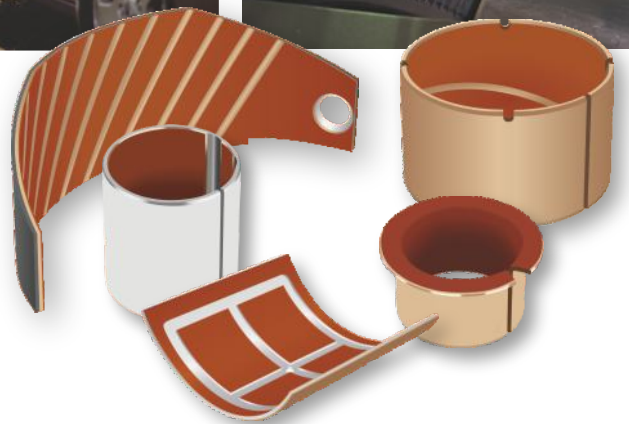
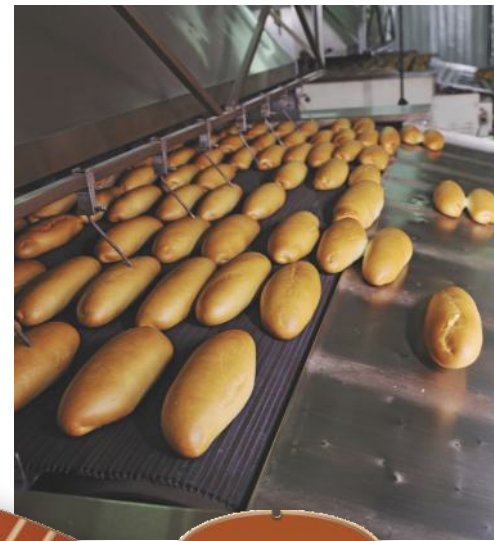
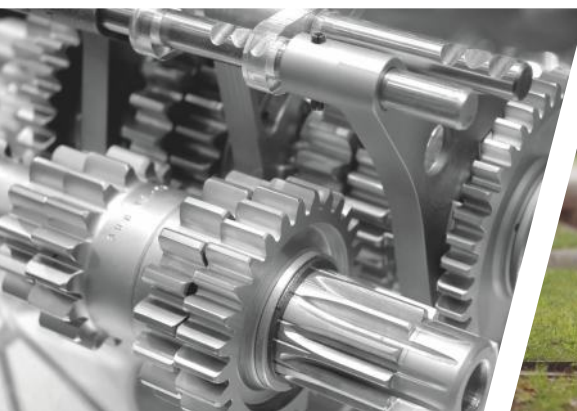




 **GGB**  
BY TIMKEN



DP4<sup>®</sup> and DP4-B  
**METAL-POLYMER SELF-LUBRICATING  
LEAD FREE BEARING SOLUTIONS**



# Pushing Boundaries to co-create A higher Quality of Life

GGB helps create a world of motion with minimal frictional loss through plain bearing and surface engineering technologies. With R&D, testing and production facilities in the United States, Germany, France, Brazil, Slovakia and China, GGB partners with customers worldwide on customized tribological design solutions that are efficient and environmentally sustainable. GGB's engineers bring their expertise and passion for tribology to a wide range of industries, including automotive, aerospace and industrial manufacturing. To learn more about tribology for surface engineering from GGB, visit [www.ggbearings.com](http://www.ggbearings.com).

Our products are used in tens of thousands of critical applications every day on our planet. It is always our goal to provide superior, high-quality solutions for our customers' needs, no matter where those demands take our products. From space vehicles to golf carts and virtually everything in between; we offer the industry's most extensive range of high performance, maintenance-free bearing solutions for a multitude of applications:

- [Aerospace](#)
- [Agricultural](#)
- [Automotive](#)
- [Construction](#)
- [E-Mobility](#)
- [Energy](#)
- [Fluid Power](#)
- [Industrial](#)
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# The GGB Advantage

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## LOWER SYSTEM COST

GGB bearings reduce shaft costs by eliminating the need for hardening and machining grease paths. Their compact, one-piece construction provides space and weight savings and simplifies assembly.



## LOW-FRICTION, HIGH WEAR RESISTANCE

Low coefficients of friction eliminate the need for lubrication, while providing smooth operation, reducing wear and extending service life. Low-friction also eliminates the effects of stick-slip or “stiction” during start up.



## MAINTENANCE-FREE

GGB bearings are self-lubricating, making them ideal for applications requiring long bearing life without continuous maintenance, as well as operating conditions with inadequate or no lubrication.



## ENVIRONMENTAL

Greaseless, lead-free GGB bearings comply with increasingly stringent environmental regulations such as the EU RoHS directive restricting the use of hazardous substances in certain types of electrical and electronic equipment.



## CUSTOMER SUPPORT

GGB's flexible production platform and extensive supply network assure quick turnaround and timely deliveries. In addition, we offer local applications engineering and technical support.

# The Highest Standards in Quality

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## SAFETY

Our deep-rooted culture of safety places a relentless focus on creating a secure, healthy work environment for all. As one of our core values, safety is essential for us to achieve our goal of having the safest employees in the industry.



## EXCELLENCE

Our world-class manufacturing plants in the United States, Brazil, China, Germany, France, and Slovakia are certified in quality and excellence according to ISO 9001, IATF 16949, ISO 14001, ISO 45001, and AS9100D/EN9100. This allows us to access the industry's best practices while aligning our management system with global standards.

For a complete listing of our certifications, please visit our website:

<https://www.ggbearings.com/en/certificates>



## RESPECT

Our teams work together with mutual respect regardless of background, nationality, or function, embracing the diversity of people and learning from one another - after all, with respect comes both individual and group growth.

# GGB - Who We Are

---

## **AT GGB, WE AREN'T AFRAID TO TAKE RISKS FOR OUR CUSTOMERS.**

We are passionate about the work we do and believe that same passion contributes to the level of innovation that can enhance human potential. We take pride in working closely with customers in the early stage of a design to think broadly and boldly, and to expand beyond traditional surface engineered solutions. We offer reliable partnerships based on trust, compassion, determination, collaboration and respect.

As the tribological leader, GGB helps create a world of motion with minimal frictional loss through plain bearing and surface engineering technologies. Thanks to our global footprint and wealth of specific applications expertise, our capabilities are virtually limitless. We work to push the boundaries of possibility, inspiring customers across all markets to partner - and innovate - alongside us.



# Table of Contents

---

<b>1 Introduction</b>	<b>7</b>	<b>5 Lubrication</b>	<b>25</b>
1.1 Characteristics and Advantages	7	5.1 Lubricants	25
1.2 Applications	8	5.2 Tribology	25
<b>2 Structure and Composition</b>	<b>9</b>	Hydrodynamic Lubrication	25
2.1 Basic Forms	9	Mixed Film Lubrication	26
Standard Components	9	Boundary Lubrication	26
Non-Standard Components	9	<b>5.3 Characteristics of Lubricated Bearings</b>	<b>27</b>
<b>3 Properties</b>	<b>10</b>	<b>5.4 Design Guidance</b>	<b>28</b>
3.1 Physical and Mechanical Properties	10	<b>5.5 Clearances for Lubricated Operation</b>	<b>29</b>
3.2 Chemical Resistance	10	<b>5.6 Grooving for Lubricated Operation</b>	<b>29</b>
3.3 Frictional Properties	11	<b>5.7 Mating Surface Finish for Lubricated Operation</b>	<b>29</b>
Effect of Temperature for Unlubricated Applications	11	<b>5.8 Grease Lubrication</b>	<b>29</b>
<b>4 Bearing Performance</b>	<b>12</b>	<b>6 Bearing Assembly</b>	<b>30</b>
4.1 McPherson Strut Applications	12	Dimensions and Tolerances	30
Wear and Friction Properties	12	<b>6.1 Allowance for Thermal Expansion</b>	<b>30</b>
McPherson Strut Test Rig	12	<b>6.2 Tolerances for Minimum Clearance</b>	<b>30</b>
Cavitation Erosion Resistance	14	Burnishing	31
Flow Erosion Resistance	15	<b>6.3 Counterface Design</b>	<b>31</b>
4.2 Hydraulic Applications	16	<b>6.4 Installation</b>	<b>32</b>
GGB Jupiter Test Rig	16	Fitting of Cylindrical Bushes	32
4.3 Dry Wear Performance	17	Fitting of Flanged Bushes	32
Design Factors	17	Insertion Forces	32
Specific Load $p$	17	Alignment	33
Sliding Speed $U$	18	Sealing	33
Continuous Rotation	18	<b>6.5 Axial Location</b>	<b>33</b>
Oscillating Movement	18	Fitting of Thrust Washers	33
$pU$ Factor	19	Slideways	34
Application Factors	19	<b>7 Modification</b>	<b>35</b>
Temperature	19	<b>7.1 Cutting and Machining</b>	<b>35</b>
Mating Surface	20	Drilling Oil Holes	35
Bearing Size	20	Cutting Strip Material	35
Bore Burnishing	21	<b>7.2 Electroplating</b>	<b>35</b>
Type of Load	21	DP4® Components	35
4.4 Calculation of Bearing Service Life	22		
Specific Load $p$	22		
High Load Factor $a_E$	22		
Modified $pU$ Factor	22		
Estimation of Bearing Life $L_H$	23		
Bore Burnishing	23		
Slideways	23		
4.5 Worked Examples	24		

# Table of Contents

---

<b>8 Standard Products</b>	<b>36</b>
8.1 DP4® Cylindrical Bushes	36
8.2 DP4® Flanged Bushes	42
8.3 DP4® Thrust Washers	44
8.4 DP4® Flanged Washers	45
8.5 DP4® Strip	46
8.6 DP4-B Cylindrical Bushes	47
8.7 DP4-B Flanged Bushes	50
8.8 DP4-B Strip	51
<b>9 Test Methods</b>	<b>52</b>
9.1 Measurement of Wrapped Bushes	52
Test A of ISO 3547 Part 2	52
Test B (alternatively to Test A)	52
Test C	52
Measurement of Wall Thickness (alternatively to Test C)	52
Test D	52
<b>10 Data Sheet for Bearing Design</b>	<b>53</b>
Formula Symbols and Designations	54
Product Information	55

# 1 Introduction

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The purpose of this handbook is to provide comprehensive technical information on the characteristics of DP4® and DP4-B bearings.

The information given permits designers to establish the correct size of bearing required and the expected life and performance.

In addition, your local sales representative is available to assist you with your design. Complete information on the range of DP4® standard stock products is given together with details of other DP4® products.

GGB is continually refining and extending its experimental and theoretical knowledge and, therefore, when using this brochure it is always worth-while to contact GGB should additional information be required.

As it is impossible to cover all conditions of operation which arise in practice, customers are advised to carry out prototype testing wherever possible.

## 1.1 CHARACTERISTICS AND ADVANTAGES

The DP4® and DP4-B materials offer the following characteristics:

- Good frictional properties with negligible stick-slip
- High static and dynamic load capacity
- Suitable for rotating, oscillating, reciprocating and sliding movements
- Compact size and low weight
- Prefinished that requires no machining after assembly
- Possibility to burnish for reduced operating clearance
- No water absorption and therefore dimensionally stable
- Suitable for a wide operating temperature range from -200 to +280 °C
- DP4-B with bronze backing for increased corrosion resistance
- Lead free in compliance with European RoHS 2002/95/EC, 2002/96/EC and EVL 2000/53/EC directives (see page 55)

In particular, depending on the dry running conditions, DP4® and DP4-B materials present the following performance advantages:

### Dry conditions

- Good friction and wear performance under light duty conditions
- Particularly suitable for intermittent oscillating and reciprocating movements
- Maintenance free as no external lubrication required
- Seizure resistant.

### Lubricated conditions

- Good wear and friction performance over a wide range of load, speed and temperature conditions
- High wear resistance in boundary operating conditions
- High resistance of bearing surface under fluid cavitation and flow erosion conditions
- Suitable for operation in diverse fluids (oil, fuel, solvents, refrigerants, water).

# 1 Introduction

## 1.2 APPLICATIONS

Given the performance characteristics in both dry and lubricated operating conditions, DP4® and DP4-B bearing materials are extensively used in a wide range of automotive and industrial applications, such as:

### Automotive

Braking systems, clutches, gearbox and transmissions, hinges - door bonnet and boot, convertible roof tops, pedal systems, pumps - axial, radial, gear and vane, seat mechanisms, steering systems, struts and shock absorbers, wiper systems.

### Industrial

Aerospace, agricultural, construction equipment, food and beverage, marine, material handling, office equipment, packaging equipment, pneumatic and hydraulic cylinders, railroad and tramways, textile machinery, valves.





# 2 Structure and Composition

## DP4<sup>®</sup> / DP4-B

DP4<sup>®</sup> is a composite bearing material. It consists of a steel DP4<sup>®</sup> / bronze DP4-B backing to which is bonded a porous sinter bronze interlayer which is overlaid and impregnated with Polytetrafluoroethylene (PTFE) containing a mixture of inorganic fillers and special polymer fibres. The steel DP4<sup>®</sup> / bronze DP4-B backing provides mechanical strength and the bronze sinter layer provides a strong mechanical bond for the filled bearing lining.

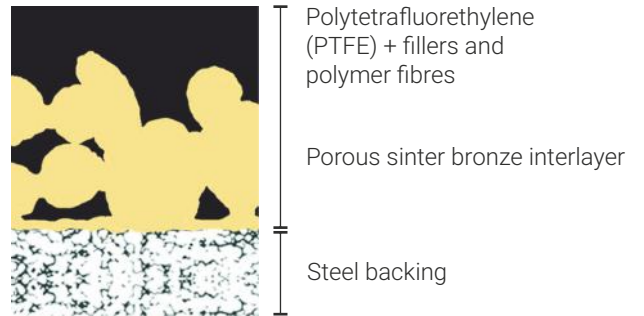


Fig.1: DP4 microsection

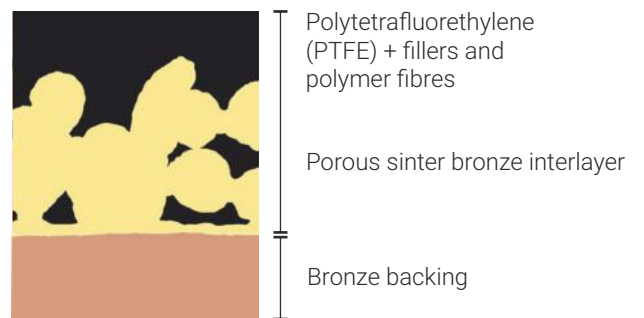


Fig.2: DP4-B microsection

### 2.1 BASIC FORMS

#### Standard Components

These products are manufactured to International, National or GGB standards. The following components are standard stock products:

- Cylindrical Bushes
- Flanged Bushes
- Thrust Washers
- Flanged Washers
- Strip Material



Fig.3: Standard stock products

#### Non-standard Components

These products are manufactured to customer's requirements and include for example:

- Modified Standard Components
- Half Bearings
- Flat Components
- Deep Drawn Parts
- Pressings
- Stampings



Fig.4: Non-standard components

# 3 Properties

## 3.1 PHYSICAL AND MECHANICAL PROPERTIES

BEARING PROPERTIES		SYMBOL	UNIT	VALUE		COMMENTS
				DP4®	DP4-B	
<b>PHYSICAL PROPERTIES</b>						
Coefficient of linear thermal expansion	parallel to surface	$\alpha_1$	$10^{-6}/K$	11	18	
	normal to service	$\alpha_2$		30	36	
Operating temperature		$T_{max}$	°C	+280	+280	
		$T_{min}$		-200	-200	
<b>MECHANICAL PROPERTIES</b>						
Compressive yield strength		$\sigma_c$	MPa	350	300	measured on disc Ø 25 mm x 2.45 mm thick
Maximum load	static	$p_{sta.max}$	MPa	250	140	
	dynamic	$p_{dyn.max}$		140	140	

Table 1: Physical and mechanical properties of DP4 and DP4-B

## 3.2 CHEMICAL PROPERTIES

The following table provides an indication of the chemical resistance of DP4® and DP4-B to various chemical media. It is recommended that the chemical resistance is confirmed by testing if possible.

CHEMICAL	%	°C	DP4®	DP4-B	CHEMICAL	°C	DP4®	DP4-B
<b>STRONG ACIDS</b>					<b>SOLVENTS</b>			
Hydrochloric Acid	5	20	-	-	Acetone	20	+	+
Nitric Acid	5	20	-	-	Carbon Tetrachloride	20	+	+
Sulfuric Acid	5	20	-	-	<b>LUBRICANTS AND FUELS</b>			
<b>WEAK ACIDS</b>					Paraffin	20	+	+
Acetic Acid	5	20	-	o	Gasolene	20	+	+
Formic Acid	5	20	-	o	Kerosene	20	+	+
<b>BASES</b>					Diesel Fuel	20	+	+
Ammonia	10	20	o	-	Mineral Oil	70	+	+
Sodium Hydroxide	5	20	o	o	HFA-ISO46 High Water Fluid	70	+	+
					HFC-Water-Glycol	70	+	+
					HFD-Phosphate Ester	70	+	+
					Water	20	o	+
					Sea Water	20	-	o

Table 2: Chemical Resistance of DP4 and DP4-B

- + **Satisfactory:** Corrosion damage is unlikely to occur
- o **Acceptable:** Some corrosion damage may occur but this will not be sufficient to impair either the structural integrity or the tribological performance of the material
- **Unsatisfactory:** Corrosion damage will occur and is likely to affect either the structural integrity and/or the tribological performance of the material

### Electrochemical Corrosion

DP4-B should not be used in conjunction with aluminium housings due to the risk of electrochemical corrosion in the presence of water or moisture.

### 3.3 FRICTIONAL PROPERTIES

DP4® bearings show negligible 'stick-slip' and provide smooth sliding between adjacent surfaces. The coefficient of friction of DP4® depends upon:

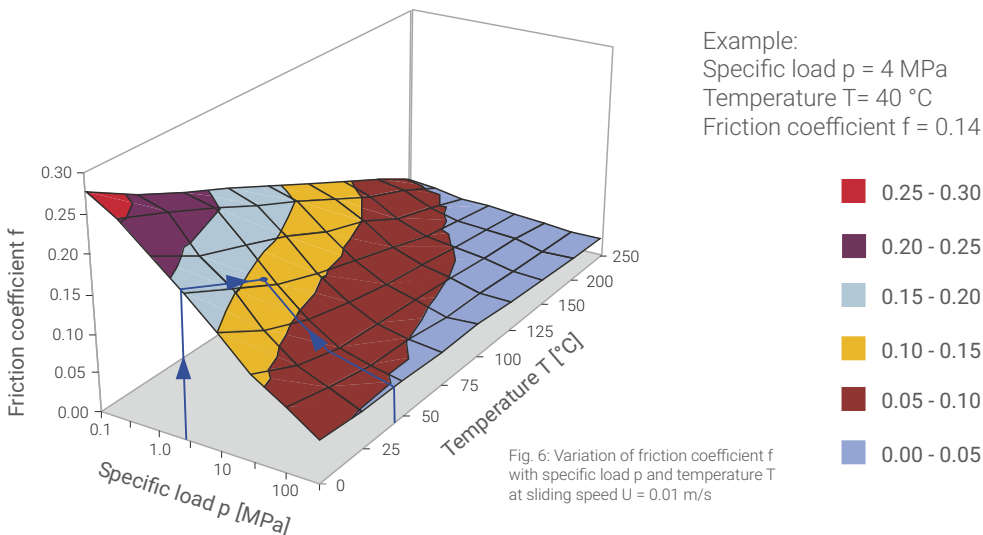
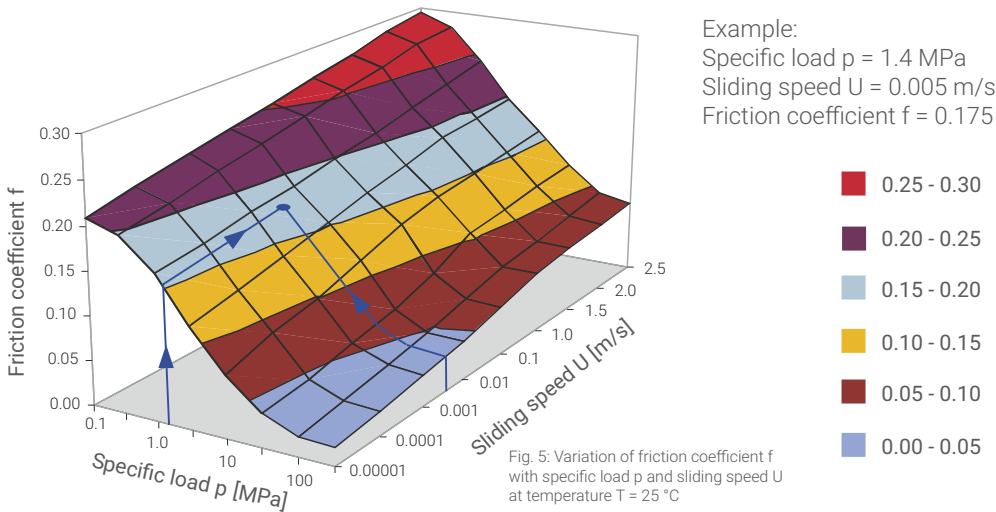
- The specific load  $p$  [MPa]
- The sliding speed  $U$  [m/s]
- The roughness of the mating running surface  $Ra$  [ $\mu\text{m}$ ]
- The bearing temperature  $T$  [ $^{\circ}\text{C}$ ].

A typical relationship is shown in Fig. 5, which can be used as a guide to establish the actual friction under clean, dry conditions after running in. Exact values may vary by  $\pm 20\%$  depending on operating conditions. Before running in, the friction may be up to 50 % higher.

After progressively longer periods of dwell under load (e.g. hours or days) the static coefficient of friction on the first movement may be between 1.5 and 3 times greater, particularly before running in.

#### Effect of Temperature for Unlubricated Applications

The coefficient of friction of DP4® varies with temperature. Typical values are shown in Fig. 6 for temperatures up to 250  $^{\circ}\text{C}$ . Friction increases at bearing temperatures below 0  $^{\circ}\text{C}$ . Where frictional characteristics are critical to a design they should be established by prototype testing.



# 4 Bearing Performance

## 4.1 MCPHERSON STRUT APPLICATIONS

DP4® has been developed to provide improved wear, erosion resistance and reduced friction in McPherson strut piston rod guide bush applications under the most demanding of operating conditions.

In the following sections, the performance of DP4® is compared with that of the material used in the majority of this type of application.

### Wear and friction properties

The wear and frictional performance of DP4® has been evaluated in the piston rod guide bush application of a McPherson strut shock absorber using the test rig shown in Fig. 7. The test conditions are designed to simulate the operational duty of the test strut in service and differ in detail according to the strut manufacturer. The test conditions used are given in Table 3 and Table 4.

### McPherson strut test rig

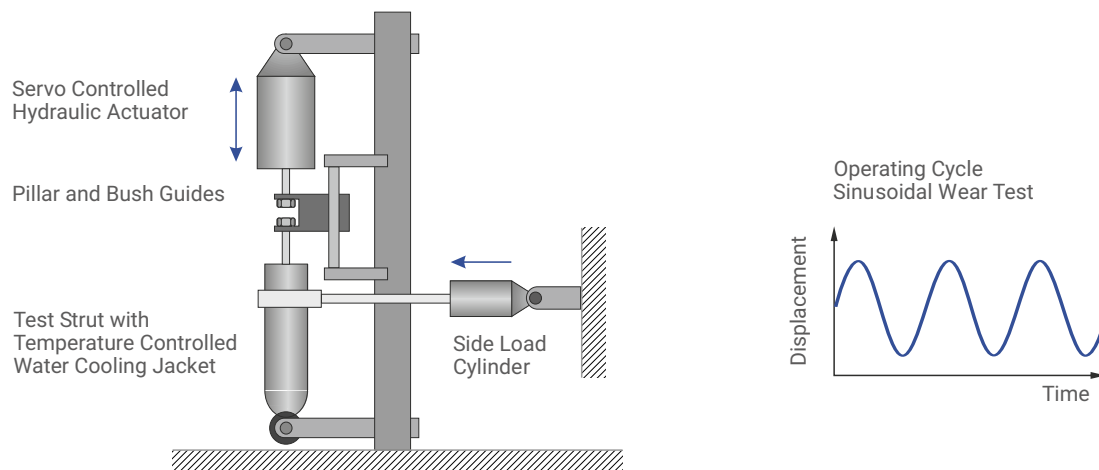


Fig. 7: Principle of the strut test rig

STRUT WEAR - TEST CONDITIONS	
Waveform	Sine
Frequency	2.5 Hz
Side load	890 N
Test duration	100 hours
Stroke	100 mm
Mean diametral clearance	0.06 mm
Lubricant	TEX 0358
Foot valve temperature	70 °C

Table 3: McPherson strut wear test conditions

### STRUT FRICTION - TEST CONDITIONS

Waveform	Sine
Frequency	0.1 Hz
Side load	600 N
Stroke	70 mm
Mean diametral clearance	0.06 mm
Lubricant	TEX 0358
Foot valve temperature	ambient

Table 4: McPherson strut friction test conditions

The relative wear and frictional performance of DP4® tested under these conditions are shown in Figures 8 - 10. Actual results for the wear rate and friction are not quoted because these depend strongly on the actual test conditions and design of the strut under test. The relative performance plots shown thus provide the best indication as to the benefits offered by DP4® in this class of application.

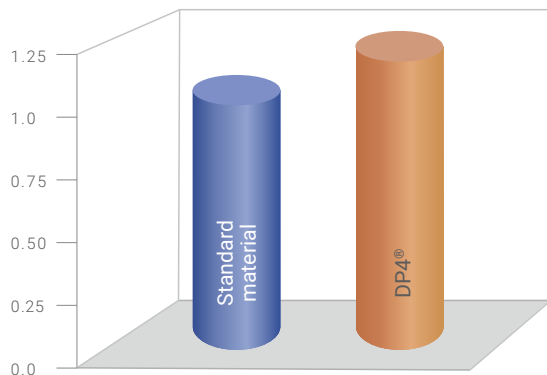


Fig. 8: Relative wear resistance

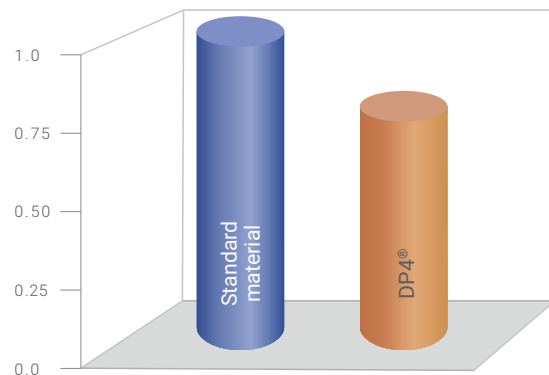


Fig. 9: Relative static friction coefficient

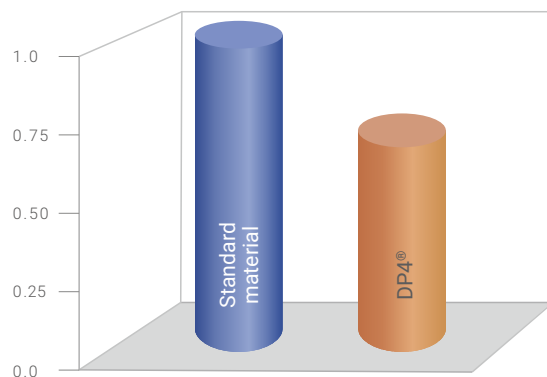


Fig. 10: Relative dynamic friction coefficient

# 4 Bearing Performance

## Cavitation Erosion Resistance

Under certain operating conditions, the PTFE lining of the McPherson strut piston rod guide bush can suffer erosion damage, due to cavitation and flow erosion effects from the oil film within the bearing. The test rig shown in Fig. 11 is designed to reproduce the cavitation erosion damage to the bearing lining of the test specimen.

The test conditions are given in Table 5.

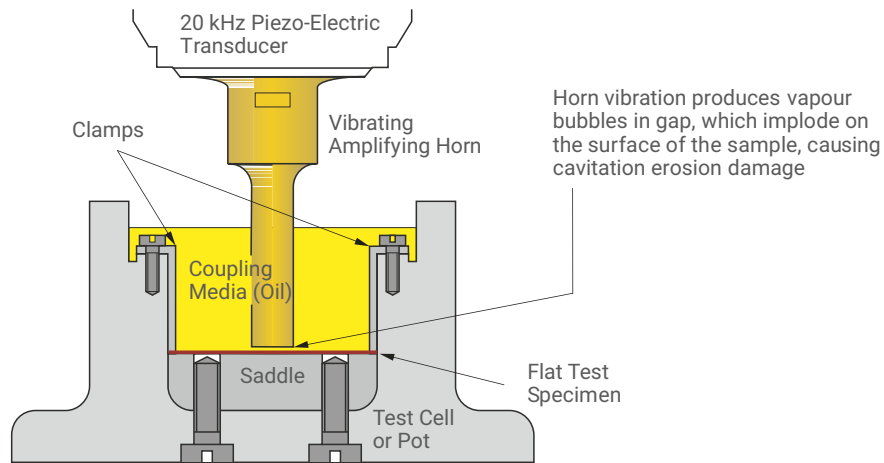


Fig. 11: Principle of the cavitation erosion test rig

### CAVITATION EROSION - TEST CONDITIONS

Amplitude	0.015 mm
Frequency	20 kHz
Separation	1 mm
Test duration	30 minutes
Lubricant	TEX 0358
Temperature	ambient

Table 5: Cavitation erosion test conditions

The relative resistance to cavitation damage of DP4® as evaluated on this test rig is shown in Fig. 12.

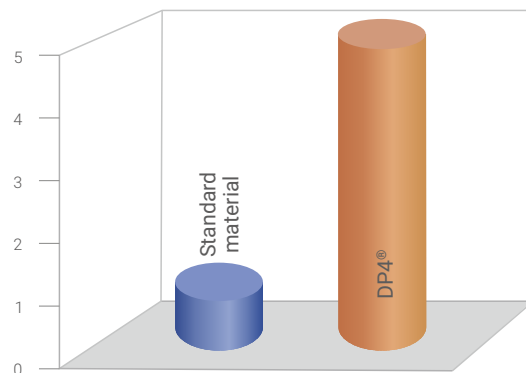


Fig. 12: Relative resistance to cavitation erosion

## Flow Erosion Resistance

The test rig shown in Fig. 13 is designed to reproduce flow erosion damage to the bearing lining of the test specimen.

The test conditions are given in Table 6.

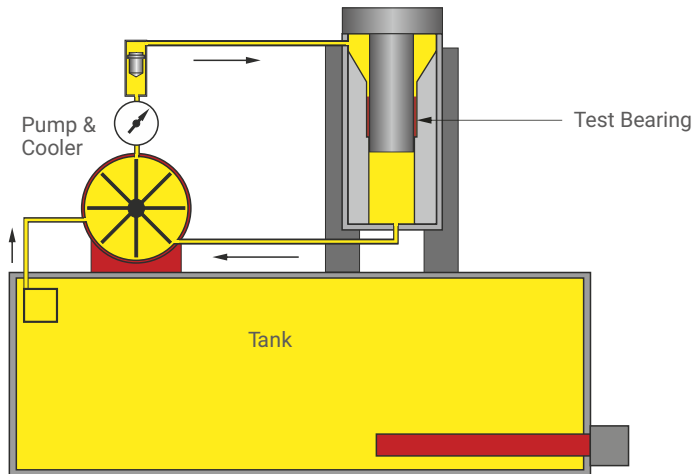


Fig. 13: Principle of the flow erosion test rig

### FLOW EROSION - TEST CONDITIONS

Bearing diameter	20 mm
Bearing length	15 mm
Diametral clearing	0.11 mm
Pressure	13.8 MPa
Flow rate	5 l/min
Test duration	20 hours
Shaft surface finish	0.15 $\mu\text{m} \pm 0.05$
Temperature	ambient

Table 6: Flow erosion test conditions

The relative resistance to flow erosion damage of DP4® as evaluated on this test rig is shown in Fig. 14.

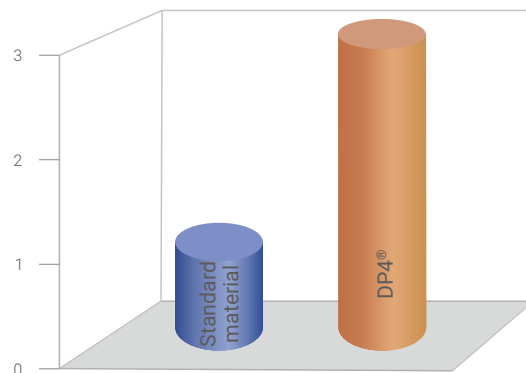


Fig. 14: Relative resistance to flow erosion

# 4 Bearing Performance

## 4.2 HYDRAULIC APPLICATIONS

DP4 also shows excellent wear and frictional performance in a wide range of oil lubricated hydraulic applications. The wear resistance of DP4 under steady load oil immersed boundary lubrication conditions has been evaluated using the test rig shown in Fig. 15. The test conditions are given in Table 7.

### GGB Jupiter Test Rig

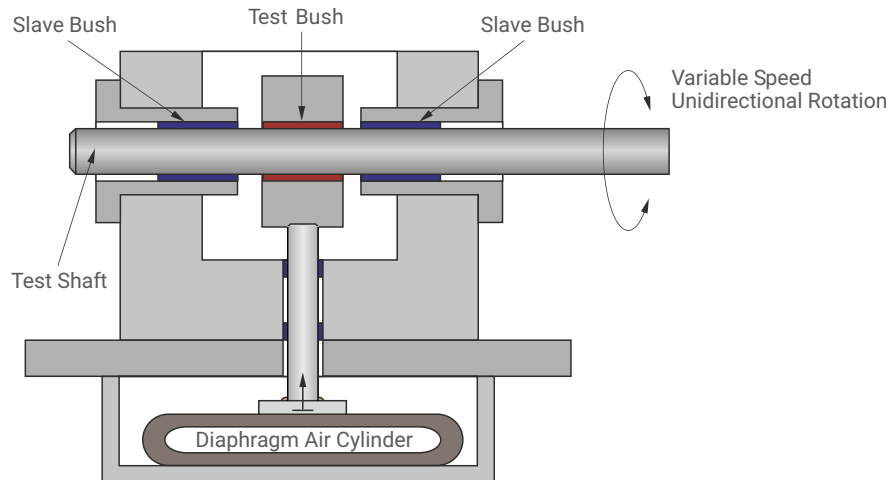


Fig. 15: Principle of the GGB Jupiter test rig

#### LUBRICATED WEAR - TEST CONDITIONS

Bearing diameter	20 mm
Bearing length	15 mm
Mean diametral clearing	0.10 mm
Speed	0.11 m/s
Lubricant	ISO VG 46 hydraulic oil

Table 7: Lubricated wear test conditions

The relative pU limits with boundary lubrication of DP4® and the material used in many high performance hydraulic pump applications as determined from these tests are shown in Fig. 16. The limiting pU depends upon the actual operating conditions and hence the relative performance only is given for guidance.

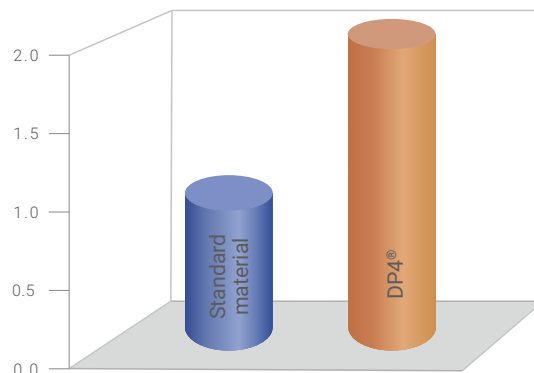


Fig. 16: Relative pU limits



## 4.3 DRY WEAR PERFORMANCE

### Design Factors

The main parameters when determining the size or calculating the service life for a DP4® bearing are:

- Specific load limit  $p_{lim}$
- Mating surface material
- pU Factor
- Temperature T
- Mating surface roughness Ra
- Other environmental factors e.g. housing design, dirt, lubrication.

The following calculation can be used to estimate the bearing service life of DP4® under dry running conditions.

### Specific Load p

For the purpose of assessing bearing performance the specific load p is defined as the working load divided by the projected area of the bearing and is expressed in MPa.

#### Cylindrical Bush

$$(4.3.1) \quad p = \frac{F}{D_i \cdot B} \quad [\text{MPa}]$$

#### Thrust Washer

$$(4.3.2) \quad p = \frac{4F}{\pi \cdot (D_o^2 - D_i^2)} \quad [\text{MPa}]$$

#### Flanged Bush (Axial Loading)

$$(4.3.3) \quad p = \frac{F}{0,04 \cdot (D_{fl}^2 - D_i^2)} \quad [\text{MPa}]$$

### Slideway

$$(4.3.4) \quad p = \frac{F}{L \cdot W} \quad [\text{MPa}]$$

### Specific Load Limit $p_{lim}$

The maximum load which can be applied to a DP4® bearing can be expressed in terms of the Specific Load Limit, which depends on the type of the loading. It is highest under steady loads. Conditions of dynamic load or oscillating movement which produce fatigue stress in the bearing result in a reduction in the permissible Specific Load Limit.

In general the specific load on a DP4® bearing should not exceed the Specific Load Limits given in Table 8.

The values of Specific Load Limit specified in Table 8 assume good alignment between the bearing and mating surface (Fig. 35, page 33).

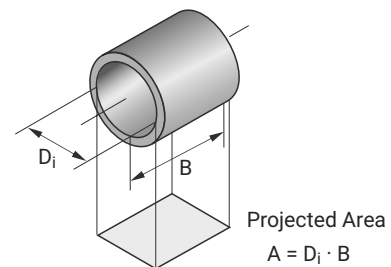


Fig. 17: Projected Area

# 4 Bearing Performance

## Maximum Specific Load $p_{lim}$

TYPE OF LOADING / $p_{lim}$ [MPa]										
<b>Steady load - rotating movement</b> $p_{lim}$ 140										
<b>Steady load - oscillating movement</b>										
$p_{lim}$	140	140	115	95	85	80	60	44	30	20
Number of movement cycles Q	1000	2000	4000	6000	8000	$10^4$	$10^5$	$10^6$	$10^7$	$10^8$
<b>Dynamic load - rotating or oscillating movement</b>										
$p_{lim}$	60	60	50	46	42	40	30	22	15	10
Number of load cycles Q	1000	2000	4000	6000	8000	$10^4$	$10^5$	$10^6$	$10^7$	$10^8$

Table 8: Maximum specific load  $p_{lim}$

Permanent deformation of the DP4® bearing lining may occur for specific loads above 140 MPa unless with slow intermittent movements. Under these conditions, it is recommended to contact GGB for further information.

The permissible maximum load on a thrust washer is higher than that on the flange of a flanged bush, and under conditions of high axial loads a thrust washer should be specified.

## Sliding Speed U

Speeds in excess of 2.5 m/s sometimes lead to overheating, and a running in procedure may be beneficial. This could consist of a series of short runs progressively increasing in duration from an initial run of a few seconds.

## Continuous Rotation

### Cylindrical Bush

$$(4.3.5) \quad U = \frac{D_i \cdot \pi \cdot N}{60 \cdot 10^3} \quad [\text{m/s}]$$

### Thrust Washer

$$(4.3.6) \quad U = \frac{D_o + D_i}{2} \cdot \pi \cdot N \quad [\text{m/s}]$$

## Oscillating Movement

### Cylindrical Bush

$$(4.3.7) \quad U = \frac{D_i \cdot \pi}{60 \cdot 10^3} \cdot \frac{4\varphi \cdot N_{osz}}{360} \quad [\text{m/s}]$$

### Thrust Washer

$$(4.3.8) \quad U = \frac{D_o + D_i}{2} \cdot \pi \cdot \frac{4\varphi \cdot N_{osz}}{360} \quad [\text{m/s}]$$

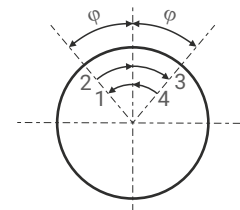


Figure 18: Oscillating cycle  $\varphi$

## pU Factor

The useful operating life of a DP4® bearing is governed by the pU factor, the product of the specific load p [MPa] and the sliding speed U [m/s].

For thrust washers and flanged bush thrust faces the rubbing velocity at the mean diameter is used.

pU factors up to 1.0 MPa x m/s can be accommodated for short periods, whilst for continuous rating, pU factors up to 0.5 MPa x m/s can be used, depending upon the operating life required.

	DU	UNIT
p	140	MPa
U	2.5	m/s
pU continuous	0.5	MPa · m/s
pU intermittent	1.0	MPa · m/s

Table 9: Typical data p, U and pU

## Calculation of pU Factor

$$(4.3.9) \quad pU = p \cdot U \quad [\text{MPa} \cdot \text{m/s}]$$

## Applicaton Factors

The following factors influence the bearing performance of DP4® and must be considered in calculating the required dimension or estimating the bearing life for a particular application.

### Temperature

The useful life of a DP4® bearing depends upon the operating temperature.

Under dry running conditions frictional heat is generated at the rubbing surface of the bearing dependent on the pU condition. For a given pU factor the operating temperature of the bearing depends upon the temperature of the surrounding environment, the heat dissipation properties of the housing and the mating surface. Intermittent operation affects the heat dissipation from the assembly and hence the operating temperature of the bearing.

The effect of temperature on the operating life of DP4® bearings is indicated by the factor  $a_T$  shown in Table 10.

MODE OF OPERATION	NATURE OF HOUSING	TEMPERATURE OF BEARING ENVIRONMENT $T_{amb}$ [°C] AND TEMPERATURE APPLICATION FACTOR $a_T$					
		[°C] 25	60	100	150	200	280
Dry continuous operation	Average heat dissipating qualities	1.0	0.8	0.6	0.4	0.2	0.1
Dry continuous operation	Light pressings or isolated housing with poor heat dissipating qualities	0.5	0.4	0.3	0.2	0.1	-
Dry continuous operation	Non-metallic housings with bad heat dissipating qualities	0.3	0.3	0.2	0.1	-	-
Dry intermittent operation (duration less than 2 min, followed by a longer dwell period)	Average heat dissipating qualities	2.0	1.6	1.2	0.8	0.4	0.2

Table 10: Temperature application factor  $a_T$

# 4 Bearing Performance

## Mating Surface

The effect of the mating surface material type on the operating life of DP4® bearings is indicated by the mating surface factor  $a_M$  and the life correction constant  $a_L$  shown in Table 11.

MATERIAL	$a_M$	$a_L$
<b>Steel and Cast Iron</b>		
Carbon Steel	1	400
Carbon Manganese Steel	1	400
Alloy Steel	1	400
Case Hardened Steel	1	400
Nitrided Steel	1	400
Salt bath nitrocarburised	1	400
Stainless Steel (7-10 % Ni, 17-20 % Cr)	2	400
Cast Iron ( $0.3 \pm 0.1 \mu\text{m } R_a$ )	1	400

Table 11: Mating surface factor  $a_M$  and life correction constant  $a_L$

### Note:

The factor values given assume a mating surface finish of  $R_a = 0.4 \pm 0.1 \mu\text{m}$ .

- A ground surface is preferred to fine turned
- Surfaces should be cleaned of abrasive particles after polishing
- Cast iron surfaces should be ground to  $R_a = 0.3 \pm 0.1 \mu\text{m}$
- The grinding cut should be in the same direction as the bearing motion relative to the shaft

## Bearing Size

The running clearance of a DP4® bearing increases with bearing diameter resulting in a proportionally smaller contact area between the shaft and bearing. This reduction in contact area has the effect of increasing the actual unit load and hence pU factor. The bearing size factor (Fig. 20) is used in the design calculations to allow for this effect.

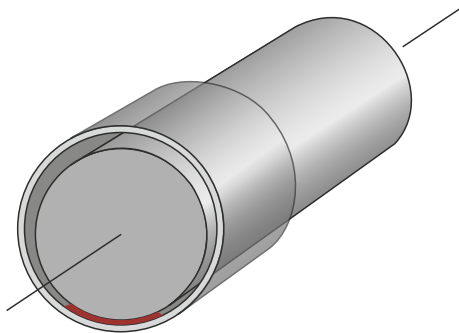


Figure 19: Contact area between bearing and shaft

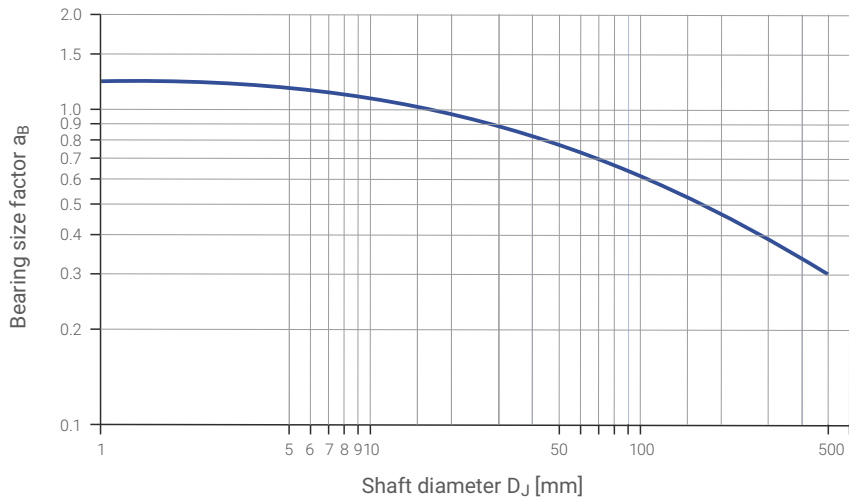


Fig. 20: Bearing size factor  $a_B$

## Bore Burnishing

Burnishing or machining the bore of a DP4® bearing results in a reduction in the wear performance. The application factor  $a_C$  given in table 12 is used in the design calculations to allow for this effect. Machining DP4® is not recommended.

DEGREE OF SIZING	APPLICATION FACTOR $a_C$	
<b>BURNISHING</b>		
Excess of burnishing tool diameter over mean bore size	0.025 mm	0.8
	0.038 mm	0.6
	0.050 mm	0.3

Table 12: Bore burnishing or machining application factor  $a_C$

## Type of Load

The type of load is considered in formula (4.4.9) page 23 and (4.4.10) page 23.

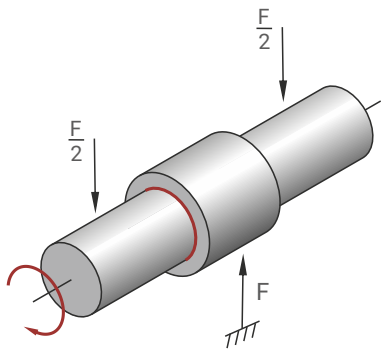


Fig. 21: Steady load, bush stationary, shaft rotating

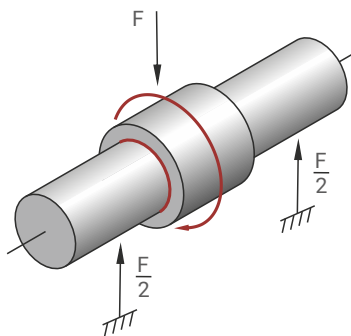


Fig. 22: Rotating load, shaft stationary, bush rotating

# 4 Bearing Performance

## 4.4 CALCULATION OF BEARING SERVICE LIFE

Where the size of a bearing is governed largely by the space available the following calculation can be used to determine whether its useful life will satisfy the requirements. If the calculated life is inadequate, a larger bearing should be considered.

### Specific Load $p$

#### Bushes

$$(4.4.1) \quad p = \frac{F}{D_i \cdot B} \quad [\text{MPa}]$$

#### Flanged bushes

$$(4.4.2) \quad p = \frac{F}{0.04 \cdot (D_f^2 - D_i^2)} \quad [\text{MPa}]$$

#### Thrust washers

$$(4.4.3) \quad p = \frac{4F}{p \cdot (D_o^2 - D_i^2)} \quad [\text{MPa}]$$

### High load factor $a_E$

$$(4.4.4) \quad a_E = \frac{p_{lim} - p}{p_{lim}} \quad [-]$$

$p_{lim}$  see Table 8, Page 18

If  $a_E$  is negative then the bearing is overloaded. Increase the bearing diameter and/or length.

### Modified $pU$ Factor

#### Bushes

$$(4.4.5) \quad pU = \frac{5.25 \cdot 10^{-5} F \cdot N}{a_E \cdot B \cdot a_T \cdot a_M \cdot a_B} \quad [\text{MPa} \cdot \text{m/s}]$$

#### Flanged bushes

$$(4.4.6) \quad pU = \frac{6.5 \cdot 10^{-4} F \cdot N}{a_E \cdot (D_f - D_i) \cdot a_T \cdot a_M \cdot a_B} \quad [\text{MPa} \cdot \text{m/s}]$$

#### Thrust washers

$$(4.4.7) \quad pU = \frac{3.34 \cdot 10^{-5} F \cdot N}{a_E \cdot (D_o - D_i) \cdot a_T \cdot a_M \cdot a_B} \quad [\text{MPa} \cdot \text{m/s}]$$

For oscillating movement, calculate the average rotational speed.

$$(4.4.8) \quad N = \frac{4\phi \cdot N_{osz}}{360} \quad [1/\text{min}]$$

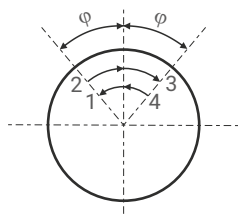


Figure 23: Oscillating cycle  $\phi$



## Estimation of Bearing Life $L_H$

### Bushes (Steady load)

$$(4.4.9) \quad L_H = \frac{265}{pU} \cdot a_L \quad [h]$$

### Bushes (Rotating load)

$$(4.4.10) \quad L_H = \frac{530}{pU} \cdot a_L \quad [h]$$

### Flanged Bushes (Axial load)

$$(4.4.11) \quad L_H = \frac{175}{pU} \cdot a_L \quad [h]$$

### Thrust Washers

$$(4.4.12) \quad L_H = \frac{175}{pU} \cdot a_L \quad [h]$$

## Bore Burnishing

If the DP4® bush is bore burnished then this must be allowed for in estimating the bearing life by the application factor  $a_C$  (Table 12, page 21).

### Estimated Bearing Life

$$(4.4.13) \quad L_H = L_H \cdot a_C \quad [h]$$

## For Oscillating Movements or Dynamic Loads

$$(4.4.14) \quad Z_T = L_H \cdot N_{osc} \cdot 60 \quad [\text{cycles}]$$

for oscillating movements

Calculate estimated number of cycles  $Z_T$

Check that  $Z_T$  is less than total number of cycles  $Q$  for the operating specific load  $p$  (Table 8, page 18)

If  $Z_T < Q$ ,  $L_H$  will be limited by wear after  $Z_T$  cycles.

If  $Z_T > Q$ ,  $L_H$  will be limited by fatigue after  $Z_T$  cycles.

$$(4.4.15) \quad Z_T = L_H \cdot C \cdot 60 \quad [\text{cycles}]$$

for dynamic loads

## Slideways

### Specific Load Factor

$$(4.4.16) \quad a_{E1} = A - \frac{F}{p_{lim}} \quad [-]$$

If negative the bearing is overloaded and the bearing area should be increased.

### Speed Temperature and Material Application Factors

$$(4.4.17) \quad a_{E2} = \frac{280 \cdot a_T \cdot a_M}{F \cdot U} \quad [-]$$

### Relative Contact Area Factor

$$(4.4.18) \quad a_{E3} = \frac{A}{A_M} \quad [-]$$

### Estimated Bearing Life

$$(4.4.19) \quad L_H = a_{E1} \cdot a_{E2} \cdot a_{E3} \cdot a_L \quad [h]$$

### Note:

Estimated bearing lives greater than 4000 h are subject to error due to inaccuracies in the extrapolation of test data.

# 4 Bearing Performance

## 4.5 WORKED EXAMPLES

### Cylindrical Bush

Given:			
Load Details	Steady Load Continuous Rotation	Inside Diameter $D_i$	40 mm 30 mm
Shaft	Steel Unlubricated at 25°C	Bearing Load $F$ Rotational Speed $N$	5.000 N 25 · 1/min

Calculation Constants and Application Factors		
Specific Load Limit $p_{lim}$	140 MPa	(Table 8, page 18)
Temperature Application Factor $a_T$	1.0	(Table 10, page 19)
Material Application Factor $a_M$	1.0	(Table 11, page 20)
Bearing Size Factor $a_B$	0.85	(Fig. 20, page 21)
Life Correction Constant $a_L$	400	(Table 11, page 20)

Calculation	Ref	Value
Specific Load $p$ [MPa]	(4.4.1) Page 22	$p = \frac{F}{D_i \cdot B} = \frac{5.000}{40 \cdot 30} = 4.17$
Sliding Speed $U$ [m/s]	(4.3.5) Page 18	$U = \frac{D_i \cdot \pi \cdot N}{60 \cdot 10^3} = \frac{40 \cdot 3.14 \cdot 25}{60 \cdot 10^3} = 0.052$
High Load Factor $a_E$ [-] must be > 0	(4.4.4) Page 22	$a_E = \frac{p_{lim} - p}{p_{lim}} = \frac{140 - 4.17}{140} = 0.97$
Modified $pU$ Factor [MPa · m/s]	(4.4.5) Page 22	$pU = \frac{5.25 \cdot 10^{-5} F \cdot N}{a_E \cdot B \cdot a_T \cdot a_M \cdot a_B} = 0.27$
Life $L_H$ [h]	(4.4.9) Page 23	$L_H = \frac{265}{pU} - a_L = \frac{265}{0.27} - 400 = 581$

### Flanged Bush

Given:			
Load Details	Axial Load Continuous Rotation	Flange Outside $\varnothing D_f$	23 mm 15 mm
Shaft	Steel Unlubricated at 25°C	Bearing Load $F$ Rotational Speed $N$	250 N 5 · 1/min

Calculation Constants and Application Factors		
Specific Load Limit $p_{lim}$	140 MPa	(Table 8, page 18)
Temperature Application Factor $a_T$	1.0	(Table 10, page 19)
Material Application Factor $a_M$	1.0	(Table 11, page 20)
Bearing Size Factor $a_B$	1.0	(Fig. 20, page 21)
Life Correction Constant $a_L$	400	(Table 11, page 20)

Calculation	Ref	Value
Specific Load $p$ [N/mm <sup>2</sup> ]	(4.4.2) Page 22	$p = \frac{250}{0.04 \cdot (23^2 - 15^2)} = 20.55$
Sliding Speed $U$ [m/s]	(4.3.6) Page 18	$U = \frac{(23 + 15)}{60 \cdot 10^3} \cdot 3.14 \cdot 5 = 0.005$
High Load Factor $a_E$ [-] must be > 0	(4.4.4) Page 22	$a_E = \frac{p_{lim} - p}{p_{lim}} = \frac{140 - 20.55}{140} = 0.853$
Modified $pU$ Factor [N/mm <sup>2</sup> · m/s]	(4.4.6) Page 22	$pU = \frac{6.5 \cdot 10^{-4} \cdot 250 \cdot 5}{0.853 \cdot (23 - 15) \cdot 1 \cdot 1 \cdot 1} = 0.119$
Life $L_H$ [h]	(3.8.11) Page 21	$L_H = \frac{175}{pU} - a_L = \frac{175}{0.119} - 400 = 1071$

### Thrust Washer

Given:			
Load Details	Axial Load Continuous Rotation	Outside Diameter $D_o$	62 mm 38 mm
Shaft	Steel Unlubricated at 25°C	Bearing Load $F$ Rotational Speed $N$	6.500 N 10 · 1/min

Calculation Constants and Application Factors		
Specific Load Limit $p_{lim}$	140 MPa	(Table 8, page 18)
Temperature Application Factor $a_T$	1.0	(Table 10, page 19)
Material Application Factor $a_M$	1.0	(Table 11, page 20)
Bearing Size Factor $a_B$	0.85	(Fig. 20, page 21)
Life Correction Constant $a_L$	400	(Table 11, page 20)

Calculation	Ref	Value
Specific Load $p$ [N/mm <sup>2</sup> ]	(4.4.3) Page 22	$p = \frac{4 \cdot 6.500}{3.14 \cdot (62^2 - 38^2)} = 3.45$
Sliding Speed $U$ [m/s]	(4.3.6) Page 18	$U = \frac{(62 + 38)}{60 \cdot 10^3} \cdot 3.14 \cdot 10 = 0.026$
High Load Factor $a_E$ [-] must be > 0	(4.4.4) Page 22	$a_E = \frac{p_{lim} - p}{p_{lim}} = \frac{140 - 3.45}{140} = 0.975$
Modified $pU$ Factor [MPa · m/s]	(4.4.7) Page 22	$pU = \frac{3.34 \cdot 10^{-5} \cdot 6.500 \cdot 10}{0.975 \cdot (62 - 38) \cdot 1 \cdot 1 \cdot 0.85} = 0.11$
Life $L_H$ [h]	(4.4.12) Page 23	$L_H = \frac{175}{pU} - a_L = \frac{175}{0.11} - 400 = 1191$



# 5 Lubrication

DP4® provides excellent performance in lubricated applications. The following sections describe the basics of lubrication and provide guidance on the application of DP4® in such environments.

## 5.1 LUBRICANTS

DP4® can be used with most fluids including:

- water
- lubricating oils
- engine oil
- turbine oil
- hydraulic fluid
- solvent
- refrigerants

In general, the fluid will be acceptable if it does not chemically attack the PTFE/lead overlay or the porous

bronze interlayer. Where there is doubt about the suitability of a fluid, a simple test is to submerge a sample of DP4® material in the fluid for two to or three weeks at 15-20 °C above the operating temperature.

The following will usually indicate that the fluid is not suitable for use with DP4®:

- A significant change in the thickness of the DP4® material,
- a visible change in the bearing surface other than some discolouration or staining,
- a visible change in the microstructure of the bronze interlayer.

## 5.2 TRIBOLOGY

There are three modes of lubricated bearing operation which relate to the thickness of the developed lubricant film between the bearing and the mating surface.

- Hydrodynamic lubrication
- Mixed film lubrication
- Boundary lubrication

These three modes of operation depend upon:

- Bearing dimensions
- Clearance
- Load
- Speed
- Lubricant Viscosity
- Lubricant Flow

### Hydrodynamic lubrication

#### Characterised by:

- Complete separation of the shaft from the bearing by the lubricant film
- Very low friction and no wear of the bearing or shaft since there is no contact.
- Coefficients of friction of 0,001 to 0,01

Hydrodynamic conditions occur when:

$$(5.2.1) \quad p \leq \frac{U \cdot \eta}{7.5} \cdot \frac{B}{D_i} \quad [\text{MPa}]$$

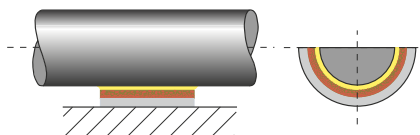


Figure 24: Hydrodynamic lubrication

# 5 Lubrication

## Mixed Film Lubrication

### Characterised by:

- Combination of hydrodynamic and boundary lubrication.
- Part of the load is carried by localised areas of self pressurised lubricant and the remainder supported by boundary lubrication.
- Friction and wear depend upon the degree of hydrodynamic support developed.

- DP4® provides low friction and high wear resistance to support the boundary lubricated element of the load.

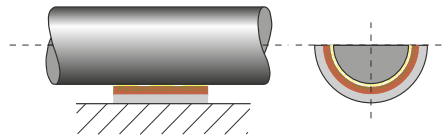


Figure 25: Mixed film lubrication

## Boundary Lubrication

### Characterised by:

- Rubbing of the shaft against the bearing with virtually no lubricant separating the two surfaces.
- Bearing material selection is critical to performance
- Shaft wear is likely due to contact between bearing and shaft.
- The excellent self lubricating properties of DP4® material minimises wear under these conditions.

- The dynamic coefficient of friction with DP4® is typically 0.05 to 0.3 under boundary lubrication conditions.
- The static coefficient of friction with DP4® is typically slightly above the dynamic coefficient of friction under boundary lubrication conditions.

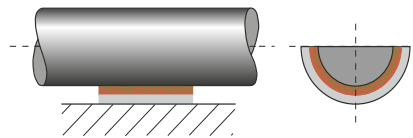


Figure 26: Boundary lubrication

## 5.3 CHARACTERISTICS OF LUBRICATED DP4® BEARINGS

DP4® is particularly effective in the most demanding of lubricated applications where full hydrodynamic operation cannot be maintained, for example:

### – High load conditions

In highly loaded applications operating under boundary or mixed film conditions DP4® shows excellent wear resistance and low friction.

### – Start up and shut down under load

With insufficient speed to generate a hydrodynamic film the bearing will operate under boundary or mixed film conditions. DP4® minimises wear and requires less start up torque than conventional metallic bearings.

### – Sparse lubrication

Many applications require the bearing to operate with less than the ideal lubricant supply, typically with splash or mist lubrication only. DP4® requires significantly less lubricant than conventional metallic bearings.

### – Non lubricating fluids

DP4® operates satisfactorily in low viscosity and non lubricating fluids such as water and some process fluids.

### Note the following however:

If a DP4 bearing is required to run dry after running in water under non hydrodynamic conditions then the wear resistance will be substantially reduced due to an increased amount of bedding in wear.

Fig. 27, page 28 shows the three lubrication regimes discussed above plotted on a graph of sliding speed vs the ratio of specific load to lubricant viscosity.

### – Using the formula in Section 4:

- Calculate the specific load  $p$ ,
- calculate the shaft surface speed  $U$ .

### – Using the viscosity temperature relationships presented in Table 13:

- Determine the viscosity in centipoise of the lubricant.

#### Note:

Viscosity is a function of operating temperature. If the operating temperature of the fluid is unknown, a provisional temperature of 25 °C above ambient can be used.

Temperature [°C]	VISCOSITY $\eta$ [cP]														
	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140
Lubricant															
ISO VG 32	310	146	77	44	27	18	13	9.3	7.0	5.5	4.4	3.6	3.0	2.5	2.2
ISO VG 46	570	247	121	67	40	25	17	12	9.0	6.9	5.4	4.4	3.6	3.0	2.6
ISO VG 68	940	395	190	102	59	37	24	17	12	9.3	7.2	5.8	4.7	3.9	3.3
ISO VG 100	2110	780	335	164	89	52	33	22	15	11.3	8.6	6.7	5.3	4.3	3.6
ISO VG 150	3600	1290	540	255	134	77	48	31	21	15	11	8.8	7.0	5.6	4.6
Diesel oil	4.6	4.0	3.4	3.0	2.6	2.3	2.0	1.7	1.4	1.1	0.95				
Petrol	0.6	0.56	0.52	0.48	0.44	0.40	0.36	0.33	0.31						
Kerosene	2.0	1.7	1.5	1.3	1.1	0.95	0.85	0.75	0.65	0.60	0.55				
Water	1.79	1.30	1.0	0.84	0.69	0.55	0.48	0.41	0.34	0.32	0.28				

Table 13: Dynamic viscosity

# 5 Lubrication

## 5.4 DESIGN GUIDANCE

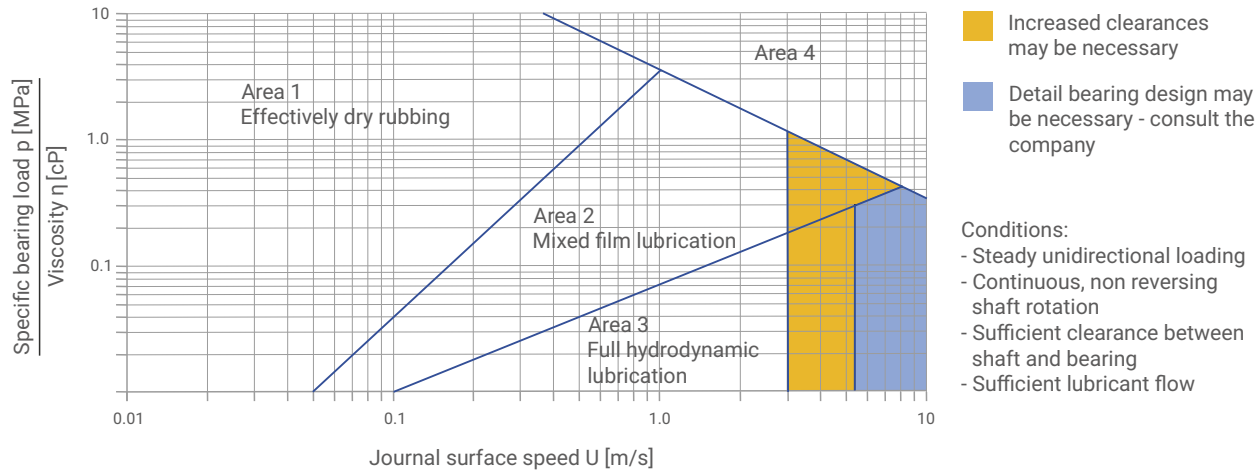


Fig. 27: Design guide for lubricated application

### Explanation to figure 27

#### Area 1

The bearing will operate with boundary lubrication and  $pU$  factor will be the major determinant of bearing life. The DP4® bearing performance can be calculated using the method given in section 4, although the result will probably underestimate the bearing life

#### Area 2

The bearing will operate with mixed film lubrication and the  $pU$  factor is no longer a significant parameter in determining the bearing life. The DP4® bearing performance will depend upon the nature of the fluid and the actual service conditions.

#### Area 3

The bearing will operate with hydrodynamic lubrication. The bearing wear will be determined only by the cleanliness of the lubricant and the frequency of start up and shut down.

#### Area 4

These are the most demanding operating conditions. The bearing is operated under either high speed or high bearing load to viscosity ratio, or a combination of both. These conditions may cause:

- excessive operating temperature and/or
- high wear rate.

The bearing performance may be improved by adding one or more grooves to the bearing and a shaft surface finish  $< 0.05 \mu\text{m } R_a$ .

## 5.5 CLEARANCES FOR LUBRICATED OPERATION

The recommended shaft and housing diameters given for standard DP4® bushes will provide sufficient clearance for applications operating with boundary lubrication.

For bearings operating with mixed film or hydrodynamic lubrication it may be necessary to improve the fluid flow through the bearing by reducing the recommended shaft diameter by approximately 0.1 %, particularly when the shaft surface speed exceeds 2.5 m/s.

## 5.6 GROOVING FOR LUBRICATED OPERATION

In demanding applications an axial oil groove will improve the performance of DP4®. Figure 28 shows the recommended form and location of a single groove with respect to the applied load and the bearing split. GGB can manufacture special DP4® bearings with embossed or milled grooves on request.

## 5.7 MATING SURFACE FINISH FOR LUBRICATED OPERATION

- $R_a \leq 0.4 \pm 0.1 \mu\text{m}$  boundary lubrication
- $R_a = 0.1 - 0.2 \mu\text{m}$  mixed film or hydrodynamic conditions
- $R_a \leq 0.05 \mu\text{m}$  for the most demanding operating conditions

## 5.8 GREASE LUBRICATION

DP4® is not generally recommended for use with grease lubrication. In particular the following must be avoided:

- Dynamic loads - which can result in erosion of the PTFE/lead bearing surface.
- Greases with EP additives or fillers such as graphite or  $\text{MoS}_2$  which can cause rapid wear of DP4®.

Under grease lubrication, improved performance can be obtained by the use of other GGB metal polymer bearing materials, for example, DX®, DX®10, DS, HI-EX®.

Please contact your local sales representative or consult: <https://www.ggbearings.com> for more details.

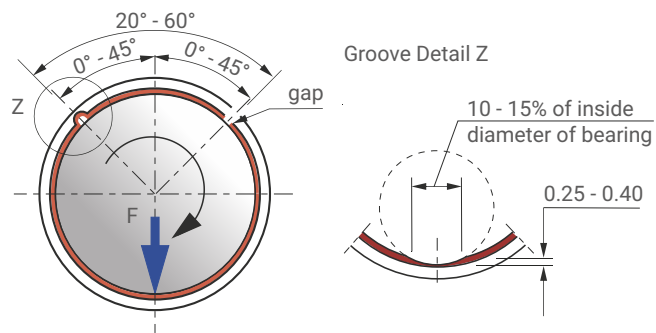


Fig. 28: Location of oil holes and grooves

# 6 Bearing Assembly

## Dimensions and Tolerances

DP4® bushes are prefinished and excluding very exceptional circumstances, must not be broached, machined or otherwise modified in the bore. It is essential that the correct running clearance is used and that both the diameter of the shaft and the bore of the housing are finished to the limits given in the tables. Under dry running conditions any increase in the clearances given will result in a proportional reduction in performance.

If the bearing housing is unusually flexible the bush will not close in by the calculated amount and the running clearance will be more than the optimum. In these circumstances the housing should be bored slightly undersize or the journal diameter increased, the correct size being determined by experiment.

Where free running is essential, or where light loads (less than 0.1 MPa) prevail and the available torque is low, increased clearance is required and it is recommended that the shaft size quoted in the table be reduced by 0.025 mm.

## 6.1 ALLOWANCE FOR THERMAL EXPANSION

For operation in high temperature environments the clearance should be increased by the amounts indicated by figure 29 to compensate for the inward thermal expansion of the bearing lining.

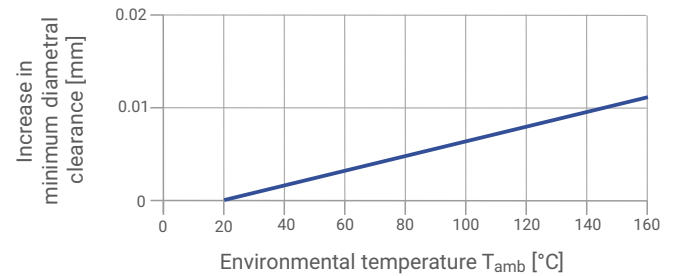


Fig. 29: Increase in diametral clearance

If the housing is non-ferrous then the bore should be reduced by the amounts given in Table 14, in order to give an increased interference fit to the bush, with a similar reduction in the journal diameter additional to that indicated by figure 29.

HOUSING MATERIAL	REDUCTION IN HOUSING DIAMETER PER 100°C RISE	REDUCTION IN SHAFT DIAMETER PER 100°C RISE
Aluminium alloys	0.1 %	0.1 % + values from Fig. 29
Copper base alloys	0.05 %	0.05 % + values from Fig. 29
Steel and cast iron	–	values from Fig. 29
Zinc base alloys	0.15 %	0.15 % + values from Fig. 29

Table 14: Allowance for high temperature

## 6.2 TOLERANCES FOR MINIMUM CLEARANCE

Where it is required to keep the variation of assembled clearance to a minimum, closer tolerances can be specified towards the upper end of the journal tolerance and the lower end of the housing tolerance. If housings to H6 tolerance are used, then the journals should be finished to the following limits. The sizes in Table 16 give the following nominal clearance range.

$D_i$	$D_j$
> 5 mm < 25 mm	-0.019 to -0.029
> 25 mm < 50 mm	-0.021 to -0.035

Table 15: Shaft tolerances for use with H6 housings

$D_i$	$D_j$
10 mm	0.009 to 0.080
50 mm	0.011 to 0.134

Table 16: Clearance vs bearing diameter

## Burnishing

The burnishing or fine boring of the bore of an assembled DP4® bush in order to achieve a smaller clearance tolerance is only permissible if a substantial reduction in performance is acceptable. Fig. 24 shows a recommended burnishing tool for the sizing of DP4® bushes.

The coining section of the burnishing tool should be case hardened (case depth 0.6 - 1.2 mm, HRC 60±2) and polished with diamond paste ( $R_z \approx 1 \mu\text{m}$ ). A TiN type surface treatment increases the wear resistance of the burnishing tool and when absent gives a visual indication of burnishing tool wear.

Note: Ball burnishing of DP4® bushes is not recommended.

The values given in Table 17 indicate the dimensions of the burnishing tool required to give specific increases in the bearing bore diameter.

Exact values must be determined by test.

The reduction in bearing performance as a result of burnishing is allowed for in the bearing life calculation by the application factor  $a_c$  (Table 12, page 21). The impact of burnishing on the bearing and assembly should be validated by trials.

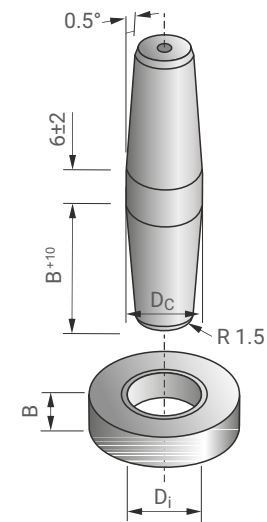


Fig. 30: Burnishing tool

ASSEMBLED BUSH INSIDE Ø	REQUIRED BUSH INSIDE Ø	REQUIRED BURNISHING TOOL Ø $D_c$
$D_{i,a}$	$D_{i,a} + 0.025$	$D_{i,a} + 0.06$
$D_{i,a}$	$D_{i,a} + 0.038$	$D_{i,a} + 0.08$
$D_{i,a}$	$D_{i,a} + 0.050$	$D_{i,a} + 0.1$

Table 17: Burnishing tool tolerances

## 6.3 COUNTERFACE DESIGN

The suitability of mating surface materials and recommendations of mating surface finish for use with DP4® are discussed in detail on page 20.

DP4® is normally used in conjunction with ferrous journals and thrust faces, but in damp or corrosive surroundings, particularly without the protection of oil or grease, stainless steel, hard chromium plated mild steel, or hard anodised aluminium is recommended. When plated mating surfaces are specified the plating should possess adequate strength and adhesion, particularly if the bearing is to operate with high fluctuating loads.

The shaft or thrust collar used in conjunction with the DP4® bush or thrust washer must extend beyond the bearing surface in order to avoid cutting into it. The mating surface must also be free from grooves or flats, the end of the shaft should be given a lead-in chamfer and all sharp edges or projections which may damage the soft overlay of the DP4® must be removed.

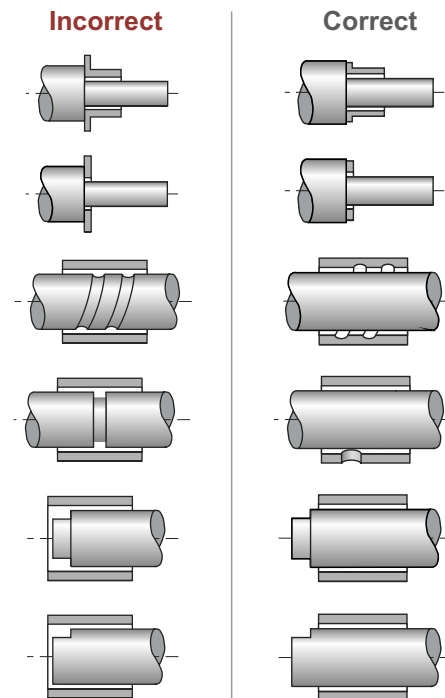


Fig. 31: Counterface Design

# 6 Bearing Assembly

## 6.4 INSTALLATION

### Fitting of Cylindrical Bushes

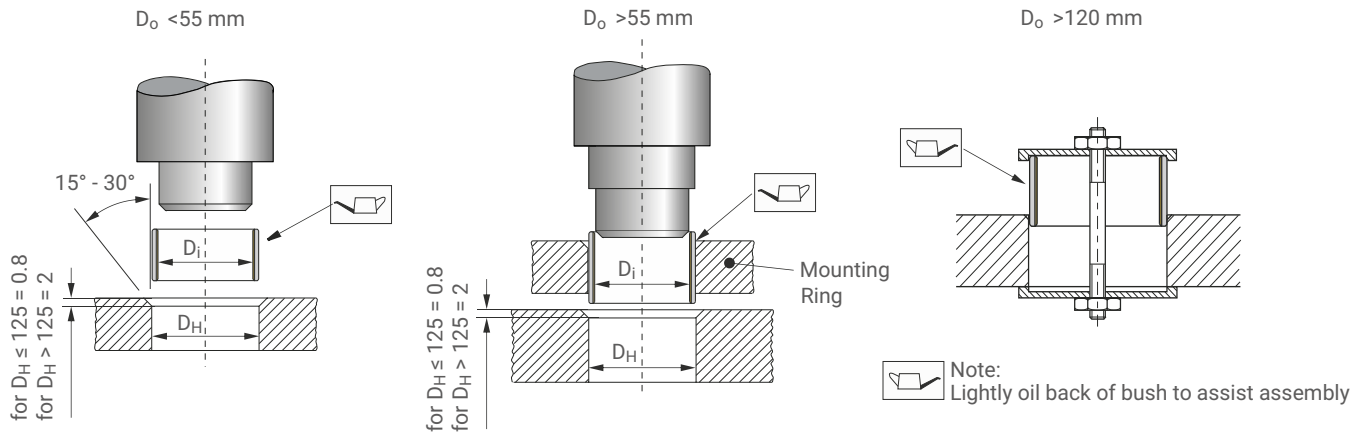


Fig. 32: Fitting of cylindrical bushes

### Fitting of Flanged Bushes

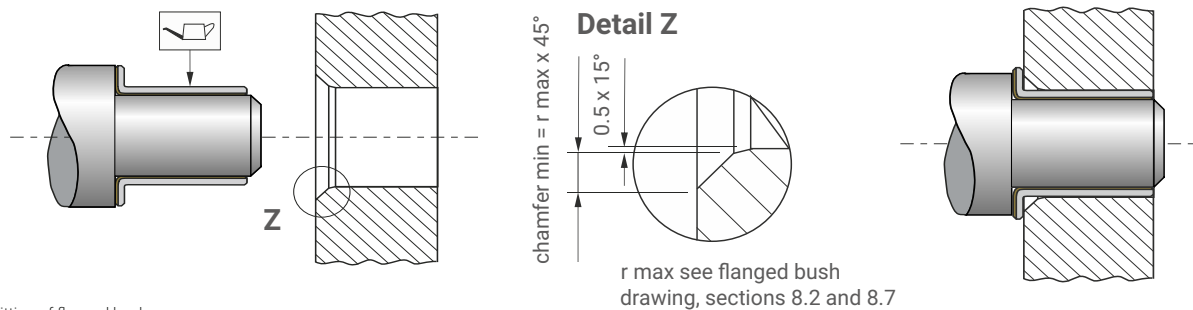


Fig. 33: Fitting of flanged bushes

### Insertion Forces

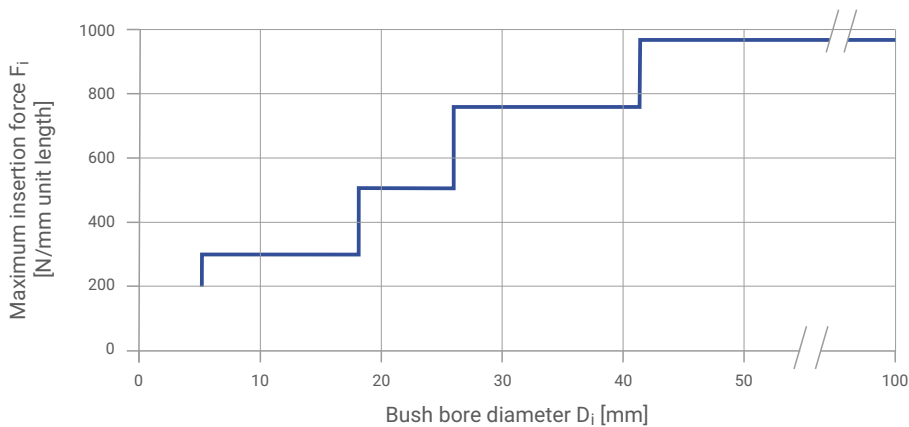


Fig. 34: Maximum Insertion Force  $F_i$



## Alignment

Accurate alignment is an important consideration for all bearing assemblies, but is particularly so for dry bearings because there is no lubricant to spread the load. With DP4® bearings misalignment over the length of a bush (or pair of bushes), or over the diameter of a thrust washer should not exceed 0.020 mm as illustrated in Fig. 35.

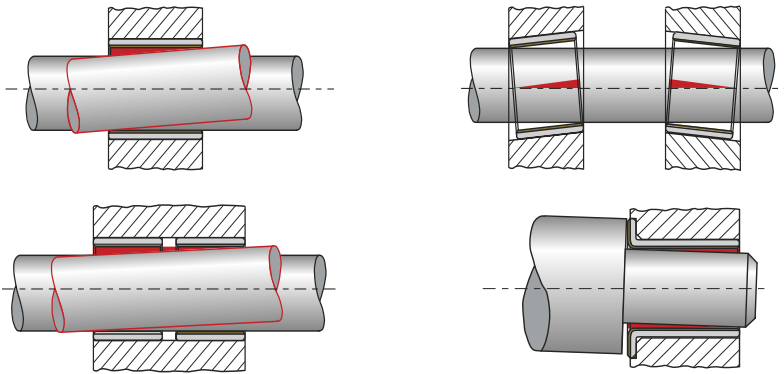


Fig. 35: Alignment

## Sealing

While DP4® can tolerate the ingress of some contaminant materials into the bearing without loss of performance, where there is the possibility of highly abrasive material entering the bearing, a suitable sealing arrangement, as illustrated in Fig. 36 should be provided.

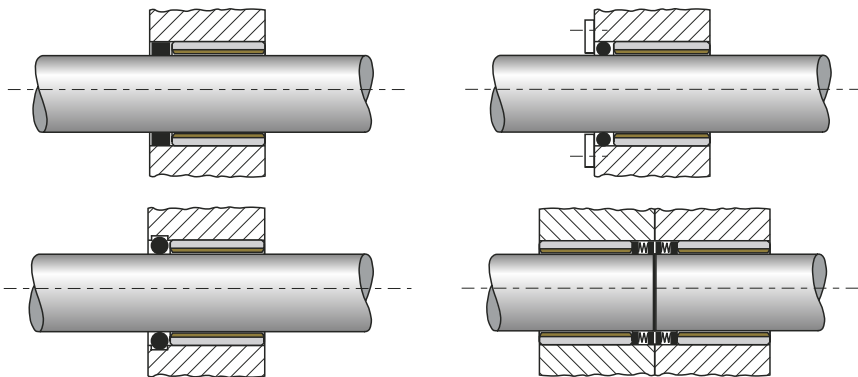


Fig. 36: Recommended sealing arrangements

## 6.5 AXIAL LOCATION

Where axial location is necessary, it is advisable to fit DP4® thrust washers in conjunction with DP4® bushes, even when the axial loads are low.

### Fitting of thrust washers

DP4® thrust washers should be located in a recess as shown in Fig. 37. For the recess diameter the tolerance class [D10] is recommended. The recess depth is given in the product tables, page 44 and following. If a recess is not possible one of the following methods may be used:

- Two dowel pins
- Two screws
- Adhesive
- Soldering (temperature < 320 °C).

# 6 Bearing Assembly

## Important Note

- Ensure the washer ID does not touch the shaft after assembly
- Ensure that the washer is mounted with the steel backing to the housing
- Dowel pins should be recessed 0.25 mm below the bearing surface
- Screws should be countersunk 0.25 mm below the bearing surface
- DP4® must not be heated above 320 °C
- Contact adhesive manufacturers for guidance selection of suitable adhesives
- Protect the bearing surface to prevent contact with adhesive

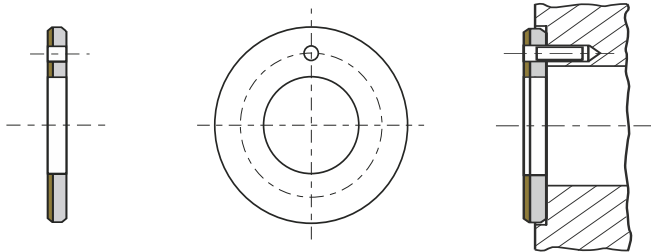


Fig. 37: Installation of Thrust-Washer

## Grooves for Wear Debris Removal

Tests with thrust washers have demonstrated that for optimum dry wear performance at specific loads in excess of 35 MPa, four wear debris removal grooves should be machined in the bearing surface as shown in Fig. 38.

Grooves in bushes have not been found to be beneficial in this respect.

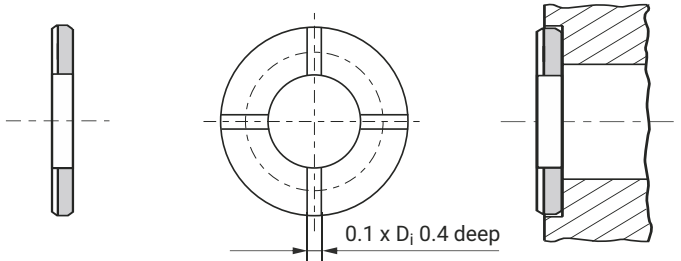


Fig. 38: Debris removal grooves

## Slideways

DP4® strip material for use as slideway bearings should be installed using one of the following methods:

- Countersunk screws
- Adhesives
- Mechanical location as shown in Fig. 39

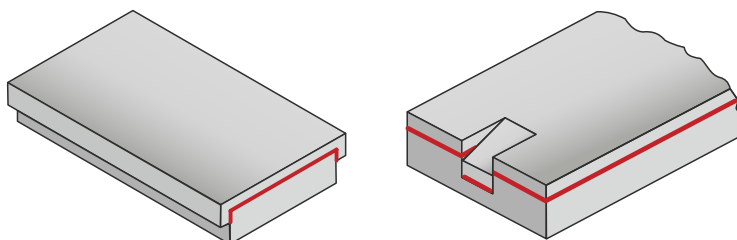


Fig. 39: Mechanical location of DU slideplates

# 7 Modification

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## 7.1 CUTTING AND MACHINING

The modification of DP4® bearing components requires no special procedures. In general it is more satisfactory to perform machining or drilling operations from the PTFE side in order to avoid burrs. When cutting is done from the steel side, the minimum cutting pressure should be used and care taken to ensure that any steel or bronze particles protruding into the remaining bearing material, and all burrs, are removed.

### Drilling Oil Holes

Bushes should be adequately supported during the drilling operation to ensure that no distortion is caused by the drilling pressure.

### Cutting Strip Material

DP4® strip material may be cut to size by any one of the following methods.

Care must be taken to protect the bearing surface from damage and to ensure that no deformation of the strip occurs:

- Using side and face cutter, or slitting saw, with the strip held flat and securely on a horizontal milling machine.

- Cropping
- Guillotine (For widths less than 90 mm only)
- Water-jet cutting
- Laser cutting (see Health Warning)

## 7.2 ELECTROPLATING

### DP4® Components

In order to provide some protection in mildly corrosive environments the steel back and end faces of standard range DP4® bearings are tin flashed.

DP4® can be electroplated with most of the conventional electroplating metals including the following:

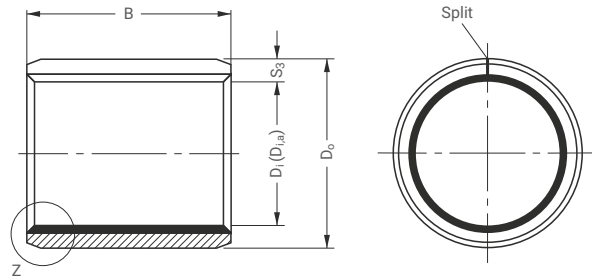
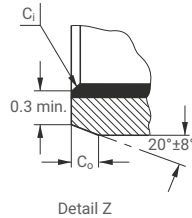
- zinc ISO 2081
- nickel ISO 1456
- hard chromium ISO 1456

For the harder materials if the specified plating thickness exceeds approximately 5 µm then the housing diameter should be increased by twice the plating thickness in order to maintain the correct assembled bearing bore size.

Where electrolytic attack is possible tests should be conducted to ensure that all the materials in the bearing environment are mutually compatible.

# 8 Standard Products

## 8.1 DP4® CYLINDRICAL BUSHES



Dimensions and Tolerances according to ISO 3547 and GGB-Specifications

### Outside C<sub>o</sub> and Inside C<sub>i</sub> Chamfers

WALL THICKNESS S <sub>3</sub>	C <sub>o</sub> (a)		C <sub>i</sub> (b)
	MACHINED	ROLLED	
0.75	0.5 ± 0.3	0.5 ± 0.3	-0.1 to -0.4
1	0.6 ± 0.4	0.6 ± 0.4	-0.1 to -0.5
1.5	0.6 ± 0.4	0.6 ± 0.4	-0.1 to -0.7

WALL THICKNESS S <sub>3</sub>	C <sub>o</sub> (a)		C <sub>i</sub> (b)
	MACHINED	ROLLED	
2	1.2 ± 0.4	1.0 ± 0.4	-0.1 to -0.7
2.5	1.8 ± 0.6	1.2 ± 0.4	-0.2 to -1.0

(a) = chamfer C<sub>o</sub> machined or rolled at the opinion of the manufacturer

(b) = C<sub>i</sub> can be a radius or a chamfer in accordance with ISO 13715

PART NO.	NOMINAL DIAMETER		WALL THICKNESS S <sub>3</sub> max. min.	WIDTH B max. min.	SHAFT Ø D <sub>J</sub> [h6, f7, h8] max. min.	HOUSING Ø D <sub>H</sub> [H6, H7] max. min.	BUSH Ø D <sub>i,a</sub> ASSEMBLY IN H6/H7 HOUSING max. min.	CLEARANCE C <sub>D</sub> max. min.			
	D <sub>i</sub>	D <sub>o</sub>									
0203DP4	2	3.5	0.750 0.730	3.25	2.000	3.508	2.048	0.054 0.000			
0205DP4				2.75							
0303DP4	3	4.5		5.25					3.000	4.508	3.048
0305DP4				4.75							
0306DP4				6.25							
0403DP4	4	5.5		5.75					4.000	5.508	4.048
0404DP4				3.25							
0406DP4				4.25							
0410DP4				3.75							
0505DP4	5	7		6.25	4.990	7.015	5.055				
0508DP4				5.75							
0510DP4				10.25							
0604DP4			9.75								
0606DP4	6	8	4.25	5.990	8.015	6.055					
0608DP4			3.75								
0610DP4			6.25								
0705DP4			5.75								
0710DP4	7	9	8.25	6.987	9.015	7.055					
0705DP4			7.75								
0710DP4			10.25								
0710DP4			9.75	6.972	9.000	6.990	0.083 0.003				

All dimensions in mm

PART NO.	NOMINAL DIAMETER		WALL THICKNESS S <sub>3</sub> max. min.	WIDTH B max. min.	SHAFT Ø D <sub>J</sub> [h6, f7, h8] max. min.	HOUSING Ø D <sub>H</sub> [H6, H7] max. min.	BUSH Ø D <sub>i,a</sub> ASSEMBLY IN H6/H7 HOUSING max. min.	CLEARANCE C <sub>D</sub> max. min.
	D <sub>i</sub>	D <sub>O</sub>						
0806DP4	8	10	1.005 0.980	6.25	7.987 7.972	10.015 10.000	8.055 7.990	0.083 0.003
0808DP4				5.75				
0810DP4				8.25				
0812DP4				7.75				
1006DP4				10.25				
1008DP4	9.75	9.987 9.972		12.018 12.000	10.058 9.990	0.086 0.003		
1010DP4	12.25							
1012DP4	11.75							
1015DP4	15.25							
1020DP4	14.75							
1208DP4	12	14		20.25	11.984 11.966	14.018 14.000	12.058 11.990	0.092 0.006
1210DP4				19.75				
1212DP4				8.25				
1215DP4				7.75				
1220DP4				10.25				
1225DP4	9.75	12.984 12.966		15.018 15.000	13.058 12.990	0.092 0.006		
1310DP4	12.25							
1320DP4	11.75							
1405DP4	15.25							
1410DP4	14.75							
1412DP4	20.25	13.984 13.966	16.018 16.000	14.058 13.990	0.092 0.006			
1415DP4	19.75							
1420DP4	25.25							
1425DP4	24.75							
1510DP4	10.25					14.984 14.966	17.018 17.000	15.058 14.990
1512DP4	9.75							
1515DP4	12.25							
1520DP4	11.75							
1525DP4	15.25							
1610DP4	16	18	20.25	15.984 15.966	18.018 18.000	16.058 15.990	0.092 0.006	
1612DP4			19.75					
1615DP4			10.25					
1620DP4			9.75					
1625DP4			12.25					
1720DP4	17	19	14.75	16.984 16.966	19.021 19.000	17.061 16.990	0.095 0.006	
1625DP4			24.75					

All dimensions in mm

# 8 Standard Products

PART NO.	NOMINAL DIAMETER		WALL THICKNESS S <sub>3</sub> max. min.	WIDTH B max. min.	SHAFT Ø D <sub>J</sub> [h6, f7, h8] max. min.	HOUSING Ø D <sub>H</sub> [H6, H7] max. min.	BUSH Ø D <sub>i,a</sub> ASSEMBLY IN H6/H7 HOUSING max. min.	CLEARANCE C <sub>D</sub> max. min.
	D <sub>i</sub>	D <sub>O</sub>						
1810DP4	18	20	1.005 0.980	10.25	17.984 17.966	20.021 20.000	18.061 17.990	0.095 0.006
1815DP4				9.75				
1820DP4				15.25				
1825DP4				14.75				
2010DP4	20	23	1.505 1.475	10.25	19.980 19.959	23.021 23.000	20.071 19.990	0.112 0.010
2015DP4				9.75				
2020DP4				15.25				
2025DP4				14.75				
2030DP4	22	25	1.505 1.475	20.25	21.980 21.959	25.021 25.000	22.071 21.990	0.112 0.010
2215DP4				19.75				
2220DP4				25.25				
2225DP4				24.75				
2230DP4	24	27	1.505 1.475	30.25	23.980 23.959	27.021 27.000	24.071 23.990	0.112 0.010
2415DP4				29.75				
2420DP4				15.25				
2425DP4				14.75				
2430DP4	25	28	1.505 1.475	20.25	24.980 24.959	28.021 28.000	25.071 24.990	0.126 0.010
2515DP4				19.75				
2520DP4				25.25				
2525DP4				24.75				
2530DP4	28	32	2.005 1.970	30.25	27.980 27.959	32.025 32.000	28.085 27.990	0.126 0.010
2550DP4				29.75				
2815DP4				15.25				
2820DP4				14.75				
2825DP4	30	34	2.005 1.970	20.25	29.980 29.959	34.025 34.000	30.085 29.990	0.126 0.010
2830DP4				19.75				
3010DP4				25.25				
3015DP4				24.75				
3020DP4	32	36	2.005 1.970	30.25	31.975 31.950	36.025 36.000	32.085 31.990	0.135 0.015
3025DP4				29.75				
3030DP4				40.25				
3040DP4				39.75				
3220DP4	32	36	2.005 1.970	20.25	31.975 31.950	36.025 36.000	32.085 31.990	0.135 0.015
3230DP4				19.75				
3240DP4				30.25				
				40.25				
				39.75				

All dimensions in mm

PART NO.	NOMINAL DIAMETER		WALL THICKNESS S <sub>3</sub> max. min.	WIDTH B max. min.	SHAFT Ø D <sub>J</sub> [h6, f7, h8] max. min.	HOUSING Ø D <sub>H</sub> [H6, H7] max. min.	BUSH Ø D <sub>i,a</sub> ASSEMBLY IN H6/H7 HOUSING max. min.	CLEARANCE C <sub>D</sub> max. min.				
	D <sub>i</sub>	D <sub>O</sub>										
3520DP4	35	39	2.005 1.970	20.25	34.975 34.950	39.025 39.000	35.085 34.990	0.135 0.015				
3530DP4				19.75								
3535DP4				30.25								
3540DP4				29.75								
3550DP4				35.25								
3720DP4	37	41		34.75					36.975	41.025	37.085	
4020DP4	40	44		19.75					39.975 39.950	44.025 44.000	40.085 39.990	0.155 0.015
4030DP4				20.25								
4040DP4				30.25								
4050DP4				29.75								
4520DP4			40.25									
4530DP4	45	50	39.75	44.975 44.950	50.025 50.000	45.105 44.990	0.160 0.015					
4540DP4			45.25									
4545DP4			44.75									
4550DP4			50.25									
5020DP4			49.75									
5030DP4	50	55	19.75	49.975 49.950	55.030 55.000	50.110 49.990	0.170 0.020					
5040DP4			30.25									
5050DP4			29.75									
5060DP4			40.25									
5520DP4			39.75									
5525DP4	55	60	24.75	54.970 54.940	60.030 60.000	55.110 54.990	0.170 0.020					
5530DP4			20.25									
5540DP4			19.75									
5550DP4			25.25									
5555DP4			24.75									
5560DP4	30.25											
6020DP4	60	65	2.505	59.970 59.940	65.030 65.000	60.110 59.990	0.170 0.020					
6030DP4			2.460									
6040DP4			30.25									
6050DP4			29.75									
6060DP4			40.25									
6070DP4			39.75									
			50.25									

All dimensions in mm

# 8 Standard Products

PART NO.	NOMINAL DIAMETER		WALL THICKNESS S <sub>3</sub> max. min.	WIDTH B max. min.	SHAFT Ø D <sub>J</sub> [h6, f7, h8] max. min.	HOUSING Ø D <sub>H</sub> [H6, H7] max. min.	BUSH Ø D <sub>i,a</sub> ASSEMBLY IN H6/H7 HOUSING max. min.	CLEARANCE C <sub>D</sub> max. min.	
	D <sub>i</sub>	D <sub>O</sub>							
6530DP4	65	70	2.505 2.460	30.25	f7	70.030 70.000	65.110 64.990	0.170 0.020	
6550DP4				29.75					64.970 64.940
6570DP4				50.25 49.75					
7040DP4	70.25 69.75	69.970 69.940							
7050DP4	40.25 39.75								
7070DP4	50.25 49.75								
7560DP4	75	80		60.25	74.970 74.940	80.030 80.000	75.110 74.990		
7580DP4				59.75					
8040DP4				80.25 79.75					
8060DP4	80	85		40.50	h8	85.035 85.000	80.155 80.020		0.209 0.020
8080DP4				39.50					
80100DP4				60.50 59.50					
8530DP4	80.50 79.50	85.000 84.946							
8560DP4	100.50 99.50								
85100DP4	60.50 59.50								
9060DP4	90	95	30.50	H7	90.035 90.000	85.155 85.020			
90100DP4			29.50						
9560DP4			60.50 59.50						
95100DP4	100.50 99.50	95.000 94.946							
10050DP4	60.50 59.50								
10060DP4	100.50 99.50								
100115DP4	100	105	60.50	h8	105.035 105.000	100.155 100.020	0.264 0.070		
10560DP4			50.50 49.50						
105115DP4			60.50 59.50						
11060DP4	115.50 114.50	105.000 104.946							
110115DP4	60.50 59.50								
11550DP4	115.50 114.50								
11570DP4	115	120	60.50	H7	110.035 110.000	105.155 105.020			
12050DP4			59.50						
12060DP4			110.000 109.946						
120100DP4	115.000 114.946	110.000 109.946							
125100DP4	60.50 59.50								
13060DP4	115.000 114.946								
130100DP4	130	135	50.50	h8	120.035 120.000	115.155 115.020	0.273 0.070		
12050DP4			49.50						
12060DP4			60.50 59.50						
125100DP4	100.50 99.50	120.000 119.946							
13060DP4	100.50 99.50								
130100DP4	100.50 99.50								

All dimensions in mm

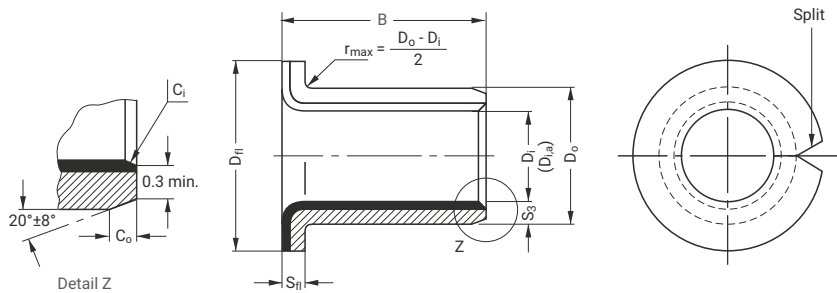


PART NO.	NOMINAL DIAMETER		WALL THICKNESS S <sub>3</sub> max. min.	WIDTH B max. min.	SHAFT Ø D <sub>J</sub> [h6, f7, h8] max. min.	HOUSING Ø D <sub>H</sub> [H6, H7] max. min.	BUSH Ø D <sub>i,a</sub> ASSEMBLY IN H6/H7 HOUSING max. min.	CLEARANCE C <sub>D</sub> max. min.			
	D <sub>i</sub>	D <sub>O</sub>									
13560DP4	135	140	2.465 2.415	60.50	135.000	140.040	135.210	0.273 0.070			
13580DP4				59.50					134.937	135.070	
14060DP4	140	145		60.50	140.000	145.040	140.210				
140100DP4				59.50					139.937	140.070	
15060DP4	150	155		100.50	150.000	155.040	150.210				
15080DP4				99.50					149.937	150.070	
150100DP4				80.50					160.000	165.040	160.210
16080DP4				79.50							
160100DP4	160	165		100.50	180.000	185.046	180.216				
180100DP4	180	185		99.50					179.937	180.070	
200100DP4	200	205		100.50 99.50	200.000	205.046	200.216		0.288 0.070		
210100DP4	210	215			199.928	205.000	200.070				
220100DP4	220	225			210.000	215.046	210.216				
250100DP4	250	255			209.928	215.000	210.070				
					220.000	225.046	220.216				
300100DP4	300	305			219.928	225.000	220.070				
			250.000	255.052	250.222	0.294 0.070					
			249.928	255.000	250.070	0.303 0.070					
			300.000	305.052	300.222						
			299.919	305.000	300.070						

All dimensions in mm

# 8 Standard Products

## 8.2 DP4® FLANGED BUSHES



Dimensions and Tolerances according to ISO 3547 and GGB-Specifications

### Outside C<sub>0</sub> and Inside C<sub>i</sub> Chamfers

WALL THICKNESS S <sub>3</sub>	C <sub>0</sub> (a)		C <sub>i</sub> (b)	WALL THICKNESS S <sub>3</sub>	C <sub>0</sub> (a)		C <sub>i</sub> (b)
	MACHINED	ROLLED			MACHINED	ROLLED	
0.75	0.5 ± 0.3	0.5 ± 0.3	-0.1 to -0.4	2	1.2 ± 0.4	1.0 ± 0.4	-0.1 to -0.7
1	0.6 ± 0.4	0.6 ± 0.4	-0.1 to -0.5	2.5	1.8 ± 0.6	1.2 ± 0.4	-0.2 to -1.0
1.5	0.6 ± 0.4	0.6 ± 0.4	-0.1 to -0.7				

(a) = chamfer C<sub>0</sub> machined or rolled at the opinion of the manufacturer

(b) = C<sub>i</sub> can be a radius or a chamfer in accordance with ISO 13715

PART NO.	NOMINAL DIAMETER		WALL THICKNESS S <sub>3</sub> max. min.	FLANGE THICKN. S <sub>f</sub> max. min.	FLANGE Ø D <sub>f</sub> max. min.	WIDTH B max. min.	SHAFT Ø D <sub>J</sub> [h6, f7, h8]		HOUSING Ø D <sub>H</sub> [H6, H7]		BUSH Ø D <sub>i,a</sub> ASSEMBLY IN H6/H7 HOUSING max. min.	CLEARANCE C <sub>D</sub> max. min.
	D <sub>i</sub>	D <sub>o</sub>					max. min.	max. min.	max. min.	max. min.		
BB0304DP4	3	4.5	0.750 0.730	0.80 0.70	7.50 6.50	4.25 3.75	h6	3.000 2.994	H6	4.508 4.500	3.048 3.000	0.054 0.000
BB0404DP4	4	5.5			9.50 8.50	4.25 3.75		4.000 3.992		5.508 4.500	4.048 4.000	0.056 0.000
BB0505DP4	5	7	1.005 0.980	1.05 0.80	10.50 9.50	5.25 4.75	f7	4.990 4.978	H7	7.015 7.000	5.055 4.990	0.077 0.000
BB0604DP4	6	8			12.50 11.50	4.25 3.75		5.990 5.978		8.015 8.000	6.055 5.990	0.077 0.000
BB0806DP4			8	10	15.50 14.50	7.75 7.25	7.987 7.972	10.015 10.000	8.055 7.990	0.083 0.003		
BB0810DP4	10	12			18.50 17.50	9.25 8.75	9.987 9.972	12.018 12.000	10.058 9.990	0.086 0.003		
BB1007DP4			12	14	20.50 19.50	11.75 11.25	11.984 11.966	14.018 14.000	12.058 11.990	0.092 0.006		
BB1009DP4	17.25 16.75	9.25 8.75										
BB1012DP4	14	16	22.50 21.50	12.25 11.75	13.984 13.966	16.018 16.000	14.058 13.990					
BB1017DP4			17.25 16.75	12.25 11.75								
BB1207DP4	12	14	20.50 19.50	12.25 11.75	11.984 11.966	14.018 14.000	12.058 11.990	0.092 0.006				
BB1209DP4			17.25 16.75	12.25 11.75								
BB1212DP4	14	16	22.50 21.50	12.25 11.75	13.984 13.966	16.018 16.000	14.058 13.990					
BB1217DP4			17.25 16.75	12.25 11.75								
BB1412DP4	14	16	22.50 21.50	12.25 11.75	13.984 13.966	16.018 16.000	14.058 13.990					
BB1417DP4			17.25 16.75	12.25 11.75								

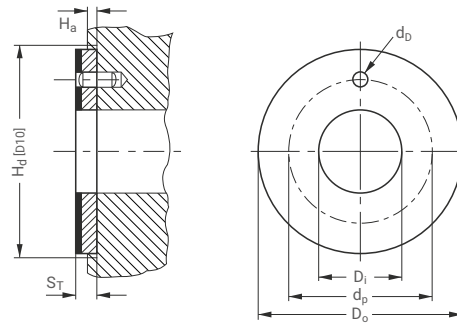
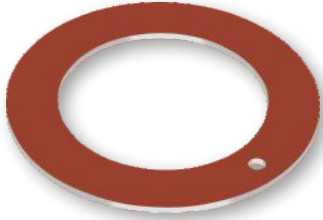
All dimensions in mm

PART NO.	NOMINAL DIAMETER		WALL THICK- NESS $S_3$	FLANGE THICKN. $S_n$	FLANGE Ø $D_n$	WIDTH B	SHAFT Ø $D_j$ [h6, f7, h8]	HOUSING Ø $D_H$ [H6, H7]	BUSH Ø $D_{i,a}$ ASSEMBLY IN H6/H7 HOUSING	CLEARANCE $C_D$										
	$D_i$	$D_o$									max. min.	max. min.	max. min.	max. min.	max. min.	max. min.				
BB1509DP4	15	17	1.005 0.980	1.05 0.80	23.50 22.50	9.25	14.984 14.966	17.018 17.000	15.058 14.990	0.092 0.006										
BB1512DP4						8.75														
BB1517DP4						12.25 11.75														
BB1612DP4	16	18			24.50 23.50	12.25 11.75					15.984 15.966	18.018 18.000	16.058 15.990							
BB1617DP4						17.25 16.75														
BB1812DP4	18	20			1.505 1.475	1.60 1.30					26.50 25.50	12.25 11.75	17.984 17.966	20.021 20.000	18.061 17.990	0.095 0.006				
BB1817DP4			17.25 16.75																	
BB1822DP4			22.25 21.75																	
BB2012DP4	20	23	1.505 1.475	1.60 1.30			30.50 29.50	11.75 11.25	19.980 19.959	23.021 23.000	20.071 19.990	0.112 0.010								
BB2017DP4								16.75 16.25												
BB2022DP4								21.75 21.25												
BB2512DP4	25	28			1.505 1.475	1.60 1.30	35.50 34.50	11.75 11.25					24.980 24.959	28.021 28.000	25.071 24.990	0.126 0.010				
BB2517DP4								16.75 16.25												
BB2522DP4								21.75 21.25												
BB3016DP4	30	34	2.005 1.970	2.10 1.80			42.50 41.50	16.25 15.75	29.980 29.959	34.025 34.000	30.085 29.990	0.135 0.015								
BB3026DP4								26.25 25.75												
BB3516DP4	35	39					2.005 1.970	2.10 1.80									47.50 46.50	16.25 15.75	34.975 34.950	39.025 39.000
BB3526DP4					26.25 25.75															
BB4016DP4	40	44			2.505 2.460	2.60 2.30							53.50 52.50	16.25 15.75	39.975 39.950	44.025 44.000	40.085 39.990			
BB4026DP4														26.25 25.75						
BB4516DP4	45	50	2.505 2.460	2.60 2.30					58.50 57.50	16.25 15.75	44.975 44.950	50.025 50.000	45.105 44.990	0.155 0.015						
BB4526DP4										26.25 25.75										

All dimensions in mm

# 8 Standard Products

## 8.3 DP4® THRUST WASHERS

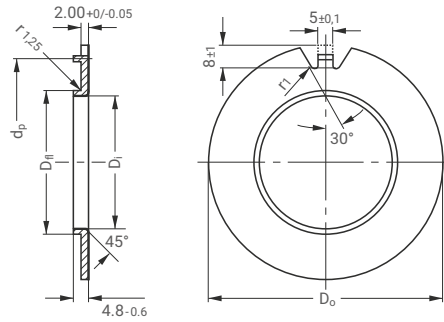
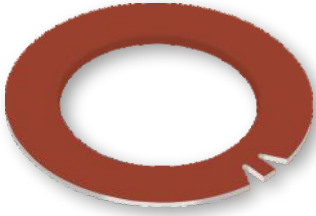


Dimensions and Tolerances according to ISO 3547 and GGB-Specifications

PART NO.	INSIDE DIAMETER $D_i$		OUTSIDE DIAMETER $D_o$		THICKNESS $S_T$ max. min.	DOWEL HOLE $\emptyset d_p$		RECESS DEPTH $H_a$ max. min.
	max.	min.	max.	min.		max. min.	PCD $\emptyset d_p$ max. min.	
WC08DP4	10.25	10.00	20.00	19.75	1.50 1.45	No Hole	No Hole	1.20 0.95
WC10DP4	12.25	12.00	24.00	23.75		1.875 1.625	18.12 17.88	
WC12DP4	14.25	14.00	26.00	25.75		2.375 2.125	20.12 19.88	
WC14DP4	16.25	16.00	30.00	29.75			22.12 21.88	
WC16DP4	18.25	18.00	32.00	31.75		3.375 3.125	25.12 24.88	
WC18DP4	20.25	20.00	36.00	35.75			28.12 27.88	
WC20DP4	22.25	22.00	38.00	37.75		4.375 4.125	30.12 29.88	
WC22DP4	24.25	24.00	42.00	41.75			33.12 32.88	
WC24DP4	26.25	26.00	44.00	43.75		61.12 60.88	35.12 34.88	
WC25DP4	28.25	28.00	48.00	47.75			38.12 37.88	
WC30DP4	32.25	32.00	54.00	53.75		2.00 1.95	43.12 42.88	
WC35DP4	38.25	38.00	62.00	61.75			50.12 49.88	
WC40DP4	42.25	42.00	66.00	65.75		76.12 75.88	54.12 53.88	
WC45DP4	48.25	48.00	74.00	73.75			61.12 60.88	
WC50DP4	52.25	52.00	78.00	77.75	1.70 1.45	65.12 64.88		
WC60DP4	62.25	62.00	90.00	89.75		76.12 75.88		

All dimensions in mm

## 8.4 DP4® FLANGED WASHERS



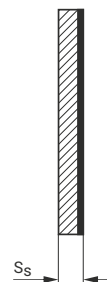
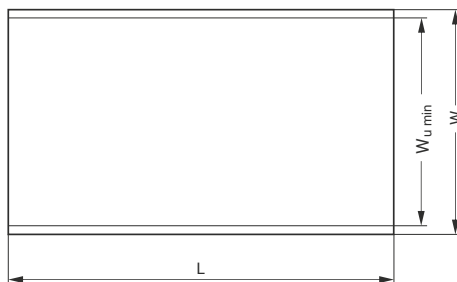
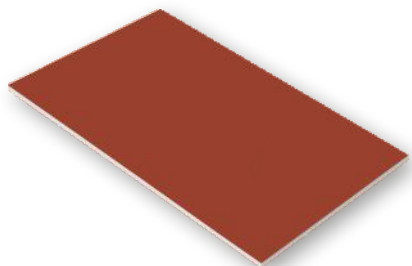
Dimensions and Tolerances according to ISO 3547 and GGB-Specifications

PART NO.	INSIDE DIAMETER $D_i$		OUTSIDE DIAMETER $D_o$		FLANGE $\phi$ $D_f$		LOCATION $\phi$ $d_p$	
	max.	min.	max.	min.	max.	min.	max.	min.
BS40DP4	40.7		75.0		44.00		65.0	
	40.2		74.5		43.90		64.5	
BS50DP4	51.5		85.0		55.00		75.0	
	51.0		84.5		54.88		74.5	
BS60DP4	61.5		95.0		65.00		85.0	
	61.0		94.5		64.88		84.5	
BS70DP4	71.5		110.0		75.00		100.0	
	71.0		109.5		74.88		99.5	
BS80DP4	81.5		120.0		85.00		110.0	
	81.0		119.5		84.86		109.5	
BS90DP4	91.5		130.0		95.00		120.0	
	91.0		129.5		94.86		119.5	
BS100DP4	101.5		140.0		105.00		130.0	
	101.0		139.5		104.86		129.5	

All dimensions in mm

# 8 Standard Products

## 8.5 DP4® STRIP

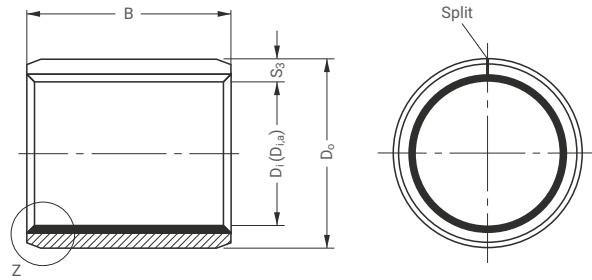
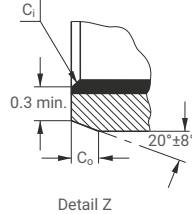


PART NO.	LENGTH L max. min.	TOTAL WIDTH W	USABLE WIDTH $W_{U \min}$	THICKNESS $S_s$ max. min.
S07190DP4	503 500	200	190	0.74
S10190DP4				0.70
S15190DP4				1.01
S20190DP4				0.97
S15240DP4		254	240	1.52
S25240DP4				1.48
				1.98
				1.94
				1.52
				1.48
				2.46
				2.42

All dimensions in mm

# 8 Standard Products

## 8.6 DP4-B CYLINDRICAL BUSHES



Dimensions and Tolerances according to ISO 3547 and GGB-Specifications

### Outside $C_o$ and Inside $C_i$ Chamfers

WALL THICKNESS $S_3$	$C_o$ (a)		$C_i$ (b)
	MACHINED	ROLLED	
0.75	$0.5 \pm 0.3$	$0.5 \pm 0.3$	-0.1 to -0.4
1	$0.6 \pm 0.4$	$0.6 \pm 0.4$	-0.1 to -0.5
1.5	$0.6 \pm 0.4$	$0.6 \pm 0.4$	-0.1 to -0.7

WALL THICKNESS $S_3$	$C_o$ (a)		$C_i$ (b)
	MACHINED	ROLLED	
2	$1.2 \pm 0.4$	$1.0 \pm 0.4$	-0.1 to -0.7
2.5	$1.8 \pm 0.6$	$1.2 \pm 0.4$	-0.2 to -1.0

(a) = chamfer  $C_o$  machined or rolled at the opinion of the manufacturer

(b) =  $C_i$  can be a radius or a chamfer in accordance with ISO 13715

PART NO.	NOMINAL DIAMETER		WALL THICKNESS $S_3$ max. min.	WIDTH B max. min.	SHAFT $\emptyset$ $D_j$ [h6, f7, h8]	HOUSING $\emptyset$ $D_H$ [H6, H7]	BUSH $\emptyset D_{i,a}$ ASSEMBLY IN H6/H7 HOUSING max. min.	CLEARANCE $C_D$ max. min.				
	$D_i$	$D_o$										
0203DP4B	2	3.5	0.750 0.730	3.25	h6	H6	2.048 2.000	0.054 0.000				
0205DP4B				5.25					1.994	3.500		
0306DP4B	3	4.5		6.25					3.000	4.508		
0404DP4B				5.75					2.994	4.500		
0406DP4B	4	5.5		4.25					4.000	5.508	4.048	0.056 0.000
0505DP4B				3.75								
0510DP4B	5	7		5.25					4.990	7.015	5.055	0.077 0.000
0606DP4B				4.75								
0608DP4B	6	8		6.25					5.990	8.015	6.055	0.083 0.003
0610DP4B				5.75								
0808DP4B	8	10	8.25	7.987	10.015	8.055	0.086 0.003					
0810DP4B			7.75					7.972	10.000			
0812DP4B	8	10	10.25	9.987	12.018	10.058	0.092 0.006					
1010DP4B			9.75					9.972	12.000			
1015DP4B	10	12	12.25	11.984	14.018	12.058	0.092 0.006					
1210DP4B			11.75					11.966	14.000			
1212DP4B	12	14	10.25	11.984	14.018	12.058	0.092 0.006					
1215DP4B			9.75					11.966	14.000			

All dimensions in mm

# 8 Standard Products

PART NO.	NOMINAL DIAMETER		WALL THICKNESS S <sub>3</sub> max. min.	WIDTH B max. min.	SHAFT Ø D <sub>J</sub> [h6, f7, h8] max. min.	HOUSING Ø D <sub>H</sub> [H6, H7] max. min.	BUSH Ø D <sub>i,a</sub> ASSEMBLY IN H6/H7 HOUSING max. min.	CLEARANCE C <sub>D</sub> max. min.			
	D <sub>i</sub>	D <sub>O</sub>									
1410DP4B	14	16	1.005 0.980	10.25	13.984 13.966	16.018 16.000	14.058 13.990	0.092 0.006			
1415DP4B				9.75							
1420DP4B				15.25							
1515DP4B	14.75										
1525DP4B	20.25										
1615DP4B	19.75										
1625DP4B	15.25	15		1.005 0.980	14.75	14.984 14.966	17.018 17.000		0.092 0.006		
1820DP4B	14.75										
1825DP4B	25.25										
2015DP4B	24.75	16			1.005 0.980	15.25	15.984 15.966			18.018 18.000	0.092 0.006
2020DP4B	14.75										
2025DP4B	25.25										
2030DP4B	24.75	18	1.005 0.980	20.25		17.984 17.966	20.021 20.000	0.095 0.006			
2215DP4B	19.75										
2220DP4B	25.25										
2225DP4B	24.75	20		1.505 1.475	15.25	19.980 19.959	23.021 23.000		0.112 0.010		
2515DP4B	14.75										
2525DP4B	20.25										
2830DP4B	19.75	22	1.505 1.475		20.25	21.980 21.959	25.021 25.000	0.112 0.010			
3020DP4B	14.75										
3030DP4B	25.25										
3040DP4B	24.75	25		2.005 1.970	15.25	24.980 24.959	28.021 28.000		0.126 0.010		
3520DP4B	14.75										
3530DP4B	20.25										
4030DP4B	19.75	28	2.005 1.970		30.25	27.980 27.959	32.025 32.000	0.126 0.010			
4040DP4B	29.75										
4050DP4B	20.25										
4530DP4B	19.75	30		2.005 1.970	30.25	29.980 29.959	34.025 34.000		0.135 0.015		
4550DP4B	29.75										
5040DP4B	40.25										
5060DP4B	39.75	35	2.505 2.460		20.25	34.975 34.950	39.025 39.000	0.135 0.015			
5540DP4B	19.75										
6040DP4B	30.25										
6050DP4B	29.75	40		2.505 2.460	30.25	39.975 39.950	44.025 44.000		0.155 0.015		
6060DP4B	49.75										
6070DP4B	50.25										
6070DP4B	49.75	45	2.505 2.460		44.975	44.950	50.025 50.000	0.155 0.015			
5540DP4B	29.75										
6040DP4B	50.25										
6050DP4B	49.75	50		2.505 2.460	49.975	49.950	55.030 55.000		0.160 0.015		
6060DP4B	39.75										
6070DP4B	60.25										
6070DP4B	59.75	55	2.505 2.460		54.970	54.940	60.030 60.000	0.170 0.020			
6040DP4B	29.75										
6050DP4B	40.25										
6050DP4B	49.75	60		2.505 2.460	59.970	59.940	65.030 65.000		0.170 0.020		
6060DP4B	59.75										
6070DP4B	70.25										
6070DP4B	69.75										

All dimensions in mm

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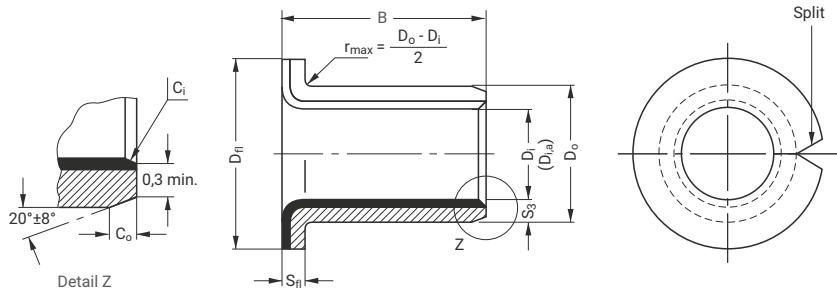


PART NO.	NOMINAL DIAMETER		WALL THICKNESS S <sub>3</sub> max. min.	WIDTH B max. min.	SHAFT Ø D <sub>J</sub> [h6, f7, h8]	HOUSING Ø D <sub>H</sub> [H6, H7]	BUSH Ø D <sub>i,a</sub> ASSEMBLY IN H6/H7 HOUSING max. min.	CLEARANCE C <sub>D</sub> max. min.			
	D <sub>i</sub>	D <sub>O</sub>									
6570DP4B	65	70	2.505 2.460	70.25 69.75	f7	70.030 70.000	65.110 64.990	0.170 0.020			
7050DP4B	70	75		50.25 49.75					64.970 64.940		
7070DP4B				70.25 69.75					69.970 69.940		
7580DP4B	75	80		80.25 79.75					74.970 74.940	75.030 75.000	70.110 69.990
8060DP4B	80	85	2.490 2.440	60.50 59.50	h8	80.000 79.946	85.035 85.000	0.201 0.020			
80100DP4B				100.50 99.50					H7		
85100DP4B	85	90		100.50 99.50						85.000 84.946	90.035 90.000
9060DP4B	90	95		60.50 59.50					90.000 89.946	95.035 95.000	90.155 90.020
90100DP4B			100.50 99.50	H7							
95100DP4B	95	100	100.50 99.50		95.000 94.946	100.035 100.000	95.155 95.020				
10060DP4B	100	105	60.50 59.50		100.000 99.946	105.035 105.000	100.155 100.020				
100115DP4B			115.50 114.50		H7						
105115DP4B	105	110	115.50 114.50	105.000 104.946		110.035 110.000	105.155 105.020				
110115DP4B	110	115	115.50 114.50	110.000 109.946		115.035 115.000	115.155 115.020				

All dimensions in mm

# 8 Standard Products

## 8.7 DP4-B FLANGED BUSHES



Dimensions and Tolerances according to ISO 3547 and GGB-Specifications

### Outside $C_o$ and Inside $C_i$ Chamfers

WALL THICKNESS $S_3$	$C_o$ (a)		$C_i$ (b)	WALL THICKNESS $S_3$	$C_o$ (a)		$C_i$ (b)
	MACHINED	ROLLED			MACHINED	ROLLED	
0.75	$0.5 \pm 0.3$	$0.5 \pm 0.3$	-0.1 to -0.4	2	$1.2 \pm 0.4$	$1.0 \pm 0.4$	-0.1 to -0.7
1	$0.6 \pm 0.4$	$0.6 \pm 0.4$	-0.1 to -0.5	2.5	$1.8 \pm 0.6$	$1.2 \pm 0.4$	-0.2 to -1.0
1.5	$0.6 \pm 0.4$	$0.6 \pm 0.4$	-0.1 to -0.7				

(a) = chamfer  $C_o$  machined or rolled at the opinion of the manufacturer

(b) =  $C_i$  can be a radius or a chamfer in accordance with ISO 13715

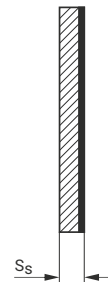
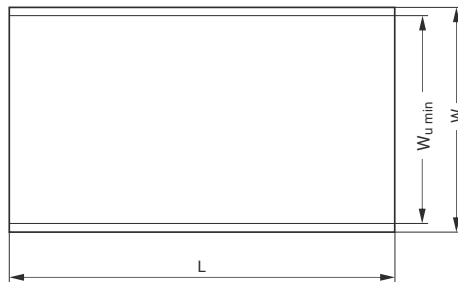
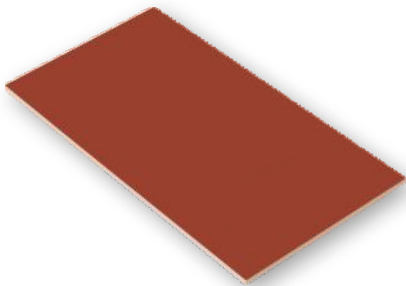
PART NO.	NOMINAL DIAMETER		WALL THICKNESS $S_3$	FLANGE THICKN. $S_F$	FLANGE $\emptyset$ $D_F$	WIDTH B	SHAFT $\emptyset$ $D_J$ [h6, f7, h8]		HOUSING $\emptyset$ $D_H$ [H6, H7]		BUSH $\emptyset$ $D_{i,a}$ ASSEMBLY IN H6/H7 HOUSING	CLEARANCE $C_D$
	$D_i$	$D_o$					max. min.	max. min.	max. min.	max. min.		
BB0304DP4B	3	4.5	0.750 0.730	0.80 0.70	7.50 6.50	4.25 3.75	h6	3.000 2.994	H6	4.508 4.500	3.048 3.000	0.054 0.000
BB0404DP4B	4	5.5			9.50 8.50	4.25 3.75		4.000 3.992		5.508 4.500	4.048 4.000	0.056 0.000
BB0505DP4B	5	7	1.005 0.980	1.05 0.80	10.50 9.50	5.25 4.75	f7	4.990 4.978	H7	7.015 7.000	5.055 4.990	0.077 0.000
BB0604DP4B	6	8			12.50 11.50	4.25 3.75		5.990 5.978		8.015 8.000	6.055 5.990	0.077 0.000
BB0608DP4B					15.50 14.50	5.75 5.25		7.987 7.972		10.015 10.000	8.055 7.990	0.083 0.003
BB0806DP4B	8	10			18.50 17.50	7.25 6.75		9.987 9.972		12.018 12.000	10.058 9.990	0.086 0.003
BB1007DP4B					20.50 19.50	9.25 8.75		11.984 11.966		14.018 14.000	12.058 11.990	0.092 0.006
BB1012DP4B	10	12			22.50 21.50	12.25 11.75		13.984 13.966		16.018 16.000	14.058 13.990	
BB1207DP4B					12	14		23.50 22.50		12.25 11.75	14.984 14.966	
BB1209DP4B	14	16						24.50 23.50		12.25 11.75	15.984 15.966	
BB1417DP4B					15	17		25.50 22.50		17.25 16.75		
BB1512DP4B	16	18						24.50 23.50		17.25 16.75		
BB1517DP4B												
BB1612DP4B												
BB1617DP4B												

All dimensions in mm

PART NO.	NOMINAL DIAMETER		WALL THICKNESS $S_3$ max. min.	FLANGE THICKN. $S_{fl}$ max. min.	FLANGE Ø $D_{fl}$ max. min.	WIDTH B max. min.	SHAFT Ø $D_j$ [h6, f7, h8] max. min.	HOUSING Ø $D_H$ [H6, H7] max. min.	BUSH Ø $D_{i,a}$ ASSEMBLY IN HG/H7 HOUSING max. min.	CLEARANCE $C_D$ max. min.
	$D_i$	$D_o$								
BB1812DP4B	18	20	1.005 0.980	1.05 0.80	26.50 25.50	12.25	17.984 17.966	20.021 20.000	18.061 17.990	0.095 0.006
BB1822DP4B						11.75				
BB2012DP4B	20	23	1.505 1.475	1.60 1.30	30.50 29.50	11.75	19.980 19.959	23.021 23.000	20.071 19.990	0.112 0.010
BB2017DP4B						11.25				
BB2512DP4B	25	28	1.505 1.475	1.60 1.30	35.50 34.50	11.75	24.980 24.959	28.021 28.000	25.071 24.990	0.112 0.010
BB2522DP4B						11.25				
BB3016DP4B	30	34	2.005 1.970	2.10 1.80	42.50 41.50	16.25	29.980 29.959	34.025 34.000	30.085 29.990	0.126 0.010
BB3026DP4B						15.75				
BB3526DP4B	35	39	2.005 1.970	2.10 1.80	47.50 46.50	26.25	34.975 34.950	39.025 39.000	35.085 34.990	0.135 0.015
BB4026DP4B	25.75									
BB4526DP4B	45	50	2.505 2.460	2.60 2.30	58.50 57.50	26.25 25.75	44.975 44.950	50.025 50.000	45.105 44.990	0.155 0.015

All dimensions in mm

## 8.8 DP4-B STRIP



PART NO.	LENGTH L max. min.	TOTAL WIDTH W	USABLE WIDTH $W_{U \min}$	THICKNESS $S_s$ max. min.
S07085DP4B	503 500	95	85	0.74
S10180DP4B				0.70
S15180DP4B		195	180	1.01
S20180DP4B				0.97
S25180DP4B				1.52
				1.48
				1.98
				1.94
				2.46
				2.42

All dimensions in mm

# 9 TEST METHODS

## 9.1 MEASUREMENT OF WRAPPED BUSHES

It is not possible to accurately measure the external and internal diameters of a wrapped bush in the free condition. In its free state a wrapped bush will not be perfectly cylindrical and the butt joint may be open. When correctly installed in a housing the butt joint will be tightly closed and the bush will conform to the housing. For this reason the external diameter and internal diameter of a wrapped bush can only be checked with special gauges and test equipment.

The checking methods are defined in ISO 3547 Parts 1 to 7.

### Test A of ISO 3547 Part 2

Checking the external diameter in a test machine with checking blocks and adjusting mandrel.

TEST A OF ISO 3547 PART 2 ON 2015DP4®	
Checking block and setting mandrel $d_{ch,1}$	23.062 mm
Test force $F_{ch}$	4500 N
Limits for $\Delta z$	0 and -0.065 mm
Bush Outside diameter $D_o$	23.035 to 23.075 mm

Table 18 : Test A of ISO 3547 Part 2

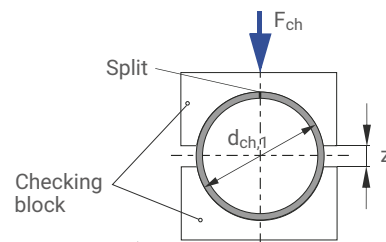


Fig.40 : Test A, data for drawing

### Test B (alternatively to Test A)

Check external diameter with GO and NO GO ring gauges.

### Test C

Checking the internal diameter of a bush pressed into a ring gauge, which nominal diameter corresponds to the dimension specified in table 6 of ISO 3547 Part 2 (Example  $D_j = 20$  mm).

### Measurement of Wall Thickness (alternatively to Test C)

The wall thickness is measured at one, two or three positions axially according to the bearing dimensions.

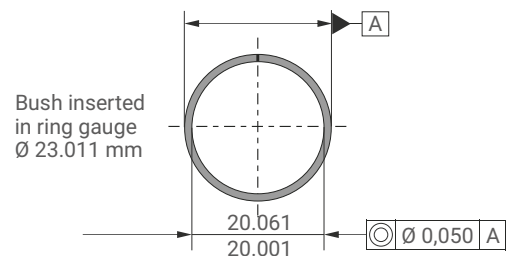


Fig.41 : Test C, data for drawing

B [mm]	X [mm]	MEASUREMENT POSITION
$\leq 15$	B/2	1
$>15 \leq 50$	4	2
$>50 \leq 90$	6 and B/2	3
$>90$	8 and B/2	3

Table 19 : Measurement position

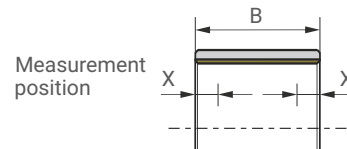


Fig.42 : Test C, measurement position

### Test D

Check external diameter by precision measuring tape.

# 10 Bearing Application Data Sheet

Please complete the form below and share it with your GGB sales engineer or send it to: [usa@ggbearings.com](mailto:usa@ggbearings.com)

## DATA FOR BEARING DESIGN CALCULATION

Application: \_\_\_\_\_

Project/No.: \_\_\_\_\_ Quantity: \_\_\_\_\_  New Design  Existing Design

Steady load  Rotating load  Rotational movement  Oscillating movement  Linear movement

### DIMENSIONS [MM]

Inside diameter	$D_i$
Outside diameter	$D_o$
Length	B
Flange Diameter	$D_{fl}$
Flange thickness	$B_{fl}$
Wall thickness	$S_T$
Length of slideplate	L
Width of slideplate	W
Thickness of slideplate	$S_s$

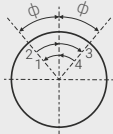
### LOAD

Static load  
 Dynamic load

Axial load F	[N]
Radial load F	[N]

### MOVEMENT

Rotational speed	N [1/min]
Speed	U [m/s]
Length of stroke	$L_s$ [mm]
Frequency of stroke	[1/min]
Oscillating cycle	$\phi$ [°]
Osc. frequency	$N_{osz}$ [1/min]



### MATING SURFACE

Material	
Hardness	HB/HRC
Surface finish	Ra [µm]

### CUSTOMER INFORMATION

Company \_\_\_\_\_  
 Street \_\_\_\_\_  
 City / State / Province / Post Code \_\_\_\_\_  
 Telephone \_\_\_\_\_ Fax \_\_\_\_\_  
 Name \_\_\_\_\_  
 Email Address \_\_\_\_\_ Date \_\_\_\_\_

### FITS & TOLERANCES

Shaft	$D_j$
Bearing housing	$D_H$

### OPERATING ENVIRONMENT

Ambient temperature	$T_{amb}$ [°]
Bearing housing material	

Housing with good heating transfer properties  
 Light pressing or insulated housing with poor heat transfer properties  
 Non metal housing with poor heat transfer properties  
 Alternate operation in water and dry

### LUBRICATION

Dry  
 Continuous lubrication  
 Process fluid lubrication  
 Initial lubrication only  
 Hydrodynamic conditions

Process fluid	
Lubricant	
Dynamic viscosity	$\eta$ [mPas]

### SERVICE HOURS PER DAY

Continuous operation	
Intermittent operation	
Operating time	
Days per year	

### SERVICE LIFE

Required service life	$L_H$ [h]
-----------------------	-----------

### BEARING TYPE

Cylindrical bush

Flanged bush

Thrust washer

Slideplate

Special parts (sketch)

## FORMULA SYMBOLS AND DESIGNATIONS

SYMBOL	UNIT	DESIGNATION
A	mm <sup>2</sup>	Surface area of DU® bearing
A <sub>M</sub>	mm <sup>2</sup>	Surface area of mating surface in contact with DU® bearing (slideway)
a <sub>B</sub>	-	Bearing size factor
a <sub>C</sub>	-	Application factor for bore burnishing or machining
a <sub>E</sub>	-	High load factor
a <sub>E1</sub>	-	Specific load factor (slideways)
a <sub>E2</sub>	-	Speed, temperature and material factor (slideways)
a <sub>E3</sub>	-	Relative contact area factor (slideways)
a <sub>L</sub>	-	Life correction constant
a <sub>M</sub>	-	Mating surface material factor
a <sub>T</sub>	-	Temperature application factor
B	mm	Nominal bush length
C	1/min	Dynamic load frequency
C <sub>D</sub>	mm	Installed diametrical clearance
C <sub>i</sub>	mm	ID chamfer length
C <sub>o</sub>	mm	OD chamfer length
C <sub>T</sub>	-	Total number of dynamic load cycles
D <sub>C</sub>	mm	Diameter of burnishing tool
D <sub>fl</sub>	mm	Nominal bush flange OD
D <sub>H</sub>	mm	Housing Diameter
D <sub>i</sub>	mm	Nominal bush and thrust washer ID
D <sub>i,a</sub>	mm	Bush ID when assembled in housing
D <sub>J</sub>	mm	Shaft diameter
D <sub>Nth</sub>	nvt	Max. thermal neutron dose
D <sub>o</sub>	mm	Nominal bush and thrust washer OD
D <sub>γ</sub>	Gy	Max. Gamma radiation dose
d <sub>D</sub>	mm	Dowel hole diameter
d <sub>L</sub>	mm	Oil hole diameter
d <sub>p</sub>	mm	Pitch circle diameter for dowel hole
F	N	Bearing load
F <sub>ch</sub>	N	Test force
F <sub>i</sub>	N	Insertion force
f	-	Coefficient of friction

SYMBOL	UNIT	DESIGNATION
H <sub>a</sub>	mm	Depth of housing recess (e.g. for thrust washers)
H <sub>d</sub>	mm	Diameter of housing recess (e.g. for thrust washers)
L	mm	Strip length
L <sub>H</sub>	h	Bearing service life
L <sub>S</sub>	mm	Length of stroke (slideway)
N	1/min	Rotational speed
N <sub>osz</sub>	1/min	Oscillating movement frequency
p	MPa	Specific load
p <sub>lim</sub>	MPa	Specific load limit
p <sub>sta,max</sub>	MPa	Maximum static load
p <sub>dyn,max</sub>	MPa	Maximum dynamic load
Q	-	Permissible number of cycles
R <sub>a</sub>	μm	Surface roughness (DIN 4768, ISO/DIN 4287/1)
R <sub>OB</sub>	Ω	Electrical resistance
s <sub>3</sub>	mm	Bush wall thickness
s <sub>fl</sub>	mm	Flange thickness
s <sub>S</sub>	mm	Strip thickness
s <sub>T</sub>	mm	Thrust washer thickness
T	°C	Temperature
T <sub>amb</sub>	°C	Ambient temperature
T <sub>max</sub>	°C	Maximum temperature
T <sub>min</sub>	°C	Minimum temperature
U	m/s	Sliding speed
W	mm	Strip width
W <sub>U min</sub>	mm	Minimum usable strip width
Z <sub>T</sub>	-	Total number of cycles
α <sub>1</sub>	1/10 <sup>6</sup> K	Coefficient of linear thermal expansion parallel to surface
α <sub>2</sub>	1/10 <sup>6</sup> K	Coefficient of linear thermal expansion normal to surface
σ <sub>c</sub>	MPa	Compressive yield strength
λ	W/mK	Thermal conductivity
φ	°	Angular displacement
η	cP	Dynamic viscosity

# Product Information

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GGB assures the products described in this document have no manufacturing errors or material deficiencies.

The details set out in this document are registered to assist in assessing material suitability for intended use. They have been developed from our own investigations as well as generally accessible publications. They do not represent any assurance for the properties themselves.

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## STATEMENT REGARDING LEAD CONTENT IN GGB PRODUCTS & EU DIRECTIVE COMPLIANCE

GGB is committed to adhering to all U.S., European, and international standards and regulations with regard to lead content. We have established internal processes that monitor any changes to existing standards and regulations, and we work collaboratively with customers and distributors to ensure all requirements are strictly followed. This includes RoHS and REACH guidelines.

GGB makes it a top priority to operate in an environmentally conscious and safe manner. We follow numerous industry best practices and are committed to meeting or exceeding a variety of internationally recognized standards for emissions control and workplace safety.

Each of our global locations has management systems in place that adhere to IATF 16949, ISO 9001, ISO 14001, OHSAS 18001, and AS9100D/EN9100 quality regulations.

All of our certificates can be found here: <https://www.ggbearings.com/en/certificates>. A detailed explanation of our commitment to REACH and RoHS directives can be found at <https://www.ggbearings.com/en/who-we-are/quality-and-environment>





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