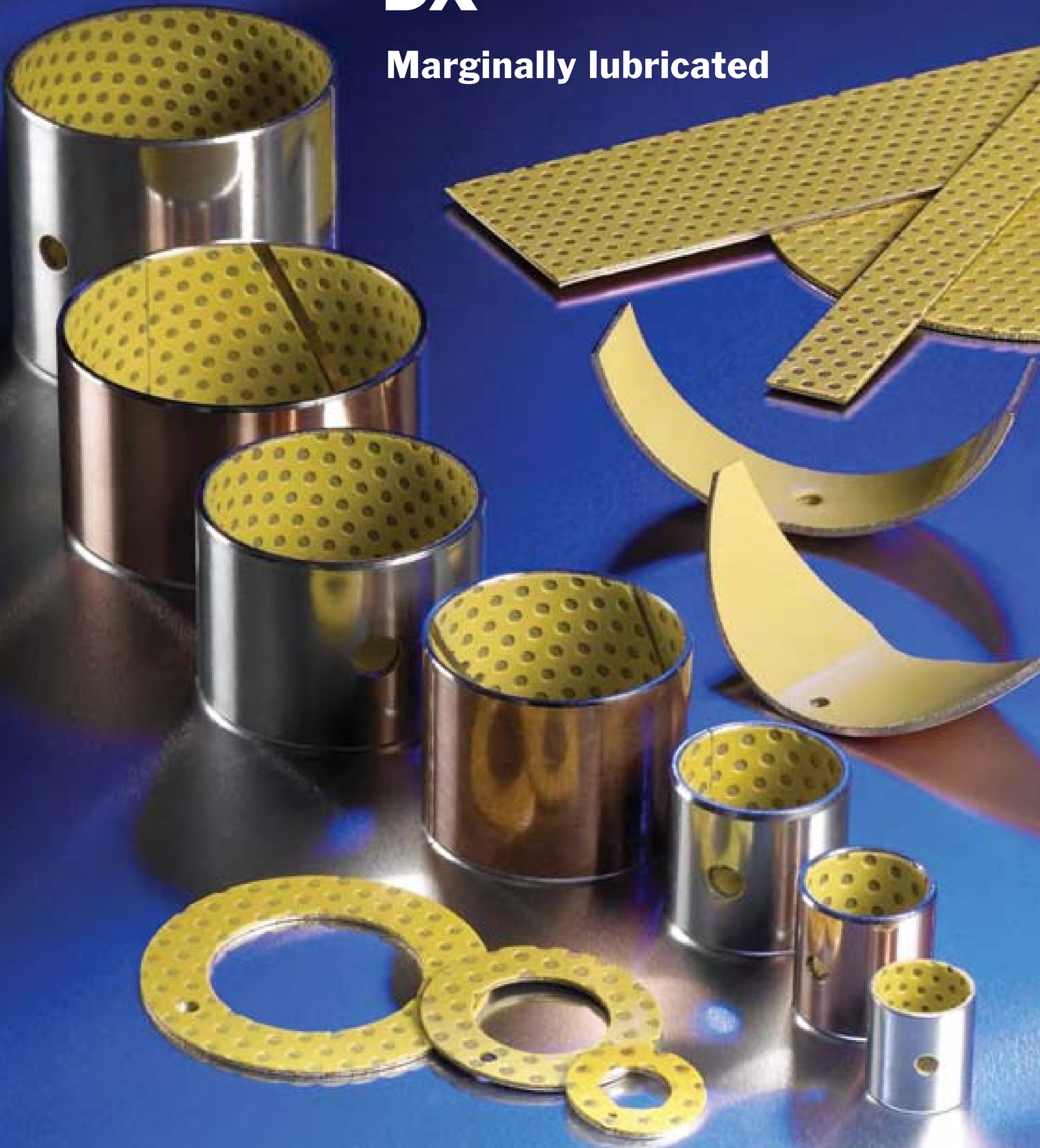
DX

Marginally lubricated



GGB
BEARING TECHNOLOGY

Designer´s Handbook

an EnPro Industries company

Quality

All the products described in this handbook are manufactured under DIN ISO 9001/2 or TS 16949 approved quality management systems.

Formula Symbols and Designations

Formula Symbol	Unit	Designation
a_B	-	Bearing size factor
a_E	-	High load factor
a_Q	-	Speed/Load factor
a_S	-	Surface finish factor
a_T	-	Temperature application factor
B	mm	Nominal bush width
C	1/min	Dynamic load frequency
C_D	mm	Installed diametral clearance
C_{Dm}	mm	Diametral clearance machined
C_T	-	Total number of dynamic load cycles
C_i	mm	ID chamfer length
C_o	mm	OD chamfer length
D_H	mm	Housing Diameter
D_i	mm	Nominal bush/thrust washer ID
$D_{i,a}$	mm	Bush ID when assembled in housing
$D_{i,a,m}$	mm	Bush ID assembled and machined
D_{Jm}	mm	Shaft for machined bushes
D_J	mm	Shaft diameter
D_o	mm	Nominal bush/thrust washer OD
d_D	mm	Dowel hole diameter
d_L	mm	Oil hole diameter
d_P	mm	Pitch circle diameter for dowel hole
F	N	Bearing load
F_i	N	Insertion force
f	-	Friction
H_a	mm	Depth of Housing Recess (e.g. for thrust washers)
H_d	mm	Diameter of Housing Recess (thrust washers)
L	mm	Strip length
L_H	h	Bearing service life
L_{RG}	h	Relubrication interval

Formula Symbol	Unit	Designation
N	1/min	Rotational speed
N_{osz}	1/min	Oscillating movement frequency
$\bar{p}$	N/mm²	Specific load
$\bar{p}_{lim}$	N/mm²	Specific load limit
$\bar{p}_{sta,max}$	N/mm²	Maximum static load
$\bar{p}_{dyn,max}$	N/mm²	Maximum dynamic load
Q	-	Total number of cycles
R	-	Number of lubrication intervals
R_a	µm	Surface roughness (DIN 4768, ISO/DIN 4287/1)
s_3	mm	Bush wall thickness
s_S	mm	Strip thickness
s_T	mm	Thrust washer thickness
T	°C	Temperature
T_{amb}	°C	Ambient temperature
T_{max}	°C	Maximum temperature
T_{min}	°C	Minimum temperature
U	m/s	Sliding speed
u	-	speed factor
W	mm	Strip width
$W_{u\ min}$	mm	Minimum usable strip width
α_1	$1/10^6K$	Coefficient of linear thermal expansion parallel to surface
α_2	$1/10^6K$	Coefficient of linear thermal expansion normal to surface
σ_c	N/mm²	Compressive Yield strength
λ	W/mK	Thermal conductivity
φ	°	Angular displacement
η	Ns/mm²	Dynamic Viscosity
Z_T	-	Total number of osscillating movements

Content

1 Introduction

The purpose of this handbook is to provide comprehensive technical information on the characteristics of DX bearings. The information given, permits designers to establish the correct size of bearing required and the expected life and performance. GGB Research and Development services are available to assist with unusual design problems.

Complete information on the range of DX standard stock products is given together with details of other DX products.

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

Customers are advised to carry out prototype testing wherever possible.

1.1 Characteristics and Advantages

- **DX provides maintenance free operation**
- **DX has a high $\bar{p}U$ capability**
- **DX exhibits low wear rate**
- **Seizure resistant**
- **Suitable for temperatures from -40 to +120 °C**
- **High static and dynamic load capacity**
- **Good frictional properties**
- **No water absorption and therefore dimensionally stable**
- **Compact and light**
- **Suitable for rotating, oscillating, reciprocating and sliding movements**
- **DX bearings are prefinished and require no machining after assembly**

2 Structure

DX is a composite bearing material developed specifically to operate with marginal lubrication and consists of three bonded layers: a steel backing strip and a sintered porous bronze matrix, impregnated and overlaid with a pigmented acetal copolymer bearing material.

The steel backing provides mechanical strength and the bronze interlayer provides a strong mechanical bond for the lining. This construction promotes dimensional stability and improves thermal conductivity, thus reducing the temperature at the bearing surface.

DX is designed for use with grease lubrication and the bearing surface is normally provided with a uniform pattern of indents These serve as a reservoir for the grease and are designed to provide the optimum distribution of the lubricant over the bearing surface.

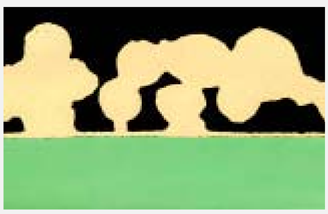


Fig. 1: DX-microsection

2.1 Basic Forms

Standard Components available from stock

These products are manufactured to International, National or GGB standard designs.

Metric and Imperial Sizes

- Cylindrical Bushes
  - PM pre finished metric range, not machinable in situ, for use with standard journals finished to h6-h8 limits.
  - MB machinable metric range, with an allowance for machining in situ.
  - Machinable inch range for use as supplied or after machining in situ.
- Thrust Washers
- Strip Material

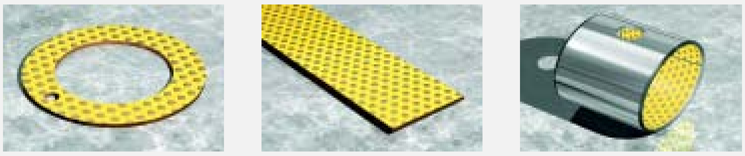


Fig. 2: Standard components

Non Standard Components not available from stock

These products are manufactured to customers' requirements with or without GGB recommendations, and include for example

- Modified Standard Components
- Half Bearings
- Flat Components
- Pressings
- Stampings

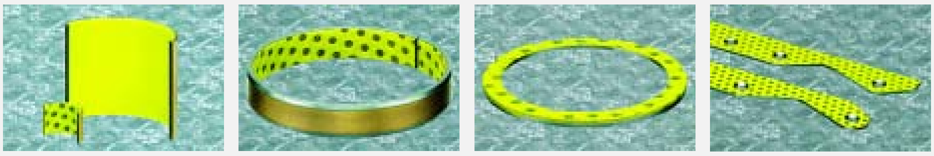


Fig. 3: Non standard components

3 Properties

3.1 Physical Properties

Characteristic		Symbol	Value DX	Unit	Comments
Physical Properties	Thermal Conductivity	λ	52	W/mK	
	Coefficient of linear thermal expansion :				
	parallel to surface	α_1	11	$1/10^6$K	
	normal to surface	α_2	29	$1/10^6$K	
	Maximum Operating Temperature	T_{max}	120	°C	
	Minimum Operating Temperature	T_{min}	–40	°C	
Mechanical Properties	Compressive Yield Strength	σ_c	380	N/mm²	measured on disc 5 mm diameter x 2.45 mm thick.
	Maximum Load				
	Static	$\overline{p}_{sta,max}$	140	N/mm²	
	Dynamic	$\overline{p}_{dyn,max}$	70	N/mm²	
Electrical Properties	Volume resistivity of acetal lining		10^{15}	Ωcm	

Table 1: Properties of DX

3.2 Chemical Properties

The following table provides an indication of the resistance of DX to various chemical media. It is recommended that the chemical resistance is confirmed by testing if possible.

+	**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.

	Chemical	%	°C	Rating
Strong Acids	**Hydrochloric Acid**	5	20	-
	Nitric Acid	5	20	-
	Sulphuric Acid	5	20	-
Weak Acids	**Acetic Acid**	5	20	-
	Formic Acid	5	20	-
Bases	**Ammonia**	10	20	o
	Sodium Hydroxide	5	20	o
Solvents	**Acetone**		20	+
	Carbon Tetrachloride		20	+
Lubricants and fuels	**Paraffin**		20	+
	Gasolene		20	+
	Kerosene		20	+
	Diesel fuel		20	+
	Mineral Oil		70	o
	HFA-ISO46 High Water fluid		70	o
	HFC-Water-Glycol		70	o
	HFD-Phosphate Ester		70	+
	Water		20	o
	Sea Water		20	-

Table 2: Chemical resistance of DX

4 Lubrication

4.1 Choice of Lubricant

DX must be lubricated. The choice of lubricant depends upon pU and the sliding speed and the stability of the lubricant under the operating conditions.

+	**Recommended**
o	**Satisfactory**
-	**Not recommended**
NA	**Data not available**

Manufacturer	Grade	Type		Rating
BP	Energrease LS2	Mineral	Lithium Soap	+
	Energrease LT2	Mineral	Lithium Soap	+
	Energrease FGL	Mineral	Non Soap	o
	Energrease GSF	Synthetic	NA	o
Century	Lacerta ASD	Mineral	Lithium/Polymer	o
	Lacerta CL2X	Mineral	Calcium	-
Dow Corning	Molykote 55M	Silicone	Lithium Soap	o
	Molykote PG65	PAO	Lithium Soap	+
	Molykote PG75	Synthetic/Mineral	Lithium Soap	+
	Molykote PG602	Mineral	Lithium Soap	o
Elf	Rolexa.1	Mineral	Lithium Soap	+
	Rolexa.2	Mineral	Lithium Soap	o
	Epexelf.2	Mineral	Lithium/Calcium Soap	o
Esso	Andok C	Mineral	Sodium Soap	o
	Andok 260	Mineral	Sodium Soap	o
	Cazar K	Mineral	Calcium Soap	-
Mobil	Mobilplex 47	Mineral	Calcium Soap	o
	Mobiltemp 1	Mineral	Non Soap	+
Rocol	BG622	White Mineral	Calcium Soap	o
	Sapphire	Mineral	Lithium Complex	o
	White Food Grease	White Oil	Clay	-
Shell	Albida R2	Mineral	Lithium Complex	+
	Axinus S2	Mineral	Lithium	o
	Darina R2	Mineral	Inorganic Non Soap	+
	Stamina U2	Mineral	Polyurea	o
	Tivela A	Synthetic	NA	+
Sovereign	Omega 77	Mineral	Lithium	o
	Omega 85	Mineral	Polyurea	-
Tom Pac	Tom Pac	NA	NA	o
Total	Aerogrease	Synthetic	NA	+
	Multis EP2	NA	Lithium	-

Table 3: Performance of greases

Grease

Grease lubrication is the recommended method of lubrication. The performance ratings of different types of grease are indicated in Table 3. For environmental temperatures above 50 °C the grease should contain an anti-oxidant additive. Greases containing EP additives or significant additions of graphite or MoS_2 are not generally recommended for use with DX.

Oil

DX is not generally suitable for use with hydrocarbon oils operating above 115 °C. At these temperatures oxidation of the oil may produce a low concentration of labile residues, acid or free radical, which will cause depolymerisation of the DX acetal copolymer bearing lining. Such oxidation can also occur after prolonged periods at lower temperatures. In practice, this means that DX is not recommended for use with recirculating oil systems or bath systems where sump temperatures of 70 °C or greater are possible.

Non lubricating fluids

Care must be taken when using DX with non lubricating fluids as indicated below.

Water

DX is only suitable for operation in water when the load and speed permit full hydrodynamic conditions to be established (see Fig. 7).

Water-Oil Emulsion

DX is suitable for use with 95/5 water/oil emulsions, however initial operation with pure oil or grease is recommended before transferring to emulsion.

Shock-Absorber Oils

DX is not compatible with shock-absorber oils at operating temperature.

Petrol

With petrol as a lubricant at a $\overline{p}U$ factor of 0.21 N/mm² x m/s the wear rate of DX has been found to be about 4-5 times greater than that of an initially greased bearing under the same $\overline{p}U$ conditions.

Kerosene and Polybutene

The wear rate of DX with these fluids has been found to be equivalent to that obtained with a light hydrocarbon oil.

Other Fluids

Polyester, polyethylene glycol and polyglycol lubricants give similar wear rates with DX to light hydrocarbon oil. With the glycol fluids however the operating temperature must not exceed 80 °C because the acetal lining of DX could then be attacked by these fluids.

In general, the fluid will be acceptable if it does not chemically attack the acetal lining or the porous bronze interlayer. Chemical resistance data are given in Table 2.

Where there is doubt about the suitability of a fluid, a simple test is to submerge a sample of DX material in the fluid for two to three weeks at 15-20 °C above the operating temperature. The following will usually indicate that the fluid is not suitable for use with DX.

- A significant change in the thickness of the DX material,
- A visible change in the bearing surface from polished to matt.
- A visible change in the microstructure of the bronze interlayer

4.2 Friction

Lubricated DX bearings show negligible 'stick-slip' and provide smooth sliding between adjacent surfaces. The coefficient of friction of lubricated DX depends upon the actual operating conditions as indicated in section 4.3. Where frictional characteristics are critical to a design they should be established by prototype testing.

4.3 Lubricated Environments

The following sections describe the basics of lubrication and provide guidance on the application of DX in such environments.

Lubrication

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.

These three modes of operation depend upon:

- Bearing dimensions
- Clearance
- Load and Speed
- Lubricant Viscosity and 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.

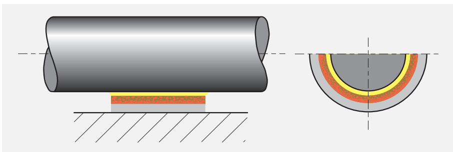


Fig. 4: Hydrodynamic lubrication

Hydrodynamic conditions occur when

(4.3.1) [N/mm²]

$$\bar{p} \leq \frac{U \cdot \eta}{7,5} \cdot \frac{B}{D_i}$$

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.
- Coefficients of friction of 0.01 to 0.10.
- Friction and wear depend upon the degree of hydrodynamic support developed.
- DX provides low friction and high wear resistance to support the boundary lubricated element of the load.

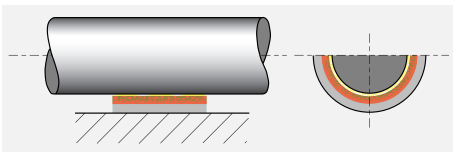


Fig. 5: Mixed film lubrication

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 properties of DX material minimises wear under these conditions.
- The dynamic coefficient of friction with DX is typically 0.02 to 0.1 under boundary lubrication conditions.
- The static coefficient of friction with DX is typically 0.03 to 0.15 under boundary lubrication conditions.

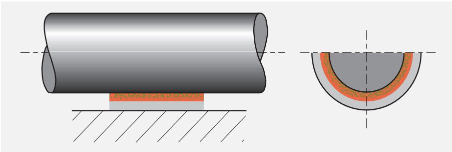


Fig. 6: Boundary lubrication

4.4 Characteristics of Fluid Lubricated DX Bearings

DX 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 DX 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.
  - DX minimises wear
  - DX 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. DX requires significantly less lubricant than conventional metallic bearings.

4.5 Design Guidance for Fluid Lubricated Applications

Fig. 7, Page 11 shows the three lubrication regimes discussed above plotted on a graph of sliding speed vs the ratio of specific load to lubricant viscosity.

In order to use Fig. 7

- Using the formulae in Section 5
  - Calculate the specific load $\overline{p}$
  - Calculate the shaft surface speed(U)
- Using the viscosity temperature relationships presented in Table 4.
  - Determine the viscosity in centipoise of the lubricant.

Note:

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

Area 1 of Fig. 7

- The bearing will operate with boundary lubrication.
- The $\bar{p}U$ factor will be the major determinant of bearing life.
- DX bearing performance can be estimated from the following equations.
- The effective $\bar{p}U$ Factor $e\bar{p}U$ can be estimated from Section 5.8.

If $e\bar{p}U/\eta \leq 0.2$ then

(4.5.1) [h]

$$L_H = \frac{2000}{\left(\frac{e\bar{p}U}{\eta}\right)^{0,5}} \cdot a_Q \cdot a_T \cdot a_S$$

If $0.2 < e\bar{p}U/\eta \leq 1.0$ then

(4.5.2) [h]

$$L_H = \frac{1000}{\left(\frac{e\bar{p}U}{\eta}\right)} \cdot a_Q \cdot a_T \cdot a_S$$

If $e\bar{p}U/\eta > 1.0$ then

(4.5.3) [h]

$$L_H = \frac{1000}{\left(\frac{e\bar{p}U}{\eta}\right)^{2}} \cdot a_Q \cdot a_T \cdot a_S$$

$e\bar{p}U$ see (5.8), page 18

Area 2 of Fig. 7

- The bearing will operate with mixed film lubrication.
- $\bar{p}U$ factor is no longer a significant parameter in determining the bearing life.
- DX bearing performance will depend upon the nature of the fluid and the actual service conditions.

Area 3 of Fig. 7

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

Area 4 of Fig. 7

- 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 use of unindented DX lining
  - by the addition of one or more grooves to the bearing
  - by shaft surface finish R_a <0.05 [µm].

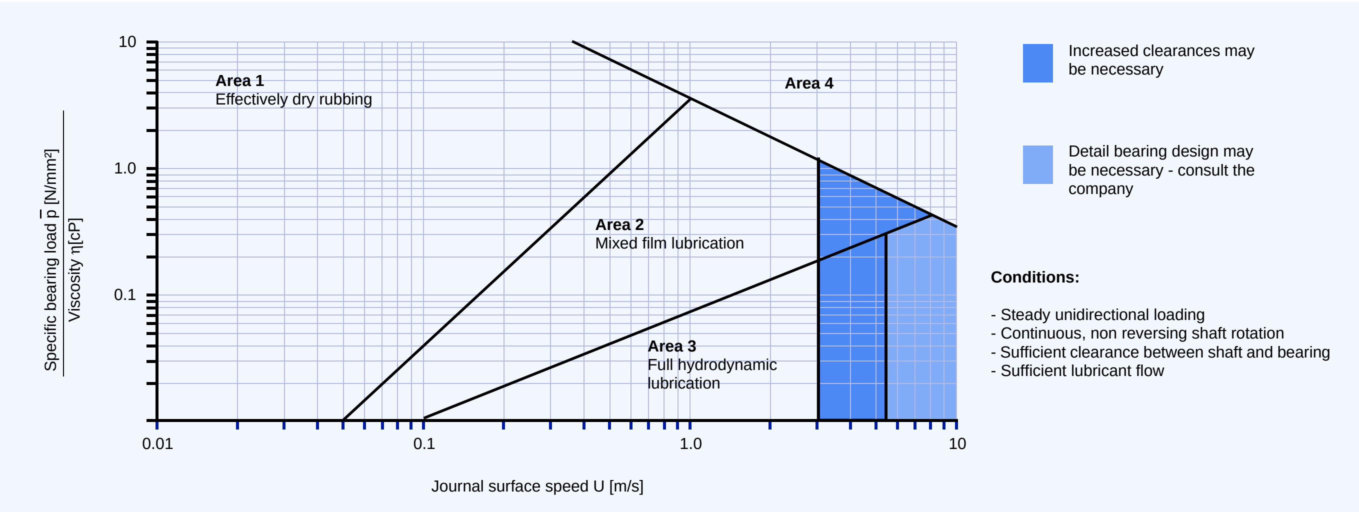


Fig. 7: Design guide for lubricated application

	cP														
Temperature [°C]	**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 4: Viscosity data

4.6 Wear Rate and Relubrication Intervals with Grease lubrication

At specific bearing loads below 100 N/mm² a grease lubricated DX bearing shows only small bedding-in wear of about 0.0025 mm. This is followed by little wear during the early part of the bearing life until the lubricant becomes exhausted and the wear rate increases. If the bearing is regreased before the rate of wear starts to increase rapidly the material will continue to function satisfactorily with little wear. Fig. 8 shows the typical wear pattern.

Under specific loads above 100 N/mm² the initial bedding-in wear is greater, typically about 0.025 mm, followed by a decreasing wear rate until the bearing exhibits a similar wear/life relationship to that shown in Fig. 8.

The useful life of the bearing is limited by wear in the loaded area. If this wear exceeds 0.15 mm the grease capacity of the indents is reduced and more frequent regreasing of the bearing will be required.

Fretting Wear

Oscillating movements of less than the dimensions of the indent pattern may cause localised wear of the mating surface after prolonged usage. This will result in the indent pattern becoming transferred onto the mating surface in contact with the DX bearing and may also give rise to fretting corrosion damage. In this situation DS^{TM} material should be considered as an alternative to DX.

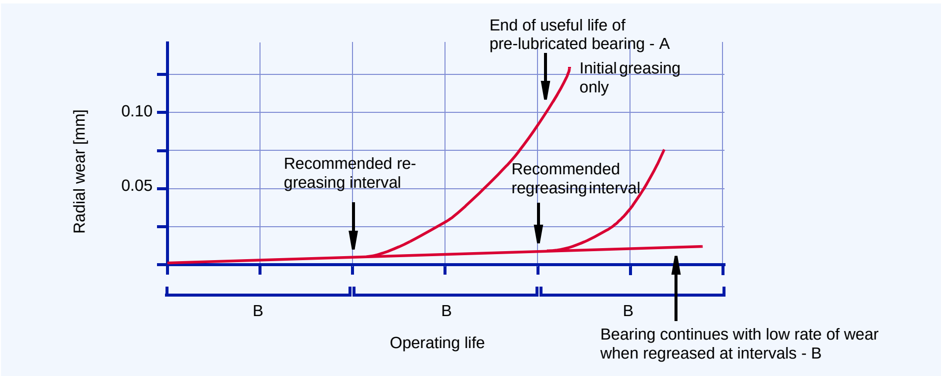


Fig. 8: Typical wear of DX

5 Design Factors

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

- Specific Load Limit $\bar{p}_{lim}$ [N/mm²]
- $\bar{p}U$ Factor [N/mm² x m/s]
- Mating surface roughness R_a [µm]
- Mating surface material
- Temperature T [°C]
- Other environmental factors eg. housing design, dirt, lubrication.

5.1 Specific Load

The specific load $\bar{p}$ is defined as the working load divided by the projected area of the bearing and is expressed in N/mm².

Bushes

(5.1.1) [N/mm²]

$$\bar{p} = \frac{F}{D_i \cdot B}$$

Thrust Washers

(5.1.2) [N/mm²]

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

Slide Plates

(5.1.3) [N/mm²]

$$\bar{p} = \frac{F}{L \cdot W}$$

Specific Load Limit

The maximum load which can be applied to a DX bearing can be expressed in terms of the Specific Load Limit, which depends on the type of the loading and lubrication It is highest under steady loads. The values of Specific Load Limit specified in Table 5 assume good alignment between the bearing and mating surface.

The Specific Load Limit for DX reduces for bearing operating temperatures in excess of 40 °C, falling to about half the values given in Table 5 for temperatures above 100 °C.

Conditions of dynamic load or oscillating movement which produce fatigue stress in the bearing result in a reduction in the permissible Specific Load Limit (Fig. 9, Page 14).

Load	Operating condition	Lubrication	$\bar{p}_{lim}$
Steady	Intermittent or very slow (below 0.01 m/s) continuous rotation or oscillating motion	Grease or oil	140
Steady	Continuous rotation or oscillating motion	Grease or oil (boundary lubrication)	70
Steady or dynamic	Continuous rotation or oscillating motion	Oil (hydrodynamic lubrication)	45

Table 5: Specific load limit $\bar{p}_{lim}$ for DX

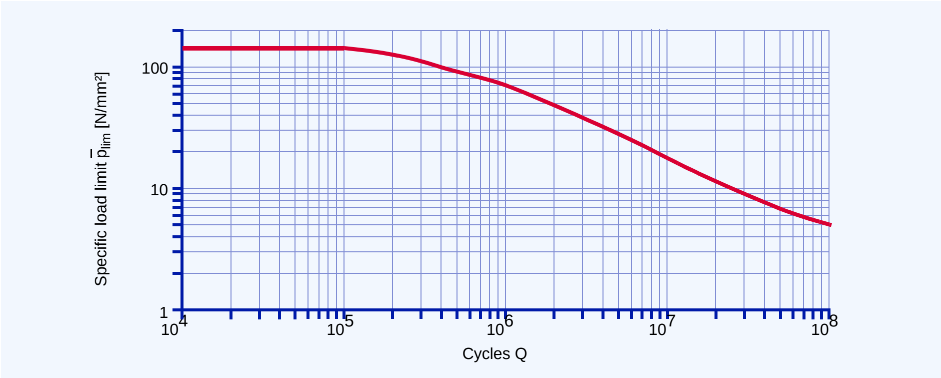


Fig. 9: DX specific load limits $\bar{p}_{lim}$ under dynamic loads or oscillating conditions

5.2 Sliding Speed

The sliding speed U [m/s] is calculated as follows:

Continuous Rotation

Bushes

(5.2.1) [N/mm²]

$$U = \frac{D_i \cdot \pi \cdot N}{60 \cdot 10^3}$$

Thrust Washers

(5.2.2) [N/mm²]

$$U = \frac{\frac{D_o + D_i}{2} \cdot \pi \cdot N}{60 \cdot 10^3}$$

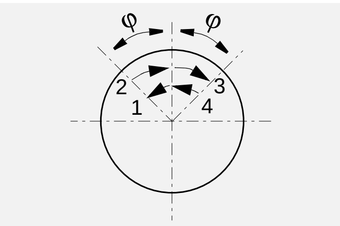


Fig. 10: Oscillating cycle φ

Oscillating Movement

Bushes

(5.2.3) [N/mm²]

$$U = \frac{D_i \cdot \pi}{60 \cdot 10^3} \cdot \frac{4\varphi \cdot N_{osz}}{360}$$

Thrust Washers

(5.2.4) [N/mm²]

$$U = \frac{\frac{D_o + D_i}{2} \cdot \pi}{60 \cdot 10^3} \cdot \frac{4\varphi \cdot N_{osz}}{360}$$

The maximum permissible effective $\bar{p}U$ factor (e$\bar{p}$U factor) for grease lubricated DX bearings is dependent upon the sliding speed as shown in Fig. 11. For sliding speeds in excess of 2.5 m/s continuous oil lubrication is recommended.

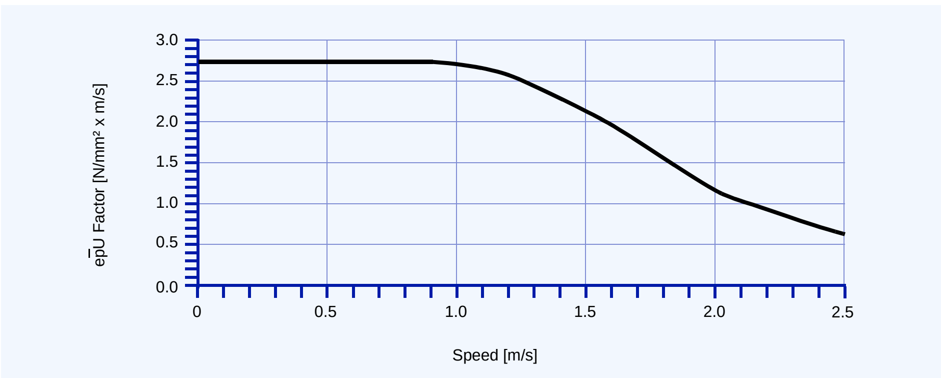


Fig. 11: Maximum e$\bar{p}$U factor for grease lubrication

5.3 $\overline{p}U$ Factor

The useful operating life of a DX bearing is governed by the $\overline{p}U$ factor, which is calculated as follows:

(5.3.1) [N/mm² x m/s]

$$\overline{p}U = \overline{p} \cdot U$$

5.4 Load

In addition to its contribution to the $\overline{p}U$ factor the type and direction of the applied load also affects the performance of a DX bearing. This is accomodated in the calculation of the bearing service life by the speed/load application factor a_Q shown in Figs. 15-17.

Type of Load

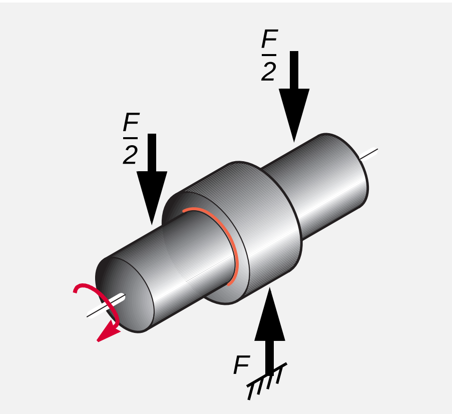


Fig. 12: Steady load, vertically downwards, bush stationary, shaft rotating. Lubricant drains to loaded area

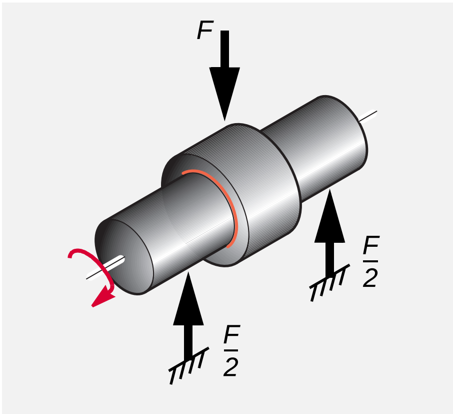


Fig. 13: Steady load, vertically upwards, bush stationary, shaft rotating. Lubricant drains away from loaded area

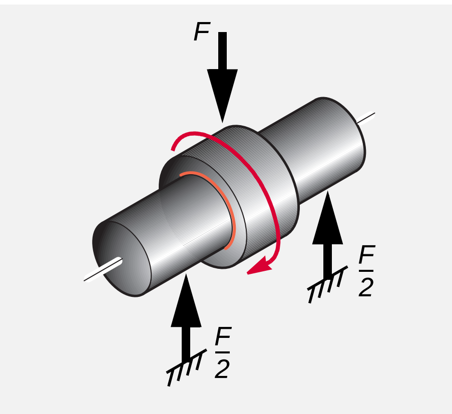


Fig. 14: Rotating load, shaft stationary, bush rotating

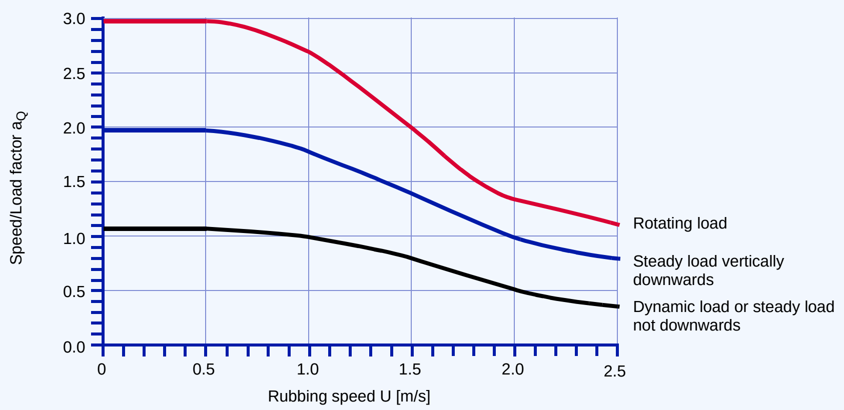


Fig. 15: Speed/Load factor a_Q for MB range bushes - unmachined

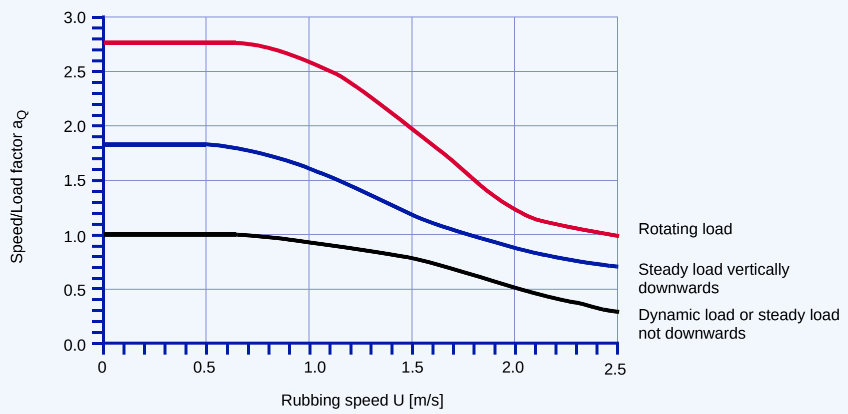


Fig. 16: Speed/Load factor a_Q for PM range and MB range bushes - machined

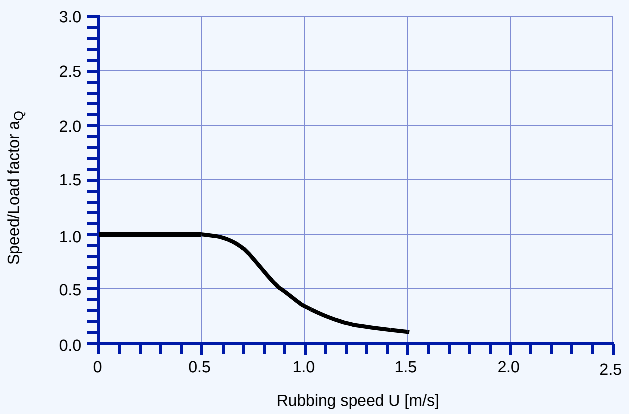


Fig. 17: Speed/Load factor a_Q for thrust washers

Note: a_Q = 1 for slideways

5.5 Temperature

The useful life of a DX bearing depends upon the operating temperature. The performance of grease lubricated DX decreases at bearing temperatures above 40 °C. This loss of performance is related to both material and lubricant effects.

For a given $\bar{p}U$ Factor the operating temperature of the bearing depends upon the temperature of the surrounding environment and the heat dissipation properties of the housing.

In calculating the service life of DX these effects are accomodated by the application factor a_T shown in Fig. 18.

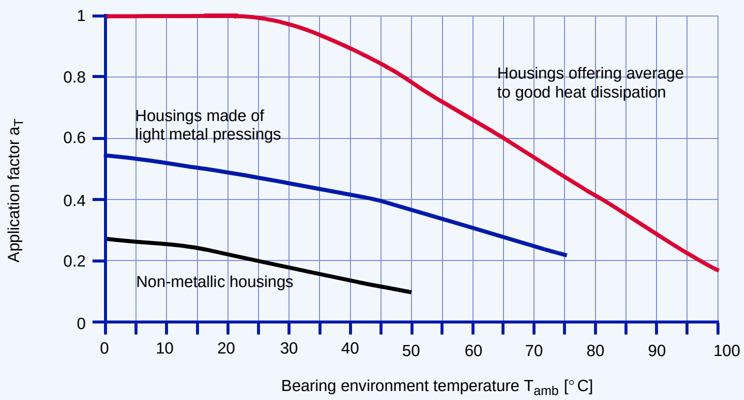


Fig. 18: DX application factor a_T

5.6 Mating Surface

The wear rate of DX is strongly dependent upon the roughness of the mating counterface. For optimum bearing performance the mating surface should be ground to better than 0.4 µm R_a. This effect is accomodated by the mating surface finish application factor a_S shown in Fig. 19.

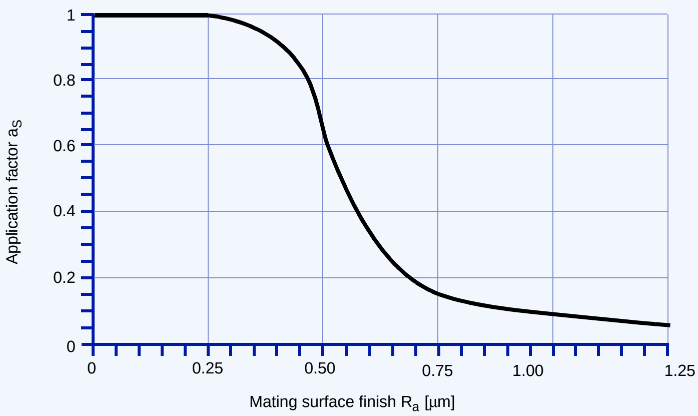


Fig. 19: DX application factor a_S

5.7 Bearing Size

Frictional heat generated at the bearing surface and dissipated through the shaft and housing depends both on the operating conditions (i.e. $\bar{p}U$ factor) and the bearing size.

For a give $\bar{p}U$ condition a large bearing will run hotter than a smaller bearing. The bearing size factor a_B shown in Fig. 20 takes account of this effect.

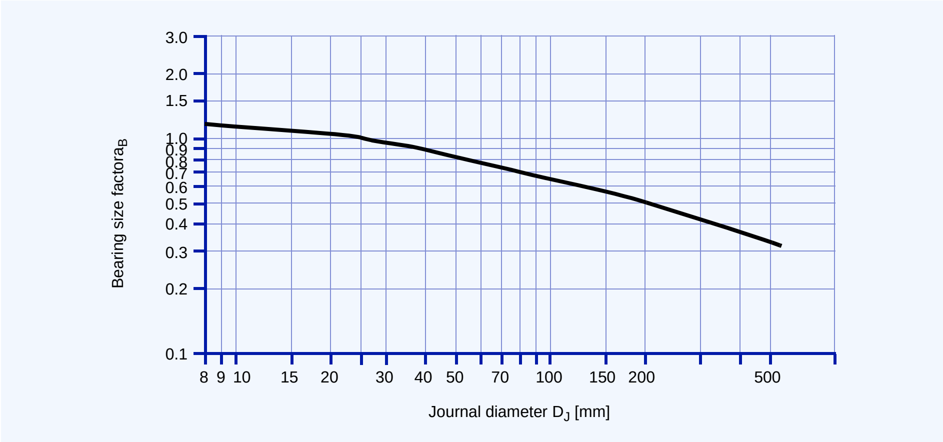


Fig. 20: Bearing size factor a_B

Note: a_B = 1 for slideways

5.8 Estimation of Bearing Service Life with Grease Lubrication

Calculation Parameters

Bushes		Thrust Washers		Slide Plates		Unit
Bearing diameter	D_i	Bearing outside diameter	D_o	Strip Length	L	[mm]
Bearing width	B	Bearing inside diameter	D_i	Strip Width	W	[mm]

Operating Conditions

Load	F	[N]
Rotational Speed (Continuous)	N	[1/min]
Oscillating Frequency	N_{osz}	[1/min]
Angular movement about mean position	φ	[°]
Specific Load Limit	see Table 5, Page 13	[N/mm²]
Application Factor a_Q	see Fig. 15-17, Page 16	[-]
Application Factor a_T	see Fig. 18, Page 17	[-]
Application Factor a_S	see Fig. 19, Page 17	[-]
Bearing Size Factor a_B	see Fig. 20, Page 18	[-]

Calculate $\bar{p}$ from the equations in 5.1 on Page 13.
Calculate U from the equations in 5.2 on Page 14.
Calculate $\bar{p}U$ from the equation in 5.3 on Page 15.

Calculate High Load Factor a_E

(5.8.1) [–]

$$a_E = \frac{\bar{p}_{lim}}{\bar{p}_{lim} - \bar{p}}$$

$\bar{p}$lim see Table 5, Page 13

Note:

If a_E >10000, or a_E <0, the bearing is overloaded.

Calculate Effective $\bar{p}U$ Factor $e\bar{p}U$

(5.8.2) [–]

$$e\bar{p}U = \frac{a_E \cdot \bar{p}U}{a_B}$$

Note:

Check that $e\bar{p}U$ is less than the limit for the sliding speed U set in Fig. 11. If NOT, increase the bearing length or use continuous lubrication.

Estimate Bearing Life

If $e\bar{p}U$ < 1.0 then

(5.8.3) [h]

$$L_H = \frac{3000}{e\bar{p}U} \cdot a_Q \cdot a_T \cdot a_S$$

If $e\bar{p}U$ > 1.0 then

(5.8.4) [h]

$$L_H = \frac{3000}{(e\bar{p}U)^{2,4}} \cdot a_Q \cdot a_T \cdot a_S$$

Estimate Re-greasing Interval

(5.8.5) [h]

$$L_{RG} = \frac{L_H}{2}$$

Oscillating Motion and Dynamic Loads

Oscillating Motion

Calculate number of cycles

(5.8.6) [–]

$$Z_T = L_{RG} \cdot N_{osz} \cdot 60 \cdot (R+2)$$

where R = Number of times bearing is regreased during total life required.

Check that Z_T (or C_T) is less than the total number of cycles Q given in Fig. 9 for actual bearing specific load $\bar{p}$.

If Z_T (or C_T) > Q then life will be limited by fatigue after Q cycles.

Dynamic Loads

Calculate number of cycles

(5.8.7) [–]

$$C_T = L_{RG} \cdot C \cdot 60 \cdot (R+2)$$

If Z_T (or C_T) < Q then life will be limited by wear after Z_T cycles.

If the estimated life or total cycles are insufficient or the regreasing intervals are too frequent, increase the bearing length or diameter, or consider drip feed or continuous oil lubrication, the quantity to be established by test.

5.9 Worked Examples

PM cylindrical Bush

Given			
Load Details	Steady Load	Inside Diameter D_i	40 mm
	Direction: down	Length B	30 mm
Shaft	Steel	Bearing Load F	15000 N
	ambient Temperature	Rotational Speed N	30 1/min
	good heat conditions	R_a	0.3 µm

Calculation Constants and Application Factors		
Specific Load Limit $\bar{p}_{lim}$	70 N/mm²	(Table 5, Page 13)
Application Factor a_T	1.0	(Fig. 18, Page 17)
Mating Surface Application Factor a_S	0.98	(Fig. 19, Page 17)
Bearing Size Factor a_B for ø 40	0.98	(Fig. 20, Page 18)
Application Factor for PM bush a_Q	1.8	(Fig. 16, Page 16)

Calculation	Ref	Value
Specific Load $\bar{p}$ [N/mm²]	(5.1.1), page 13	$\bar{p} = \frac{F}{D_i \cdot B} = \frac{15000}{40 \cdot 30} = 12,5$
Sliding Speed U [m/s]	(5.2.1), page 14	$U = \frac{D_i \cdot \pi \cdot N}{60 \cdot 10^3} = \frac{40 \cdot \pi \cdot 30}{60000} = 0,063$
High Load Factor a_E [-] (must be >0)	(5.8.1), page 19	$a_E = \frac{\bar{p}_{lim}}{\bar{p}_{lim} - \bar{p}} = \frac{70}{70 - 12,5} = 1,22$
$e\bar{p}U$ Factor [-]	(5.8.3), page 19	$e\bar{p}U = \frac{a_E \cdot \bar{p}U}{a_B} = \frac{1,22 \cdot 12,5 \cdot 0,063}{0,98} = 0,98$
Life L_H [h] for $e\bar{p}U$<1	(5.8.3), page 19	$L_H = \frac{3000}{e\bar{p}U} \cdot a_Q \cdot a_T \cdot a_S = \frac{3000}{0,98} \cdot 1,8 \cdot 1,0 \cdot 0,98 = 5400$
L_{RG} [h]	(5.8.3), page 19	$L_{RG} = \frac{L_H}{2} = \frac{5400}{2} = 2700$

PM cylindrical Bush

Given			
Load Details	Steady Load	Inside Diameter D_i	90 mm
	Direction: up	Length B	60 mm
Shaft	Steel	Bearing Load F	45000 N
	Temperature 80° C	Rotational Speed N	20 1/min
	good heat conditions	R_a	0.3 µm

Calculation Constants and Application Factors		
Specific Load Limit $\bar{p}_{lim}$ at 80 °C	46.7 N/mm²	(Table 5, Page 13)
Application Factor a_T	0.4	(Fig. 18, Page 17)
Mating Surface Application Factor a_S	0.98	(Fig. 19, Page 17)
Bearing Size Factor a_B for ø 40	0.70	(Fig. 20, Page 18)
Application Factor for PM bush a_Q	1.0	(Fig. 16, Page 16)

Calculation	Ref	Value
Specific Load $\bar{p}$ [N/mm²]	(5.1.1), page 13	$\bar{p} = \frac{F}{D_i \cdot B} = \frac{45000}{90 \cdot 60} = 8,33$
Sliding Speed U [m/s]	(5.2.1), page 14	$U = \frac{D_i \cdot \pi \cdot N}{60 \cdot 10^3} = \frac{90 \cdot \pi \cdot 20}{60000} = 0,094$
High Load Factor a_E [-] (must be >0)	(5.8.1), page 19	$a_E = \frac{\bar{p}_{lim}}{\bar{p}_{lim} - \bar{p}} = \frac{46,7}{46,7 - 8,33} = 1,22$
$e\bar{p}U$ Factor [-]	(5.8.3), page 19	$e\bar{p}U = \frac{a_E \cdot \bar{p}U}{a_B} = \frac{1,22 \cdot 8,33 \cdot 0,094}{0,70} = 1,36$
Life L_H [h] for $e\bar{p}U$>1	(5.8.3), page 19	$L_H = \frac{3000}{(e\bar{p}U)^{2,4}} \cdot a_Q \cdot a_T \cdot a_S = \frac{3000}{1,36^{2,4}} \cdot 1,0 \cdot 0,4 \cdot 0,98 = 562$
L_{RG} [h]	(5.8.3), page 19	$L_{RG} = \frac{L_H}{2} = \frac{562}{2} = 281$

Thrust washer

Given			
Load Details	Steady Load	Inside Diameter D_i	26 mm
	Direction: down	Outside Diameter D_o	44 mm
Shaft	Steel	Bearing Load F	10000 N
	ambient Temperature	Rotational Speed N	10 1/min
	good heat conditions	R_a	0.3 µm

Calculation Constants and Application Factors		
Specific Load Limit $\bar{p}_{lim}$	70 N/mm²	(Table 5, Page 13)
Application Factor a_T	1.0	(Fig. 18, Page 17)
Mating Surface Application Factor a_S	0.98	(Fig. 19, Page 17)
Bearing Size Factor a_B for ø 35	0.90	(Fig. 20, Page 18)
Application Factor for Thrust washers a_Q	1.0	(Fig. 17, Page 16)

Calculation	Ref	Value
Specific Load $\bar{p}$ [N/mm²]	(5.1.2), page 13	$\bar{p} = \frac{4 \cdot F}{\pi \cdot (D_o^2 - D_i^2)} = \frac{4 \cdot 10000}{\pi \cdot (44^2 - 26^2)} = 10,11$
Sliding Speed U [m/s]	(5.2.2), page 14	$U = \frac{\frac{D_o + D_i}{2} \cdot \pi \cdot N}{60 \cdot 10^3} = \frac{\frac{44+26}{2} \cdot \pi \cdot 10}{60 \cdot 10^3} = 0,018$
High Load Factor a_E [-] (must be >0)	(5.8.1), page 19	$a_E = \frac{\bar{p}_{lim}}{\bar{p}_{lim} - \bar{p}} = \frac{70}{70 - 10,11} = 1,169$
$e\bar{p}U$ Factor [-]	(5.8.2), page 19	$e\bar{p}U = \frac{a_E \cdot \bar{p}U}{a_B} = \frac{1,169 \cdot 10,11 \cdot 0,018}{0,90} = 0,236$
Life L_H [h] for $e\bar{p}U$<1	(5.8.3), page 19	$L_H = \frac{3000}{e\bar{p}U} \cdot a_Q \cdot a_T \cdot a_S = \frac{3000}{0,236} \cdot 1,0 \cdot 1,0 \cdot 0,98 = 12460$
L_{RG} [h]	(5.8.3), page 19	$L_{RG} = \frac{L_H}{2} = \frac{12460}{2} = 6230$

Slideways

Given			
Load Details	Steady Load	Length L	50 mm
	Direction: down	Width W	20 mm
Mating Surface	Steel (R_a = 0.3 µm)	Bearing Load F	20000 N
	Temperature 80° C	Stroke	15 mm
	good heat conditions	Frequency	10 1/min

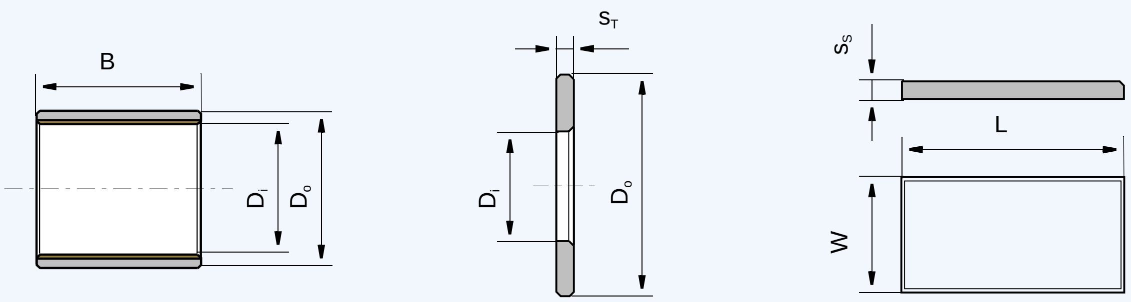
Calculation Constants and Application Factors		
Specific Load Limit $\bar{p}_{lim}$ at 80 °C	93 N/mm²	(Table 5, Page 13)
Application Factor a_T	0.4	(Fig. 18, Page 17)
Mating Surface Application Factor a_S	0.98	(Fig. 19, Page 17)
Bearing Size Factor a_B	1.0	(Fig. 20, Page 18)
Application Factor for Slideways a_Q	1.0	(Fig. 17, Page 16)

Calculation	Ref	Value
Specific Load $\bar{p}$ [N/mm²]	(5.1.3), page 13	$\bar{p} = \frac{F}{L \cdot W} = \frac{20000}{50 \cdot 20} = 20$
Sliding Speed U [m/s]		$U = \frac{15 \cdot 2 \cdot 10}{60 \cdot 10^3} = 0,005$
High Load Factor a_E [-] (must be >0)	(5.8.1), page 19	$a_E = \frac{\bar{p}_{lim}}{\bar{p}_{lim} - \bar{p}} = \frac{93}{93 - 20} = 1,27$
$e\bar{p}U$ Factor [-]	(5.8.2), page 19	$e\bar{p}U = \frac{a_E \cdot \bar{p}U}{a_B} = \frac{1,27 \cdot 20 \cdot 0,005}{1,0} = 0,127$
Life L_H [h] for $e\bar{p}U$<1	(5.8.3), page 19	$L_H = \frac{3000}{e\bar{p}U} \cdot a_Q \cdot a_T \cdot a_S = \frac{3000}{0,127} \cdot 1,0 \cdot 0,4 \cdot 0,98 = 9260$
L_{RG} [h]	(5.8.3), page 19	$L_{RG} = \frac{L_H}{2} = \frac{9260}{2} = 4630$

6 Data Sheet

Application: ____________________

6.1 Data for bearing design calculations



☐ Cylindrical Bush ☐ Thrust Washer ☐ Slideplate ☐ Special (Sketch)

☐ Rotational movement ☐ Steady load ☐ Rotating load ☐ Oscillating movement ☐ Linear movement

☐ Existing Design ☐ New Design

Quantity ______

Dimensions in mm

Inside Diameter	D_i	
Outside Diameter	D_o	
Width	B	
Length of slideplate	L	
Width of slideplate	W	
Thickness of slideplate	s_S	

Load

Radial load	F [N]	
or specific load	$\bar{p}$ [N/mm²]	
Axial load	F [N]	
or specific load	$\bar{p}$ [N/mm²]	

Movement

Rotational speed	N [1/min]	
Speed	U [m/s]	
Length of Stroke	L_S [mm]	
Frequency of Stroke	[1/min]	
Oscillating cycle	φ [°]	
Oscillating frequency	N_{osz} [1/min]	

Service hours per day

Continuous operation	
Intermittent operation	
Operating time	
Days per year	

Fits and Tolerances

Shaft	D_J	
Bearing Housing	D_H	

Operating Environment

Ambient temperature	T_{amb} [°]	

Housing with good heat 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 ☐

Mating surface

Material		
Hardness	HB/HRC	
Surface finish	R_a [µm]	

Lubrication

Dry ☐

Continuous lubrication ☐

Process fluid lubrication ☐

Initial lubrication only ☐

Hydrodynamic conditions ☐

Process Fluid		
Lubricant		
Dynamic viscosity	η	

Service life

Required service life	L_H [h]	

Customer Data
Company: City:
Street: Post Code:

Project:
Name:
Tel.:

Date:
Signature:
Fax:

7 Bearing Assembly

7.1 Dimensions and Tolerances

For optimum performance 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.

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.

7.2 Tolerances for minimum clearance

Grease lubrication

The minimum clearance required for satisfactory performance of DX depends upon the $\bar{p}U$ factor, the sliding speed and the environmental temperature, any one or combination of which may reduce the diametral clearance in operation due to inward thermal expansion of the DX polymer lining. It is therefore necessary to compensate for this.

Fig. 21 shows the minimum diametral clearance plotted stepped against journal diameter at an ambient 20 °C. Where the stepped lines show a change of clearance for a given journal diameter, the lower value is used.

The superimposed straight lines indicate the minimum permissible diametral clearance for various values of $\bar{p}Uu$ (Fig. 21), where $\bar{p}U$ is calculated as in 5.3 on Page 15, and u is a sliding speed factor for speeds in excess of 0.5 m/s given in Fig. 22.

If the clearance indicated for a $\bar{p}Uu$ factor lies below the stepped lines the recommended standard shaft may be used. If above, the shaft size must be reduced to obtain the clearance indicated on the vertical axis of the relevant figure.

Under slow speed and high load conditions it may be possible to achieve satisfactory performance with diametral clearances less than those indicated. But adequate prototype testing is recommended in such cases.

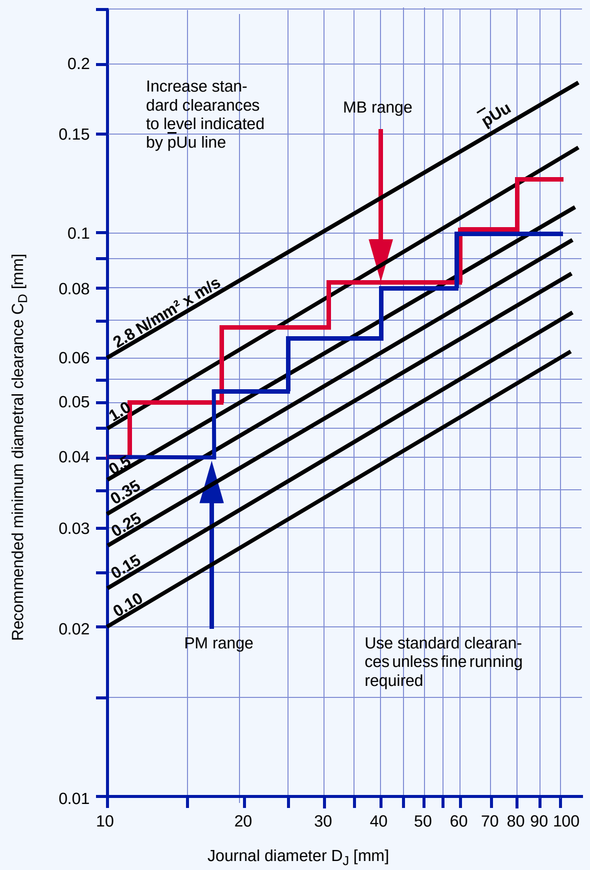


Fig. 21: Minimum clearance for PM prefinished and MB machinable metric range machined to H7 bore

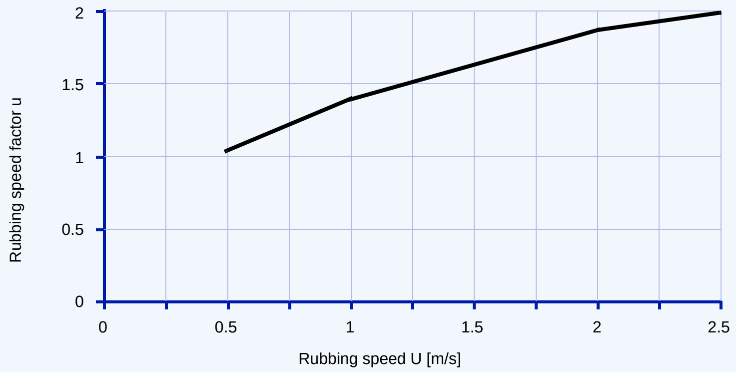


Fig. 22: Rubbing speed factor u

Fluid Lubrication

The minimum clearance required for journal bearings operating under hydrodynamic or mixed film conditions for a range of shaft rotational speeds and diameters is shown in Fig. 23 It is recommended that the bearing performance under minimum clearance conditions be confirmed by testing if possible.

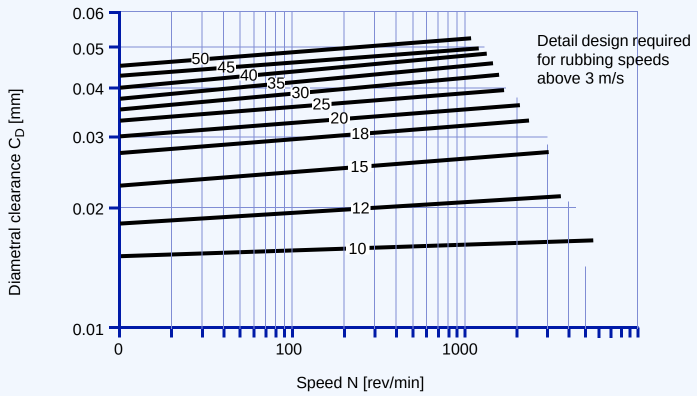


Fig. 23: DX minimum clearances - bush diameters D_i 10-50 mm

Allowance for Thermal Expansion

For operation in high temperature environments the clearance should be increased by the amounts indicated by Fig. 24 to compensate for the inward thermal expansion of the bearing lining.

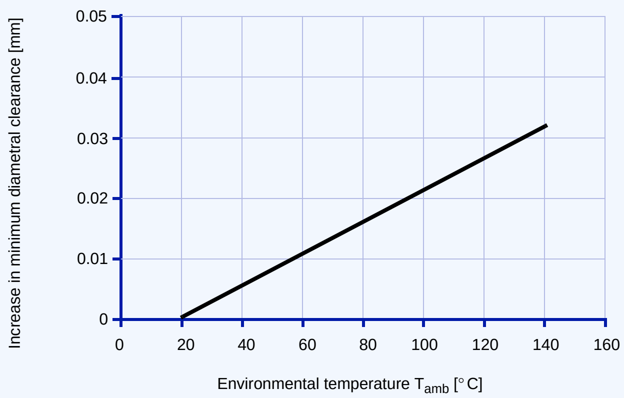


Fig. 24: Recommended increase in diametral clearance

If the housing is non-ferrous then the bore should be reduced by the amounts given in Table 6, in order to give an increased interference fit to the bush, with a similar reduction in the journal diameter additional to that indicated by Fig. 24.

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. 24
Copper base alloys	0.05%	0.05% + values from Fig. 24
Steel and cast iron	Nil	values from Fig. 24
Zinc base alloys	0.15%	0.15% + values from Fig. 24

Table 6: Allowance for high temperature

7.3 Counterface Design

DX bearings may be used with all conventional mating surface materials. Hardening of steel journals is not required unless abrasive dirt is present or if the projected bearing life is in excess of 2000 hours, in which cases a minimum shaft hardness of 350 HB is recommended.

A ground surface finish of better than 0.4μm R_a is recommended. The final direction of machining of the mating surface should preferably be the same as the direction of motion relative to the bearing in service.

DX is normally used in conjunction with ferrous journals and thrust faces, but in damp or corrosive surroundings stainless steel or hard chromium plated mild steel, alternatively WH shaft sleeves (Standard programm available) are 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 DX 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 polymer lining of the DX must be removed.

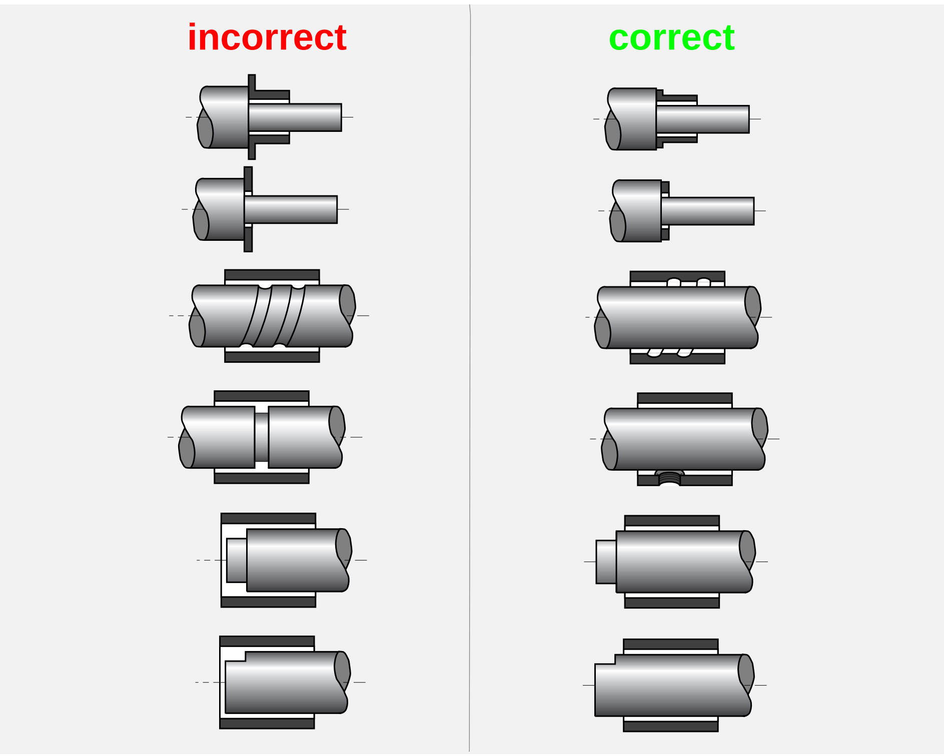


Fig. 25: Counterface design

7.4 Installation

Important Note

Care must be taken to ensure that the DX lining material is not damaged during the installation.

Fitting of Bushes

The bush is inserted into its housing with the aid of a stepped mandrel, preferably made from case hardened mild steel, as shown in Fig. 26. The following should be noted to avoid damage to the bearing:

- Housing diameter is as recommended
- 15-30° lead-in chamfer on housing
- edges of lead-in chamfer are deburred
- The bush must be square to the housing
- Light smear of oil on bush OD

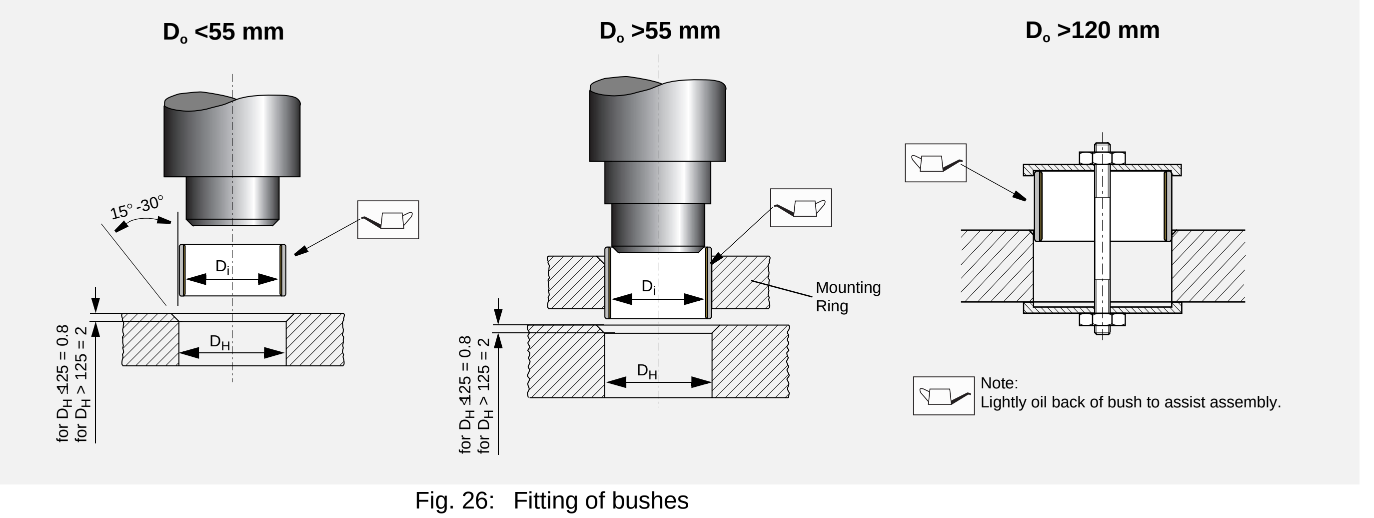


Fig. 26: Fitting of bushes

Insertion Forces

Fig. 27 gives an indication of the maximum insertion force required to correctly install standard DX bushes.

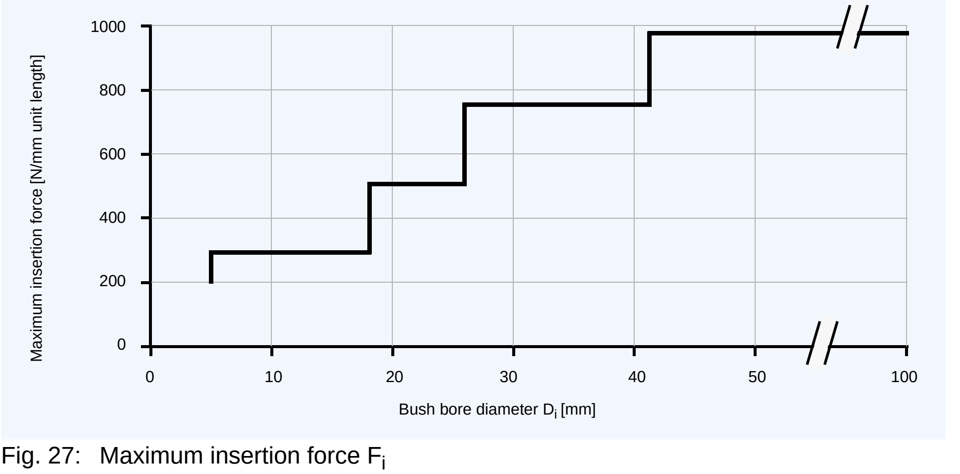


Fig. 27: Maximum insertion force F_i

Alignment

Accurate alignment is an important consideration for all bearing assemblies. With DX 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. 28.

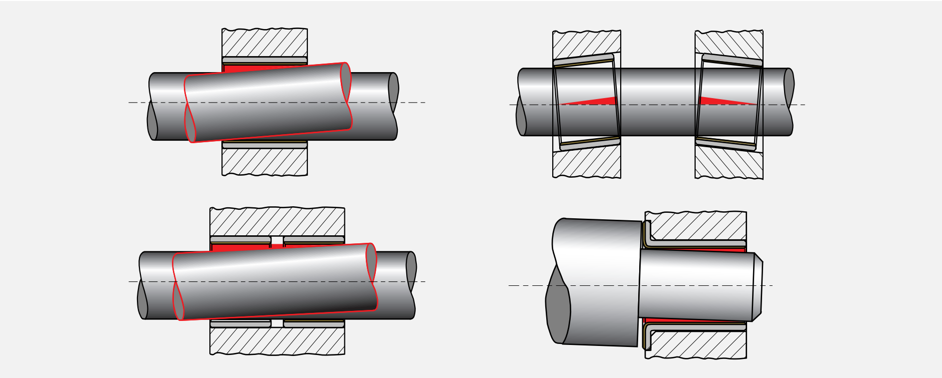


Fig. 28: Alignment

Sealing

While DX 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. 29 should be provided.

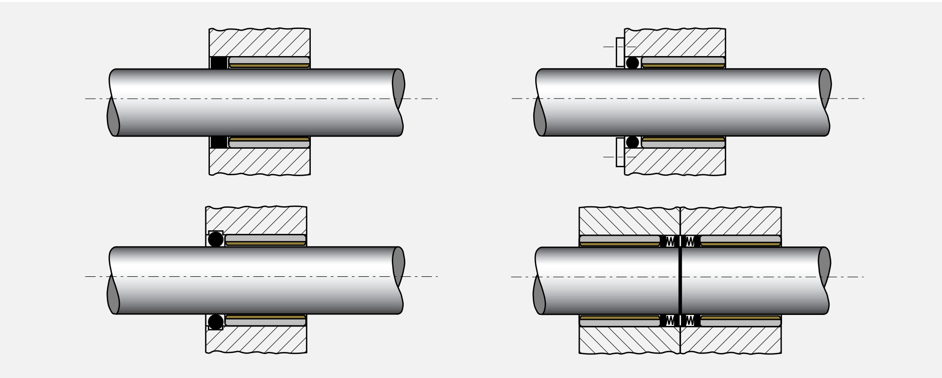


Fig. 29: Recommended sealing arrangements

Axial Location

Where axial location is necessary, it is generally advisable to fit DX thrust washers in conjunction with DX bushes, even when the axial loads are low. Experience has shown that fretting debris from unsatisfactory locating surfaces can enter an adjacent DX bush and adversely affect the bearing life and performance.

Fitting of Thrust Washers

DX thrust washers should be located on the outside diameter in a recess as shown in Fig. 30. The inside diameter must be clear of the shaft in order to prevent contact with the steel backing of the DX material. The recess diameter should be 0.125 mm larger than the washer diameter and the depth as given in the product tables.

If there is no recess for the thrust washer one of the following methods of fixing may be used:

- two dowel pins
- two screws
- adhesive.

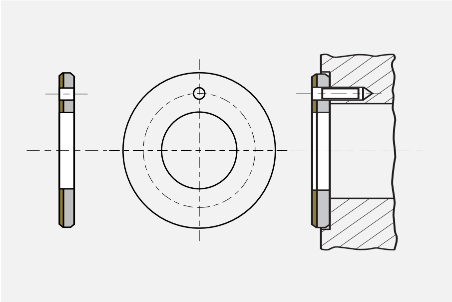


Fig. 30: Installation of Thrust-Washer

Important Note

- Dowel pins should be recessed 0.25 mm below the bearing surface
- Screws should be countersunk 0.25 mm below the bearing surface
- DX must not be heated above 130 °C
- Contact adhesive manufacturers for guidance on the selection of suitable adhesives
- Protect the bearing surface to prevent contact with adhesive
- Ensure the washer ID does not touch the shaft after assembly
- Ensure that the washer is mounted with the steel backing to the housing.

Slideways

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

- countersunk screws
- adhesives
- mechanical location.

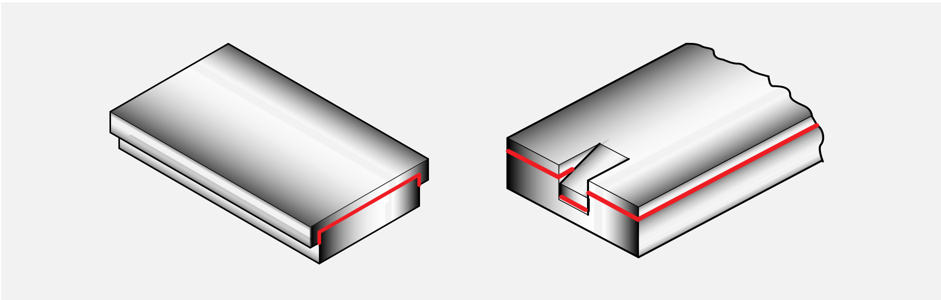


Fig. 31: Mechanical location of DX slideways

8 Machining

8.1 Machining Practice

The acetal copolymer lining of DX has good machining characteristics and can be treated as a free cutting brass in most respects. The indents in the bearing surface may lead to the formation of burrs or whiskers due to the resilience of the lining material, but this can be avoided by using machining methods which remove the lining as a ribbon, rather than a narrow thread.

When machining DX it is recommended that not more than 0.125 mm is removed from the lining thickness in order to ensure that the lubricant capacity of the indents remaining after machining is not significantly reduced.

Boring, reaming and broaching are all suitable machining methods for use with DX. The recommended tool material is high speed steel or tungsten carbide.

8.2 Boring

Fig. 32 illustrates a recommended boring tool which should be mounted with its axis at right angles to the direction of feed.

The essential characteristic required in the boring tool is a tip radius greater than 1.5 mm, which combined with a side rake of 30° will produce the ribbon effect required.

Cutting speeds should be high, the optimum between 2.0 and 4.5 m/s. The feed should be low, in the range 0.05/0.025 mm for cuts of 0.125 mm, the lower feeds being used with the higher cutting speeds.

Satisfactory finishes can usually be obtained machining dry and an air blast may facilitate swarfe removal. The use of coolant is not detrimental.

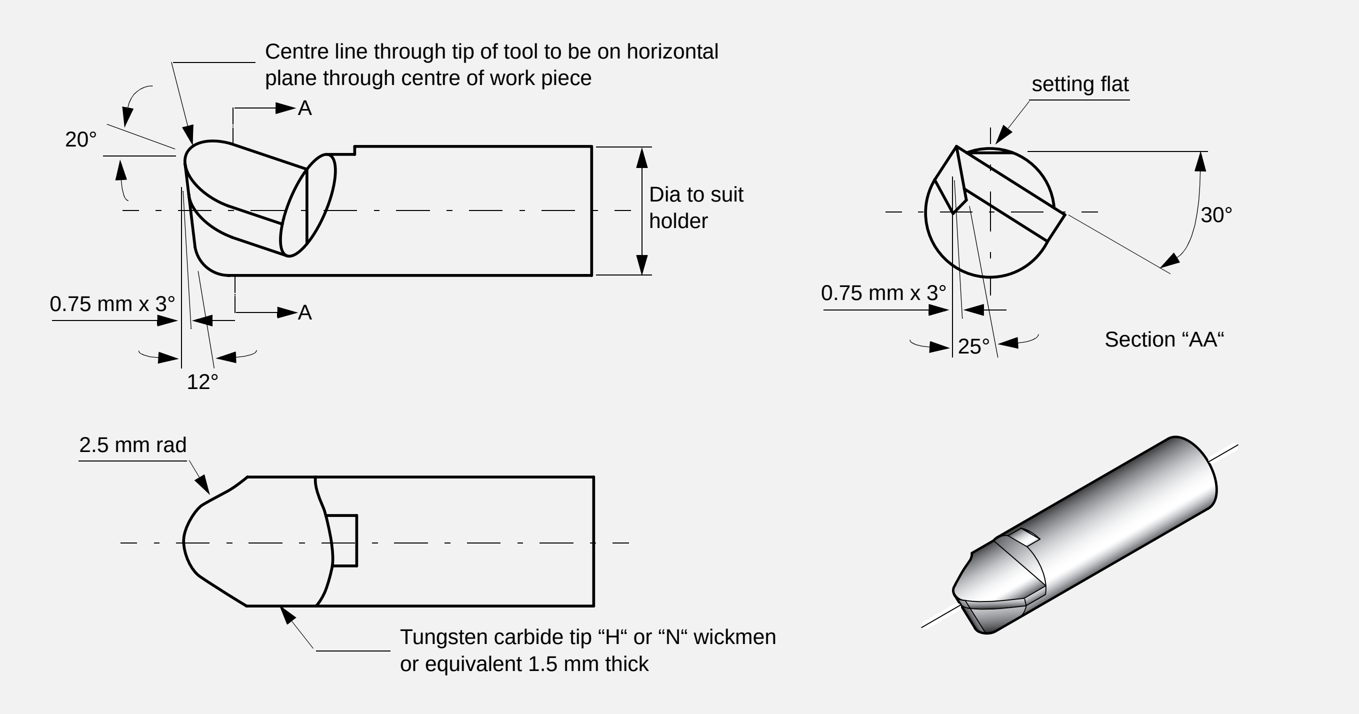


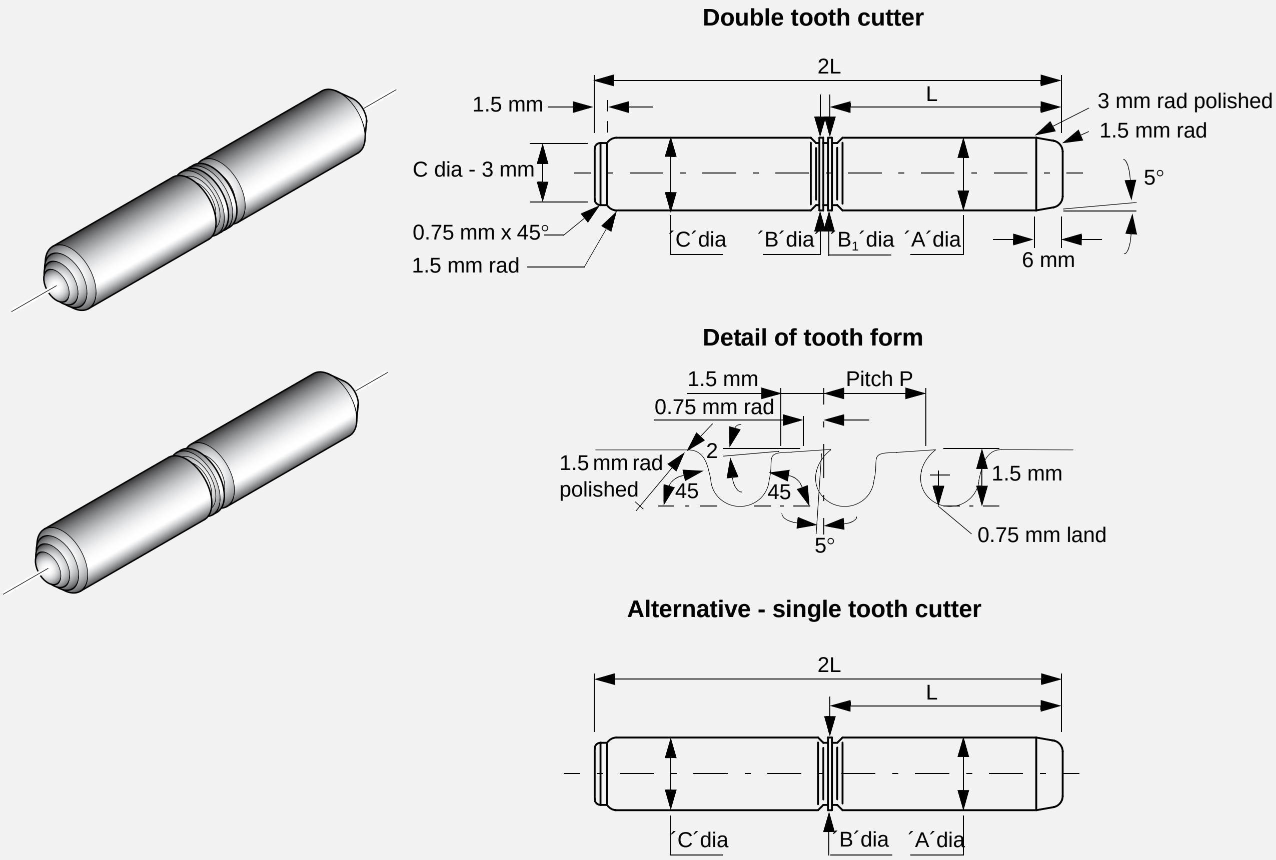
Fig. 32: Boring tool for DX

8.3 Reaming

MB-DX-bushes can be reamed satisfactorily by hand with a straight-fluted expanding reamer. For best results the reamer should be sharp, the cut 0.025-0.050 mm and the feed slow. Where hand reaming is not desired machining speeds of about 0.05 m/s are recommended with the cuts and feeds as for boring.

8.4 Broaching

Fig. 33 shows broaches suitable for finishing MB-DX-bushes up to 65 mm diameter. The broach should be used dry, at a speed of 0.1-0.5 m/s.



Bush Width		Pitch
B		P
Over	To	
10	13	3
13	20	4
20	30	5
30	50	5.5
50	70	6
70	95	7
95	130	8

Diameter		
´A´	Min. ass. bore	+0.013 +0.000
´B´	Nominal bore	+0.038 +0.025
´C´	Nominal bore	+0.015 +0.005
Min. ass. bore = $D_{o\ min}$ - 2 x $s_{3\ max}$		
Nominal bore = min. finished bore		
´B_1´*	Nominal bore	-0.065 -0.076

	Min. length of Pilot Guide L_{min}
Single bush	B + 6
2 or more bushes in line	B + 6 + bush spacing

* First tooth of double tooth cutter

Fig. 33: Suitable broaches for MB-DX

Use the single tooth version where the bush is less than 25 mm long, and the double tooth broach for longer bushes or for two or more bushes together.

If it is necessary to make up a special form of broach the following points should be noted:

- Adequate provision should be made for locating the bush by providing a pilot to suit the bore of the bush when pressed home. A rear support shoulder should locate in the broached bore of the bush after cutting. Alternatively, special guides may be provided external to the work-piece.
- If two bushes are to be broached in line, then the pilot guide and rear support should be longer than the distance between the two bushes.
- For large bushes it may be necessary to provide axial relief along the length of the pilot guide and rear support, in order to reduce the broaching forces.
- Unless a guided broach is used, the tool will follow the initial bore alignment of the bush, broaching cannot improve concentricity and parallelism unless external guides are used.

In general owing to the variation in wall thickness of large diameter bushes, broaching is not suitable for finishing bores of more than 60 mm diameter unless external guides are used.

8.5 Vibrobroaching

This technique may also be used. A single cutter is propelled with progressive reciprocating motion with a vibration frequency of typically 50 Hz. The cutter should have a primary rake of 1.5° for 0.5 mm. A cut of 0.25 mm on diameter may be made at an average cutting speed of 0.15 m/s to give a surface finish of better than 0.8 µm R_a, which is acceptable.

8.6 Modification of components

The modification of DX bearing components requires no special procedures. In general it is more satisfactory to perform machining or drilling operations from the polymer lining 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.

8.7 Drilling Oil Holes

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

8.8 Cutting Strip Material

DX 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

9 Electroplating

DX Components

To provide corrosion protection the mild steel backing of DX may be electroplated with most of the conventional electroplating metals including the following:

- zinc ISO 2081-2
- cadmium ISO 2081-2
- nickel ISO 1456-8
- hard chromium ISO 1456-8.

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.

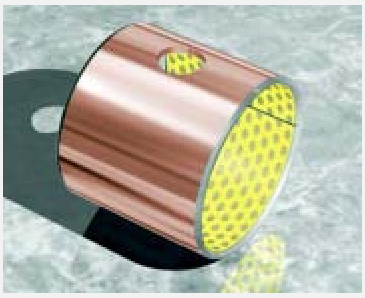
Where electrolytic attack is possible tests should be conducted to ensure that all the materials in the bearing environment are mutually compatible.

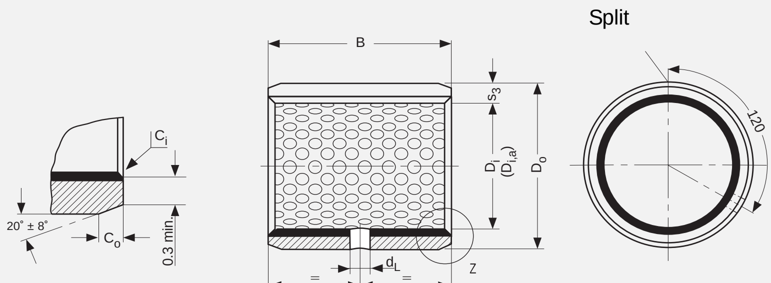
Mating Surfaces

DX can be used against hard chrome plated materials and care should be taken to ensure that the recommended shaft sizes and surface finish are achieved after the plating process.

10 Standard Products

10.1 PM-DX cylindrical bushes





Dimensions and tolerances follow ISO 3547 and GSP-Specifications

All dimensions in mm

Outside Co and Inside Ci chamfers

Wall thickness s_3	C_o (a) machined	C_o (a) rolled	C_i (b)
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_3	C_o (a) machined	C_o (a) rolled	C_i (b)
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_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 D_i	Nominal Diameter D_o	Wall thickness s_3 max. min.	Width B max. min.	Shaft-ø D_J [h8]	Shaft-ø D_J [h8] max. min.	Housing-ø D_H [H7]	Housing-ø D_H [H7] max. min.	Bush-ø $D_{i,a}$ Ass. in H7 housing max. min.	Clearance C_D max. min.	Oil hole-ø d_L
PM0808DX	8	10	0.980 0.955	8.25 7.75	h8	8.000 7.978	H7	10.015 10.000	8.105 8.040	0.127 0.040	No hole
PM0810DX				10.25 9.75							
PM0812DX				12.25 11.75							
PM1010DX	10	12		10.25 9.75		10.000 9.978		12.018 12.000	10.108 10.040	0.130 0.040	3
PM1012DX				12.25 11.75							4
PM1015DX				15.25 14.75							
PM1020DX				20.25 19.75							
PM1210DX	12	14		10.25 9.75		12.000 11.973		14.018 14.000	12.108 12.040	0.135 0.040	3
PM1212DX				12.25 11.75							4
PM1215DX				15.25 14.75							
PM1220DX				20.25 19.75							
PM1225DX				25.25 24.75							
PM1415DX	14	16		15.25 14.75		14.000 13.973		16.018 16.000	14.108 14.040		
PM1420DX				20.25 19.75							
PM1425DX				25.25 24.75							
PM1510DX	15	17		10.25 9.75		15.000 14.973		17.018 17.000	15.108 15.040		3
PM1512DX				12.25 11.75							4

Part No.	Nominal Diameter		Wall thickness s_3	Width B	Shaft-ø D_J [h8]		Housing-ø D_H [H7]		Bush-ø $D_{i,a}$ Ass. in H7 housing	Clearance C_D	Oil hole-ø d_L
	D_i	D_o	max. min.	max. min.	max. min.		max. min.		max. min.	max. min.	
PM1515DX	15	17	0.980 0.955	15.25 14.75	h8	15.000 14.973	H7	17.018 17.000	15.108 15.040	0.135 0.040	4
PM1520DX				20,25 19,75							
PM1525DX				25.25 24.75							
PM1615DX	16	18		15.25 14.75		16.000 15.973		18.018 18.000	16.108 16.040		
PM1620DX				20.25 19.75							
PM1625DX				25.25 24.75							
PM1815DX	18	20		15.25 14.75		18.000 17.973		20.021 20.000	18.111 18.040	0.138 0.040	
PM1820DX				20.25 19.75							
PM1825DX				25.25 24.75							
PM2010DX	20	23	1.475 1.445	10.25 9.75		20.000 19.967		23.021 23.000	20.131 20.050	0.164 0.050	
PM2015DX				15.25 14.75							
PM2020DX				20.25 19.75							
PM2025DX				25.25 24.75							
PM2030DX				30.25 29.75							
PM2215DX	22	25		15.25 14.75		22.000 21.967		25.021 25.000	22.131 22.050		6
PM2220DX				20.25 19.75							
PM2225DX				25.25 24.75							
PM2230DX				30.25 29.75							
PM2415DX	24	27		15.25 14.75		24.000 23.967		27.021 27.000	24.131 24.050		
PM2420DX				20.25 19.75							
PM2425DX				25.25 24.75							
PM2430DX				30.25 29.75							
PM2515DX	25	28		15.25 14.75		25.000 24.967		28.021 28.000	25.131 25.050		
PM2520DX				20.25 19.75							
PM2525DX				25.25 24.75							
PM2530DX				30.25 29.75							
PM283130DX	28	31		30.25 29.75		28.000 27.967		31.025 31.000	28.135 28.050	0.168 0.050	
PM2820DX		32	1.970 1.935	20.25 19.75				32.025 32.000	28.155 28.060	0.188 0.060	
PM2825DX				25.25 24.75							
PM2830DX				30.25 29.75							
PM3020DX	30	34		20.25 19.75		30.000 29.967		34.025 34.000	30.155 30.060		
PM3030DX				30.25 29.75							
PM3040DX				40.25 39.75							

Part No.	Nominal Diameter D_i	Nominal Diameter D_o	Wall thickness s_3 max. min.	Width B max. min.	Shaft-ø D_J [h8]	Shaft-ø D_J [h8] max. min.	Housing-ø D_H [H7]	Housing-ø D_H [H7] max. min.	Bush-ø $D_{i,a}$ Ass. in H7 housing max. min.	Clearance C_D max. min.	Oil hole-ø d_L
PM3220DX	32	36	1.970 1.935	20.25 19.75	h8	32.000 31.961	H7	36.025 36.000	32.155 32.060	0.194 0.060	6
PM3230DX				30.25 29.75							
PM3235DX				35.25 34.75							
PM3240DX				40.25 39.75							
PM3520DX	35	39		20.25 19.75		35.000 34.961		39.025 39.000	35.155 35.060		
PM3530DX				30.25 29.75							
PM3535DX				35.25 34.75							
PM3550DX				50.25 49.75							
PM3635DX	36	40		35.25 34.75		36.000 35.961		40.025 40.000	36.155 36.060		
PM3720DX	37	41		20.25 19.75		37.000 36.961		41.025 41.000	37.155 37.060		
PM4020DX	40	44		20.25 19.75		40.000 39.961		44.025 44.000	40.155 40.060		8
PM4030DX				30.25 29.75							
PM4040DX				40.25 39.75							
PM4050DX				50.25 49.75							
PM4520DX	45	50	2.460 2.415	20.25 19.75		45.000 44.961		50.025 50.000	45.195 45.080	0.234 0.080	
PM4530DX				30.25 29.75							
PM4540DX				40.25 39.75							
PM4545DX				45.25 44.75							
PM4550DX				50.25 49.75							
PM5040DX	50	55		40.25 39.75		50.000 49.961		55.030 55.000	50.200 50.080	0.239 0.080	
PM5045DX				45,25 44,75							
PM5050DX				50.25 49.75							
PM5060DX				60.25 59.75							
PM5520DX	55	60		20.25 19.75		55.000 54.954		60.030 60.000	55.200 55.080	0.246 0.080	
PM5525DX				25.25 24.75							
PM5530DX				30.25 29.75							
PM5540DX				40.25 39.75							
PM5550DX				50.25 49.75							
PM5560DX				60.25 59.75							
PM6030DX	60	65		30.25 29.75		60.000 59.954		65.030 65.000	60.200 60.080		
PM6040DX				40.25 39.75							
PM6060DX				60.25 59.75							
PM6070DX				70.25 69.75							

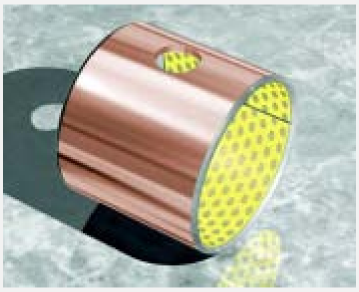
Part No.	Nominal Diameter D_i	Nominal Diameter D_o	Wall thickness s_3 max. min.	Width B max. min.	Shaft-ø D_J [h8]	Shaft-ø D_J [h8] max. min.	Housing-ø D_H [H7]	Housing-ø D_H [H7] max. min.	Bush-ø $D_{i,a}$ Ass. in H7 housing max. min.	Clearance C_D max. min.	Oil hole-ø d_L
PM6540DX	65	70	2.450 2.384	40.25 39.75	h8	65.000 64.954	H7	70.030 70.000	65.262 65.100	0.308 0.100	8
PM6550DX				50.25 49.75							
PM6560DX				60.25 59.75							
PM6570DX				70.25 69.75							
PM7040DX	70	75		40.25 39.75		70.000 69.954		75.030 75.000	70.262 70.100		
PM7050DX				50.25 49.75							
PM7060DX				60,25 59,75							
PM7065DX				65.25 64.75							
PM7070DX				70.25 69.75							
PM7080DX				80.25 79.75							
PM7540DX	75	80		40.25 39.75		75.000 74.954		80.030 80.000	75.262 75.100		9.5
PM7560DX				60.25 59.75							
PM7580DX				80.25 79.75							
PM8040DX	80	85		40.50 39.50		80.000 79.954		85.035 85.000	80.267 80.100	0.313 0.100	
PM8050DX				50,50 49,50							
PM8060DX				60.50 59.50							
PM8080DX				80.50 79.50							
PM80100DX				100.50 99.50							
PM8530DX	85	90		30.50 29.50		85.000 84.946		90.035 90.000	85.267 85.100	0.321 0.100	
PM8540DX				40.50 39.50							
PM8560DX				60.50 59.50							
PM8580DX				80.50 79.50							
PM85100DX				100.50 99.50							
PM9040DX	90	95		40.50 39.50		90.000 89.946		95.035 95.000	90.267 90.100		
PM9060DX				60.50 59.50							
PM9080DX				80.50 79.50							
PM9090DX				90.50 89.50							
PM90100DX				100.50 99.50							
PM9560DX	95	100		60.50 59.50		95.000 94.946		100.035 100.000	95.267 95.100		
PM95100DX				100.50 99.50							

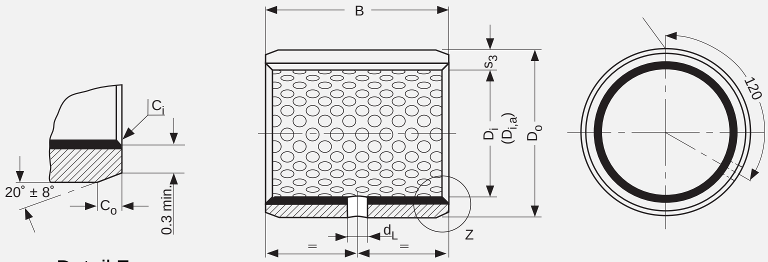
Part No.	Nominal Diameter		Wall thickness s_3	Width B	Shaft-ø D_J [h8]		Housing-ø D_H [H7]		Bush-ø $D_{i,a}$ Ass. in H7 housing	Clearance C_D	Oil hole-ø d_L
	D_i	D_o	max. min.	max. min.	max. min.		max. min.		max. min.	max. min.	
PM10050DX	100	105	2.450 2.384	50.50 49.50	h8	100.000 99.946	H7	105.035 105.000	100.267 100.100	0.321 0.100	9.5
PM10060DX				60.50 59.50							
PM10080DX				80.50 79.50							
PM10095DX				95.50 94.50							
PM100115DX				115.50 114.50							
PM10560DX	105	110		60.50 59.50		105.000 104.946		110.035 110.000	105.267 105.100		
PM105110DX				110.50 109.50							
PM105115DX				115.50 114.50							
PM11060DX	110	115		60.50 59.50		110.000 109.946		115.035 115.000	110.267 105.100		
PM110110DX				110.50 109.50							
PM110115DX				115.50 114.50							
PM11550DX	115	120		50.50 49.50		115.000 114.946		120.035 120.000	115.267 115.100		
PM11570DX				70.50 69.95							
PM12060DX	120	125	2.435 2.380	60.50 59.50		120.000 119.946		125.040 125.000	120.280 120.130	0.334 0.130	
PM120100DX				100.50 99.50							
PM120110DX				110.50 109.50							
PM12560DX	125	130		60.50 59.50		125.000 124.937		130.040 130.000	125.280 125.130	0.340 0.130	
PM125100DX				100.50 99.50							
PM125110DX				110.50 109.50							
PM13050DX	130	135		50.50 49.50		130.000 129.937		135.040 135.000	130.280 130.130		No hole
PM13060DX				60.50 59.50							
PM13080DX				80.50 79.50							
PM130100DX				100.50 99.50							
PM13560DX	135	140		60.50 59.50		135.000 134.937		140.040 140.000	135.280 135.130		
PM13580DX				80.50 79.50							
PM14050DX	140	145		50.50 49.50		140.000 139.937		145.040 145.000	140.280 140.130		
PM14060DX				60.50 59.50							
PM14080DX				80.50 79.50							
PM140100DX				100.50 99.50							
PM15050DX	150	155		50.50 49.50		150.000 149.937		155.040 155.000	150.280 150.130		
PM15060DX				60.50 59.50							
PM15080DX				80.50 79.50							
PM150100DX				100.50 99.50							

Part No.	Nominal Diameter D_i	Nominal Diameter D_o	Wall thickness s_3 max. min.	Width B max. min.	Shaft-ø D_J [h8]	Shaft-ø D_J [h8] max. min.	Housing-ø D_H [H7]	Housing-ø D_H [H7] max. min.	Bush-ø $D_{i,a}$ Ass. in H7 housing max. min.	Clearance C_D max. min.	Oil hole-ø d_L
PM16050DX	160	165	2.435 2.380	50.50 49.50	h8	160.000 159.937	H7	165.040 165.000	160.280 160.130	0.343 0.130	No hole
PM16060DX				60.50 59.50							
PM16080DX				80.50 79.50							
PM160100DX				100.50 99.50							
PM17050DX	170	175		50.50 49.50		170.000 169.937		175.040 175.000	170.280 170.130		
PM17060DX				60.50 59.50							
PM17080DX				80.50 79.50							
PM170100DX				100.50 99.50							
PM18050DX	180	185		50.50 49.50		180.000 179.937		185.046 185.000	180.286 180.130	0.349 0.130	
PM18060DX				60.50 59.50							
PM18080DX				80.50 79.50							
PM180100DX				100.50 99.50							
PM19050DX	190	195		50.50 49.50		190.000 189.928		195.046 195.000	190.286 190.130	0.358 0.130	
PM19060DX				60.50 59.50							
PM19080DX				80.50 79.50							
PM190100DX				100.50 99.50							
PM190120DX				120.50 19.50							
PM20050DX	200	205		50.50 49.50		200.000 199.928		205.046 205.000	200.286 200.130		
PM20060DX				60.50 59.50							
PM20080DX				80.50 79.50							
PM200100DX				100.50 99.50							
PM200120DX				120.50 119.50							
PM22050DX	220	225		50.50 49.50		220.000 219.928		225.046 225.000	220.286 220.130		
PM22060DX				60.50 59.50							
PM22080DX				80.50 79.50							
PM220100DX				100.50 99.50							
PM220120DX				120.50 119.50							
PM24050DX	240	245		50.50 49.50		240.000 239.928		245.046 245.000	240.286 240.130		
PM24060DX				60.50 59.50							
PM24080DX				80.50 79.50							
PM240100DX				100.50 99.50							
PM240120DX				120.50 119.50							

Part No.	Nominal Diameter D_i	Nominal Diameter D_o	Wall thickness s_3 max. min.	Width B max. min.	Shaft-ø D_J [h8]	Shaft-ø D_J [h8] max. min.	Housing-ø D_H [H7]	Housing-ø D_H [H7] max. min.	Bush-ø $D_{i,a}$ Ass. in H7 housing max. min.	Clearance C_D max. min.	Oil hole-ø d_L
PM25050DX	250	255	2.435 2.380	50.50 49.50	h8	250.000 249.928	H7	255.052 255.000	250.292 250.130	0.364 0.130	No hole
PM25060DX				60.50 59.50							
PM25080DX				80.50 79.50							
PM250100DX				100.50 99.50							
PM250120DX				120.50 119.50							
PM26050DX	260	265		50.50 49.50		260.000 259.919		265.052 265.000	260.292 260.130	0.373 0.130	
PM26060DX				60.50 59.50							
PM26080DX				80.50 79.50							
PM260100DX				100.50 99.50							
PM260120DX				120.50 119.50							
PM28050DX	280	285		50.50 49.50		280.000 279.919		285.052 285.000	280.292 280.130		
PM28060DX				60.50 59.50							
PM28080DX				80.50 79.50							
PM280100DX				100.50 99.50							
PM280120DX				120.50 119.50							
PM30050DX	300	305		50.50 49.50		300.000 299.919		305.052 305.000	300.292 300.130		
PM30060DX				60.50 59.50							
PM30080DX				80.50 79.50							
PM300100DX				100.50 99.50							
PM300120DX				120.50 119.50							

10.2 MB-DX cylindrical bushes





Detail Z

Split

Dimensions and tolerances follow ISO 3547 and GSP-Specifications

All dimensions in mm

Outside Co and Inside Ci chamfers

Wall thickness s_3	C_o (a)		C_i (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_3	C_o (a)		C_i (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_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

PartNo.	Nominal Diameter		Wall thickness s_3	Width B	Shaft-ø D_{Jm} [d8]		Housing-ø D_H [H7]		Bush-∅ $D_{i,a,m}$ Ass. in H7 housing	Clearance C_{Dm}	Oil hole-ø d_L
	D_i	D_o	max. min.	max. min.	max. min.		max. min.		max. min.	max. min.	
MB0808DX	8	10	1.108 1.082	8.25 7.75	d8	7.960 7.938	H7	10.015 10.000	8.015 8.000	0.077 0.040	No hole
MB0810DX				10.25 9.75							
MB0812DX				12.25 11.75							
MB1010DX	10	12		10.25 9.75		9.960 9.938		12.018 12.000	10.018 10.000	0.080 0.040	3
MB1012DX				12.25 11.75							4
MB1015DX				15.25 14.75							
MB1020DX				20.25 19.75							
MB1210DX	12	14		10.25 9.75		11.950 11.923		14.018 14.000	12.018 12.000	0.095 0.050	3
MB1212DX				12.25 11.75							4
MB1215DX				15.25 14.75							
MB1220DX				20.25 19.75							
MB1225DX				25.25 24.75							
MB1415DX	14	16		15.25 14.75		13.950 13.923		16.018 16.000	14.018 14.000		
MB1420DX				20.25 19.75							
MB1425DX				25.25 24.75							
MB1510DX	15	17		10.25 9.75		14.950 14.923		17.018 17.000	15.018 15.000		3
MB1512DX				12.25 11.75							4
MB1515DX				15.25 14.75							
MB1525DX				25.25 24.75							

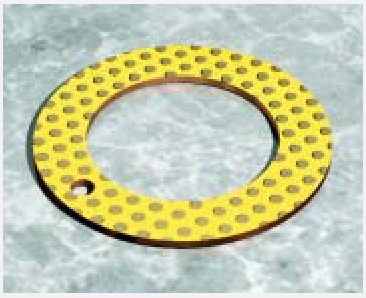
PartNo.	Nominal Diameter		Wall thickness s_3	Width B	Shaft-ø D_{Jm} [d8]		Housing-ø D_H [H7]		Bush-∅ $D_{i,a,m}$ Ass. in H7 housing	Clearance C_{Dm}	Oil hole-ø d_L
	D_i	D_o	max. min.	max. min.	max. min.		max. min.		max. min.	max. min.	
MB1615DX				15.25 14.75							
MB1620DX	16	18		20.25 19.75		15.950 15.923		18.018 18.000	16.018 16.000		
MB1625DX			1.108 1.082	25.25 24.75						0.095 0.050	
MB1815DX				15.25 14.75							
MB1820DX	18	20		20.25 19.75		17.950 17.923		20.021 20.000	18.018 18.000		
MB1825DX				25.25 24.75							4
MB2010DX				10.25 9.75							
MB2015DX				15.25 14.75							
MB2020DX	20	23		20.25 19.75		19.935 19.902		23.021 23.000	20.021 20.000		
MB2025DX				25.25 24.75							
MB2030DX				30.25 29.75							
MB2215DX				15.25 14.75							
MB2220DX	22	25		20.25 19.75		21.935 21.902		25.021 25.000	22.021 22.000		
MB2225DX				25.25 24.75							
MB2230DX			1.608 1.576	30.25 29.75	d8		H7				
MB2415DX				15.25 14.75							
MB2420DX	24	27		20.25 19.75		23.935 23.902		27.021 27.000	24.021 24.000		
MB2425DX				25.25 24.75						0.119 0.065	
MB2430DX				30.25 29.75							
MB2515DX				15.25 14.75							6
MB2520DX	25	28		20.25 19.75		24.935 24.902		28.021 28.000	25.021 25.000		
MB2525DX				25.25 24.75							
MB2530DX				30.25 29.75							
MB2820DX				20.25 19.75							
MB2825DX	28	32		25.25 24.75		27.935 27.902		32.025 32.000	28.021 28.000		
MB2830DX			2.108 2.072	30.25 29.75							
MB3020Dx				20.25 19.75							
MB3030DX	30	34		30.25 29.75		30.000 29.967		34.025 34.000	30.021 30.000		
MB3040DX				40.25 39.75							

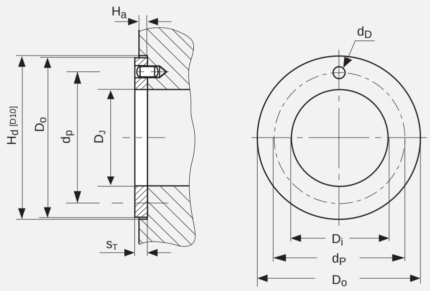
PartNo.	Nominal Diameter		Wall thickness s_3	Width B	Shaft-ø D_{Jm} [d8]		Housing-ø D_H [H7]		Bush-∅ $D_{i,a,m}$ Ass. in H7 housing	Clearance C_{Dm}	Oil hole-ø d_L
	D_i	D_o	max. min.	max. min.	max. min.		max. min.		max. min.	max. min.	
MB3220DX	32	36	2.108 2.072	20.25 19.75	d8	31.920 31.881	H7	36.025 36.000	32.025 32.000	0.144 0.080	6
MB3230DX				30.25 29.75							
MB3235DX				35.25 34.75							
MB3240DX				40.25 39.75							
MB3520DX	35	39		20.25 19.75		34.920 34.881		39.025 39.000	35.025 35.000		
MB3530DX				30.25 29.75							
MB3550DX				50.25 49.75							
MB3720DX	37	41		20.25 19.75		36.920 36.881		41.025 41.000	37.025 37.000		
MB4020DX	40	44		20.25 19.75		39.920 39.881		44.025 44.000	40.025 40.000		8
MB4030DX				30.25 29.75							
MB4040DX				40.25 39.75							
MB4050DX				50.25 49.75							
MB4520DX	45	50	2.634 2.588	20.25 19.75		44.920 44.881		50.025 50.000	45.025 45.000		
MB4530DX				30.25 29.75							
MB4540DX				40.25 39.75							
MB4545DX				45.25 44.75							
MB4550DX				50.25 49.75							
MB5040DX	50	55		40.25 39.75		49.920 49.881		55.030 55.000	50.025 50.000		
MB5060DX				60.25 59.75							
MB5520DX	55	60		20.25 19.75		54.900 54.854		60.030 60.000	55.030 55.000	0.176 0.100	
MB5525DX				25.25 24.75							
MB5530DX				30.25 29.75							
MB5540DX				40.25 39.75							
MB5550DX				50.25 49.75							
MB5560DX				60.25 59.75							
MB6030DX	60	65		30.25 29.75		59.900 59.854		65.030 65.000	60.030 60.000		
MB6040DX				40.25 39.75							
MB6060DX				60.25 59.75							
MB6070DX				70.25 69.75							

PartNo.	Nominal Diameter		Wall thickness s_3	Width B	Shaft-ø D_{Jm} [d8]		Housing-ø D_H [H7]		Bush-∅ $D_{i,a,m}$ Ass. in H7 housing	Clearance C_{Dm}	Oil hole-ø d_L
	D_i	D_o	max. min.	max. min.		max. min.		max. min.	max. min.	max. min.	
MB6540DX	65	70	2.634 2.568	40.25 39.75	d8	64.900 64.854	H7	70.030 70.000	65.030 65.000	0.176 0.100	8
MB6550DX				50.25 49.75							
MB6560DX				60.25 59.75							
MB6570DX				70.25 69.75							
MB7040DX	70	75		40.25 39.75		69.900 69.854		75.030 75.000	70.030 70.000		
MB7050DX				50.25 49.75							
MB7065DX				65.25 64.75							
MB7070DX				70.25 69.75							
MB7080DX				80.25 79.75							
MB7540DX	75	80		40.25 39.75		74.900 74.854		80.030 80.000	75.030 75.000		9.5
MB7560DX				60.25 59.75							
MB7580DX				80.25 79.75							
MB8040DX	80	85		40.50 39.50		79.900 79.854		85.035 85.000	80.030 80.000		
MB8060DX				60.50 59.50							
MB8080DX				80.50 79.50							
MB80100DX				100.50 99.50							
MB8530DX	85	90		30.50 29.50		84.880 84.826		90.035 90.000	85.035 85.000	0.209 0.120	
MB8540DX				40.50 39.50							
MB8560DX				60.50 59.50							
MB8580DX				80.50 79.50							
MB85100DX				100.50 99.50							
MB9040DX	90	95		40.50 39.50		89.880 89.826		95.035 95.000	90.035 90.000		
MB9060DX				60.50 59.50							
MB9090DX				90.50 89.50							
MB90100DX				100.50 99.50							
MB9560DX	95	100		60.50 59.50		94.880 94.826		100.035 100.000	95.035 95.000		
MB95100DX				100.50 99.50							
MB10050DX	100	105		50.50 49.50		99.880 99.826		105.035 105.000	100.035 100.000		
MB10060DX				60.50 59.50							
MB10080DX				80.50 79.50							
MB10095DX				95.50 94.50							
MB100115DX				115.50 114.50							

PartNo.	Nominal Diameter		Wall thickness s_3	Width B	Shaft-ø D_{Jm} [d8]		Housing-ø D_H [H7]		Bush-∅ $D_{i,a,m}$ Ass. in H7 housing	Clearance C_{Dm}	Oil hole-ø d_L
	D_i	D_o	max. min.	max. min.	max. min.		max. min.		max. min.	max. min.	
MB10560DX	105	110	2.634 2.568	60.50 59.50	d8	104.880 104.826	H7	110.035 110.000	105.035 105.000	0.209 0.120	9.5
MB105110DX				110.50 109.50							
MB105115DX				115.50 114.50							
MB11060DX	110	115		60.50 59.50		109.880 109.826		115.035 115.000	110.035 105.000		
MB110115DX				115.50 114.50							
MB11550DX	115	120		50.50 49.50		114.880 114.826		120.035 120.000	115.035 115.000		
MB11570DX				70.50 69.95							
MB12060DX	120	125		60.50 59.50		119.880 119.826		125.040 125.000	120.035 120.000		
MB120100DX				100.50 99.50							
MB125100DX	125	130		100.50 99.50		124.855 124.792		130.040 130.000	125.040 125.000	0.248 0.145	
MB13050DX	130	135	2.619 2.564	50.50 49.50		129.855 129.792		135.040 135.000	130.040 130.000		No hole
MB13060DX				60.50 59.50							
MB130100DX				100.50 99.50							
MB13560DX	135	140		60.50 59.50		134.855 134.792		140.040 140.000	135.040 135.000		
MB13580DX				80.50 79.50							
MB14060DX	140	145		60.50 59.50		139.855 139.792		145.040 145.000	140.040 140.000		
MB140100DX				100.50 99.50							
MB15060DX	150	155		60.50 59.50		149.855 149.792		155.040 155.000	150.040 150.000		
MB15080DX				80.50 79.50							
MB150100DX				100.50 99.50							

10.3 DX Thrust Washers

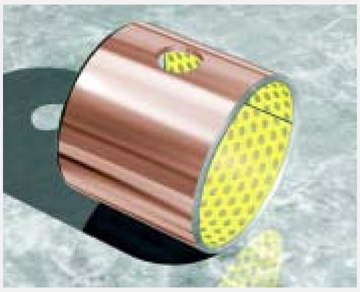


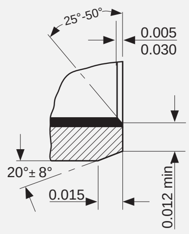


All dimensions in mm

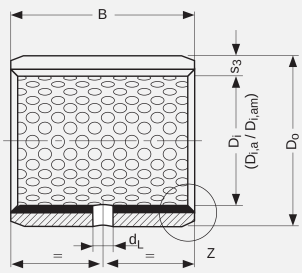
Part No.	Inside-ø D_i	Outside-ø D_o	Thickness s_T	Dowel hole ø d_D	Dowel hole PCD-ø d_p	Recess depth H_a
	max. min.	max. min.	max. min.	max. min.	max. min.	max. min.
WC08DX	10.25 10.00	20.00 19.75	1.58 1.49	No hole	No hole	1.20 0.95
WC10DX	12.25 12.00	24.00 23.75		1.875 1.625	18.12 17.88	
WC12DX	14.25 14.00	26.00 25.75		2.375 2.125	20.12 19.88	
WC14DX	16.25 16.00	30.00 29.75			22.12 21.88	
WC16DX	18.25 18.00	32.00 31.75			25.12 24.88	
WC18DX	20.25 20.00	36.00 35.75		3.375 3.125	28.12 27.88	
WC20DX	22.25 22.00	38.00 37.75			30.12 29.88	
WC22DX	24.25 24.00	42.00 41.75			33.12 32.88	
WC24DX	26.25 26.00	44.00 43.75			35.12 34.88	
WC25DX	28.25 28.00	48.00 47.75		4.375 4.125	38.12 37.88	
WC30DX	32.25 32.00	54.00 53.75			43.12 42.88	
WC35DX	38.25 38.00	62.00 61.75			50.12 49.88	
WC40DX	42.25 42.00	66.00 65.75			54.12 53.88	
WC45DX	48.25 48.00	74.00 73.75	2.60 2.51		61.12 60.88	1.70 1.45
WC50DX	52.25 52.00	78.00 77.75			65.12 64.88	
WC60DX	62.25 62.00	90.00 89.75			76.12 75.88	

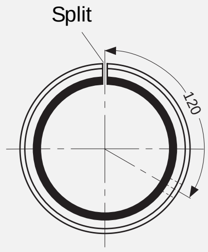
10.4 DX cylindrical bushes - Inch sizes





Detail Z





All dimensions in inch

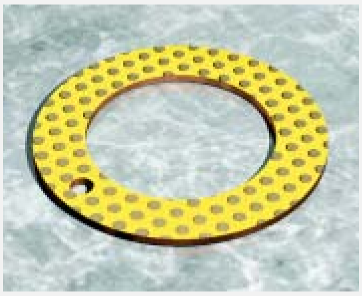
Part No.	Nominal Diameter		Housing-ø D_H [BS 1916 H7]	As supplied					Machined in situ			Oil hole-ø d_L
	D_i	D_o	max. min.	Wall Thickness s_3 max. min.	Width B max. min.	Shaft-ø D_J max. min.	Bush-ø $D_{i,a}$ Ass. in an H7 housing max. min.	Clearance C_D max. min.	Shaft-ø D_{Jm} [BS 1916 d8] max. min.	Bush-ø $D_{i,am}$ Machined in situ to BS 1916 H7 max. min.	Clearance C_{Dm} max. min.	
06DX06	3/8	15/32	0.4694 0.4687	0.0510 0.0500	0.385 0.365	0.3648 0.3639	0.3694 0.3667	0.0055 0.0019	0.3734 0.3725	0.3756 0.3750	0.0031 0.0016	No hole
06DX08					0.510 0.490							5/32
06DX12					0.760 0.740							
07DX08	7/16	17/32	0.5319 0.5312		0.510 0.490	0.4273 0.4263	0.4319 0.4292	0.0056 0.0019	0.4355 0.4345	0.4382 0.4375	0.0037 0.0020	
07DX12					0.760 0.740							
08DX06	1/2	19/32	0.5944 0.5937		0.385 0.365	0.4897 0.4887	0.4944 0.4917	0.0057 0.0020	0.4980 0.4970	0.5007 0.5000		
08DX08					0.510 0.490							
08DX10					0.635 0.615							
08DX14					0.885 0.865							
09DX08	9/16	21/32	0.6569 0.6562		0.510 0.490	0.5522 0.5512	0.5569 0.5542		0.5605 0.5595	0.5632 0.5625		
09DX12					0.760 0.740							
10DX08	5/8	23/32	0.7195 0.7187		0.510 0.490	0.6146 0.6136	0.6195 0.6167	0.0059 0.0021	0.6230 0.6220	0.6257 0.6250		
10DX10					0.635 0.615							
10DX12					0.760 0.740							
10DX14					0.885 0.865							
11DX14	11/16	25/32	0.7820 0.7812		0.885 0.865	0.6770 0.6760	0.6820 0.6792	0.0060 0.0022	0.6855 0.6845	0.6882 0.6875		
12DX08	3/4	7/8	0.8758 0.8750	0.0669 0.0657	0.510 0.490	0.7390 0.7378	0.7444 0.7412	0.0066 0.0022	0.7475 0.7463	0.7508 0.7500	0.0045 0.0025	
12DX12					0.760 0.740							
12DX16					1.010 0.990							

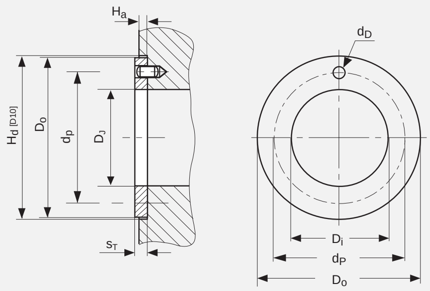
Part No.	Nominal Diameter		Housing-ø D_H [BS 1916 H7]	As supplied					Machined in situ			Oil hole-ø d_L
				Wall Thickness s_3	Width B	Shaft-ø D_J	Bush-ø $D_{i,a}$ Ass. in an H7 housing	Clearance C_D	Shaft-ø D_{Jm} [BS 1916 d8]	Bush-ø $D_{i,am}$ Machined in situ to BS 1916 H7	Clearance C_{Dm}	
	D_i	D_o	max. min.	max. min.	max. min.	max. min.	max. min.	max. min.	max. min.	max. min.	max. min.	
14DX12	$^{7}/_{8}$	1	1.0008 1.0000	0.0669 0.0657	0.760 0.740	0.8639 0.8627	0.8694 0.8662	0.0067 0.0023	0.8725 0.8713	0.8758 0.8750	0.0045 0.0025	$^{1}/_{4}$
14DX14					0.885 0.865							
14DX16					1.010 0.990							
16DX12	1	$1^{1}/_{8}$	1.1258 1.1250		0.760 0.740	0.9888 0.9876	0.9944 0.9912	0.0068 0.0024	0.9975 0.9963	1.0008 1.0000		
16DX16					1.010 0.990							
16DX24					1.510 1.490							
18DX12	$1^{1}/_{8}$	$^{19}/_{32}$	1.2822 1.2812	0.0824 0.0810	0.760 0.740	1.1138 1.1126	1.1202 1.1164	0.0076 0.0026	1.1225 1.1213	1.1258 1.2500		
18DX16					1.010 0.990							
20DX12	$1^{1}/_{4}$	$1^{13}/_{32}$	1.4072 1.4062		0.760 0.740	1.2387 1.2371	1.2452 1.2414	0.0081 0.0027	1.2470 1.2454	1.2510 1.2500	0.0056 0.0030	
20DX16					1.010 0.990							
20DX20					1.260 1.240							
20DX28					1.760 1.740							
22DX16	$1^{3}/_{8}$	$1^{17}/_{32}$	1.5322 1.5312		1.010 0.990	1.3635 1.3619	1.3702 1.3664	0.0083 0.0029	1.3720 1.3704	1.3760 1.3750		
22DX22					1.385 0.365							
22DX28					1.760 1.740							
24DX16	$1^{1}/_{2}$	$1^{21}/_{32}$	1.6572 1.6562		1.010 0.990	1.4884 1.4868	1.4952 1.4914	0.0084 0.0030	1.4970 1.4954	1.5010 1.5000		$^{5}/_{16}$
24DX20					1.260 1.240							
24DX24					1.510 1.490							
24DX32					2.010 1.990							
26DX16	$1^{5}/_{8}$	$1^{25}/_{32}$	1.7822 1.7812		1.010 0.990	1.6133 1.6117	1.6202 1.6164	0.0085 0.0031	1.6220 1.6204	1.6260 1.6250		
26DX24					1.510 1.490							
28DX16	$1^{3}/_{4}$	$1^{15}/_{16}$	1.9385 1.9375	0.0980 0.0962	1.010 0.990	1.7383 1.7367	1.7461 1.7415	0.0094 0.0032	1.7470 1.7454	1.7510 1.7500		
28DX24					1.510 1.490							
28DX28					1.760 1.740							
28DX32					2.010 1.990							
30DX16	$1^{7}/_{8}$	$2^{1}/_{16}$	2.0637 2.0625		1.510 1.490	1.8632 1.8616	1.8713 1.8665	0.0097 0.0033	1.8720 1.8704	1.8760 1.8750		
30DX30					1.885 1.865							
30DX36					2.260 2.240							
32DX16	2	$2^{3}/_{16}$	2.1887 2.1875		1.010 0.990	1.9881 1.9863	1.9963 1.9915	0.0100 0.0034	1.9960 1.9942	2.0012 2.0000	0.0070 0.0040	
32DX24					1.510 1.490							
32DX32					2.010 1.990							
32DX40					2.510 2.490							

10 Standard Products

Part No.	Nominal Diameter D_i	Nominal Diameter D_o	Housing-ø D_H [BS 1916 H7] max. min.	As supplied: Wall Thickness s_3 max. min.	As supplied: Width B max. min.	As supplied: Shaft-ø D_J max. min.	As supplied: Bush-ø $D_{i,a}$ Ass. in an H7 housing max. min.	As supplied: Clearance C_D max. min.	Machined in situ: Shaft-ø D_{Jm} [BS 1916 d8] max. min.	Machined in situ: Bush-ø $D_{i,am}$ Machined in situ to BS 1916 H7 max. min.	Machined in situ: Clearance C_{Dm} max. min.	Oil hole-ø d_L
36DX32	$2^{1}/_{4}$	$2^{7}/_{16}$	2.4387 2.4375	0.0980 0.0962	2.010 1.990	2.2378 2.2360	2.2463 2.2415	0.0103 0.0037	2.2460 2.2442	2.2512 2.2500	0.0070 0.0040	$^{5}/_{16}$
36DX36					2.260 2.240							
36DX40					2.510 2.490							
40DX32	$2^{1}/_{2}$	$2^{11}/_{16}$	2.6887 2.6875		2.010 1.990	2.4875 2.4857	2.4963 2.4915	0.0106 0.0040	2.4960 2.4942	2.5012 2.5000		
40DX40					2.510 2.490							
44DX32	$2^{3}/_{4}$	$2^{15}/_{16}$	2.9387 2.9375	0.0991 0.0965	2.010 1.990	2.7351 2.7333	2.7457 2.7393	0.0124 0.0042	2.7460 2.7442	2.7512 2.7500		
44DX40					2.510 2.490							
44DX48					3.010 2.990							
44DX56					3.510 3.490							
48DX32	3	$3^{3}/_{16}$	3.1889 3.1875		2.010 1.990	2.9849 2.9831	2.9959 2.9893	0.0128 0.0044	2.9960 2.9942	3.0012 3.0000		$^{3}/_{8}$
48DX48					3.010 2.990							
48DX60					3.760 3.740							
56DX40	$3^{1}/_{2}$	$3^{11}/_{16}$	3.6889 3.6875		2.510 2.490	3.4844 3.4822	3.4959 3.4893	0.0137 0.0049	3.4950 3.4928	3.5014 3.5000	0.0086 0.0050	
56DX48					3.010 2.990							
56DX60					3.760 3.740							
64DX48	4	$4^{3}/_{16}$	4.1889 4.1875		3.010 2.990	3.9839 3.9817	3.9959 3.9893	0.0142 0.0054	3.9950 3.9928	4.0014 4.0000		
64DX60					3.760 3.740							
64DX76					4.760 4.740							

10.5 DX Thrust Washers - Inch sizes

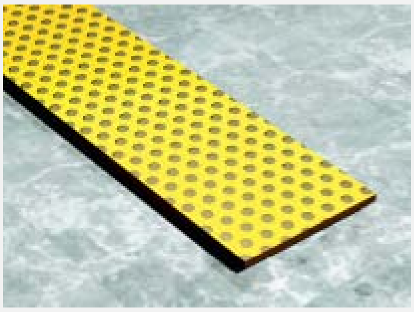


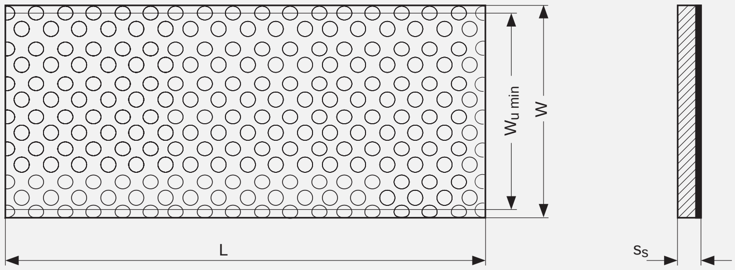


All dimensions in inch

Part No.	Inside-ø D_i	Outside-ø D_o	Thickness s_T	Dowel hole ø d_D	Dowel hole PCD-ø d_P	Recess depth H_a
	max. min.	max. min.	max. min.	max. min.	max. min.	max. min.
DX06	0.5100 0.5000	0.8750 0.8650	0.0660 0.0625	0.0770 0.0670	0.6920 0.6820	0.050 0.040
DX07	0.5720 0.5620	1.0000 0.9900			0.7860 0.7760	
DX08	0.6350 0.6250	1.1250 1.1150		0.1090 0.0990	0.8800 0.8700	
DX09	0.6970 0.6870	1.1870 1.1770			0.9420 0.9320	
DX10	0.7600 0.7500	1.2500 1.2400			1.0050 0.9950	
DX11	0.8220 0.8120	1.3750 1.3650			1.0990 1.0890	
DX12	0.8850 0.8750	1.5000 1.4900		0.1400 0.1300	1.1920 1.1820	
DX14	1.0100 1.0000	1.7500 1.7400			1.3800 1.3700	
DX16	1.1350 1.1250	2.0000 1.9900		0.1710 0.1610	1.5670 1.5570	
DX18	1.2600 1.2500	2.1250 2.1150			1.6920 1.6820	
DX20	1.3850 1.3750	2.2500 2.2400			1.8170 1.8070	
DX22	1.5100 1.5000	2.5000 2.4900		0.2020 0.1920	2.0050 1.9950	
DX24	1.6350 1.6250	2.6250 2.6150			2.1300 2.1200	
DX26	1.7600 1.7500	2.7500 2.7400			2.2550 2.2450	
DX28	2.0100 2.0000	3.0000 2.9900	0.0970 0.0935		2.5050 2.4950	0.080 0.070
DX30	2.1350 2.1250	3.1250 3.1150			2.6300 2.6200	
DX32	2.2600 2.2500	3.2500 3.2400			2.7550 2.7450	

10.6 DX Strip





All dimensions in mm

Part No.	Length L	Total Width W	Usable Width $W_{U\ min}$	Thickness s_S max. min.
S10150DX	503 500	160	150	1.07 1.03
S15190DX		200	190	1.56 1.52
S20190DX				2.05 2.01
S25190DX				2.57 2.53

10.7 DX Strip - Inch sizes

DX Strip Inch sizes are available as Non-Standard products on request.

GGB warrants that products described in this brochure are free from defects in workmanship and material but unless expressly agreed in writing GGB gives no warranty that these products are suitable for any particular purpose of for use under any specific conditions notwithstanding that such purpose would appear to be covered by this publication. GGB accepts no liability for any loss, damage, or expense whatsoever arising directly or indirectly from use of its products. All business undertaken by GGB is subject to its standard Conditions of Sale, copies of which are available upon request. GGB products are subject to continual development and GGB reserves the right to make changes in the specification and design of its products without prior notice.

GGB™ is a Trademark of GGB.

DX™ is a Trademark of GGB.

DS™ is a Trademark of GGB.

Declaration on the RoHS Directive

On 1 July 2006, the EU directive 2002/95/EC (“RoHS-directive, Restriction of Hazardous Substances”) became effective. It forbids placing products into circulation that contain lead, cadmium, chromium (VI), mercury or PBB/PBDE-containing flame retardants.

All GGB products, except DU and DUB, comply with the EU directives 2002/96/EG (End of Life directive for electric and electronic devices) and 2002/95/EG (constraint of certain hazardous materials in electric and electronic devices).

As an environmentally conscious company, GGB worked within its guidelines on a conversion to environmentally friendly materials.

Today, the entire product range is lead-free.

Visit us on the internet:
www.ggbearings.com

This handbook was designed by
Profidoc Silvia Freitag

www.profidoc.de

06-07