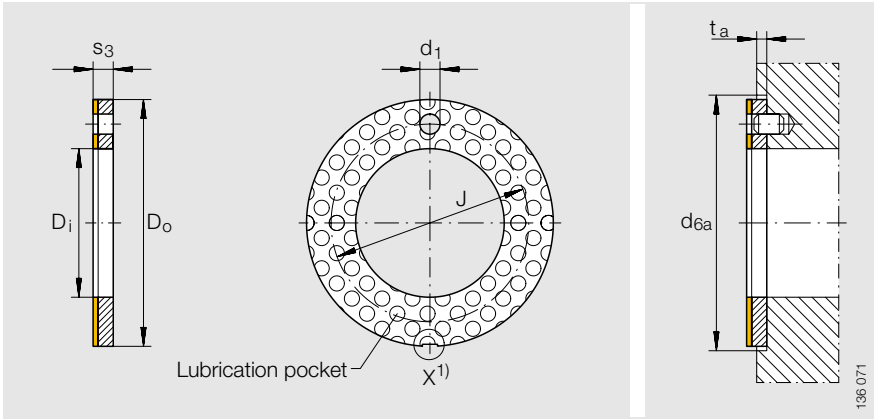
[1] No lubrication hole.

Permaglide®

Thrust washers

Low-maintenance

Series PAW..P20



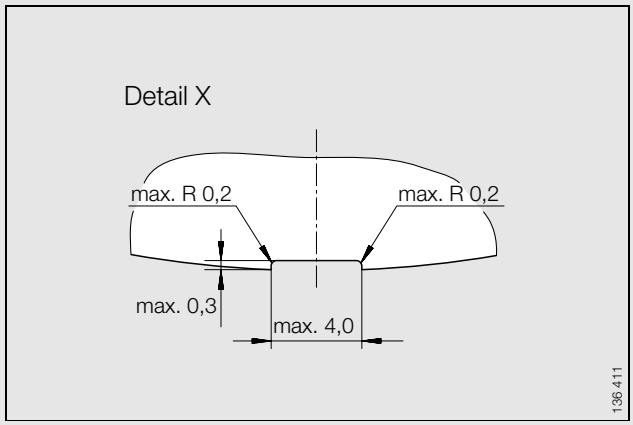
PAW

Dimension table · Dimensions in mm

Designation	Mass	Dimensions					Mounting dimensions	
		D_i	D_o	s_3	J	d_1 +0,4	t_a	d_{6a}
	g	+0,25	–0,25	–0,05	±0,12	+0,1	±0,2	+0,12
PAW 12 P20	3,5	12	24	1,5	18	1,5	1	24
PAW 14 P20	3,7	14	26	1,5	20	2	1	26
PAW 18 P20	5,6	18	32	1,5	25	2	1	32
PAW 20 P20	7,4	20	36	1,5	28	3	1	36
PAW 22 P20	7,9	22	38	1,5	30	3	1	38
PAW 26 P20	10,3	26	44	1,5	35	3	1	44
PAW 28 P20	12,4	28	48	1,5	38	4	1	48
PAW 32 P20	15,2	32	54	1,5	43	4	1	54
PAW 38 P20	19,5	38	62	1,5	50	4	1	62
PAW 42 P20	20,8	42	66	1,5	54	4	1	66
PAW 48 P20	34,9	48	74	2	61	4	1,5	74
PAW 52 P20	36,1	52	78	2	65	4	1,5	78

Thrust washers in special sizes are available by agreement.

1) A maximum of 4 cut-outs are permissible on the outside diameter in any position.

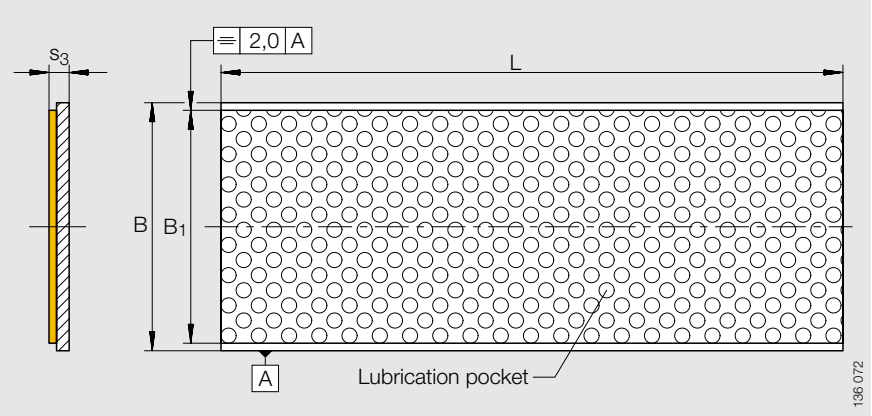


Permaglide®

Strips

Low-maintenance

Séries PAS..P20
PAS..P21
PAS..P22



PAS..P20, with lubrication pockets
PAS..P21, with machining allowance and lubrication pockets

Dimension table · Dimensions in mm

Designation	Mass	Dimensions			
PAS..P20		s_3	B	B_1	L
	g	–0,04	+1,5		+3
PAS 10180 P20	640	0,99	180	168	500
PAS 15180 P20	951	1,48	180	168	500
PAS 20180 P20	1 281	1,97	180	168	500
PAS 25180 P20	1 602	2,46	180	168	500

B = Total widt
B_1 = Usable width
Strips in special sizes are available by agreement.

Dimension table · Dimensions in mm

Designation	Mass	Dimensions			
PAS..P21		s_3 [1)]	B	B_1	L
	g	–0,04	+1,5		+3
PAS 10180 P21	711	1,11	180	168	500
PAS 15180 P21	990	1,61	180	168	500
PAS 20180 P21	1 320	2,11	180	168	500
PAS 25180 P21	1 641	2,63	180	168	500

Available by agreement.

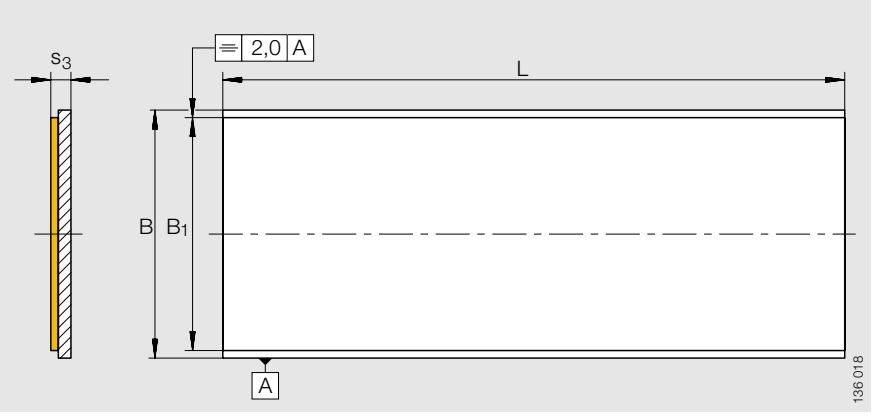
1) Machining allowance: 0,15 mm.

Dimension table · Dimensions in mm

Designation	Mass	Dimensions			
PAS..P22		s_3 [1)]	B	B_1	L
	g	–0,04	+1,5		+3
PAS 10180 P22	711	1,11	180	168	500
PAS 15180 P22	990	1,61	180	168	500
PAS 20180 P22	1 320	2,11	180	168	500
PAS 25180 P22	1 641	2,63	180	168	500

Available by agreement.

1) Machining allowance: 0,15 mm.



PAS..P22, with machining allowance, without lubrication pockets

Special designs
Linear plain bearings

In addition to the products presented in this catalogue, numerous special designs are available:

- made from any Permaglide® plain bearing material
- in non-standard dimensions
- as combined components ①, ②
  - pressed into rings
  - with plastic outer tyres
- in different shapes ⑦, ⑭
  - bushes with windows and holes ③, ⑤
  - bushes with stamped oil grooves ④, ⑥
  - blanked parts ⑬, ⑮, ⑯
  - ball cups ⑩, ⑪, ⑫
  - bearing shells ⑰, ⑱
- with an external sliding layer ⑧, ⑨
- with different butt joint forms ⑨.

A small selection of special components already produced is shown here.

Special designs can be made in the following sizes:

- with bush outside diameters between 3 mm and 305 mm (in special cases up to 800 mm)
- with a strip width up to 250 mm
- with wall thicknesses from 0,5 to 3,06 mm.

The feasibility of special designs should be confirmed as early as possible. This applies not only to the geometry but also to costs. Please contact INA for further information.

Permaglide® linear plain bearings

Permaglide® linear plain bearings PAB consist of Permaglide® bushes PAP..P20 ⑲ pressed into an outer ring.
The PABO design has a segment cut out of the bearing for use with supported shafts.

Permaglide® linear plain bearing units PAGH and PAGBA consist of a Permaglide® linear plain bearing PAB or PABO ⑳ pressed into a housing.

Further information on Permaglide® linear plain bearings: *INA publication LIF* "*Linear Guidance Systems*", CD ROM "***medias®** professional*"

136 409


⑦
⑧
⑨
⑩
⑪
⑫
⑬
⑭
⑮
⑯
⑰
⑱
⑲
⑳
136 410

Subject index

A

Adhesive fastening 20
Alignment 23

B

Basic rating life
- Correction factors 14
- Linear movement, Permaglide® P1 12
- Oscillating movement 12
- Rotary movement 12
- Sliding speed 12
- Specific bearing load 12

Bronze intermediate layer, Permaglide® P2 44
Bush, flanged bush
- Calculation of specific bearing load 12
- Oscillation angle 13
- Oscillation frequency 13

Bushes, flanged bushes
- Calculation of press-in force 32
- Design of bearing arrangements 19
- Internal clearance 24
- Pressing in 30
- Wall thickness 25

C

Calculation example
- Bush PAP..P10 17
- Thrust washer PAW..P20 18

Calculation of rating life
- Guide values, special operating conditions 11
- Life calculation diagram 11
- Permissible load data 11
- Range, Permaglide® P1 11
- Range, Permaglide® P2 11

Chamfers
- Chamfers on the bushes
  - Inch sizes 29
  - Metric sizes 25
- Chamfers on the housing bore 19

Chemical resistance and corrosion protection
- Permaglide® P1 38
- Permaglide® P2 46

Coefficient of friction
- Permaglide® P1 38
- Permaglide® P2 46

Coefficient of thermal conductivity
- Permaglide® P1 37
- Permaglide® P2 45

Coefficient of thermal expansion
- Permaglide® P1 37
- Permaglide® P2 45

Conversion to DIN ISO 3547 25
- Outside diameter 25
- Wall thickness 25

Correction factors
- Correction factor for linear movement 16
- Correction factor for load 14
- Correction factor for loading 14
- Correction factor for material 14
- Correction factor for roughness depth 14
- Correction factor for speed 14
- Correction factor for temperature 14

Corrosion protection
- Mating surface 21
- Permaglide® P1 38
- Permaglide® P2 46

Cutting tool, Permaglide® P2 47

D

Delivered condition 35
Design and safety information 38, 46
- Permaglide® P1 38
- Permaglide® P2 46

Design of bearing arrangements
- Alignment 23
- Heat dissipation 22
- Housing 19
- Machining of bearing elements 22
- Mating surface 21
- Seals 22
- Shaft 21

Designs 50

Dimension tables 53, 63
Bushes
PAP..P10 53
PAP..P11 59
PAP..P20 63
PAPZ..P10, inch sizes 56
Flanged bushes
PAF..P10, PAF..P11 60
Strips
PAS..P10, PAS..P11 62
PAS..P20, PAS..P21, PAS..P22 65
Thrust washers
PAW..P10 61
PAW..P20 64

E

Electrical conductivity, Permaglide® P1 39
Electrochemical contact corrosion
Permaglide® P1 39
Permaglide® P2 46
Environmental considerations 35

F

Fretting corrosion
Permaglide® P1 39
Permaglide® P2 46

G

Grinding of a cast shaft 21

H

Health and safety at work 35
Heat dissipation 22
High ambient temperatures 27
Housing 19
Chamfers 19
Design, bushes and flanged bushes 19
Design, thrust washer 20
Other location methods 20
Hydrodynamic operation
Mating surface 21
Permaglide® P1 40
Permaglide® P2 47

I

Inch sizes 28
Internal clearance and mounting tolerances 28
Outer chamfer and inner edge break 29
Inner edge break
Inch sizes 29
Metric sizes 25
Interference fit and internal clearance 24
High ambient temperatures 27
Reduced tolerances 24
Internal clearance 24
Expansion of the housing bore 24
Recommended mounting tolerances 24

L

Laser welding 20
Linear movement 16
Load data, permissible
Permaglide® P1 11
Permaglide® P2 11
Location by means of dowel pins 20
Location methods 20
Low-maintenance Permaglide® plain bearing P2
Bushes 50
Strips 50
Thrust washers 50
Low-maintenance plain bearing material, Permaglide® P2 44
Lubricating greases, Permaglide® P2 46
Lubrication
Permaglide® P1 39
Permaglide® P2 46
Lubrication pockets, Permaglide® P20, P21 44

M

Machining allowance, Permaglide® P2 44
Machining of bearing elements 22
Maintenance-free Permaglide® plain bearings P1
- Bushes 50
- Flanged bushes 50
- Strips 50
- Thrust washers 50

Maintenance-free plain bearing material, Permaglide® P1 . 36
Material transfer 40
- Running-in process, Permaglide® P1 41

Materials
- Permaglide® P1, maintenance-free 36
- Permaglide® P2, low maintenance 44

Mating surface
- Design of bearing arrangements 21
- Grinding of a cast shaft 21
- Hydrodynamic operation 21
- Optimum operating life 21
- Surface roughness 21

Modulus of elasticity 32
Mounting tolerances 24

O

Operating behaviour, Permaglide® P1 40
Operating life 10
Operating temperature
- Permaglide® P1, permissible 37
- Permaglide® P2, permissible 45

Ordering examples 52
Oscillation angle 13
Oscillation frequency 13
Outer chamfer
- Inch sizes 29
- Metric sizes 25

Outside diameter
- Deviations according to DIN ISO 3547–2 25

P

Paste formation, Permaglide® P1 39
Plain bearing material, materials
- Permaglide® P1 36
- Permaglide® P2 44

Press-in force 32
- Calculation example 34

Pressing in of bushes 30
pv value, maximum
- for dry running of Permaglide® P1 37
- Permaglide® P2 45

R

Range of the life calculation
- Permaglide® P1 11
- Permaglide® P2 11

Rating life 10
- Basic rating life 12
- Calculation examples 17
- Calculation of basic rating life 10
- Operating life 10

Relative electrical resistance, Permaglide® P1 37
Roughness depth, mating surface 21
Running-in layer, Permaglide® P1 36
Running-in process, Permaglide® P1 40

S

Seals 22
Shaft, design of bearing arrangements 21
Sizing, Permaglide® P1 42
Sliding layer
- Machining of Permaglide® P2 47
- Permaglide® P1 36
- Permaglide® P2 44

Sliding speed 12
- Oscillation angle 13
- Oscillation frequency 13
- Permaglide® P1, permissible 37
- Permaglide® P2, permissible 45

Soldering 20
Special designs
Permaglide® P1 43
Permaglide® P2 48
Special operating conditions
Guide values for Permaglide® P1 11
Specific bearing load
Permaglide® P1, permissible 37
Permaglide® P2, permissible 45
Storage 35
Stroke length for linear movement 16
Surface protection
Permaglide® P1 36
Permaglide® P2 44
Surface roughness, mating surface 21
Symbols and units 7

T

Temperature
High ambient temperatures 27
High temperatures, Permaglide® P1 40
Thrust washer
Calculation of specific bearing load 12
Design of bearing arrangements 20
Life calculation 12
Location of a thrust washer 20
Oscillation angle 13
Oscillation frequency 13
Sliding speed 12
Transversal contraction 32

U

Units and symbols 7
US conversions 6

V

Variants, plain bearing material
Permaglide® P10 36
Permaglide® P11 36
Permaglide® P14 43
Permaglide® P16 43
Permaglide® P18 43
Permaglide® P20 44
Permaglide® P21 44
Permaglide® P22 44
Permaglide® P23 44
Permaglide® P25 48

W

Wall thickness
Inch sizes 28
Metric sizes 25

INA Bearing Company Ltd.

Forge Lane, Minworth · Sutton Coldfield
West Midlands · B76 1AP
Telephone: 0121 351 3833
Fax: 0121 351 7686
Website: www.ina.co.uk
E-mail: ina.bearing@ina.co.uk

Sach-Nr. 011-338-032/706 GB-GB 0302XX

Each section of Catalogue 706 starts with a description of the product series and product features.

The significant characteristics of the products are indicated by means of pictograms.

The advantages of this type of presentation include:

- less reading is required
- the required information is accessed more quickly
- a direct comparison between alternative products is possible.

Definition of pictograms

Pictogram	Description
	The products can support radial loads
	The products can support axial loads
	If this information is not adhered to, there is a direct or indirect risk to the product and/or the adjacent construction.