

DX

Marginally lubricated



Designer's Handbook

 **GGB**
BEARING TECHNOLOGY

an EnPro Industries company

Quality

All the products described in this handbook are manufactured under DIN EN ISO 9001, ISO/TS 16949 and ISO 14001 approved quality management systems.

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<p>ISO/TS 16949:2002 GGB, LLC 700 Mid Atlantic Parkway Thorofore, NJ 08086 The design and manufacture of self-lubricated bearings... Certificate Number 035502</p>	<p>ISO 14001:1996 GGB, LLC 700 Mid Atlantic Parkway Thorofore, NJ 08086 The environmental management system... Certificate Number 035502</p>	<p>ISO 9001:2000 GGB, LLC 700 Mid Atlantic Parkway Thorofore, NJ 08086 The design and manufacture of self-lubricated bearings... Certificate Number 035502</p>	<p>ISO 14001 (1996) GGB, LLC 700 Mid Atlantic Parkway Thorofore, NJ 08086 The environmental management system... Certificate Number 035502</p>

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/mm ²	Specific load
\bar{p}_{lim}	N/mm ²	Specific load limit
$\bar{p}_{sta,max}$	N/mm ²	Maximum static load
$\bar{p}_{dyn,max}$	N/mm ²	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 ⁶ K	Coefficient of linear thermal expansion parallel to surface
α_2	1/10 ⁶ K	Coefficient of linear thermal expansion normal to surface
σ_c	N/mm ²	Compressive Yield strength
λ	W/mK	Thermal conductivity
φ	°	Angular displacement
η	Ns/mm ²	Dynamic Viscosity
Z_T	-	Total number of oscillating movements

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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 pU 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.

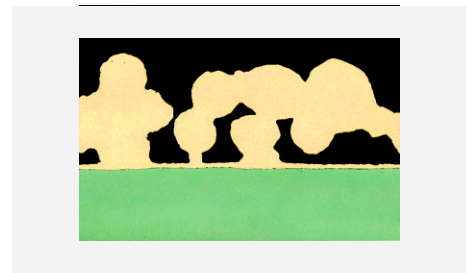


Fig. 1: DX-microsection

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

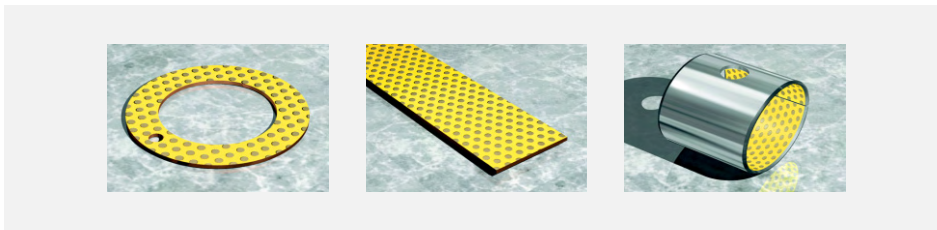


Fig. 2: Standard components

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/mm ²	measured on disc 5 mm diameter x 2.45 mm thick.
	Maximum Load				
	Static	$\bar{\rho}_{sta,max}$	140	N/mm ²	
	Dynamic	$\bar{\rho}_{dyn,max}$	70	N/mm ²	
Electrical Properties	Volume resistivity of acetal lining		10 ¹⁵	Ω cm	

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 chemi-

cal 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 $\bar{p}U$ 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 MoS₂ 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 hydro-

dynamic 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 $\bar{p}U$ 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 $\bar{p}U$ 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.

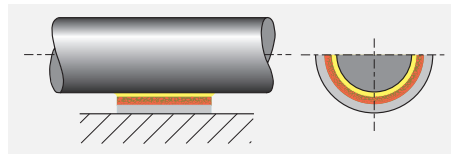


Fig. 4: Hydrodynamic lubrication

Hydrodynamic conditions occur when

$$(4.3.1) \quad \bar{p} \leq \frac{U \cdot \eta}{7.5} \cdot \frac{B}{D_i} \quad [\text{N/mm}^2]$$

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.

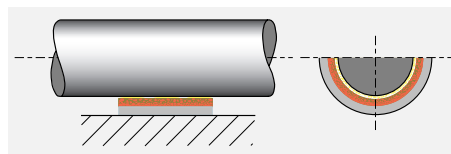


Fig. 5: Mixed film lubrication

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.

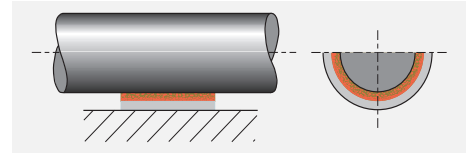


Fig. 6: Boundary lubrication

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 \bar{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.

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

$$(4.5.1) \quad L_H = \frac{2000}{\left(\frac{e\bar{p}U}{\eta}\right)^{0.5}} \cdot a_Q \cdot a_T \cdot a_S \quad [h]$$

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

$$(4.5.2) \quad L_H = \frac{1000}{\left(\frac{e\bar{p}U}{\eta}\right)} \cdot a_Q \cdot a_T \cdot a_S \quad [h]$$

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.

Area 3 of Fig. 7

- The bearing will operate with hydrodynamic lubrication.

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.

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

$$(4.5.3) \quad L_H = \frac{1000}{\left(\frac{e\bar{p}U}{\eta}\right)^2} \cdot a_Q \cdot a_T \cdot a_S \quad [h]$$

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

- DX bearing performance will depend upon the nature of the fluid and the actual service conditions.

- Bearing wear will be determined only by the cleanliness of the lubricant and the frequency of start up and shut down.

- 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 $R_a < 0.05 \mu m$.

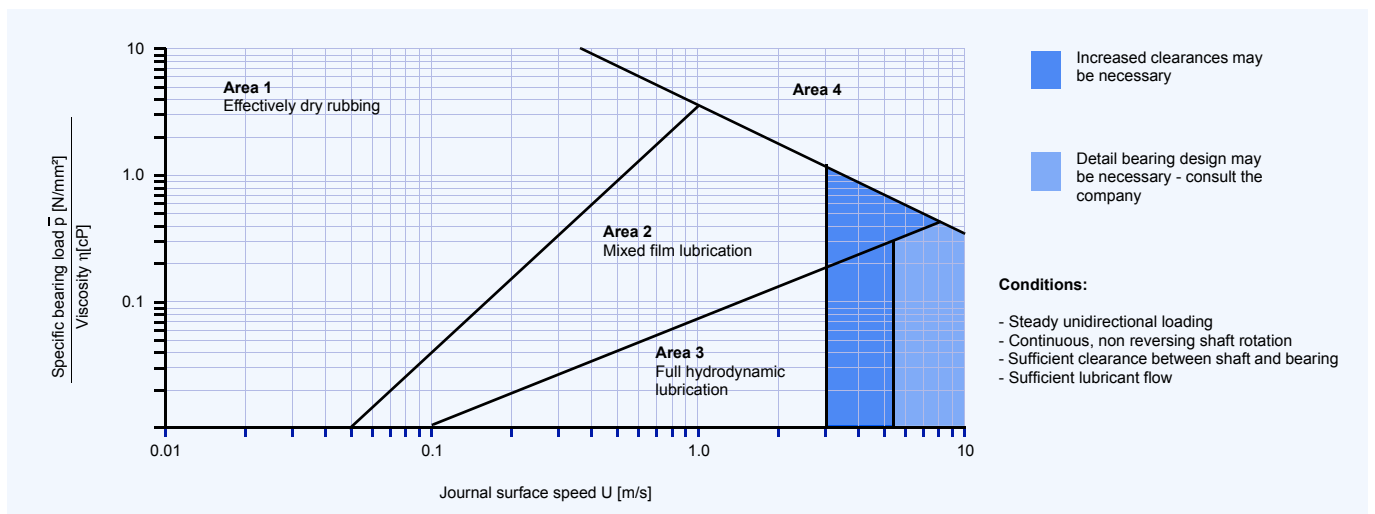


Fig. 7: Design guide for lubricated application

Temperature [°C]	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 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 DSTM material should be considered as an alternative to DX.

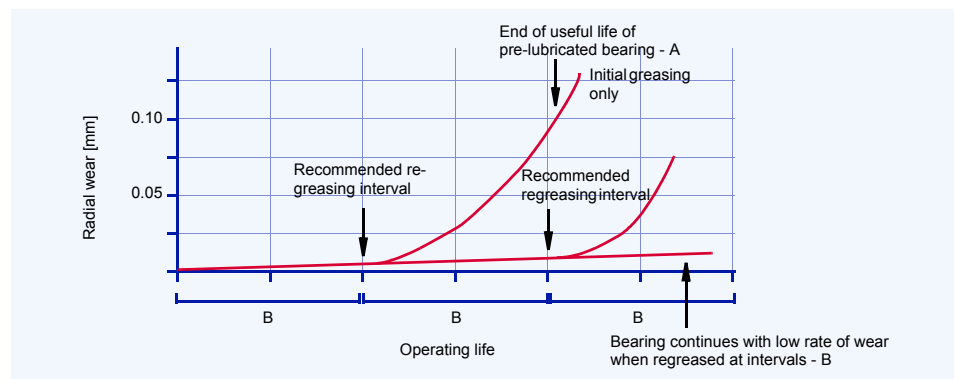


Fig. 8: Typical wear of DX

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 [μ m]
- Mating surface material
- Temperature T [$^{\circ}$ 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

$$(5.1.1) \quad \bar{p} = \frac{F}{D_i \cdot B} \quad [\text{N/mm}^2]$$

Slide Plates

$$(5.1.3) \quad \bar{p} = \frac{F}{L \cdot W} \quad [\text{N/mm}^2]$$

Thrust Washers

$$(5.1.2) \quad \bar{p} = \frac{4F}{\pi \cdot (D_o^2 - D_i^2)} \quad [\text{N/mm}^2]$$

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 $^{\circ}$ C, falling to about half the values given in Table 5 for temperatures above 100 $^{\circ}$ 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

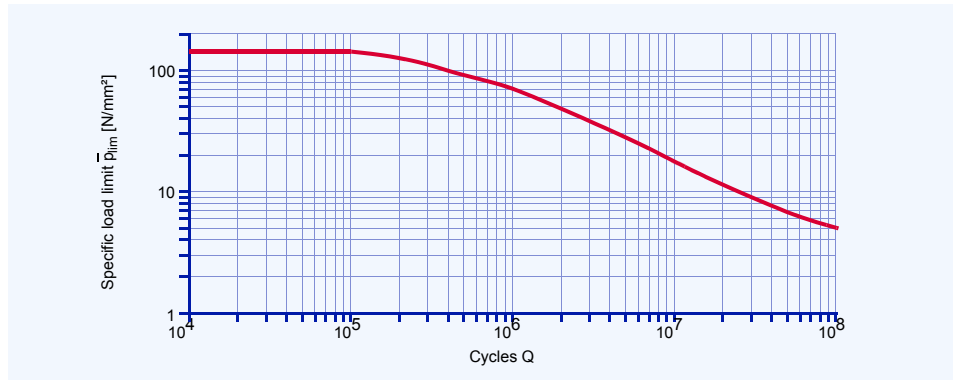


Fig. 9: DX specific load limits \bar{p}_{lim} under dynamic loads or oscillating conditions

5.2 Sliding Speed

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

Continuous Rotation

Bushes

$$(5.2.1) \quad U = \frac{D_i \cdot \pi \cdot N}{60 \cdot 10^3} \quad [\text{m/s}]$$

Thrust Washers

$$(5.2.2) \quad U = \frac{D_o + D_i}{2} \cdot \pi \cdot N \quad [\text{m/s}]$$

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

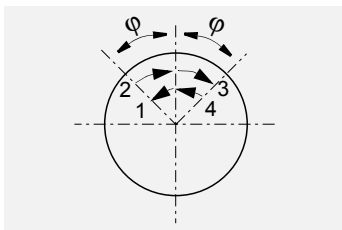


Fig. 10: Oscillating cycle φ

Oscillating Movement

Bushes

$$(5.2.3) \quad U = \frac{D_i \cdot \pi}{60 \cdot 10^3} \cdot \frac{4\varphi \cdot N_{osz}}{360} \quad [\text{m/s}]$$

Thrust Washers

$$(5.2.4) \quad U = \frac{D_o + D_i}{2} \cdot \pi \cdot \frac{4\varphi \cdot N_{osz}}{360} \quad [\text{m/s}]$$

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

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.

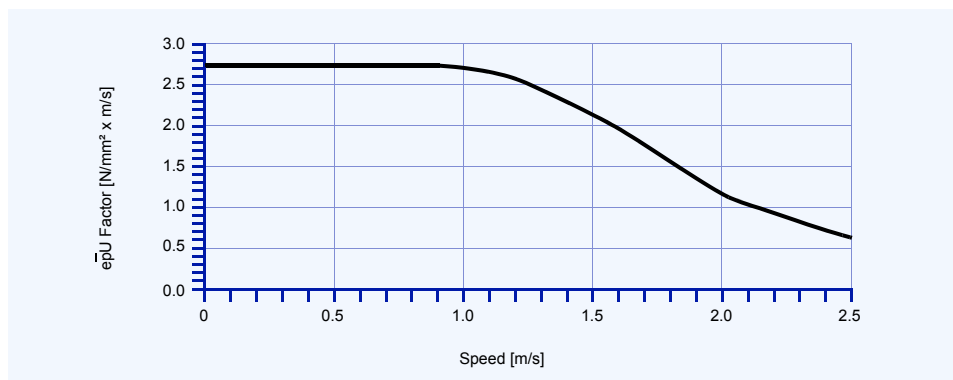


Fig. 11: Maximum $e\bar{p}U$ factor for grease lubrication

5.3 $\bar{p}U$ Factor

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

$$(5.3.1) \quad \bar{p}U = \bar{p} \cdot U \quad [\text{N/mm}^2 \times \text{m/s}]$$

5.4 Load

In addition to its contribution to the $\bar{p}U$ factor the type and direction of the applied load also affects the performance of a DX bearing. This is accommodated in the calcu-

lation of the bearing service life by the speed/load application factor a_Q shown in Figs. 15-17.

Type of Load

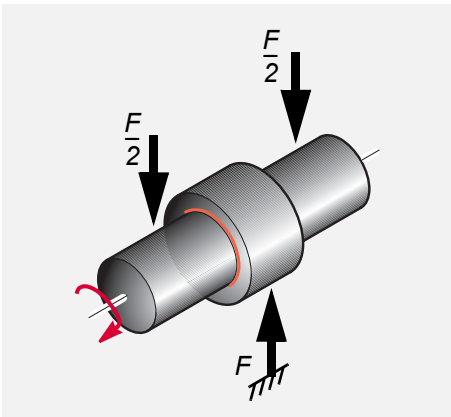


Fig. 12: Steady load, vertically downwards, bush stationary, shaft rotating. Lubricant drains to loaded area

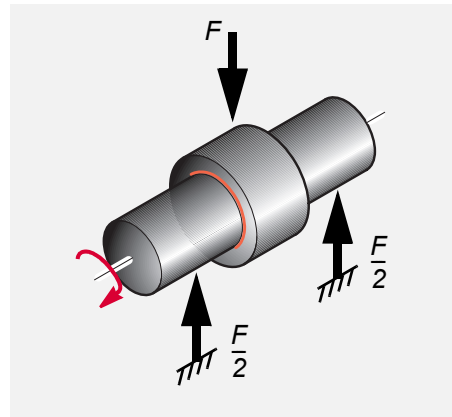


Fig. 13: Steady load, vertically upwards, bush stationary, shaft rotating. Lubricant drains away from loaded area

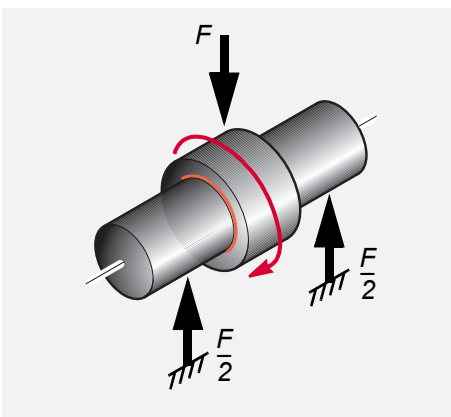


Fig. 14: Rotating load, shaft stationary, bush rotating

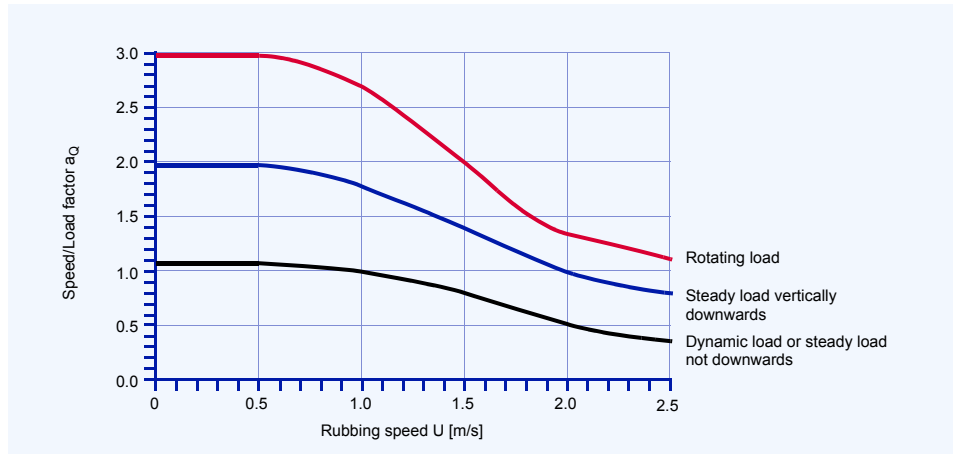


Fig. 15: Speed/Load factor a_Q for MB range bushes - unmachined

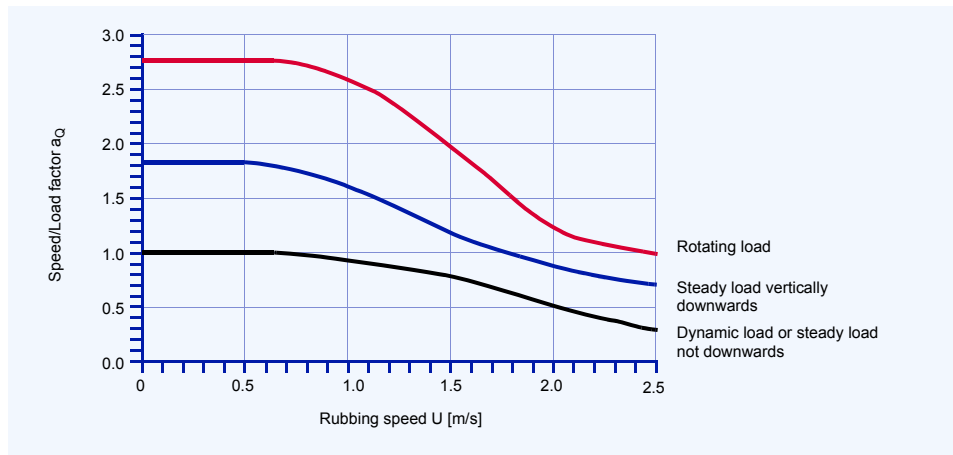


Fig. 16: Speed/Load factor a_Q for PM range and MB range bushes - machined

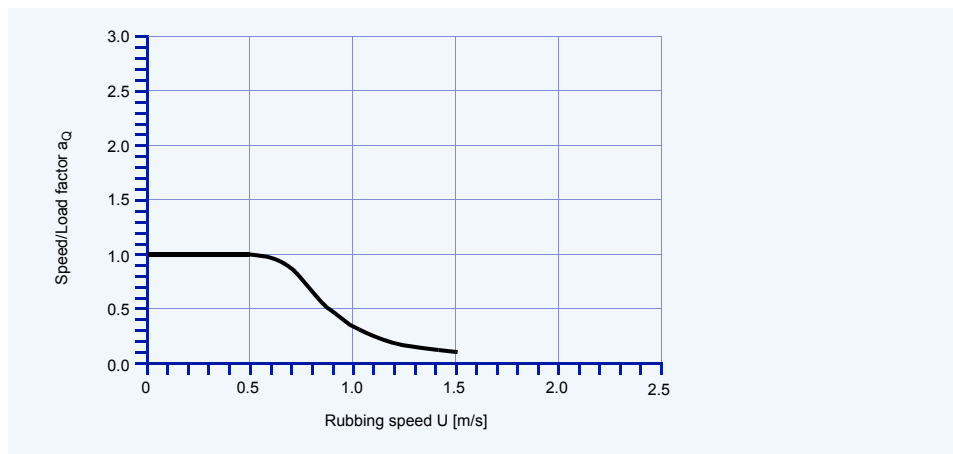


Fig. 17: Speed/Load factor a_Q for thrust washers

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 accommodated by the application factor a_T shown in Fig. 18.

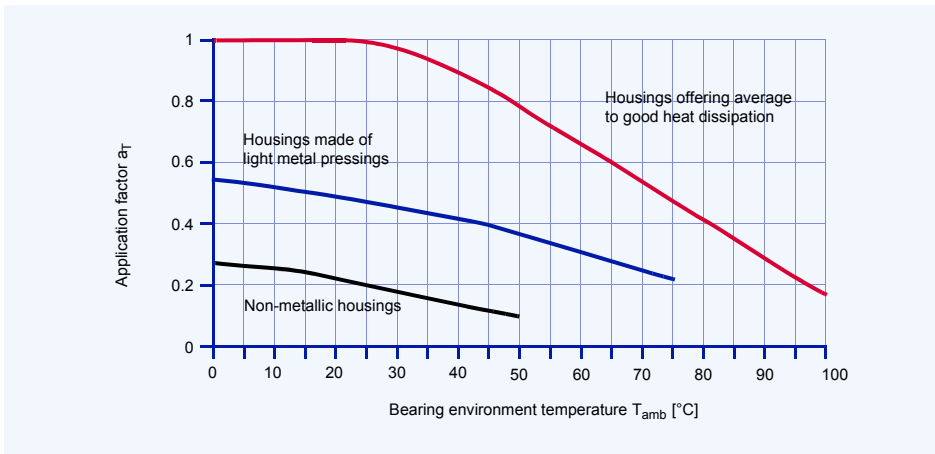


Fig. 18: DX application factor a_T

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 $0.4 \mu m R_a$. This effect is accommodated by the mating surface finish application factor a_S shown in Fig. 19.

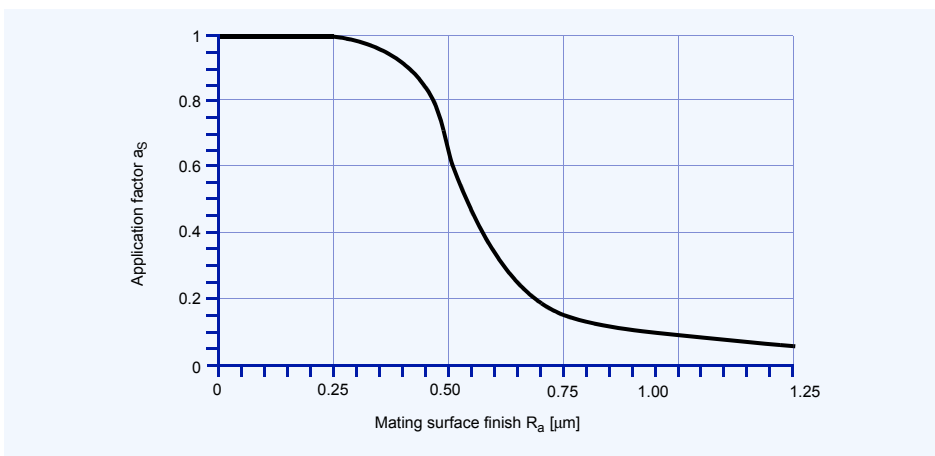


Fig. 19: DX application factor a_S

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.

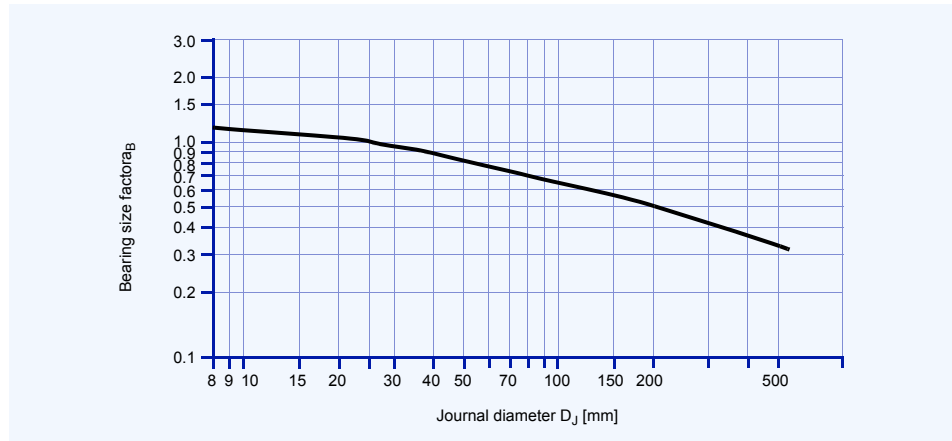


Fig. 20: Bearing size factor a_B

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/mm ²]
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 \bar{U} from the equations in 5.2 on Page 14.

Calculate \bar{pU} from the equation in 5.3 on Page 15.

Calculate High Load Factor a_E

$$(5.8.1) \quad a_E = \frac{\bar{p}_{lim}}{\bar{p}_{lim} - \bar{p}} \quad [-]$$

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

Note:

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

Calculate Effective \bar{pU} Factor $e\bar{pU}$

$$(5.8.2) \quad e\bar{pU} = \frac{a_E \cdot \bar{pU}}{a_B} \quad [-]$$

Note:

Check that $e\bar{pU}$ 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 $e\bar{pU} < 1.0$ then

$$(5.8.3) \quad L_H = \frac{3000}{e\bar{pU}} \cdot a_Q \cdot a_T \cdot a_S \quad [h]$$

If $e\bar{pU} > 1.0$ then

$$(5.8.4) \quad L_H = \frac{3000}{(e\bar{pU})^{2.4}} \cdot a_Q \cdot a_T \cdot a_S \quad [h]$$

Estimate Re-greasing Interval

$$(5.8.5) \quad L_{RG} = \frac{L_H}{2} \quad [h]$$

Oscillating Motion and Dynamic Loads

Oscillating Motion

Calculate number of cycles

$$(5.8.6) \quad Z_T = L_{RG} \cdot N_{osz} \cdot 60 \cdot (R+2) \quad [-]$$

Dynamic Loads

Calculate number of cycles

$$(5.8.7) \quad C_T = L_{RG} \cdot C \cdot 60 \cdot (R+2) \quad [-]$$

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.

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/mm ²	(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 $\phi 40$	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/mm ²]	(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	$a_E = \frac{\bar{p}_{lim}}{\bar{p}_{lim} - \bar{p}} = \frac{70}{70 - 12.5} = 1.22$
epU 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/mm ²	(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 $\phi 40$	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/mm ²]	(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	$a_E = \frac{\bar{p}_{lim}}{\bar{p}_{lim} - \bar{p}} = \frac{46.7}{46.7 - 8.33} = 1.22$
epU 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/mm ²	(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 $\phi 35$	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/mm ²]	(5.1.2), page 13	$\bar{p} = \frac{4 \cdot F}{\pi (D_o^2 - D_i^2)} = \frac{4 \cdot 10000}{\pi (44^2 - 26^2)} = 10.11$
Sliding Speed U [m/s]	(5.2.2), page 14	$U = \frac{D_o + D_i}{2} \cdot \pi \cdot N = \frac{44 + 26}{2} \cdot \pi \cdot 10 = 1018$
High Load Factor a_E [-] (must be >0)	(5.8.1), page 19	$a_E = \frac{\bar{p}_{lim}}{\bar{p}_{lim} - \bar{p}} = \frac{70}{70 - 10.11} = 1.169$
epU 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 ($R_a = 0.3 \mu\text{m}$)	Bearing Load F	20000 N
	Temperature 80 °C	Stroke	15 mm
	good heat conditions	Frequency	10 1/min

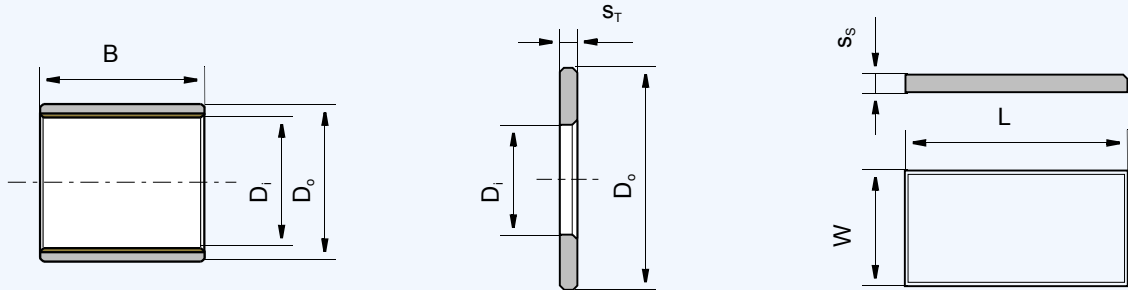
Calculation Constants and Application Factors			
Specific Load Limit \bar{p}_{lim} at 80 °C	93 N/mm ²	(Table 5, Page 13)	
Application Factor a_T	0.4	(Fig. 18, Page 17)	
Mating Surface Application Factor a_S	0.98	(Fig. 19, Page 17)	
Bearing Size Factor a_B	1.0	(Fig. 20, Page 18)	
Application Factor for Slideways a_Q	1.0	(Fig. 17, Page 16)	

Calculation	Ref	Value
Specific Load \bar{p} [N/mm ²]	(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	$a_E = \frac{\bar{p}_{lim}}{\bar{p}_{lim} - \bar{p}} = \frac{93}{93 - 20} = 1.27$
epU 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 or specific load F [N]
 \bar{p} [N/mm²]

Axial load or specific load F [N]
 \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:
 Street:

City:
 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 clear-

ance 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.

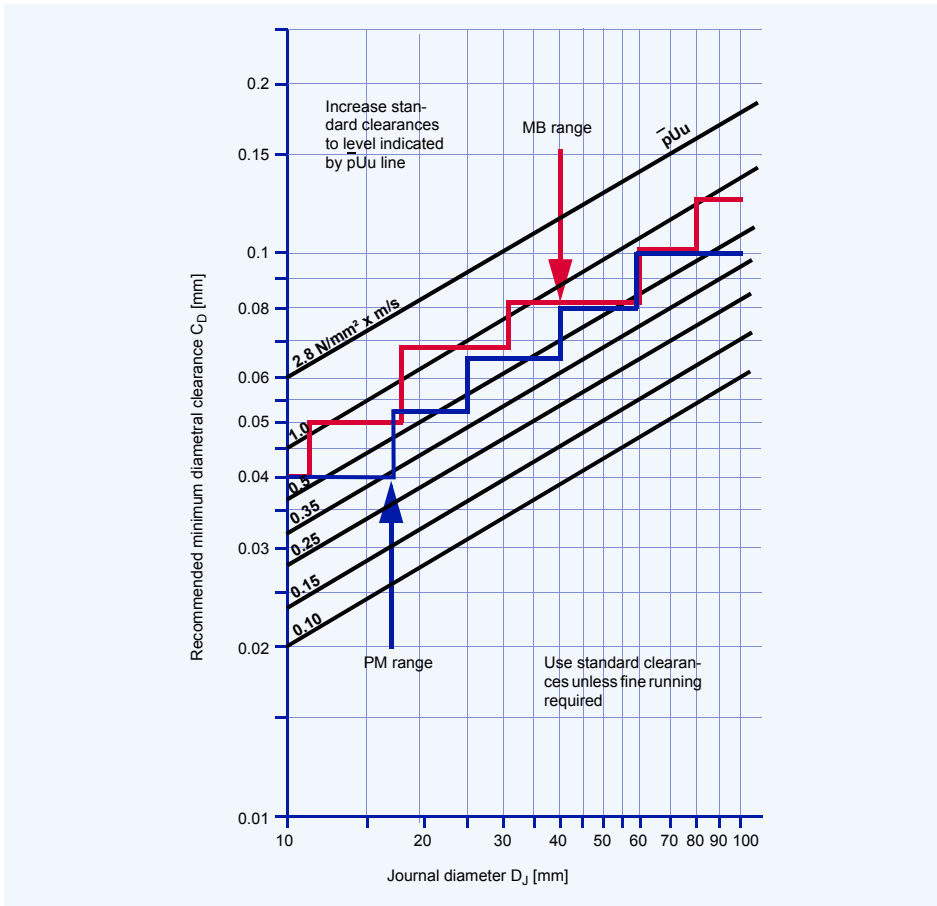


Fig. 21: Minimum clearance for PM prefinished and MB machinable metric range machined to H7 bore

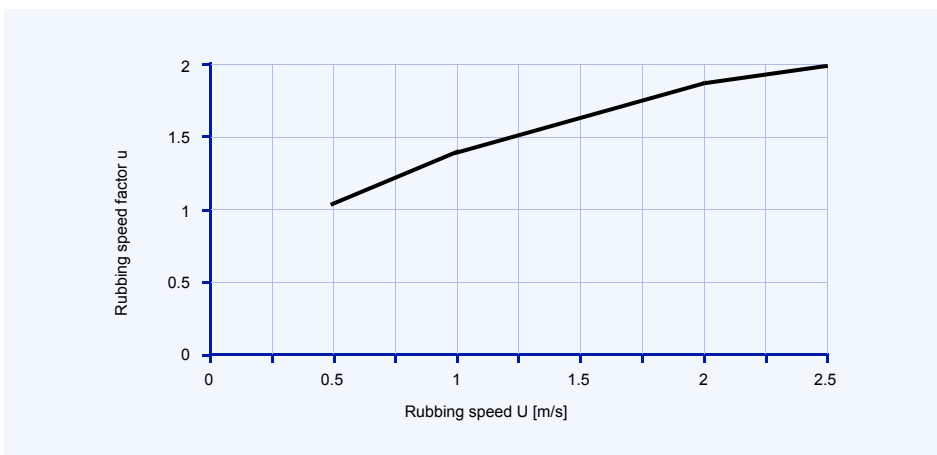


Fig. 22: Rubbing speed factor u

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.

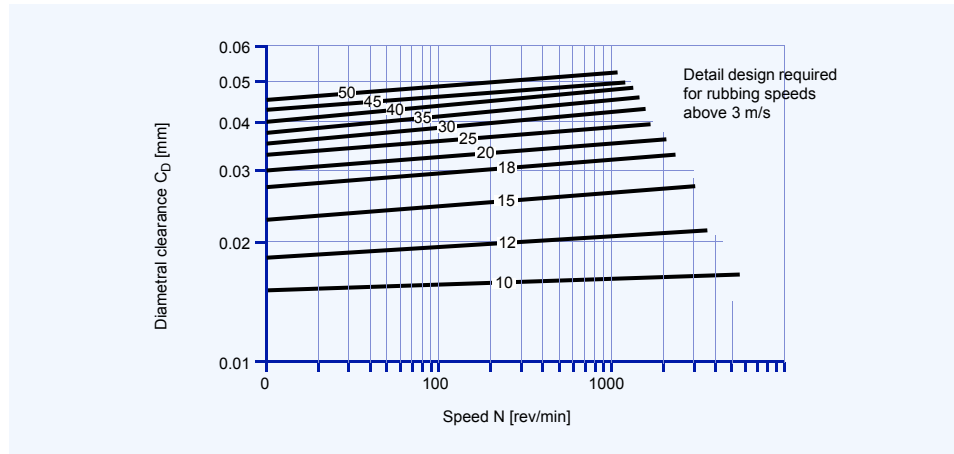


Fig. 23: DX minimum clearances - bush diameters D_i 10-50 mm

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.

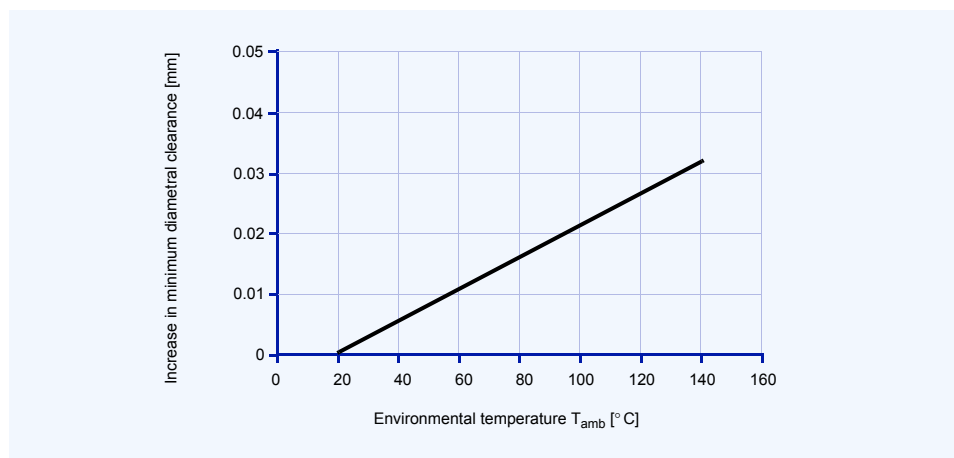


Fig. 24: Recommended increase in diametral clearance

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 inter-

ference 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 $0.4 \mu\text{m } R_a$ 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, alterna-

tively WH shaft sleeves (Standard programme 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.

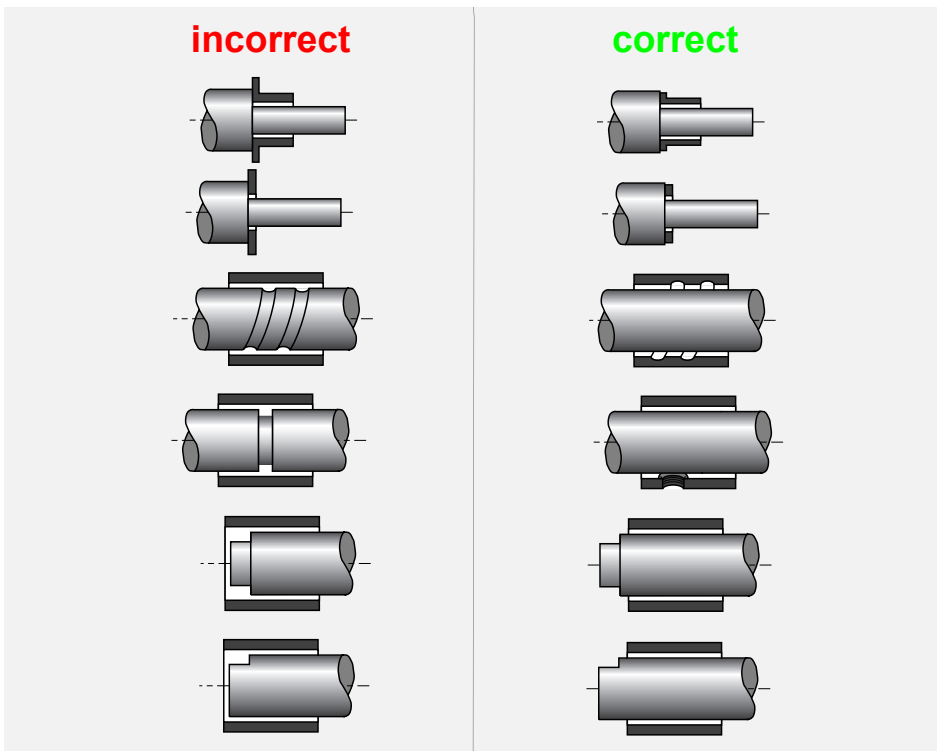


Fig. 25: Counterface design

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

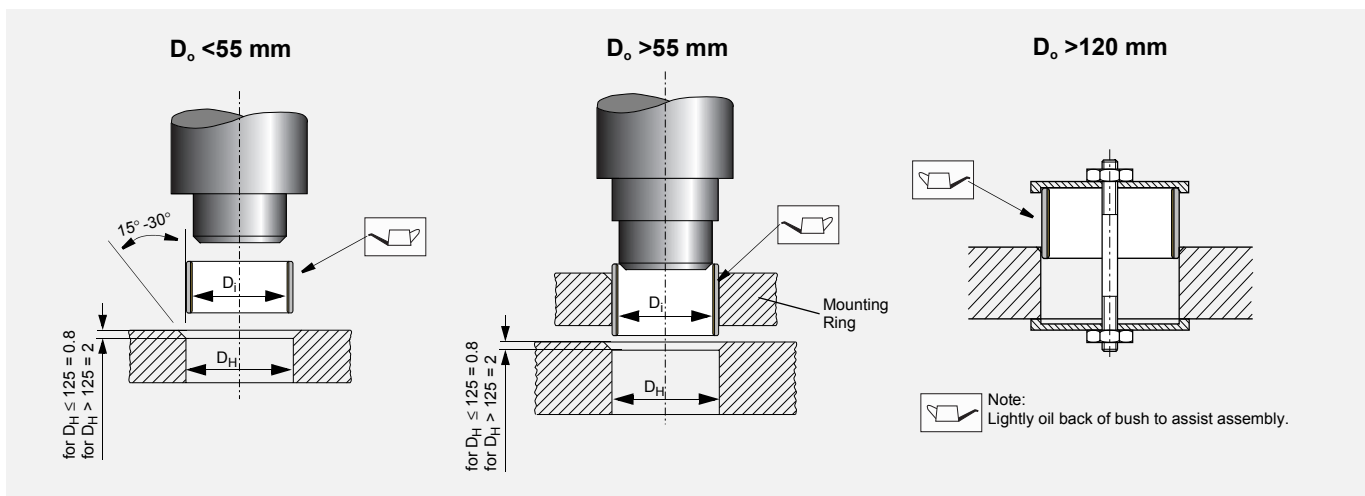


Fig. 26: Fitting of bushes

Insertion Forces

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

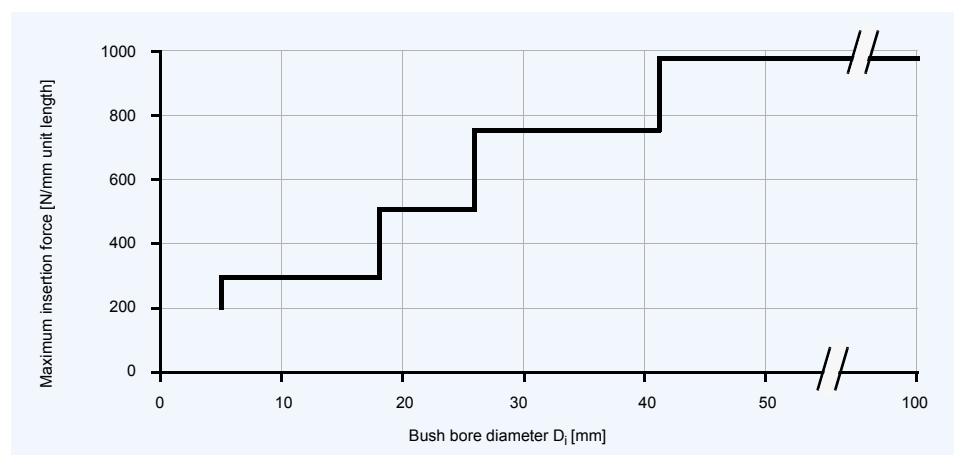


Fig. 27: Maximum insertion force F_i

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.

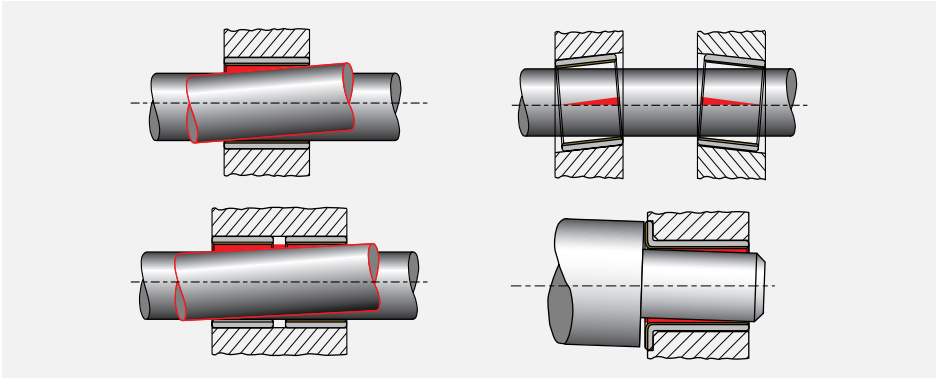


Fig. 28: Alignment

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.

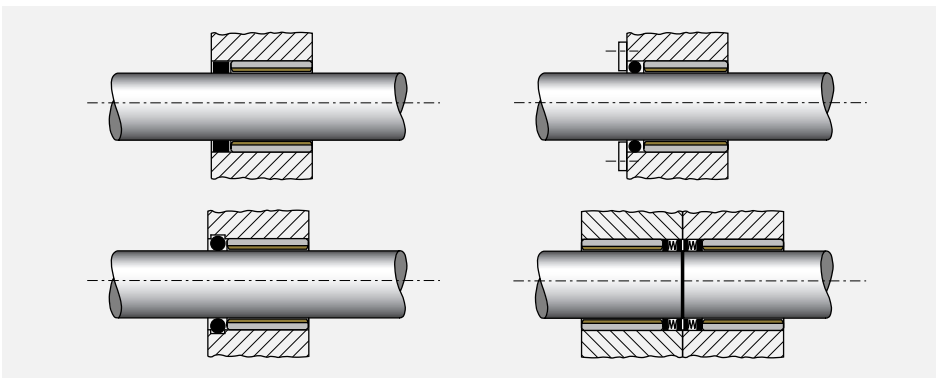


Fig. 29: Recommended sealing arrangements

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.

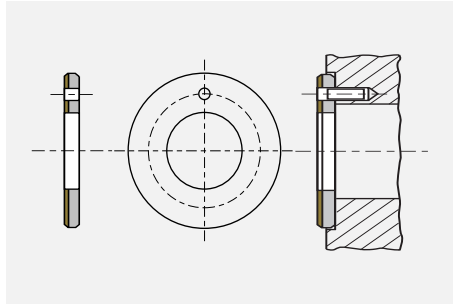


Fig. 30: Installation of Thrust-Washer

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.

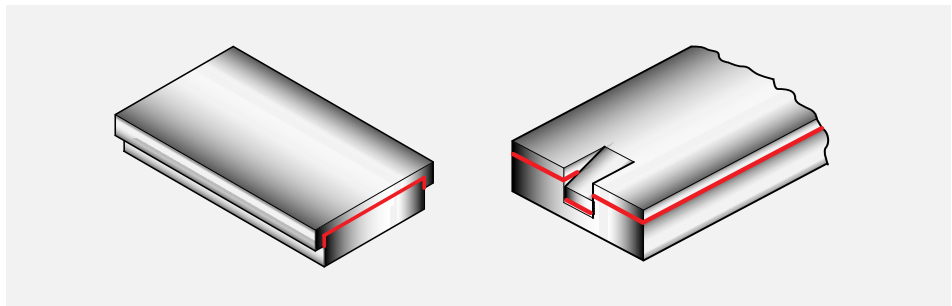


Fig. 31: Mechanical location of DX slideways

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 swarf removal. The use of coolant is not detrimental.

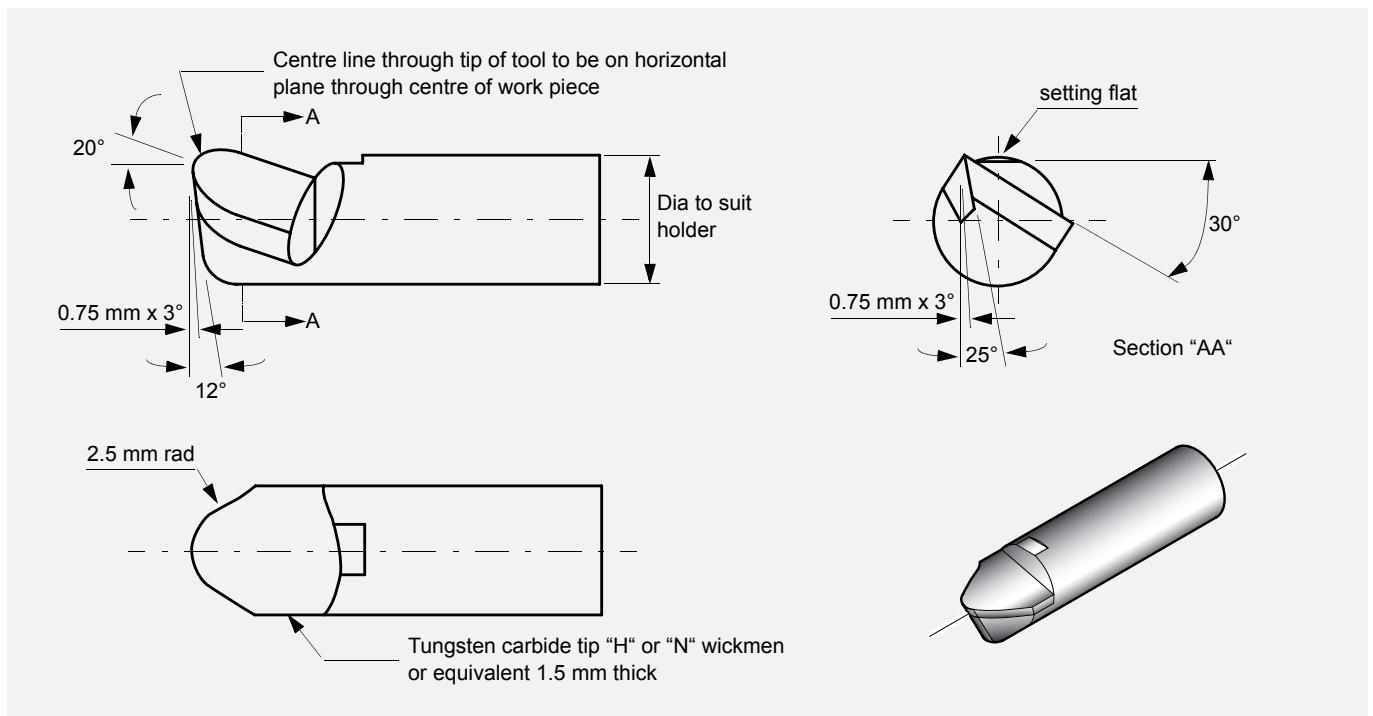


Fig. 32: Boring tool for DX

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.

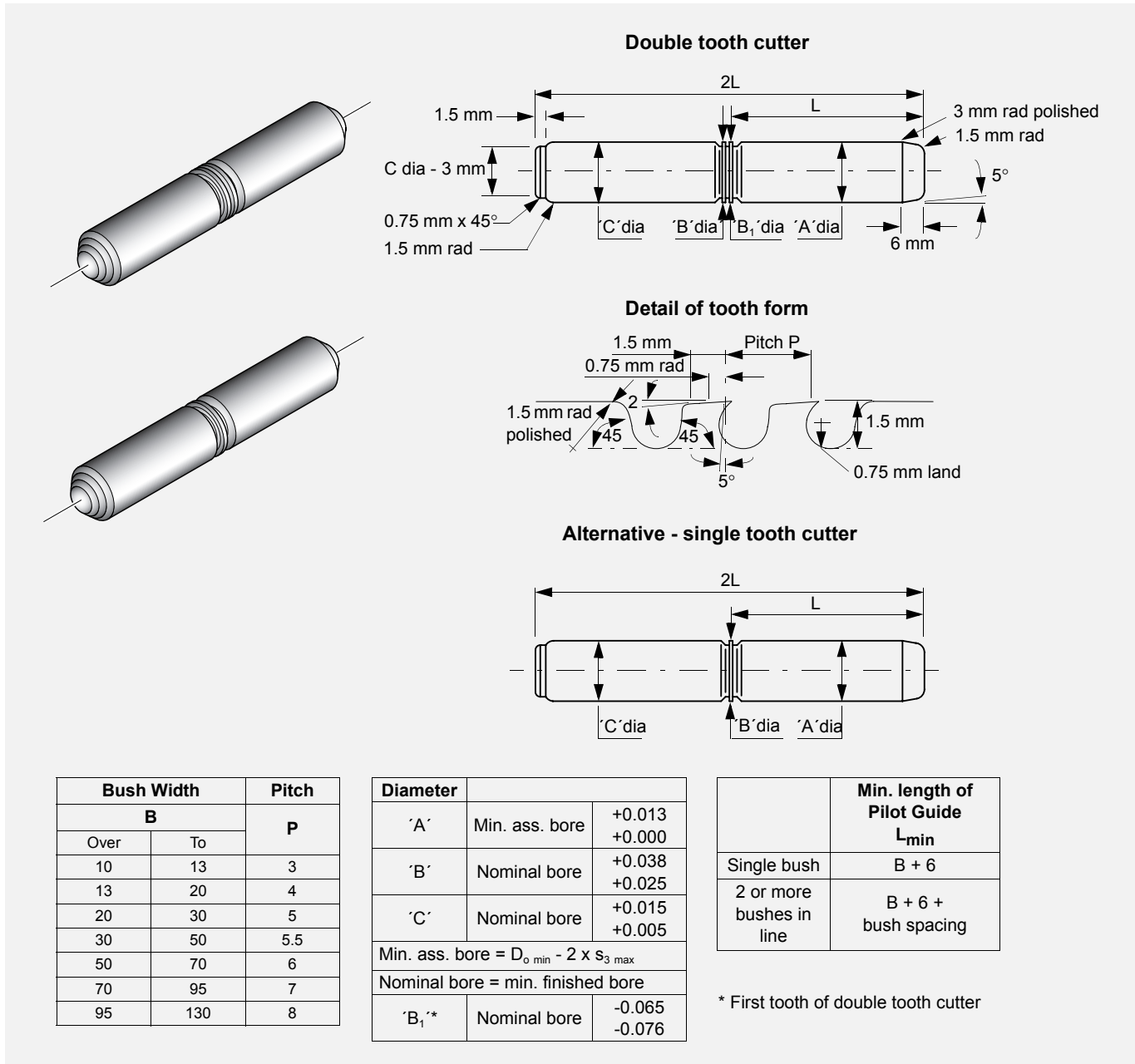


Fig. 33: Suitable broaches for MB-DX

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 $0.8 \mu\text{m } R_a$, 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.

Mating Surfaces

DX can be used against hard chrome plated materials and care should be taken to ensure that the recommended shaft

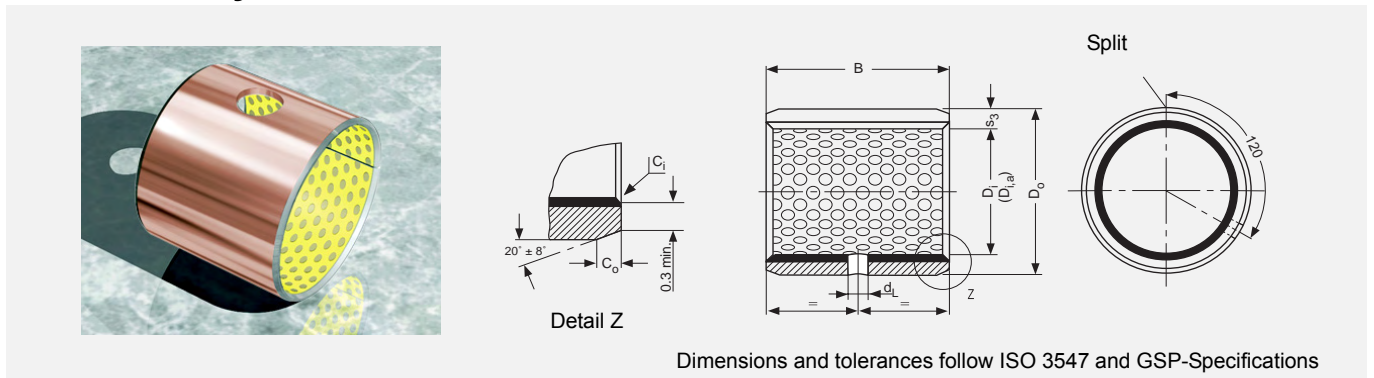
For the harder materials if the specified plating thickness exceeds approximately 5 μm then the housing diameter should be increased by twice the plating thickness in order to maintain the correct assembled bearing bore size.

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

sizes and surface finish are achieved after the plating process.

10 Standard Products

10.1 PM-DX cylindrical bushes



All dimensions in mm

Outside Co and Inside Ci chamfers

Wall thickness s ₃	C ₀ (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 ₀ (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 C₀ 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	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.			
PM0808DX	8	10	0.980 0.955	8.25	8.000 7.978	10.015 10.000	8.105 8.040	0.127 0.040	No hole	
PM0810DX				10.25						
PM0812DX				12.25						
PM1010DX	10	12		9.75	10.000 9.978	12.018 12.000	10.108 10.040	0.130 0.040	3	
PM1012DX				11.75						
PM1015DX				15.25						
PM1020DX				17.75						
PM1210DX	12	14		10.25	12.000 11.973	14.018 14.000	12.108 12.040	0.135 0.040	3	
PM1212DX				12.25						
PM1215DX				14.75						
PM1220DX				20.25						
PM1225DX				24.75						
PM1415DX	14	16		15.25	14.000 13.973	16.018 16.000	14.108 14.040	0.135 0.040	4	
PM1420DX				17.75						
PM1425DX				22.25						
PM1510DX			10.25	15.000 14.973						17.018 17.000
PM1512DX	12.25									
	11.75									

10 Standard Products

Part No.	Nominal Diameter		Wall thickness S_3	Width B	Shaft- \emptyset D_J [h8]	Housing- \emptyset D_H [H7]	Bush- \emptyset $D_{L,a}$ Ass. in H7 housing	Clearance C_D	Oil hole- \emptyset d_L																			
	D_i	D_o								max. min.	max. min.	max. min.	max. min.	max. min.														
PM1515DX	15	17	0.980 0.955	15.25	15.000	17.018	15.108	0.135 0.040	4																			
PM1520DX				14.75						14.973	15.040																	
PM1525DX				20.25						17.000	15.040																	
PM1615DX	16	18		25.25	16.000	18.018	16.108			0.164 0.050	6																	
PM1620DX				24.75								15.973	16.040															
PM1625DX				15.25								18.000	16.040															
PM1815DX	18	20		14.75	18.000	20.021	18.111					0.164 0.050	6															
PM1820DX				20.25										17.973	18.040													
PM1825DX				19.75										20.000	18.040													
PM2010DX	20	23		1.475 1.445	10.25	20.000	23.021							20.131	0.164 0.050	6												
PM2015DX					9.75												19.967	20.050										
PM2020DX					14.75												20.000	20.050										
PM2025DX			20.25		23.000			20.050																				
PM2030DX			19.75		23.000			20.050																				
PM2215DX			25.25		25.021			22.131																				
PM2220DX	24.75	25.000	22.050																									
PM2225DX	30.25	24.000	27.021		24.131	24.050	0.164 0.050	6																				
PM2230DX	29.75								27.000	24.050																		
PM2415DX	15.25								24.000	27.021	24.131	24.050	0.164 0.050	6														
PM2420DX	14.75																27.000	24.050										
PM2425DX	20.25																27.000	24.050										
PM2430DX	19.75																27.000	24.050										
PM2515DX	25.25	25.000	28.021		25.131	25.050											0.164 0.050	6										
PM2520DX	24.75																		28.000	25.050								
PM2525DX	30.25								28.000	25.050																		
PM2530DX	29.75								28.000	25.050																		
PM283130DX	31								31.025	28.135	0.168	0.050							0.164 0.050	6								
PM2820DX	28								32	31.000	28.050	0.168									0.050							
PM2825DX		20.25	28.000		32.025	28.155				28.060	0.188 0.060	6																
PM2830DX		19.75																			32.000	28.060						
PM3020DX		25.25																			30.000	34.025	30.155	30.060	0.188 0.060	6		
PM3025DX		24.75																									34.000	30.060
PM3030DX		30.25																									34.000	30.060
PM3040DX	29.75	34.000		30.060																								
	40.25																											
	39.75																											

Part No.	Nominal Diameter		Wall thickness s_3	Width B	Shaft- \varnothing D_J [h8]	Housing- \varnothing D_H [H7]	Bush- \varnothing $D_{1,a}$ Ass. in H7 housing	Clearance C_D	Oil hole- \varnothing d_L
	D_i	D_o							
PM3220DX	32	36	1.970 1.935	20.25	32.000 31.961	36.025 36.000	32.155 32.060	0.194 0.060	6
PM3230DX				19.75					
PM3235DX				30.25					
PM3240DX				29.75					
PM3520DX	35	39		35.25	35.000 34.961	39.025 39.000	35.155 35.060		
PM3530DX				34.75					
PM3535DX				40.25					
PM3550DX				39.75					
PM3635DX	36	40		20.25	36.000	40.025	36.155		
PM3720DX	37	41		19.75	35.961	40.000	36.060		
PM4020DX	40	44		20.25	40.000 39.961	44.025 44.000	40.155 40.060		
PM4030DX				19.75					
PM4040DX			30.25						
PM4050DX			29.75						
PM4520DX	45	50	40.25	45.000 44.961	50.025 50.000	45.195 45.080			
PM4530DX			39.75						
PM4540DX			45.25						
PM4545DX			44.75						
PM4550DX	50.25	50	49.75	50.000	55.030	50.200			
PM5030DX	50	55	30.25	50.000 49.961	55.030 55.000	50.080			
PM5040DX			29.75						
PM5045DX			40.25						
PM5050DX			39.75						
PM5060DX	45.25	55	44.75	50.000	55.000	50.080			
PM5520DX	55	60	60.25	55.000 54.954	60.030 60.000	55.200 55.080			
PM5525DX			59.75						
PM5530DX			20.25						
PM5540DX			19.75						
PM5550DX	25.25	60	24.75	55.000	60.000	55.080			
PM5560DX	30.25	60	29.75	55.000	60.000	55.080			
PM6030DX	60	65	40.25	60.000 59.954	65.030 65.000	60.200 60.080			
PM6040DX			39.75						
PM6050DX			50.25						
PM6060DX			49.75						
PM6070DX	60.25	65	59.75	60.000	65.000	60.080			
			69.75	59.954	65.000	60.080			

10 Standard Products

Part No.	Nominal Diameter		Wall thickness S_3	Width B	Shaft- \varnothing D_J [h8]	Housing- \varnothing D_H [H7]	Bush- \varnothing $D_{L,a}$ Ass. in H7 housing	Clearance C_D	Oil hole- \varnothing d_L
	D_i	D_o							
PM6540DX	65	70	2.450 2.384	40.25	65.000 64.954	70.030 70.000	65.262 65.100	8	
PM6550DX				39.75					
PM6560DX				50.25					
PM6570DX				49.75					
PM7040DX	70	75		60.25	70.000 69.954	75.030 75.000	70.262 70.100		
PM7050DX				59.75					
PM7060DX				70.25					
PM7065DX				69.75					
PM7070DX				60.25					
PM7080DX				59.75					
PM7540DX	75	80		65.25	75.000 74.954	80.030 80.000	75.262 75.100		
PM7560DX				64.75					
PM7580DX				70.25					
PM8040DX	80	85		69.75	80.000 79.954	85.035 85.000	80.267 80.100		
PM8050DX				80.25					
PM8060DX				79.75					
PM8080DX				40.50					
PM80100DX				39.50					
PM8530DX				50.50					
PM8540DX	49.50								
PM8560DX	85	90	60.50	85.000 84.946	90.035 90.000	85.267 85.100			
PM8580DX			59.50						
PM85100DX			80.50						
PM9040DX			79.50						
PM9060DX	90	95	100.50	90.000 89.946	95.035 95.000	90.267 90.100			
PM9080DX			99.50						
PM9090DX			40.50						
PM90100DX			39.50						
PM9560DX	95	100	60.50	95.000 94.946	100.035 100.000	95.267 95.100			
PM95100DX			59.50						

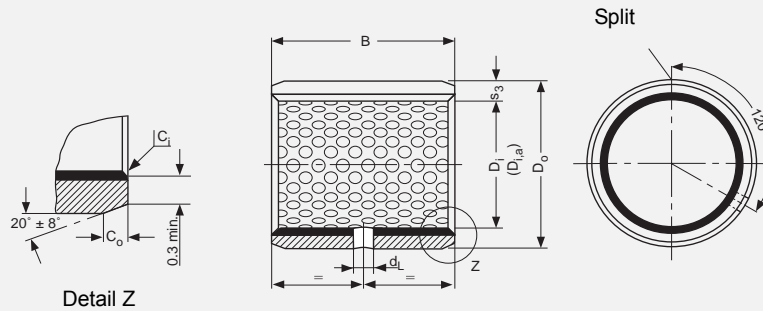
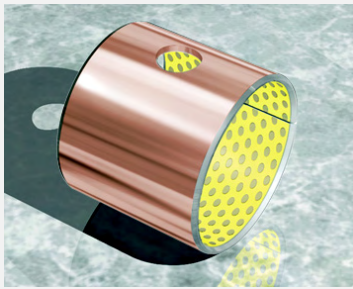
Part No.	Nominal Diameter		Wall thickness s_3	Width B	Shaft- ϕ D_J [h8]	Housing- ϕ D_H [H7]	Bush- ϕ $D_{I,a}$ Ass. in H7 housing	Clearance C_D	Oil hole- ϕ d_L											
	D_i	D_o								max. min.	max. min.	max. min.	max. min.	max. min.						
PM10050DX	100	105	2.450 2.384	50.50	100.000 99.946	105.035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

10 Standard Products

Part No.	Nominal Diameter		Wall thickness S_3	Width B	Shaft- ϕ D_J [h8]	Housing- ϕ D_H [H7]	Bush- ϕ $D_{L,a}$ Ass. in H7 housing	Clearance C_D		Oil hole- ϕ d_L
	D_i	D_o						max. min.	max. min.	
PM16050DX	160	165	2.435 2.380	50.50	160.000 159.937	165.040 165.000	160.280 160.130	0.343 0.130	No hole	
PM16060DX				49.50						
PM16080DX				60.50						
PM160100DX				59.50						
PM17050DX				80.50						170.000 169.937
PM17060DX	79.50									
PM17080DX	100.50									
PM170100DX	99.50									
PM18050DX	50.50	180.000 179.937		185.046 185.000	180.286 180.130					
PM18060DX	49.50									
PM18080DX	60.50									
PM180100DX	59.50									
PM19050DX	80.50					190.000 189.928	195.046 195.000	190.286 190.130		
PM19060DX	79.50									
PM19080DX	100.50									
PM190100DX	99.50									
PM190120DX	120.50	200.000 199.928		205.046 205.000	200.286 200.130					
PM20050DX	19.50									
PM20060DX	50.50									
PM20080DX	49.50									
PM200100DX	60.50		220.000 219.928			225.046 225.000	220.286 220.130			
PM200120DX	59.50									
PM22050DX	80.50									
PM22060DX	79.50									
PM22080DX	100.50	240.000 239.928		245.046 245.000	240.286 240.130					
PM24050DX	99.50									
PM24060DX	120.50									
PM24080DX	119.50									
PM240100DX	50.50									
PM240120DX	49.50									
PM240100DX	60.50									
PM240120DX	59.50									
PM240120DX	80.50									
PM240120DX	79.50									
PM240100DX	100.50									
PM240120DX	99.50									
PM240120DX	120.50									
PM240120DX	119.50									

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

10.2MB-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_0 (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_0 (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_0 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- \emptyset D_{Jm} [d8]	Housing- \emptyset D_H [H7]	Bush- \emptyset $D_{i.a.m}$ Ass. in H7 housing	Clearance C_{Dm}	Oil hole- \emptyset d_L								
	D_i	D_o								max. min.	max. min.	max. min.	max. min.	max. min.			
MB0808DX	8	10	1.108 1.082	8.25	d8	H7	8.015 8.000	0.077 0.040	No hole								
MB0810DX				7.75						7.960	10.015						
MB0812DX				9.75						10.000	8.000						
MB1010DX	10	12		10.25						9.960 9.938	12.018 12.000	10.018 10.000	0.080 0.040	3			
MB1012DX				11.75										12.018	10.018	4	
MB1015DX				15.25										12.000	10.000		
MB1020DX				14.75										12.000	10.000		
MB1210DX	12	14		19.75						11.950 11.923	14.018 14.000	12.018 12.000	0.095 0.050	3			
MB1212DX				10.25										13.950	16.018	4	
MB1215DX				9.75										13.923	16.000		14.018
MB1220DX				12.25										13.923	16.000	14.000	
MB1225DX				11.75										13.923	16.000	14.000	
MB1415DX	14	16		15.25						14.950 14.923	17.018 17.000	15.018 15.000	0.095 0.050	3			
MB1420DX				14.75											14.923	17.000	4
MB1425DX				20.25											14.923	17.000	
MB1510DX	15	17	24.75	14.923	17.000	15.000	0.095 0.050	3									
MB1512DX			10.25					14.923	17.000	4							
MB1515DX			9.75					14.923	17.000								
MB1525DX			12.25					14.923	17.000								

PartNo.	Nominal Diameter		Wall thickness s_3	Width B	Shaft- ϕ D_{Jm} [d8]	Housing- ϕ D_H [H7]	Bush- ϕ $D_{I,a,m}$ Ass. in H7 housing	Clearance C_{Dm}	Oil hole- ϕ d_L
	D_i	D_o							
MB1615DX	16	18	1.108 1.082	15.25	15.950 15.923	18.018 18.000	16.018 16.000	0.095 0.050	4
MB1620DX				14.75					
MB1625DX				20.25					
MB1815DX	18	20	1.108 1.082	25.25	17.950 17.923	20.021 20.000	18.018 18.000	0.095 0.050	
MB1820DX				24.75					
MB1825DX				15.25					
MB2010DX	20	23	1.608 1.576	14.75	19.935 19.902	23.021 23.000	20.021 20.000	0.119 0.065	
MB2015DX				15.25					
MB2020DX				19.75					
MB2025DX				24.75					
MB2030DX				30.25					
MB2215DX	22	25	1.608 1.576	14.75	21.935 21.902	25.021 25.000	22.021 22.000	0.119 0.065	
MB2220DX				20.25					
MB2225DX				19.75					
MB2230DX				24.75					
MB2415DX	24	27	1.608 1.576	15.25	23.935 23.902	27.021 27.000	24.021 24.000	0.119 0.065	
MB2420DX				14.75					
MB2425DX				20.25					
MB2430DX				24.75					
MB2515DX	25	28	2.108 2.072	30.25	24.935 24.902	28.021 28.000	25.021 25.000	0.119 0.065	
MB2520DX				29.75					
MB2525DX				15.25					
MB2530DX				14.75					
MB2820DX				28					32
MB2825DX	19.75								
MB2830DX	24.75								
MB3020DX	30	34	2.108 2.072	30.25	30.000 29.967	34.025 34.000	30.021 30.000	6	
MB3030DX				29.75					
MB3040DX				40.25					

10 Standard Products

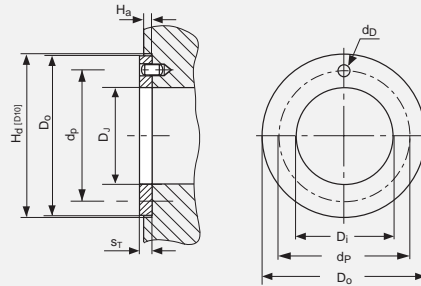
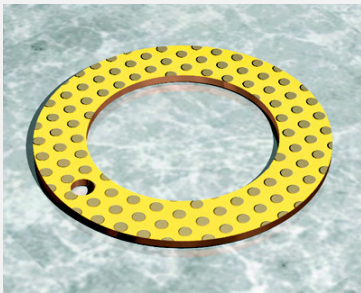
PartNo.	Nominal Diameter		Wall thickness S_3	Width B	Shaft- \varnothing D_{Jm} [d8]	Housing- \varnothing D_H [H7]	Bush- \varnothing $D_{i,a,m}$ Ass. in H7 housing	Clearance C_{Dm}	Oil hole- \varnothing d_L
	D_i	D_o							
MB3220DX	32	36	2.108 2.072	20.25	31.920 31.881	36.025 36.000	32.025 32.000	0.144 0.080	6
MB3230DX				19.75					
MB3235DX				30.25					
MB3240DX				29.75					
MB3520DX	35	39		35.25	34.920 34.881	39.025 39.000	35.025 35.000		
MB3530DX				34.75					
MB3550DX				40.25					
MB3720DX	37	41		39.75	36.920 36.881	41.025 41.000	37.025 37.000		
MB4020DX	40	44		20.25	39.920 39.881	44.025 44.000	40.025 40.000		
MB4030DX				19.75					
MB4040DX				30.25					
MB4050DX				29.75					
MB4520DX	45	50	40.25	44.920 44.881	50.025 50.000	45.025 45.000			
MB4530DX			19.75						
MB4540DX			30.25						
MB4545DX			29.75						
MB4550DX	45.25								
MB5040DX	50	55	44.75	49.920 49.881	55.030 55.000	50.025 50.000			
MB5060DX			50.25						
MB5520DX			49.75						
MB5525DX	55	60	20.25	54.900 54.854	60.030 60.000	55.030 55.000			
MB5530DX			19.75						
MB5540DX			25.25						
MB5550DX			24.75						
MB5560DX	30.25								
MB6030DX	60	65	29.75	59.900 59.854	65.030 65.000	60.030 60.000			
MB6040DX			40.25						
MB6060DX			39.75						
MB6070DX			60.25						
			59.75						
	70.25								
	69.75								

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

10 Standard Products

PartNo.	Nominal Diameter		Wall thickness S_3	Width B	Shaft- \varnothing D_{Jm} [d8]	Housing- \varnothing D_H [H7]	Bush- \varnothing $D_{i,a,m}$ Ass. in H7 housing	Clearance C_{Dm}	Oil hole- \varnothing d_L			
	D_i	D_o								max. min.	max. min.	max. min.
MB10560DX	105	110	2.634 2.568	60.50	104.880 104.826	110.035 110.000	105.035 105.000	0.209 0.120	9.5			
MB105110DX				59.50								
MB105115DX				110.50								
MB11060DX	109.50											
MB110115DX	115.50											
MB11550DX	114.50											
MB11570DX	60.50	114.880 114.826		120.035 120.000	115.035 115.000							
MB12060DX	59.50											
MB120100DX	115.50											
MB125100DX	120	125		114.50	50.50	124.855 124.792	130.040 130.000			125.040 125.000	0.248 0.145	No hole
MB13050DX	125	130		49.50								
MB13060DX	130	135		60.50								
MB130100DX	135	140	59.50	129.855 129.792	135.040 135.000	130.040 130.000						
MB13560DX			100.50									
MB13580DX			99.50									
MB14060DX	140	145	60.50	134.855 134.792	140.040 140.000	135.040 135.000						
MB140100DX			59.50									
MB15060DX			80.50									
MB15080DX	150	155	79.50	139.855 139.792	145.040 145.000	140.040 140.000						
MB150100DX			60.50									
			59.50									
				80.50	149.855 149.792	155.040 155.000	150.040 150.000					
				79.50								
				100.50								
				99.50								

10.3DX Thrust Washers

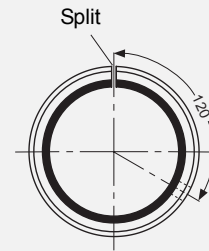
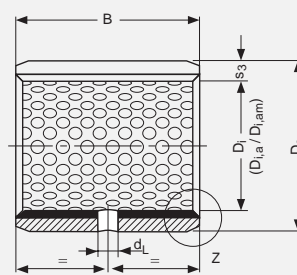
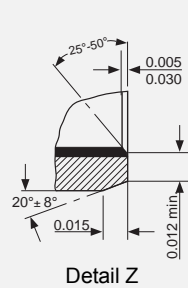
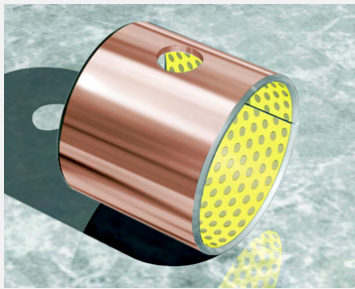


All dimensions in mm

Part No.	Inside- \varnothing D_i		Outside- \varnothing D_o		Thickness s_T		Dowel hole		Recess depth H_a	
	max. min.	max. min.	max. min.	max. min.	max. min.	max. min.	$\varnothing d_D$ max. min.	PCD- $\varnothing d_p$ 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	No hole			
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					3.375 3.125	25.12 24.88		
WC18DX	20.25 20.00	36.00 35.75						28.12 27.88		
WC20DX	22.25 22.00	38.00 37.75					4.375 4.125	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					1.70 1.45	35.12 34.88		
WC25DX	28.25 28.00	48.00 47.75						38.12 37.88		
WC30DX	32.25 32.00	54.00 53.75					61.12 60.88	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					65.12 64.88	54.12 53.88		
WC45DX	48.25 48.00	74.00 73.75						61.12 60.88		
WC50DX	52.25 52.00	78.00 77.75	76.12 75.88	65.12 64.88						
WC60DX	62.25 62.00	90.00 89.75		76.12 75.88						

10 Standard Products

10.4DX cylindrical bushes - Inch sizes



All dimensions in inch

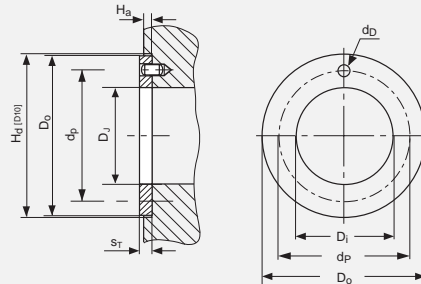
Part No.	Nominal Diameter		Housing- ϕ D_H [BS 1916 H7]	As supplied					Machined in situ			Oil hole- ϕ d_L		
	D_i	D_o		Wall Thickness s_3	Width B	Shaft- ϕ D_J	Bush- ϕ $D_{i,a}$ Ass. in an H7 housing	Clearance C_D	Shaft- ϕ D_{Jm} [BS 1916 d8]	Bush- ϕ $D_{i,am}$ Machined in situ to BS 1916 H7	Clearance C_{Dm}			
			max. min.	max. min.	max. min.	max. min.	max. min.	max. min.	max. min.	max. min.	max. min.			
06DX06	$3/8$	$15/32$	0.4694 0.4687	0.0510 0.0500	0.385		0.3648 0.3639	0.3694 0.3667	0.0055 0.0019	0.3734 0.3725	0.3756 0.3750	0.0031 0.0016		
06DX08					0.490									
06DX12					0.760 0.740									
07DX08	$7/16$	$17/32$	0.5319 0.5312		0.510		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					0.490									
08DX06					$1/2$									$19/32$
08DX08	0.385 0.365													
08DX10	0.510													
08DX14	0.635 0.615													
09DX08	$9/16$	$21/32$	0.6569 0.6562		0.885 0.865		0.5522 0.5512	0.5569 0.5542		0.5605 0.5595	0.5632 0.5625			$5/32$
09DX12					0.510									
10DX08					0.490									
10DX10	$5/8$	$23/32$	0.7195 0.7187		0.510		0.6146 0.6136	0.6195 0.6167	0.0059 0.0021	0.6230 0.6220	0.6257 0.6250			
10DX12					0.635									
10DX14					0.615									
11DX14				0.760 0.740										
12DX08	$3/4$	$7/8$	0.8758 0.8750	0.885 0.865		0.6770 0.6760	0.6820 0.6792	0.0060 0.0022	0.6855 0.6845	0.6882 0.6875				
12DX12				0.510 0.490										
12DX16				0.760 0.740 1.010 0.990										

Part No.	Nominal Diameter		Housing- ϕ D_H [BS 1916 H7]	As supplied					Machined in situ			Oil hole- ϕ d_L						
				Wall Thickness s_3	Width B	Shaft- ϕ D_J	Bush- ϕ $D_{i,a}$ Ass. in an H7 housing	Clearance C_D	Shaft- ϕ D_{Jm} [BS 1916 d8]	Bush- ϕ $D_{i,am}$ 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.								
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	0.0669 0.0657	0.760 0.740	0.9888 0.9876	0.9944 0.9912	0.0068 0.0024	0.9975 0.9963	1.0008 1.0000			0.0045 0.0025	1/4				
16DX16					1.010 0.990													
16DX24					1.510 1.490													
18DX12	1 1/8	19/32	1.2822 1.2812	0.0669 0.0657	0.760 0.740	1.1138 1.1126	1.1202 1.1164	0.0076 0.0026	1.1225 1.1213	1.1258 1.2500					0.0045 0.0025	1/4		
18DX16					1.010 0.990													
20DX12	1 1/4	1 13/32	1.4072 1.4062	0.0669 0.0657	0.760 0.740	1.2387 1.2371	1.2452 1.2414	0.0081 0.0027	1.2470 1.2454	1.2510 1.2500							0.0045 0.0025	1/4
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	0.0824 0.0810	1.010 0.990	1.3635 1.3619	1.3702 1.3664	0.0083 0.0029	1.3720 1.3704	1.3760 1.3750	0.0056 0.0030	5/16						
22DX22					1.385 0.365													
22DX28					1.760 1.740													
24DX16	1 1/2	1 21/32	1.6572 1.6562	0.0824 0.0810	1.010 0.990	1.4884 1.4868	1.4952 1.4914	0.0084 0.0030	1.4970 1.4954	1.5010 1.5000			0.0056 0.0030	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	0.0824 0.0810	1.010 0.990	1.6133 1.6117	1.6202 1.6164	0.0085 0.0031	1.6220 1.6204	1.6260 1.6250					0.0056 0.0030	5/16		
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							0.0056 0.0030	5/16
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	0.0980 0.0962	1.510 1.490	1.8632 1.8616	1.8713 1.8665	0.0097 0.0033	1.8720 1.8704	1.8760 1.8750	0.0070 0.0040	5/16						
30DX30					1.885 1.865													
30DX36					2.260 2.240													
32DX16	2	2 3/16	2.1887 2.1875	0.0980 0.0962	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	5/16				
32DX24					1.510 1.490													
32DX32					2.010 1.990													
32DX40					2.510 2.490													

10 Standard Products

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

10.5DX Thrust Washers - Inch sizes

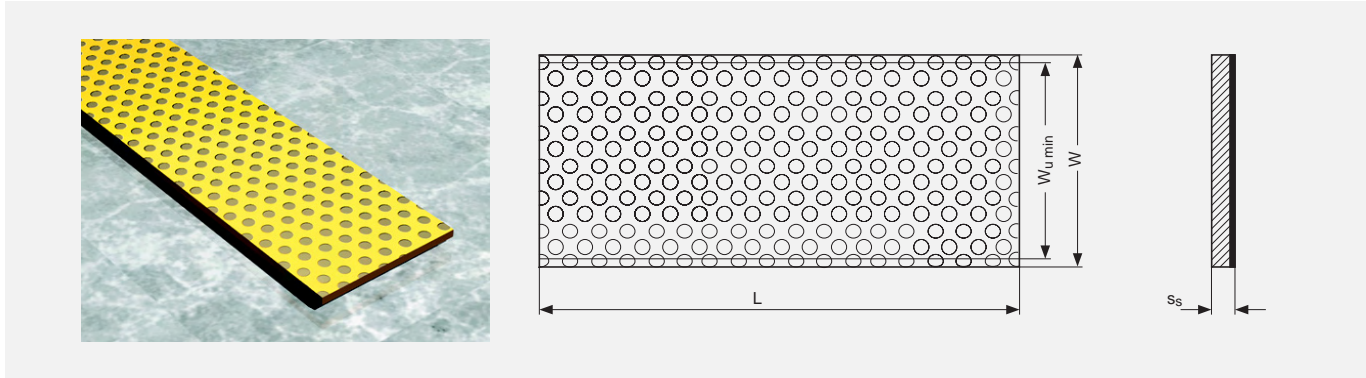


All dimensions in inch

Part No.	Inside-ø D _i		Outside-ø D _o		Thickness s _T	Dowel hole		Recess depth H _a
	max. min.	max. min.	max. min.	max. min.		ø d _D	PCD-ø d _p	
DX06	0.5100	0.8750	0.0660 0.0625	0.0770	0.6920	0.050 0.040		
DX07	0.5000	0.8650		0.0670	0.6820			
DX08	0.5720	1.0000		0.1090	0.7860		0.8800	
DX09	0.5620	0.9900			0.7760		0.8700	
DX10	0.6350	1.1250			0.9420		0.8700	
DX11	0.6250	1.1150			0.9320		1.0050	
DX12	0.6970	1.1870			0.9950		1.0890	
DX14	0.6870	1.1770			1.0990		1.0890	
DX16	0.8220	1.3750		0.1400	1.1920		1.1920	
DX18	0.8120	1.3650			1.1820		1.1820	
DX20	0.8850	1.5000			1.3800		1.3700	
DX22	0.8750	1.4900		0.1710	1.5670		1.5670	
DX24	1.0100	1.7500			1.5570		1.6920	
DX26	1.0000	1.7400			1.6820		1.6820	
DX28	1.1350	2.0000			1.8170		1.8170	
DX30	1.1250	1.9900			1.8070		1.8070	
DX32	1.3850	2.2500			0.2020		2.0050	2.0050
DX34	1.3750	2.2400		1.9950			1.9950	
DX36	1.5100	2.5000	2.1300	2.1300				
DX38	1.5000	2.4900	2.1200	2.1200				
DX40	1.6350	2.6250	2.2550	2.2550				
DX42	1.6250	2.6150	2.2450	2.2450				
DX44	1.7600	2.7500	0.0970 0.0935	2.5050	2.5050	0.080 0.070		
DX46	1.7500	2.7400		2.4950	2.4950			
DX48	2.0100	3.0000		2.6300	2.6300			
DX50	2.0000	2.9900		2.6200	2.6200			
DX52	2.1350	3.1250		2.7550	2.7550			
DX54	2.1250	3.1150		2.7450	2.7450			

10 Standard Products

10.6DX 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				1.56	1.52
S20190DX	200	190	2.05	2.01	
S25190DX			2.57	2.53	

10.7DX Strip - Inch sizes

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

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Declaration on the RoHS Directive

On July the 1st 2006 the EU directive 2002/95/EG ("RoHS-directive, Restriction of Hazardous Substances") became effective. It forbids to place products into circulation that contain lead, cadmium, chrome (VI), mercury or PBB/PBDE containing flame retardants.

All products of GGB except DU and DUB comply with the EU directives 2002/96/EG (End of life directive on electric and electronic devices) and 2002/95/EG (Constraint of certain hazardous materials in electric and electronic devices) and End of Life Vehicles directive (2000/53/EC) on the elimination of hazardous materials in the construction of passenger cars and light trucks.

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