GGB HI-EX®

METAL-POLYMER SUPERIOR PERFORMANCE BEARING SOLUTIONS FOR LUBRICATED APPLICATIONS

PUSHING BOUNDARIES TO CO-CREATE A HIGHER QUALITY OF LIFE

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

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

- Aerospace
- Agricultural
- Automotive
- Construction
- E-Mobility
- Energy
- Fluid Power
- Industrial
- Medical
- Mining
- Oil & Gas
- Primary Metals
- Railway
- Recreation

The GGB Advantage

LOWER SYSTEM COST

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

LOW-FRICTION, HIGH WEAR RESISTANCE

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

MAINTENANCE-FREE

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

ENVIRONMENTAL

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

CUSTOMER SUPPORT

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

The Highest Standards in Quality

SAFETY

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

EXCELLENCE

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

For a complete listing of our certifications, please visit our website:
www.ggbearings.com/en/certificates

RESPECT

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

GGB Who We Are

GGB'S HISTORY AS THE GLOBAL LEADER IN PLAIN BEARING TECHNOLOGIES DATES BACK MORE THAN 120 YEARS.

Beginning with the founding of Glacier Antifriction Metal Company in 1899 and later introducing the industry-leading DU® bearing in 1965, GGB has continued to create innovative technologies and solutions that improve safety, performance, and profitability in a wide range of markets. Today, our products can be found everywhere - from scientific vessels at the bottom of the ocean to racecars speeding down the tarmac to jumbo jets slicing through the sky to the Curiosity rover exploring the surface of Mars.

Throughout our history, safety, excellence, and respect have formed the foundational values for the entire GGB family. They are of paramount importance as we seek to maximize personal possibility, achieve excellence, and establish open, creative work environments

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1 Introduction

The purpose of this handbook is to provide comprehensive technical information on the characteristics of HI-EX® 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 HI-EX® standard stock products is given together with details of other HI-EX® products.

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

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

1.1 CHARACTERISTICS AND ADVANTAGES

- HI-EX® provides maintenance free operation
- HI-EX® has a high pU capability
- HI-EX® exhibits low wear rate
- Seizure resistant
- Suitable for temperatures from -150 °C to +250 °C
- High static and dynamic load capacity
- HI-EX polymer bearing lining has good chemical resistance
- No water absorption and therefore dimensionally stable
- Compact and light
- Suitable for rotating, oscillating, reciprocating and sliding movements
- HI-EX® bearings are prefinished and require no machining after assembly
- Suitable for use with low viscosity and low lubricant fluids.

2 Structure

HI-EX® 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 PEEK (polyetherether ketone) polymer bearing material, containing fillers including PTFE (polytertafluorethylene).

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.

For grease lubricated applications HI-EX® is manufactured with a polymer overlay thickness above the bronze sinter layer of 0,30 mm nominal, and the bearing surface is 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 (e.g. PM2020HX).

For fluid lubricated applications where the bearing surface may be required to be machined subsequent to assembly, HI-EX® is manufactured with a polymer overlay thickness above the bronze sinter layer of 0,30 mm nominal, and the indent pattern omitted from the bearing surface (e.g. PM2020HXU).

Fig. 1: HI-EX Microsection

2.1 BASIC FORMS

HI-EX® is not available from stock and is manufactured only to order as follows:

Standard Components

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

- 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.
- Thrust Washers
- Strip Material

Fig. 2: Standard Components

Non Standard Components

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, MECHANICAL AND ELECTRICAL PROPERTIES

BEARING PROPERTIES		SYMBOL	UNIT	VALUE HI-EX®	COMMENTS
PHYSICAL PROPERTIES					
Thermal conductivity		λ	W/mK	52	
Coefficient of linear thermal expansion	parallel to surface normal to service	α_1 α_2	10^{-6}/K	11 29	
Operating temperature		T_{max} T_{min}	°C	+250 - 150	
MECHANICAL PROPERTIES					
Compressive yield strength		σ_C	N/mm²	380	measured on disc Ø 25 mm x 2,45 mm thick
Maximum load	static dynamic	$p_{sta.max}$ $p_{dyn.max}$	N/mm²	140 140	
ELECTRICAL PROPERTIES					
Volume resistivity of PEEK lining		p_D	Ωcm	$>10^9$	

Table 1: Physical, mechanical and electrical properties of HI-EX

3.2 CHEMICAL PROPERTIES

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

CHEMICAL	%	°C	HI-EX®
STRONG ACIDS			
Hydrochloric Acid	5	20	-
Nitric Acid	5	20	-
Sulfuric Acid	5	20	-
WEAK ACIDS			
Acetic Acid	5	20	-
Formic Acid	5	20	-
BASES			
Ammonia	10	20	o
Sodium Hydroxide	5	20	o

CHEMICAL	°C	HI-EX®
SOLVENTS		
Acetone	20	+
Carbon Tetrachloride	20	+
LUBRICANTS AND FUELS		
Paraffin	20	+
Gasolene	20	+
Kerosene	20	+
Diesel Fuel	20	+
Mineral Oil	70	+
HFA-ISO46 High Water Fluid	70	+
HFC-Water-Glycol	70	+
HFD-Phosphate Ester	70	+
Water	20	o
Sea Water	20	-

Table 2: Chemical Resistance of HI-EX

\+ 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

4 Lubrication and Friction

4.1 DRY OPERATION

HI-EX® will operate satisfactorily without lubrication under light duty running conditions at pU factors below 0,01 N/mm^2 x m/s and sliding speeds below 2,5 m/s. The wear performance should be confirmed by testing if possible.

4.2 CHOICE OF LUBRICANT

HI-EX® will generally be lubricated, the choice of lubricant depending upon:

- pU and sliding speed
- the stability of the lubricant under the operating conditions.

Grease

The performance ratings of different types of grease are indicated in Table 3. Greases containing EP additives or significant additions of graphite or MoS_2 are not generally recommended for use with HI-EX®.

HI-EX® is able to withstand environmental temperatures beyond those generally suitable for grease lubrication and the performance is therefore likely to be limited by the lubricant and not by the bearing material. For environmental temperatures above 80 °C suitability of the grease should be established by test and a silicone oil base or high temperature grease is recommended. For applications above 150 °C pU values should be limited to below 1,0 N/mm^2 x m/s and re-lubrication intervals should not exeed 500 hours.

Oil

HI-EX® is recommended for use with oil lubrication. HI-EX® is compatible with mineral oils up to 150 °C and is resistant to the oxidation products which may occur with mineral oils at temperatures above 115 °C. Degradation of oils is likely to occur following extended exposure to high temperatures and synthetic lubricants are recommended under these circumstances.

Non lubricating fluids

HI-EX® has been found to perform satisfactorily with low viscosity and non lubricating fluids such as polyethylene glycol and polyglycol lubricants, water-oil emulsion, shock-absorber oils, kerosene and water.

In general, the fluid will be acceptable if it does not chemically attack the PEEK 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 HI-EX® 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 HI-EX®.

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

4 Lubrication and Friction

MANUFACTURER	GRADE	TYPE: OIL	TYPE: THICKENER	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	o
	Molykote PG602	Mineral	Lithium Soap	o
Elf	Rolexa.1	Mineral	Lithium Soap	+
	Rolexa.2	Mineral	Lithium Soap	o
	Epexelf.2	Mineral	Lithium/Calcium Soap	-
Esso	Andok C	Mineral	Sodium Soap	o
	Andok 260	Mineral	Sodium Soap	o
	Cazar K	Mineral	Calcium Soap	-
Mobil	Mobilplex 47	Mineral	Calcium Soap	-
	Mobiltemp 1	Mineral	Non Soap	o
Rocol	BG622	White Mineral	Calcium Soap	o
	Sapphire	Mineral	Lithium Complex	-
	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	-
	Tivela A	Synthetic	**NA**	o
Total	Aerogrease	Synthetic	**NA**	+
	Multis EP2	**NA**	Lithium	+

Table 3: Performance of greases

+ Recommended

o Satisfactory

- Not recommended

NA Data not available

4.3 FRICTION

The coefficient of friction of lubricated HI-EX® depends upon the actual operating conditions as indicated in section 4.4. Where frictional characteristics are critical to a design they should be established by prototype testing.

4.4 LUBRICATED ENVIRONMENTS

The following sections describe the basics of lubrication and provide guidance on the application of HI-EX® 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

Hydrodynamic conditions occur when:

(4.4.1) [N/mm²]

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

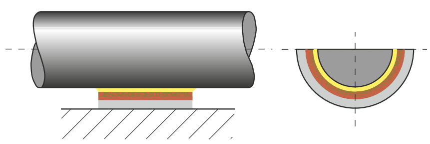


Figure 4: Hydrodynamic lubrication

Mixed Film Lubrication

Characterised by:

- Combination of hydrodynamic and boundary lubrication.
- Part of the load is carried by localised areas of self pressurised lubricant and the remainder supported by boundary lubrication.
- Friction and wear depend upon the degree of hydrodynamic support developed.
- HI-EX® provides low friction and high wear resistance to support the boundary lubricated element of the load.

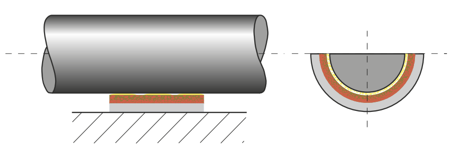


Figure 5: Mixed film lubrication

4 Lubrication and Friction

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.

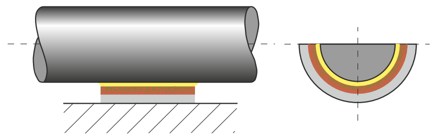


Figure 6: Hydrodynamic lubrication

- The excellent properties of HI-EX® material minimises wear under these conditions.
- The dynamic coefficient of friction with HI-EX® is typically 0,02 to 0,15 under boundary lubrication conditions.
- The static coefficient of friction with HI-EX® is typically 0,05 to 0,20 under boundary lubrication conditions.

4.5 CHARACTERISTICS OF FLUID LUBRICATED HI-EX® BEARINGS

High load conditions

In highly loaded applications operating under boundary or mixed film conditions HI-EX® shows excellent wear resistance.

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.

- HI-EX® minimises wear

Sparse lubrication

Many applications require the bearing to operate with less than the ideal lubricant supply, typically with splash or mist lubrication only. The PEEK lining of HI-EX® has low thermal conductivity relative to conventional metallic bearings, and therefore depending upon the operating conditions may require a greater lubricant supply to remove the generated heat in the bearing.

- HI-EX® shows greater wear resistance than conventional metallic bearings.

4.6 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 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 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 Figure 7

The bearing will operate with boundary lubrication. The pU factor will be the major determinant of bearing life.

HI-EX® bearing performance can be estimated from the following:

Calculate effective pU factor from section 5.8.

If epU/η ≤ 0,2 then

(4.6.1) [h]

$$L_H = \frac{2250}{\left(\frac{epU}{\eta}\right)^{0,5}} \cdot a_Q \cdot a_T \cdot a_S$$

If 0,2 < epU/η ≤ 1,0 then

(4.6.2) [h]

$$L_H = \frac{1000}{\left(\frac{epU}{\eta}\right)} \cdot a_Q \cdot a_T \cdot a_S$$

If epU/η >1,0 then

(4.6.3) [h]

$$L_H = \frac{1000}{\left(\frac{epU}{\eta}\right)^{2}} \cdot a_Q \cdot a_T \cdot a_S$$

epU see (5.8.2), page 21

Area 2 of Figure 7

The bearing will operate with mixed film lubrication.

pU factor is no longer a significant parameter in determining the bearing life.

HI-EX® bearing performance will depend upon the nature of the fluid and the actual service conditions.

Area 3 of Figure 7

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

Area 4 of Figure 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.
- Bearing performance may be improved:
  - by use of unindented HI-EX® lining
  - by the addition of one or more grooves to the bearing
  - by shaft surface finish < 0,05 [µm Ra].

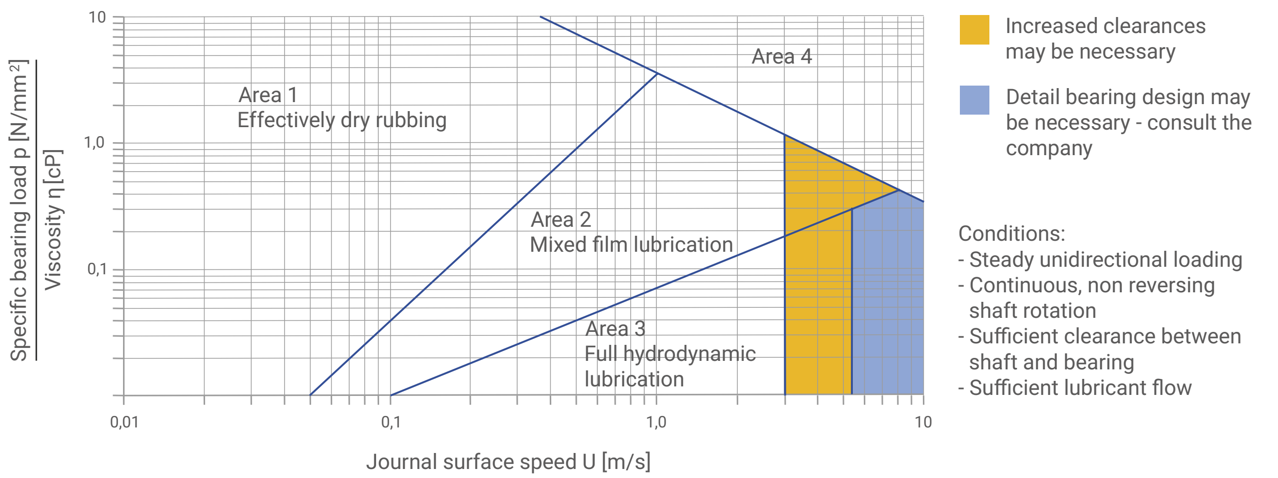


Fig. 7: Design guide for lubricated application

4 Lubrication and Friction

VISCOSITY 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

4.7 WEAR RATE AND RE-LUBRICATION INTERVALS WITH GREASE LUBRICATION

At specific bearing loads below 100 N/mm^2 a grease lubricated HI-EX® 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/mm^2 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 HI-EX® bearing and may also give rise to fretting corrosion damage. In this situation DS material should be considered as an alternative to HI-EX®.

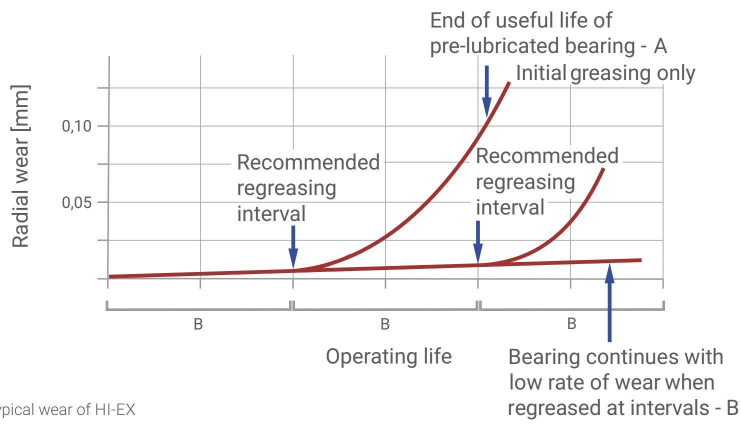


Fig. 8: Typical wear of HI-EX

5 Design Factors

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

- Specific load limit p_{lim} [N/mm²]
- pU 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 p is defined as the working load devided by the projected area of the bearing and is expressed in N/mm²

Cylindrical Bush

(5.1.1) [N/mm²]

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

Thrust Washer

(5.1.2) [N/mm²]

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

Slide Plate

(5.1.3) [N/mm²]

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

Specific load limit

The maximum load which can be applied to a HI-EX® 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. Conditions of dynamic load or oscillating movement which produce fatigue stress in the bearing result in a reduction in the specific load limit. The values of specific load limit specified in table 5 assume good alignment between the bearing and mating surface.

The specific load limit for HI-EX® reduces for bearing operating temperatures in excess of 70 °C, falling to about half the values given in table 5 for temperatures above 150 °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 16).

LOAD	OPERTATING CONDITION	LUBRICATION	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)	90
Steady or dynamic	Continuous rotation or oscillating motion	Oil (hydrodynamic lubrication)	60

Table 5: Specific load limit p_{lim} for HI-EX

5 Design Factors

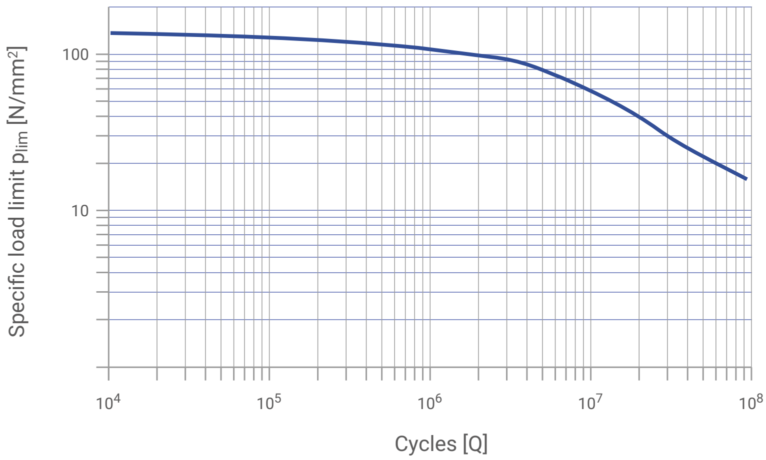


Fig. 9: HI-EX specific load limits p_{lim} under dynamic loads or oscillating conditions

5.2 SLIDING SPEED U

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

Continuous Rotation

Cylindrical Bush

(5.2.1) [m/s]

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

Thrust Washer

(5.2.2) [m/s]

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

Oscillating Movement

Cylindrical Bush

(5.2.3) [m/s]

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

Thrust Washer

(5.2.4) [m/s]

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

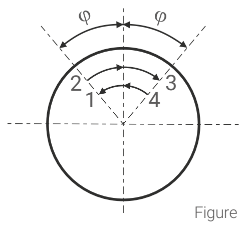


Figure 10: Oscillating cycle φ

The maximum permissible effective pU factor (epU factor) for grease lubricated HI-EX® bearings is dependent upon the sliding speed as shown in Figure 11. For sliding speeds in excess of 2,5 m/s continuous oil lubrication is recommended.

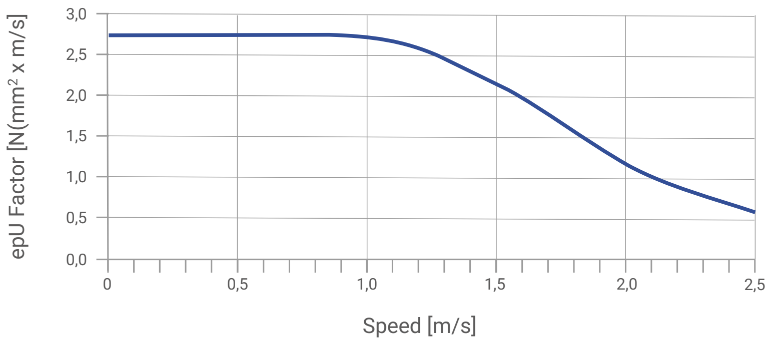


Fig. 11: Maximum epU factor for grease lubrication

5.3 pU FACTOR

The useful operating life of a HI-EX® bearing is governed by the pU factor, which is calculated as follows:

(5.3.1) [N/mm² · m/s]

$$pU = p \cdot U$$

5.4 LOAD

In addition to its contribution to the pU factor the type and direction of the applied load also affects the performance of a HI-EX® bearing. This is accomodated in the calculation of the bearing service life by the speed/load application factor a_Q shown in Figures 15 - 17.

Type of Load

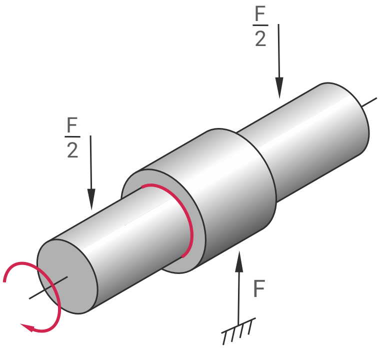


Fig. 12: Steady load, vertically downwards, bush stationary, shaft rotating. Lubricant drains to loaded area.

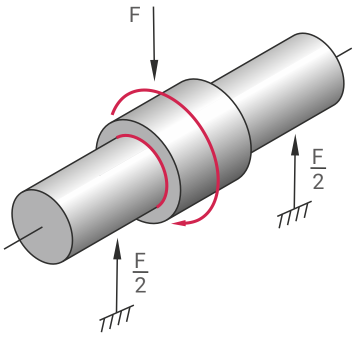


Fig. 13: Steady load, vertically upwards, bush stationary, shaft rotating. Lubricant drains away from loaded area

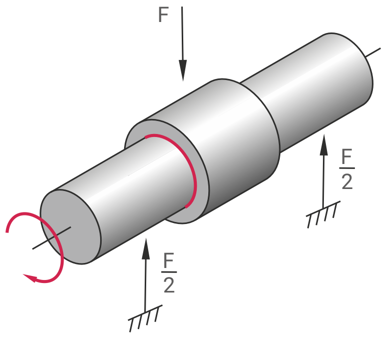
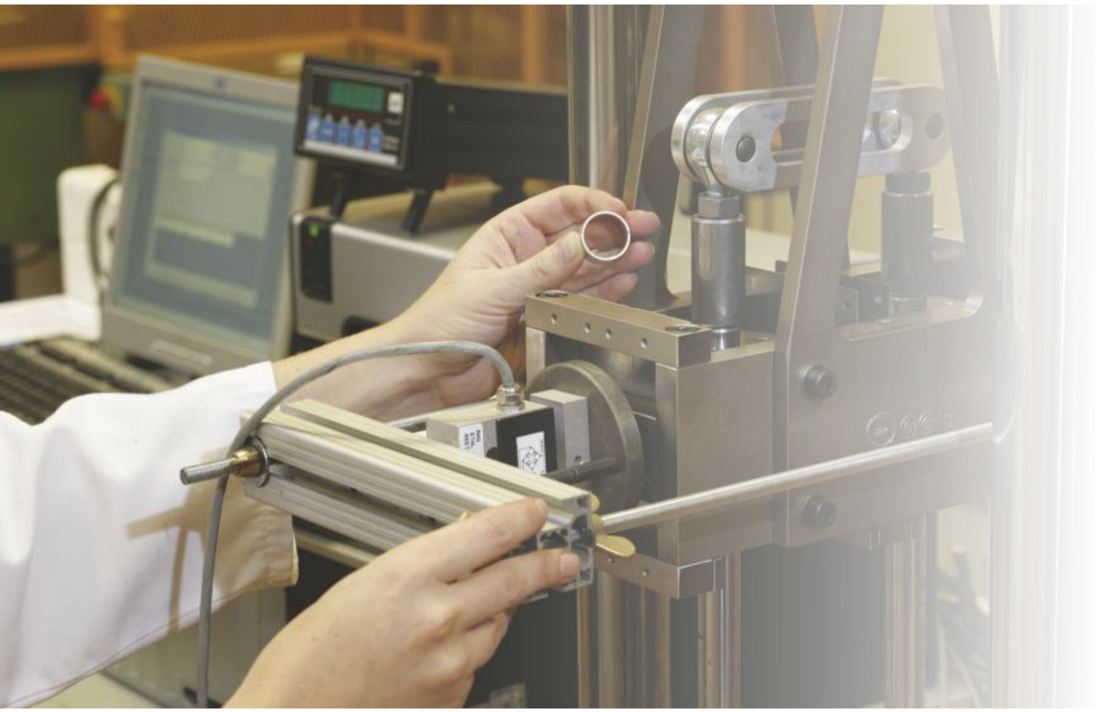


Fig. 14: Rotating load, shaft stationary, bush rotating



5 Design Factors

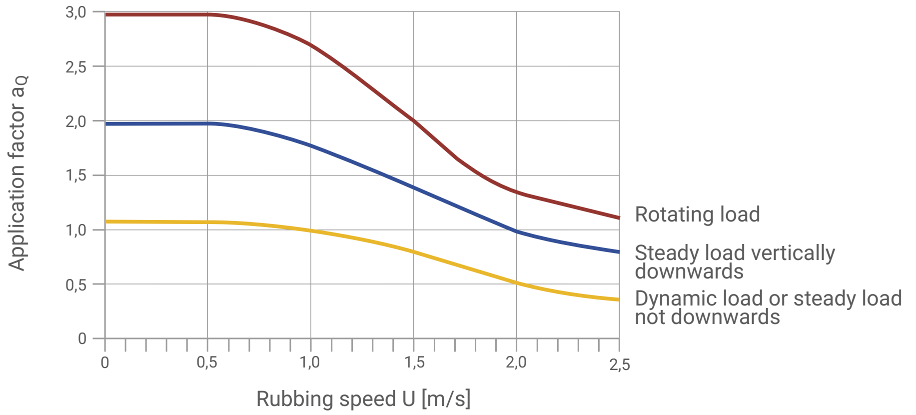


Fig. 15: Application factor a_Q for MB range bushes - unmachined

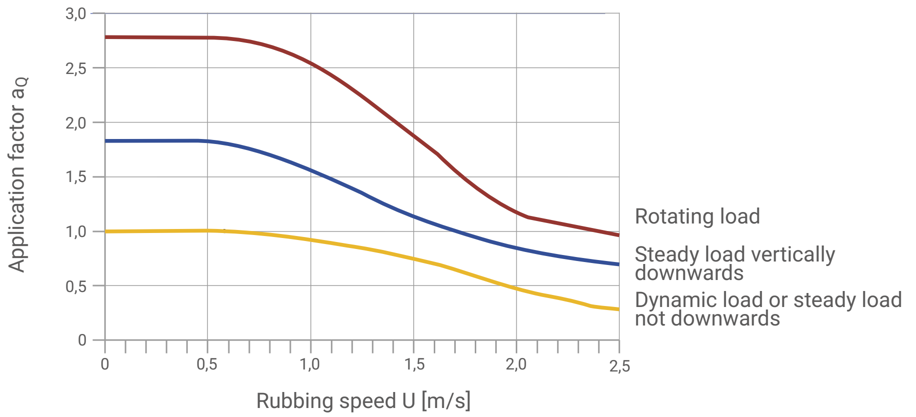


Fig. 16: Application factor a_Q for PM range and MB range bushes - machined

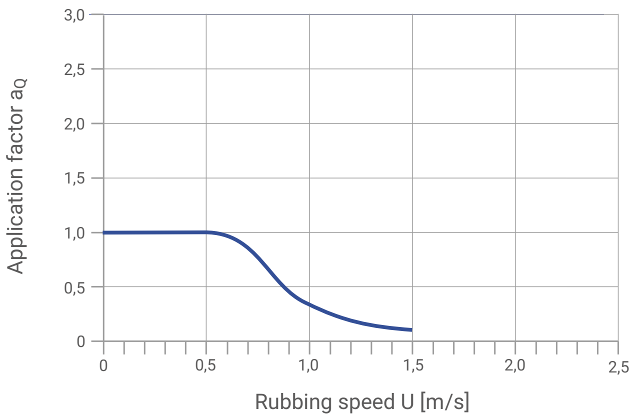


Fig. 17: Application factor a_Q for thrust washers

Note: a_Q = 1 for slideways

5.5 TEMPERATURE

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

For a given pU 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 HI-EX® these effects are accomodated by the application factor a_T shown in Fig. 18

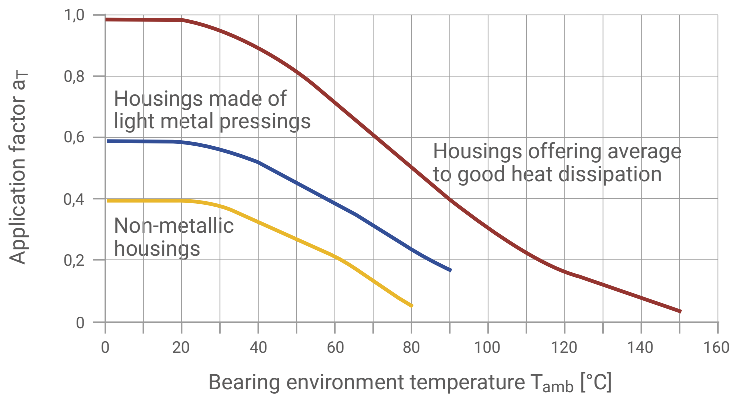


Fig. 18: HI-EX application factor a_T

5.6 MATING SURFACE

The wear rate of HI-EX® 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.

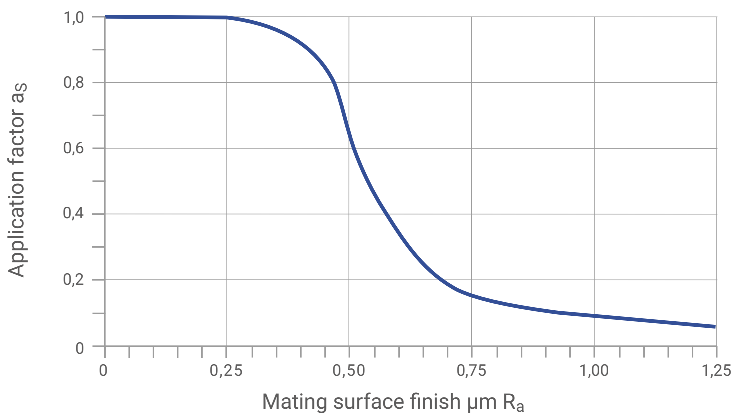


Fig. 19: HI-EX application factor a_S

5 Design Factors

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. pU factor) and the bearing size.

For a given pU condition a large bearing will run hotter than a smaller bearing. The bearing size factor a_B shown in Figure 20 takes account of this effect.

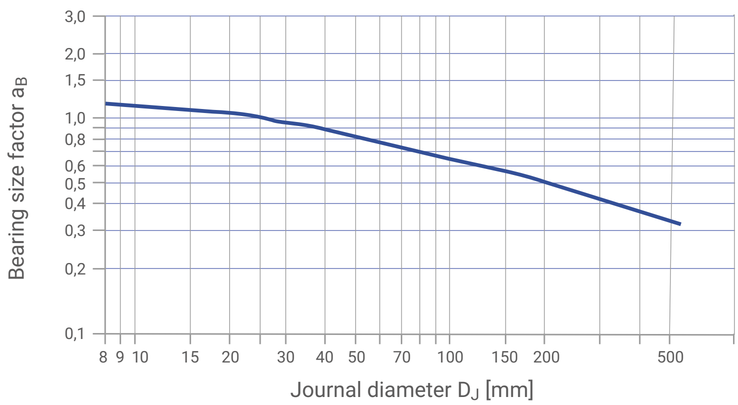


Fig. 20: Bearing size factor a_B

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	Bearing length L	[mm]
Bearing width B	Bearing inside diameter D_i	Bearing width W	[mm]

Operating Conditions

Load	F	[N]
Rotational speed (continuous)	N	[1/min]
Oscillating frequency	N_{osc}	[1/min]
Angular movement about mean position	φ	[°]
Specific load limit	see table 5, page 15	[MPa]
Application factor a_Q	see figure 15 - 17, page 18	[-]
Application factor a_T	see figure 18, page 19	[-]
Application factor a_S	see figure 19, page 19	[-]
Bearing size factor a_B	see figure 20, page 20	[-]

Calculate p from the equations in 5.1 on Page 15.

Calculate U from the equations in 5.2 on Page 16.

Calculate pU from the equation in 5.3 on Page 17.

Calculate high load factor a_E

(5.8.1) [-]

$$a_E = \frac{p_{lim} - p}{p_{lim}}$$

p_{lim} see Table 5, Page 15

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

Calculate effective pU factor epU

(5.8.2) [-]

$$epU = \frac{a_E \cdot pU}{a_B}$$

Note:
Check that epU is less than limit set in Fig. 11 for the sliding speed U. If NOT, increase the bearing length or use continuous lubrication.

Estimate bearing life

If epU ≤ 1,0 then

(5.8.3) [h]

$$L_H = \frac{3000}{epU} \cdot a_Q \cdot a_T \cdot a_S$$

If epU > 1,0 then

(5.8.4) [h]

$$L_H = \frac{3000}{(epU)^{2,4}} \cdot a_Q \cdot a_T \cdot a_S$$

Estimate regreasing interval

(5.8.5) [h]

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

Oscillating motion

Calculate number of cycles

(5.8.6) [-]

$$Z_T = L_{RG} \cdot n_{osc} \cdot 60 \cdot (R + 2)$$

Dynamic loads

Calculate number of cycles

(5.8.7) [-]

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

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 Figure 9 for actual bearing specific load 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 Direction: down	Inside Diameter D_i Length B	40 mm 30 mm
Shaft	Steel, R_a = 0,4 µm Temperature 85 °C	Bearing Load F Rotational Speed N	20.000 N 30 · 1/min
Housing	Light metal - poor heat dissipation		

Calculation Constants and Application Factors		
Specific Load Limit p_{lim} at 85 °C	81,5 N/mm²	(Table 5, Page 15)
Application Factor a_T	0,2	(Fig. 18, Page 19)
Mating Surface Applic. Factor a_S	0,85	(Fig. 19, Page 19)
Bearing Size Factor a_B for Ø 40	0,95	(Fig. 20, Page 20)
Application Factor for PM bush a_Q	1,8	(Fig. 16, Page 18)

Calculation	**Ref**	**Value**
Specific Load p [N/mm²]	(5.1.1) Page 15	$p = \frac{F}{D_i \cdot B} = \frac{20.000}{40 \cdot 30} = 16{,}67$
Sliding Speed U [m/s]	(5.2.1) Page 16	$U = \frac{D_i \cdot \pi \cdot N}{60 \cdot 10^3} = \frac{40 \cdot 3{,}14 \cdot 30}{60 \cdot 10^3} = 0{,}063$
High Load Factor a_E [-] must be > 0	(5.8.1) Page 21	$a_E = \frac{p_{lim}}{p_{lim} - p} = \frac{81{,}5}{81{,}5 - 16{,}67} = 1{,}25$
epU Factor [-]	(5.8.2) Page 21	$epU = \frac{a_E \cdot pU}{a_B} = \frac{1{,}25 \cdot 16{,}67 \cdot 0{,}063}{0{,}95} = 1{,}328$
Life L_H [h] for epU > 1	(5.8.4) Page 21	$L_H = \frac{3000}{epU^{2,4}} \cdot a_Q \cdot a_T \cdot a_S$ $= \frac{3000}{1{,}382^{2,4}} \cdot 1{,}8 \cdot 0{,}2 \cdot 0{,}85 = 434$
L_{RG} [h]	(5.8.5) Page 21	$L_{RG} = \frac{L_H}{2} = \frac{434}{2} = 217$

PM cylindrical bush

Given:			
Load Details	Steady Load Direction: up	Inside Diameter D_i Length B	100 mm 60 mm
Shaft	Steel, R_a = 0,3 µm Temperature 80 °C	Bearing Load F Rotational Speed N	45.000 N 35 · 1/min
	good heat dissipation		

Calculation Constants and Application Factors		
Specific Load Limit p_{lim} at 40 °C	90 N/mm²	(Table 5, Page 15)
Application Factor a_T	0,5	(Fig. 18, Page 19)
Mating Surface Applic. Factor a_S	1,0	(Fig. 19, Page 19)
Bearing Size Factor a_B for Ø 100	0,65	(Fig. 20, Page 20)
Application Factor for PM bush a_Q	1,0	(Fig. 16, Page 18)

Calculation	**Ref**	**Value**
Specific Load p [N/mm²]	(5.1.1) Page 15	$p = \frac{F}{D_i \cdot B} = \frac{45.000}{100 \cdot 60} = 7{,}5$
Sliding Speed U [m/s]	(5.2.1) Page 16	$U = \frac{D_i \cdot \pi \cdot N}{60 \cdot 10^3} = \frac{100 \cdot 3{,}14 \cdot 35}{60 \cdot 10^3} = 0{,}183$
High Load Factor a_E [-] must be > 0	(5.8.1) Page 21	$a_E = \frac{p_{lim}}{p_{lim} - p} = \frac{90}{90 - 7{,}5} = 1{,}091$
epU Factor [-]	(5.8.2) Page 21	$epU = \frac{a_E \cdot pU}{a_B} = \frac{1{,}091 \cdot 7{,}5 \cdot 0{,}183}{0{,}65} = 2{,}307$
Life L_H [h] for epU > 1	(5.8.4) Page 21	$L_H = \frac{3000}{epU^{2,4}} \cdot a_Q \cdot a_T \cdot a_S$ $= \frac{3000}{2{,}307^{2,4}} \cdot 1{,}0 \cdot 1{,}0 \cdot 0{,}5 = 202$
L_{RG} [h]	(5.8.5) Page 21	$L_{RG} = \frac{L_H}{2} = \frac{202}{2} = 101$

MB cylindrical bush

Given:			
Load Details	Steady Load oscill. Direction: down	Inside Diameter D_i Length B	80 mm 40 mm
Shaft	Steel, R_a = 0,3 µm Temperature 85 °C	Bearing Load F Rotational Speed N	200.000 N 1,11 · 1/min
Housing	Light metal - poor heat dissipation	Angle φ	20°

Calculation Constants and Application Factors		
Specific Load Limit p_{lim}	140 N/mm²	(Table 5, Page 15)
Application Factor a_T	0,6	(Fig. 18, Page 19)
Mating Surface Applic. Factor a_S	1,0	(Fig. 19, Page 19)
Bearing Size Factor a_B for Ø 80	0,75	(Fig. 20, Page 20)
Application Factor for PM bush a_Q	1,8	(Fig. 16, Page 18)

Calculation	Ref	Value
Specific Load p [N/mm²]	(5.1.1) Page 15	$p = \frac{F}{D_i \cdot B} = \frac{200.000}{80 \cdot 40} = 62,5$
Sliding Speed U [m/s]	(5.2.3) Page 16	$U = \frac{D_i \cdot \pi}{60 \cdot 10^3} \cdot \frac{4\varphi \cdot N_{osc}}{360}$ $= \frac{80 \cdot \pi}{60.000} \cdot \frac{4 \cdot 20 \cdot 1,11}{360} = 0,001$
High Load Factor a_E [-] must be > 0	(5.8.1) Page 21	$a_E = \frac{p_{lim}}{p_{lim} - p} = \frac{140}{140 - 62,5} = 1,806$
epU Factor [-]	(5.8.2) Page 21	$epU = \frac{a_E \cdot pU}{a_B} = \frac{1,806 \cdot 62,5 \cdot 0,001}{0,75} = 0,151$
Life L_H [h] for epU < 1	(5.8.3) Page 21	$L_H = \frac{3000}{epU} \cdot a_Q \cdot a_T \cdot a_S$ $= \frac{3000}{0,151} \cdot 1,8 \cdot 0,6 \cdot 1,0 = 21.456$
L_{RG} [h]	(5.8.5) Page 21	$L_{RG} = \frac{L_H}{2} = \frac{21.456}{2} = 10.728$
Z_T [-]	(5.8.6) Page 21	$Z_T = L_{RG} \cdot N_{osc} \cdot 60 \cdot (R + 2)$ $= 10.728 \cdot 1,11 \cdot 60 \cdot 2 = 1,43 \cdot 10^6$ Q for p = 62,5 = $1,43 \cdot 10^6$; Z_T > Q, therefore bearing fails by fatigue after $1,43 \cdot 10^6$ cycles

Thrust washer

Given:			
Load Details	Steady Load Direction: down	Inside Diameter D_i Outside Diameter D_o	40 mm 78 mm
Counterface	Steel, R_a = 0,2 µm Temperature 50 °C	Bearing Load F Rotational Speed N	50.000 N 25 · 1/min
Housing	Light metal - poor heat dissipation		

Calculation Constants and Application Factors		
Specific Load Limit p_{lim}	90 N/mm²	(Table 5, Page 15)
Application Factor a_T for 50 °C	0,5	(Fig. 18, Page 19)
Mating Surface Applic. Factor a_S	1,0	(Fig. 19, Page 19)
Bearing Size Factor a_B for Ø 40	0,95	(Fig. 20, Page 20)
Applic. Factor for Thrust Washer a_Q	1,0	(Fig. 17, Page 18)

Calculation	Ref	Value
Specific Load p [N/mm²]	(5.1.1) Page 15	$p = \frac{4 \cdot F}{\pi \cdot (D_o^2 - D_i^2)} = \frac{4 \cdot 50.000}{\pi \cdot (78^2 - 40^2)} = 14,2$
Sliding Speed U [m/s]	(5.2.2) Page 16	$U = \frac{\frac{D_o + D_i}{2} \cdot \pi \cdot N}{60 \cdot 10^3}$ $= \frac{\frac{78 + 40}{2} \cdot \pi \cdot 25}{60 \cdot 10^3} = 0,0772$
High Load Factor a_E [-] must be > 0	(5.8.1) Page 21	$a_E = \frac{p_{lim}}{p_{lim} - p} = \frac{90}{90 - 14,2} = 1,187$
epU Factor [-]	(5.8.2) Page 21	$epU = \frac{a_E \cdot pU}{a_B} = \frac{1,187 \cdot 14,2 \cdot 0,0772}{0,95} = 1,37$
Life L_H [h] for epU > 1	(5.8.4) Page 21	$L_H = \frac{3000}{epU^{2,4}} \cdot a_Q \cdot a_T \cdot a_S$ $= \frac{3000}{1,37^{2,4}} \cdot 1,0 \cdot 0,5 \cdot 1,0 = 704$
L_{RG} [h]	(5.8.5) Page 21	$L_{RG} = \frac{L_H}{2} = \frac{704}{2} = 352$

6 Bearing Assembly

6.1 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.

6.2 TOLERANCES FOR MINIMUM CLEARANCE

Grease lubrication

The minimum clearance required for satisfactory performance of HI-EX® depends upon the pv 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 HI-EX® polymer lining. It is therefore necessary to compensate for this.

Figure 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 pUu (Figure 21), where pU is calculated as in 5.3 on page 17, and u is a sliding speed factor for speeds in excess of 0,5 m/s given in Figure 22.

If the clearance indicated for a pUu 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.

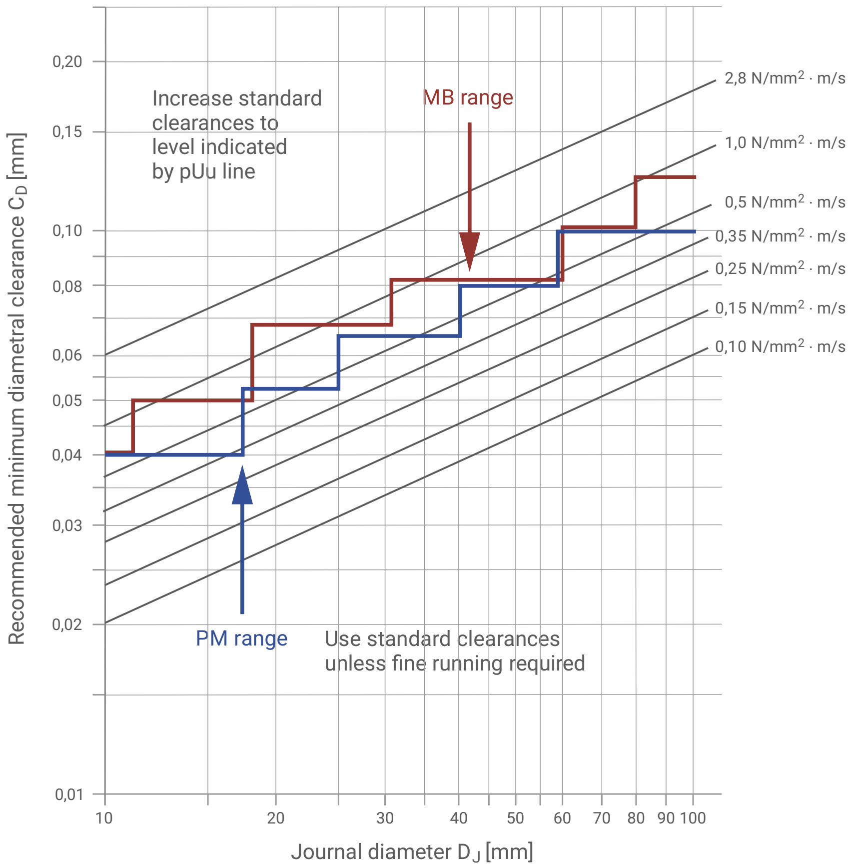


Fig. 21: Minimum clearance for PM prefinished and MB machinable range machined to H7 bore

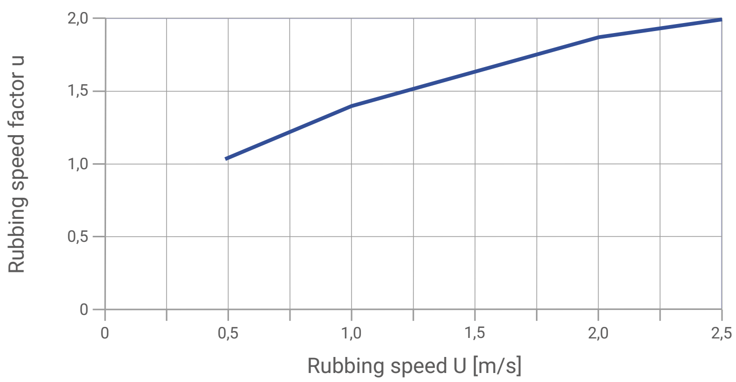


Fig. 22: Rubbing speed factor u

6 Bearing Assembly

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 Figure 23. It is recommended that the bearing performance under minimum clearance conditions be confirmed by testing if possible.

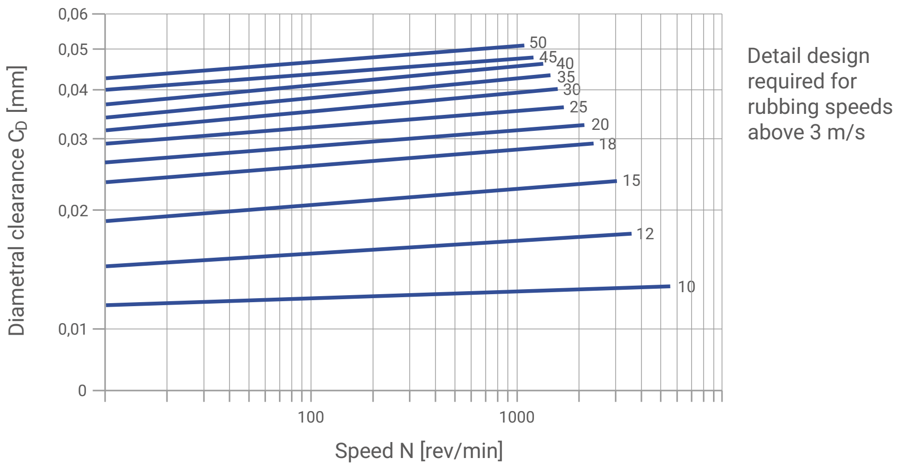


Fig. 23: HI-EX minimum clearances - bush diameters D_i 10 - 50 mm

Allowance for thermal expansion

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

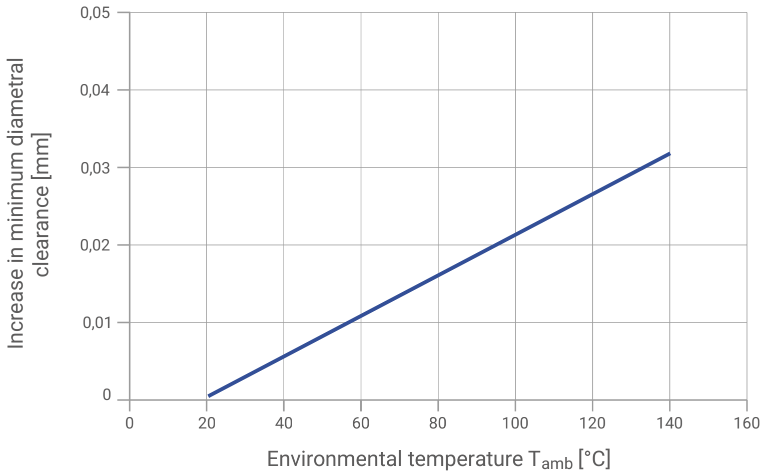


Fig. 24: Recommended increase in diametral clearance

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 Figure 24.

HOUSING MATERIAL	REDUCTION IN HOUSING DIAMETER PER 100°C RISE	REDUCTION IN SHAFT DIAMETER PER100°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	–	values from Fig. 24
Zinc base alloys	0,15 %	0,15 % + values from Fig. 24

Table 6: Allowance for high temperature

6.3 COUNTERFACE DESIGN

HI-EX® 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 350HB is recommended.

A ground surface finish of better than 0,4 µm 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.

HI-EX® is normally used in conjunction with ferrous journals and thrust faces, but in damp or corrosive surroundings stainless steel, hard chromium plated mild steel, or alternatively WH shaft sleeves 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 HI-EX® 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 HI-EX® must be removed.

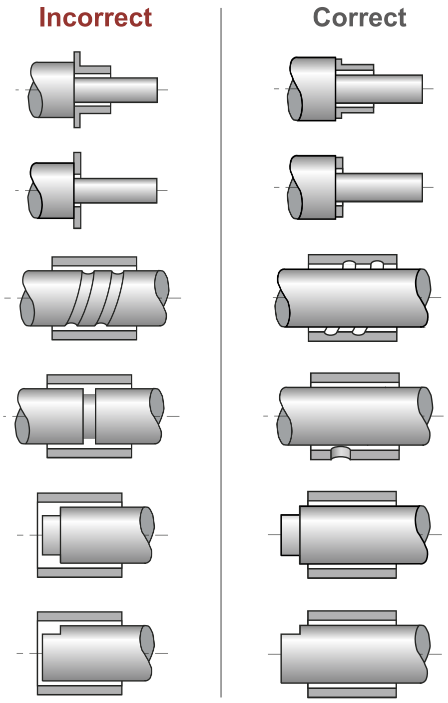


Fig. 25: Counterface Design

6.4 INSTALLATION

Important note:

Care must be taken to ensure that the HI-EX® 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 Figure 26. The following should be noted to avoid damage to the bearing:

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

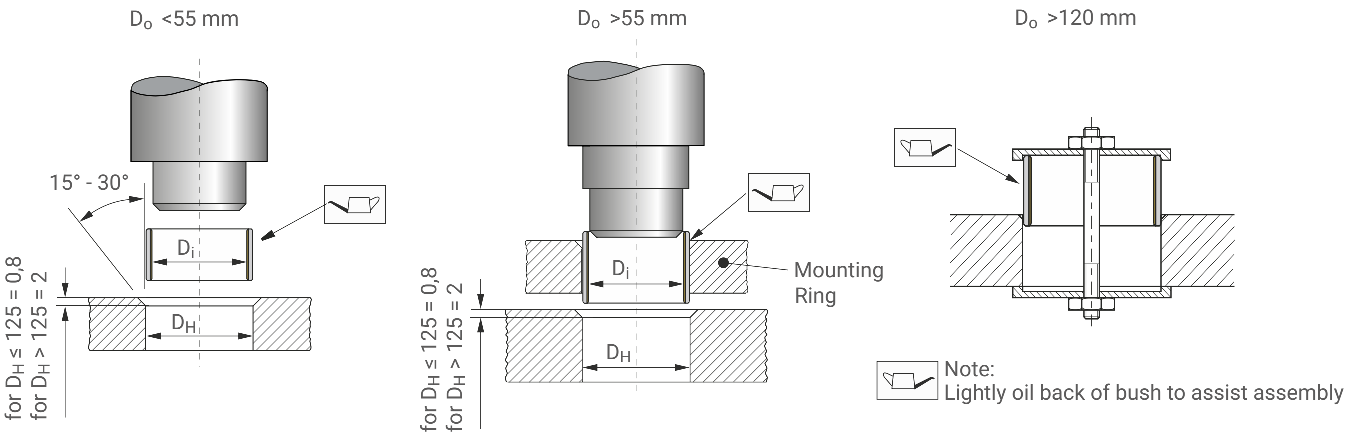


Fig. 26: Fitting of cylindrical bushes

Insertion forces

Figure 27 gives an indication of the maximum insertion force required to correctly install standard HI-EX® bushes.

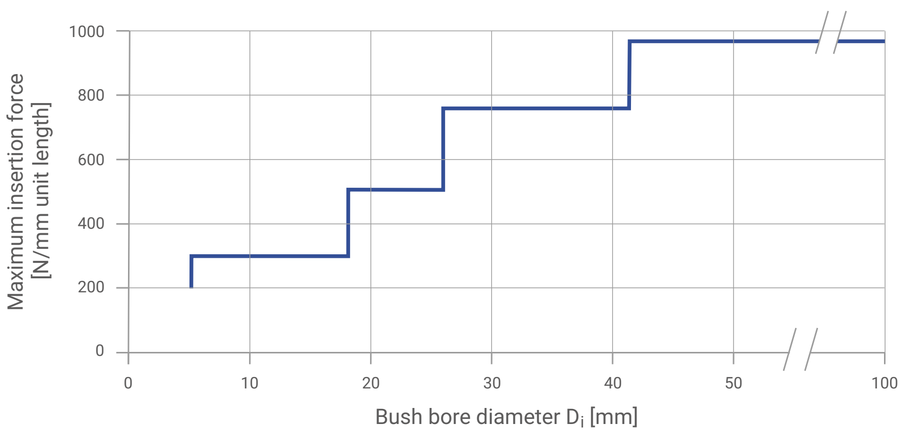


Fig. 27: Maximum Insertion Force

Alignment

Accurate alignment is an important consideration for all bearing assemblies, but is particularly so for dry bearings because there is no lubricant to spread the load. With HI-EX® 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 Figure 28.

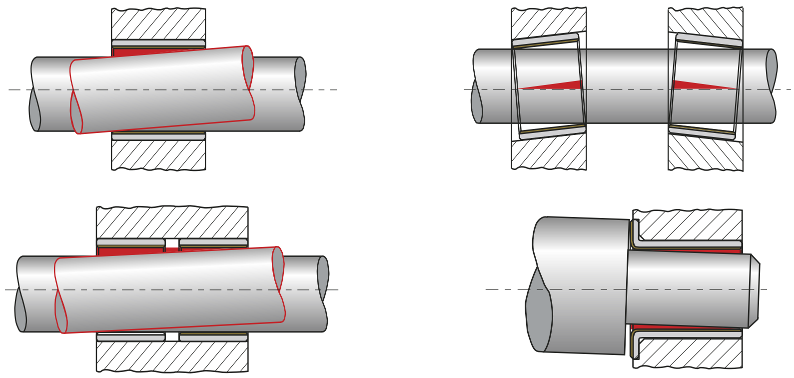


Fig. 28: Alignment

Sealing

While HI-EX® 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 Figure 29 should be provided.

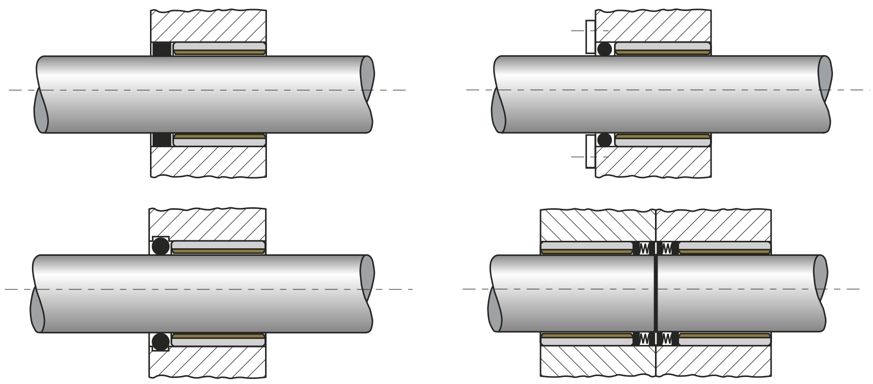


Fig. 29: Recommended sealing arrangements

Axial location

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

6 Bearing Assembly

Fitting of thrust washers

HI-EX® 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 HI-EX® 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

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
- HI-EX® must not be heated above 250 °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

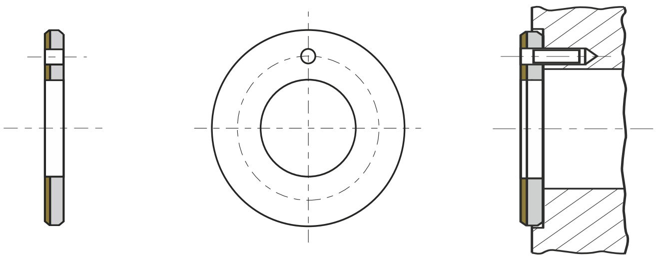


Fig. 30: Installation of thrust-washer

Slideways

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

- Countersunk screws
- Adhesives
- Mechanical location

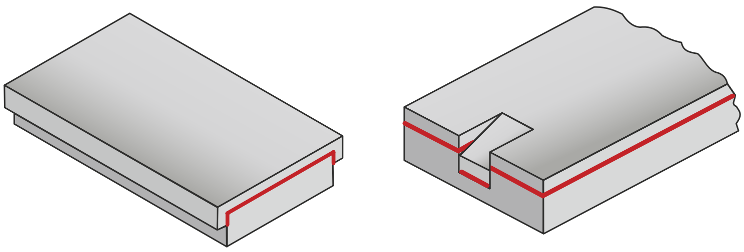


Fig. 31: Mechanical location of HI-EX slideplates

7 Machining

7.1 MACHINING PRACTICE

The PEEK polymer lining of HI-EX® 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 HI-EX® 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 HI-EX®. The recommended tool material is high speed steel or tungsten carbide, respectively diamonds for long toolservice times.

7.2 BORING

Figure 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.

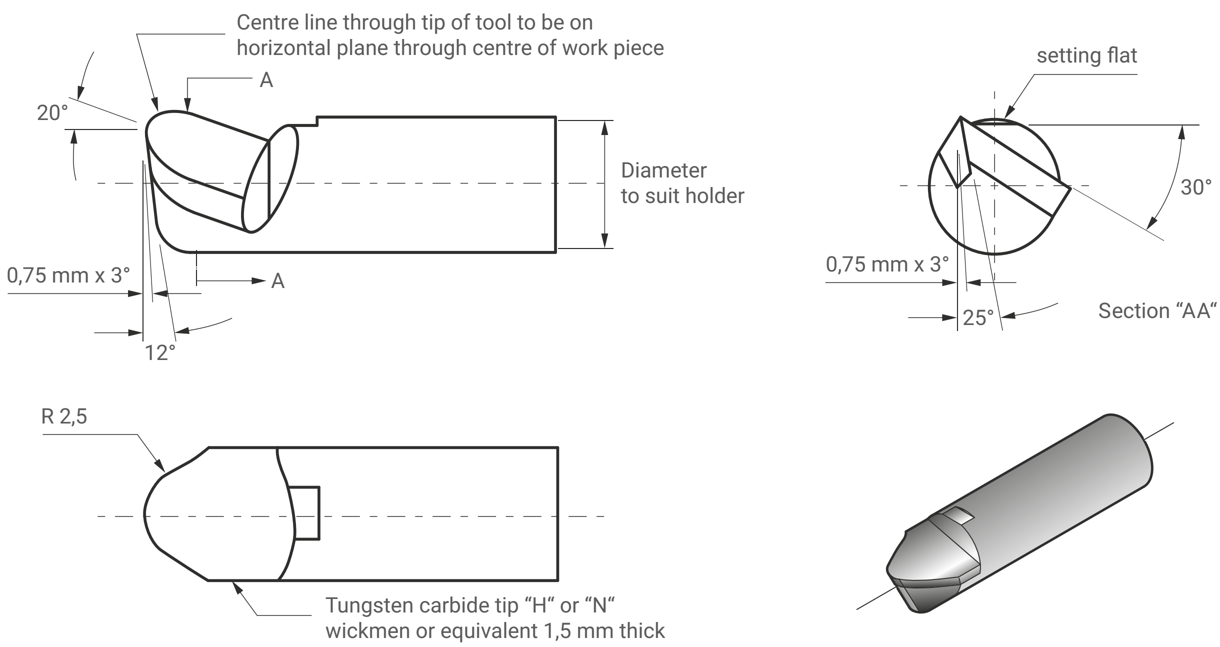


Fig. 32: Boring tool for HI-EX

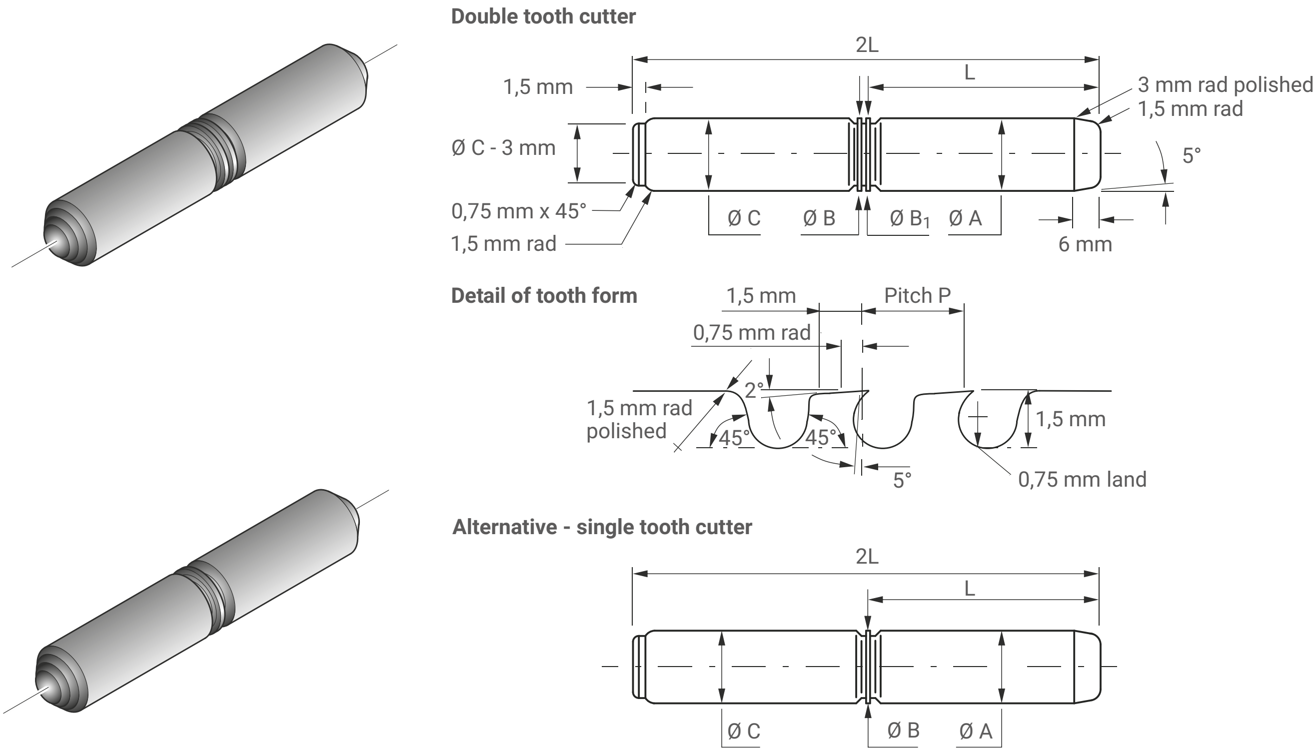
7 Machining

7.3 REAMING

HI-EX® 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.

7.4 BROACHING

Fig. 33 shows broaches suitable for finishing bushes up to 65 mm diameter. The broach should be used dry, at a speed of 0,1 - 0,5 m/s.



BUSH WIDTH B OVER	TO	PITCH P
10	13	3
13	20	4
20	30	5
30	50	5,5
50	70	6
70	95	7
95	130	8

Fig. 33: Suitable broaches for HI-EX

DIAMETER		
Ø A	Min. ass. bore	+0,013 +0
Ø B	Nominal bore	+0,038 +0,025
Ø C	Nominal bore	+0,015 +0,005
Min. ass. bore = $D_{o\ min} - 2 \cdot s_{3\ max}$ Nominal bore = min. finished bore		
Ø B_1*	Nominal bore	-0,065 -0,076

* First tooth of double tooth cutter

	MIN. LENGTH OF PILOT GUIDE L_{min}
Single bush	B + 6
2 or more bushes in line	B + 6 + bush spacing

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, pecial guides may be provided external to the workpiece.

- 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.

7.5 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.

7.6 MODIFICATION OF COMPONENTS

The modification of HI-EX® 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.

7.7 DRILLING OIL HOLES

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

7.8 CUTTING STRIP MATERIAL

HI-EX® 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

8 Electroplating

HI-EX® components

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

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

For the harder materials if the specified plating thickness exceeds approximately 5μm 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.

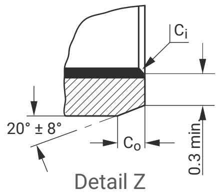
Mating surfaces

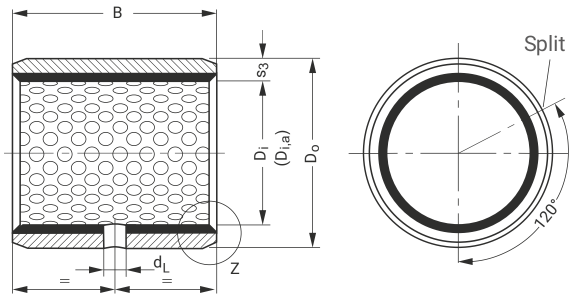
HI-EX® can be used against hard chrome plated materials and care should be taken to ensure that the recommended shaft sizes and surface finish are achieved after the plating process.

Note:
The parts shown in the following tables are not available from stock.

9 Standard Products

9.1 PM HI-EX® CYLINDRICAL BUSHES





Dimensions and Tolerances according to ISO 3547 and GGB-Specifications
Note: For $D_i \leq 40$ mm, bush backing is tin flashed; for $D_i > 40$ mm, bush backing is copper flashed

Outside C_o and Inside C_i chamfers

WALL THICKNESS S_3	C_o (a) MACHINED	/ ROLLED	C_i (b)
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	/ 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	D_O	WALL THICKNESS S_3 max. min.	WIDTH B max. min.	SHAFT Ø D_J [h8]	max. min.	HOUSING Ø D_H [H7]	max. min.	BUSH Ø $D_{i,a}$ ASSEMBLY IN H7 HOUSING max. min.	CLEARANCE C_D max. min.	OIL HOLE Ø d_L
PM0808HX	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
PM0810HX				10,25 9,75							
PM0812HX				12,25 11,75							
PM1010HX	10	12		10,25 9,75		10,000 9,978		12,018 12,000	10,108 10,040	0,130 0,040	3
PM1012HX				12,25 11,75							4
PM1015HX				15,25 14,75							
PM1020HX				20,25 19,75							
PM1210HX	12	14		10,25 9,75		12,000 11,973		14,018 14,000	12,108 12,040	0,135 0,040	3
PM1212HX				12,25 11,75							4
PM1215HX				15,25 14,75							
PM1220HX				20,25 19,75							
PM1225HX				25,25 24,75							
PM1415HX	14	16		15,25 14,75		14,000 13,973		16,018 16,000	14,108 14,040		
PM1420HX				20,25 19,75							
PM1425HX				25,25 24,75							
PM1508HX	15	17		8,25 7,75		15,000 14,973		17,018 17,000	15,108 15,040		3
PM1510HX				10,25 9,75							
PM1512HX				12,25 11,75							4
PM1515HX				15,25 14,75							
PM1520HX				20,25 19,75							
PM1525HX				25,25 24,75							

All dimensions in mm

9 Standard Products

PART NO.	NOMINAL DIAMETER D_i	D_o	WALL THICKNESS S_3 max. min.	WIDTH B max. min.	SHAFT Ø D_J [h8]	max. min.	HOUSING Ø D_H [H7]	max. min.	BUSH Ø $D_{i,a}$ ASSEMBLY IN H7 HOUSING max. min.	CLEARANCE C_D max. min.	OIL HOLE Ø d_L
PM1615HX				15,25 14,75							
PM1620HX	16	18		20,25 19,75		16,000 15,973		18,018 18,000	16,108 16,040		
PM1625HX			0,980 0,955	25,25 24,75						0,135 0,040	
PM1815HX				15,25 14,75							
PM1820HX	18	20		20,25 19,75		18,000 17,973		20,021 20,000	18,111 18,040		
PM1825HX				25,25 24,75							4
PM2010HX				10,25 9,75							
PM2015HX				15,25 14,75							
PM2020HX	20	23		20,25 19,75		20,000 19,967		23,021 23,000	20,131 20,050		
PM2025HX				25,25 24,75							
PM2030HX				30,25 29,75							
PM2215HX				15,25 14,75							
PM2220HX	22	25		20,25 19,75		22,000 21,967		25,021 25,000	22,131 22,050		
PM2225HX				25,25 24,75							
PM2230HX			1,475 1,445	30,25 29,75						0,164 0,050	
PM2415HX				15,25 14,75							
PM2420HX	24	27		20,25 19,75		24,000 23,967		27,021 27,000	24,131 24,050		
PM2425HX				25,25 24,75	h8		H7				
PM2430HX				30,25 29,75							
PM2515HX				15,25 14,75							
PM2520HX	25	28		20,25 19,75		25,000 24,967		28,021 28,000	25,131 25,050		
PM2525HX				25,25 24,75							
PM2530HX				30,25 29,75							
PM283130HX		31		30,25 29,75				31,025 31,000	28,135 28,050	0,168 0,050	6
PM2820HX	28			20,25 19,75		28,000 27,967					
PM2825HX		32		25,25 24,75				32,025 32,000	28,155 28,060		
PM2830HX				30,25 29,75							
PM3020HX				20,25 19,75						0,188 0,060	
PM3025HX	30	34		25,25 24,75		30,000 29,967		34,025 34,000	30,155 30,060		
PM3030HX			1,970 1,935	30,25 29,75							
PM3040HX				40,25 39,75							
PM3220HX				20,25 19,75							
PM3230HX	32	36		30,25 29,75		32,000 31,961		36,025 36,000	32,155 32,060	0,194 0,060	
PM3235HX				35,25 34,75							
PM3240HX				40,25 39,75							

All dimensions in mm

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 $D_{i,a}$ ASSEMBLY IN H7 HOUSING max. min.	CLEARANCE C_D max. min.	OIL HOLE Ø d_L
PM3520HX	35	39	1,970 1,935	20,25 19,75	h8	35,000 34,961	H7	39,025 39,000	35,155 35,060	0,194 0,060	6
PM3530HX				30,25 29,75							
PM3535HX				35,25 34,75							
PM3540HX				40,25 39,75							
PM3550HX				50,25 49,75							
PM3635HX	36	40		35,25 34,75		36,000 35,961		40,025 40,000	36,155 36,060		
PM3720HX	37	41		20,25 19,75		37,000 36,961		41,025 41,000	37,155 37,060		
PM4020HX	40	44		20,25 19,75		40,000 39,961		44,025 44,000	40,155 40,060		8
PM4030HX				30,25 29,75							
PM4040HX				40,25 39,75							
PM4050HX				50,25 49,75							
PM4520HX	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	
PM4525HX				25,25 24,75							
PM4530HX				30,25 29,75							
PM4540HX				40,25 39,75							
PM4545HX				45,25 44,75							
PM4550HX				50,25 49,75							
PM5030HX	50	55		30,25 29,75		50,000 49,961		55,030 55,000	50,200 50,080	0,239 0,080	
PM5040HX				40,25 39,75							
PM5045HX				45,25 44,75							
PM5050HX				50,25 49,75							
PM5060HX				60,25 59,75							
PM5520HX	55	60		20,25 19,75		55,000 54,954		60,030 60,000	55,200 55,080	0,246 0,080	
PM5525HX				25,25 24,75							
PM5530HX				30,25 29,75							
PM5540HX				40,25 39,75							
PM5550HX				50,25 49,75							
PM5560HX				60,25 59,75							
PM6030HX	60	65		30,25 29,75		60,000 59,954		65,030 65,000	60,200 60,080		
PM6040HX				40,25 39,75							
PM6050HX				50,25 49,75							
PM6060HX				60,25 59,75							
PM6070HX				70,25 69,75							

All dimensions in mm

9 Standard Products

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 max. min.	HOUSING Ø D_H [H7]	HOUSING Ø D_H max. min.	BUSH Ø $D_{i,a}$ ASSEMBLY IN H7 HOUSING max. min.	CLEARANCE C_D max. min.	OIL HOLE Ø d_L
PM6530HX	65	70	2,450 2,384	30,25 29,75	h8	65,000 64,954	H7	70,030 70,000	65,262 65,100	0,308 0,100	8
PM6540HX				40,25 39,75							
PM6550HX				50,25 49,75							
PM6560HX				60,25 59,75							
PM6570HX				70,25 69,75							
PM7030HX	70	75		30,25 29,75		70,000 69,954		75,030 75,000	70,262 70,100		
PM7040HX				40,25 39,75							
PM7045HX				45,25 44,75							
PM7050HX				50,25 49,75							
PM7060HX				60,25 59,75							
PM7065HX				65,25 64,75							
PM7070HX				70,25 69,75							
PM7080HX				80,25 79,75							
PM7540HX	75	80		40,25 39,75		75,000 74,954		80,030 80,000	75,262 75,100		9,5
PM7560HX				60,25 59,75							
PM7580HX				80,25 79,75							
PM8040HX	80	85		40,50 39,50		80,000 79,954		85,035 85,000	80,267 80,100	0,313 0,100	
PM8050HX				50,50 49,50							
PM8060HX				60,50 59,50							
PM8080HX				80,50 79,50							
PM80100HX				100,50 99,50							
PM8530HX	85	90		30,50 29,50		85,000 84,946		90,035 90,000	85,267 85,100	0,321 0,100	
PM8540HX				40,50 39,50							
PM8560HX				60,50 59,50							
PM8580HX				80,50 79,50							
PM85100HX				100,50 99,50							
PM9040HX	90	95		40,50 39,50		90,000 89,946		95,035 95,000	90,267 90,100		
PM9060HX				60,50 59,50							
PM9080HX				80,50 79,50							
PM9090HX				90,50 89,50							
PM90100HX				100,50 99,50							
PM9560HX	95	100		60,50 59,50		95,000 94,946		100,035 100,000	95,267 95,100		
PM95100HX				100,50 99,50							

All dimensions in mm

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 $D_{i,a}$ ASSEMBLY IN H7 HOUSING max. min.	CLEARANCE C_D max. min.	OIL HOLE Ø d_L
PM10040HX	100	105	2,450 2,384	40,50 59,50	h8	100,000 99,946	H7	105,035 105,000	100,267 100,100	0,321 0,100	9,5
PM10050HX				50,50 49,50							
PM10060HX				60,50 59,50							
PM10080HX				80,50 79,50							
PM10095HX				95,50 94,50							
PM100115HX				115,50 114,50							
PM10560HX	105	110		60,50 59,50		105,000 104,946		110,035 110,000	105,267 105,100		
PM10565HX				65,50 64,50							
PM105110HX				110,50 109,50							
PM105115HX				115,50 114,50							
PM11050HX	110	115		50,50 49,50		110,000 109,946		115,035 115,000	110,267 105,100		
PM11060HX				60,50 59,50							
PM110100HX				100,50 99,50							
PM110110HX				110,50 109,50							
PM110115HX				115,50 114,50							
PM11550HX	115	120		50,50 49,50		115,000 114,946		120,035 120,000	115,267 115,100		
PM11570HX				70,50 69,95							
PM12060HX	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	
PM120100HX				100,50 99,50							
PM120110HX				110,50 109,50							
PM12560HX	125	130		60,50 59,50		125,000 124,937		130,040 130,000	125,280 125,130	0,343 0,130	
PM125100HX				100,50 99,50							
PM125110HX				110,50 109,50							
PM13050HX	130	135		50,50 49,50		130,000 129,937		135,040 135,000	130,280 130,130		No hole
PM13060HX				60,50 59,50							
PM13080HX				80,50 79,50							
PM130100HX				100,50 99,50							
PM13560HX	135	140		60,50 59,50		135,000 134,937		140,040 140,000	135,280 135,130		
PM13580HX				80,50 79,50							
PM14050HX	140	145		50,50 49,50		140,000 139,937		145,040 145,000	140,280 140,130		
PM14060HX				60,50 59,50							
PM14080HX				80,50 79,50							
PM140100HX				100,50 99,50							

All dimensions in mm

9 Standard Products

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 $D_{i,a}$ ASSEMBLY IN H7 HOUSING max. min.	CLEARANCE C_D max. min.	OIL HOLE Ø d_L
PM15050HX	150	155	2,435 2,380	50,50 49,50	h8	150,000 149,937	H7	155,040 155,000	150,280 150,130	0,343 0,130	No hole
PM15060HX				60,50 59,50							
PM15080HX				80,50 79,50							
PM150100HX				100,50 99,50							
PM16050HX	160	165		50,50 49,50		160,000 159,937		165,040 165,000	160,280 160,130		
PM16060HX				60,50 59,50							
PM16080HX				80,50 79,50							
PM160100HX				100,50 99,50							
PM17050HX	170	175		50,50 49,50		170,000 169,937		175,040 175,000	170,280 170,130		
PM17060HX				60,50 59,50							
PM17080HX				80,50 79,50							
PM170100HX				100,50 99,50							
PM18050HX	180	185		50,50 49,50		180,000 179,937		185,046 185,000	180,286 180,130	0,349 0,130	
PM18060HX				60,50 59,50							
PM18080HX				80,50 79,50							
PM180100HX				100,50 99,50							
PM19050HX	190	195		50,50 49,50		190,000 189,928		195,046 195,000	190,286 190,130	0,358 0,130	
PM19060HX				60,50 59,50							
PM19080HX				80,50 79,50							
PM190100HX				100,50 99,50							
PM190120HX				120,50 119,50							
PM20050HX	200	205		50,50 49,50		200,000 199,928		205,046 205,000	200,286 200,130		
PM20060HX				60,50 59,50							
PM20080HX				80,50 79,50							
PM200100HX				100,50 99,50							
PM200120HX				120,50 119,50							
PM22050HX	220	225		50,50 49,50		220,000 219,928		225,046 225,000	220,286 220,130		
PM22060HX				60,50 59,50							
PM22080HX				80,50 79,50							
PM220100HX				100,50 99,50							
PM220120HX				120,50 119,50							
PM24050HX	240	245		50,50 49,50		240,000 239,928		245,046 245,000	240,286 240,130		
PM24060HX				60,50 59,50							
PM24080HX				80,50 79,50							
PM240100HX				100,50 99,50							
PM240120HX				120,50 119,50							

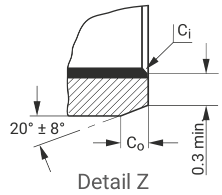
All dimensions in mm

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 $D_{i,a}$ ASSEMBLY IN H7 HOUSING max. min.	CLEARANCE C_D max. min.	OIL HOLE Ø d_L
PM25050HX	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
PM25060HX				60,50 59,50							
PM25080HX				80,50 79,50							
PM250100HX				100,50 99,50							
PM250120HX				120,50 119,50							
PM26050HX	260	265		50,50 49,50		260,000 259,919		265,052 265,000	260,292 260,130	0,373 0,130	
PM26060HX				60,50 59,50							
PM26080HX				80,50 79,50							
PM260100HX				100,50 99,50							
PM260120HX				120,50 119,50							
PM28050HX	280	285		50,50 49,50		280,000 279,919		285,052 285,000	280,292 280,130		
PM28060HX				60,50 59,50							
PM28080HX				80,50 79,50							
PM280100HX				100,50 99,50							
PM280120HX				120,50 119,50							
PM30050HX	300	305		50,50 49,50		300,000 299,919		305,052 305,000	300,292 300,130		
PM30060HX				60,50 59,50							
PM30080HX				80,50 79,50							
PM300100HX				100,50 99,50							
PM300120HX				120,50 119,50							

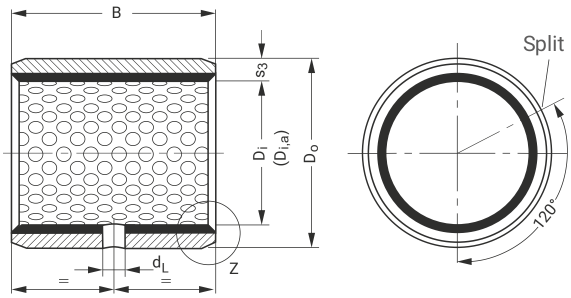
All dimensions in mm

9 Standard Products

9.2 MB HI-EX® CYLINDRICAL BUSHES



Detail Z



Dimensions and Tolerances according to ISO 3547 and GGB-Specifications
Note: For $D_i \leq 40$ mm, bush backing is tin flashed; for $D_i > 40$ mm, bush backing is copper flashed

Outside C_o and Inside C_i chamfers

WALL THICKNESS S_3	C_o (a) MACHINED	/ ROLLED	C_i (b)
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	/ 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	D_o	WALL THICKNESS S_3 max. min.	WIDTH B max. min.	SHAFT Ø D_{Jm} [d8]	max. min.	HOUSING Ø D_H [H7]	max. min.	BUSH Ø $D_{i,a,m}$ ASSEMBLY IN H7 HOUSING max. min.	CLEARANCE C_{Dm} max. min.	OIL HOLE Ø d_L
MB0808HX				8,25 7,75							
MB0810HX	8	10		10,25 9,75		7,960 7,938		10,015 10,000	8,015 8,000	0,077 0,040	No hole
MB0812HX				12,25 11,75							
MB1010HX				10,25 9,75							3
MB1012HX	10	12		12,25 11,75		9,960 9,938		12,018 12,000	10,018 10,000	0,080 0,040	
MB1015HX				15,25 14,75							4
MB1020HX				20,25 19,75							
MB1210HX				10,25 9,75							3
MB1212HX				12,25 11,75							
MB1215HX	12	14	1,108 1,082	15,25 14,75	d8	11,950 11,923	H7	14,018 14,000	12,018 12,000		
MB1220HX				20,25 19,75							
MB1225HX				25,25 24,75							4
MB1415HX				15,25 14,75							
MB1420HX	14	16		20,25 19,75		13,950 13,923		16,018 16,000	14,018 14,000	0,095 0,050	
MB1425HX				25,25 24,75							
MB1510HX				10,25 9,75							3
MB1512HX	15	17		12,25 11,75		14,950 14,923		17,018 17,000	15,018 15,000		
MB1515HX				15,25 14,75							4
MB1525HX				25,25 24,75							

All dimensions in mm

PART NO.	NOMINAL DIAMETER D_i	NOMINAL DIAMETER D_o	WALL THICKNESS S_3 max. min.	WIDTH B max. min.	SHAFT Ø D_{Jm} [d8]	SHAFT Ø D_{Jm} [d8] max. min.	HOUSING Ø D_H [H7]	HOUSING Ø D_H [H7] max. min.	BUSH Ø $D_{i,a,m}$ ASSEMBLY IN H7 HOUSING max. min.	CLEARANCE C_{Dm} max. min.	OIL HOLE Ø d_L
MB1615HX	16	18	1,108 1,082	15,25 14,75	d8	15,950 15,923	H7	18,018 18,000	16,018 16,000	0,095 0,050	4
MB1620HX				20,25 19,75							
MB1625HX				25,25 24,75							
MB1815HX	18	20		15,25 14,75		17,950 17,923		20,021 20,000	18,018 18,000		
MB1820HX				20,25 19,75							
MB1825HX				25,25 24,75							
MB2010HX	20	23	1,608 1,576	10,25 9,75		19,935 19,902		23,021 23,000	20,021 20,000	0,119 0,065	
MB2015HX				15,25 14,75							
MB2020HX				20,25 19,75							
MB2025HX				25,25 24,75							
MB2030HX				30,25 29,75							
MB2215HX	22	25		15,25 14,75		21,935 21,902		25,021 25,000	22,021 22,000		6
MB2220HX				20,25 19,75							
MB2225HX				25,25 24,75							
MB2230HX				30,25 29,75							
MB2415HX	24	27		15,25 14,75		23,935 23,902		27,021 27,000	24,021 24,000		
MB2420HX				20,25 19,75							
MB2425HX				25,25 24,75							
MB2430HX				30,25 29,75							
MB2515HX	25	28		15,25 14,75		24,935 24,902		28,021 28,000	25,021 25,000		
MB2520HX				20,25 19,75							
MB2525HX				25,25 24,75							
MB2530HX				30,25 29,75							
MB2820HX	28	32	2,108 2,072	20,25 19,75		27,935 27,902		32,025 32,000	28,021 28,000		
MB2825HX				25,25 24,75							
MB2830HX				30,25 29,75							
MB3020HX	30	34		20,25 19,75		30,000 29,967		34,025 34,000	30,021 30,000		
MB3030HX				30,25 29,75							
MB3040HX				40,25 39,75							

All dimensions in mm

9 Standard Products

PART NO.	NOMINAL DIAMETER D_i	NOMINAL DIAMETER D_o	WALL THICKNESS S_3 max. min.	WIDTH B max. min.	SHAFT Ø D_{Jm} [d8]	SHAFT Ø D_{Jm} [d8] max. min.	HOUSING Ø D_H [H7]	HOUSING Ø D_H [H7] max. min.	BUSH Ø $D_{i,a,m}$ ASSEMBLY IN H7 HOUSING max. min.	CLEARANCE C_{Dm} max. min.	OIL HOLE Ø d_L
MB3220HX	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
MB3230HX				30,25 29,75							
MB3235HX				35,25 34,75							
MB3240HX				40,25 39,75							
MB3520HX	35	39		20,25 19,75		34,920 34,881		39,025 39,000	35,025 35,000		
MB3530HX				30,25 29,75							
MB3550HX				50,25 49,75							
MB3720HX	37	41		20,25 19,75		36,920 36,881		41,025 41,000	37,025 37,000		
MB4020HX	40	44		20,25 19,75		39,920 39,881		44,025 44,000	40,025 40,000		8
MB4030HX				30,25 29,75							
MB4040HX				40,25 39,75							
MB4050HX				50,25 49,75							
MB4520HX	45	50	2,634 2,588	20,25 19,75		44,920 44,881		50,025 50,000	45,025 45,000		
MB4530HX				30,25 29,75							
MB4540HX				40,25 39,75							
MB4545HX				45,25 44,75							
MB4550HX				50,25 49,75							
MB5040HX	50	55		40,25 39,75		49,920 49,881		55,030 55,000	50,025 50,000		
MB5060HX				60,25 59,75							
MB5520HX	55	60		20,25 19,75		54,900 54,854		60,030 60,000	55,030 55,000	0,144 0,080	
MB5525HX				25,25 24,75							
MB5530HX				30,25 29,75							
MB5540HX				40,25 39,75							
MB5550HX				50,25 49,75							
MB5560HX				60,25 59,75							
MB6030HX	60	65		30,25 29,75		59,900 59,854		65,030 65,000	60,030 60,000		
MB6040HX				40,25 39,75							
MB6060HX				60,25 59,75							
MB6070HX				70,25 69,75							

All dimensions in mm

PART NO.	NOMINAL DIAMETER D_i	NOMINAL DIAMETER D_o	WALL THICKNESS S_3 max. min.	WIDTH B max. min.	SHAFT Ø D_{Jm} [d8]	SHAFT Ø D_{Jm} [d8] max. min.	HOUSING Ø D_H [H7]	HOUSING Ø D_H [H7] max. min.	BUSH Ø $D_{i,a,m}$ ASSEMBLY IN H7 HOUSING max. min.	CLEARANCE C_{Dm} max. min.	OIL HOLE Ø d_L
MB6540HX	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
MB6550HX				50,25 49,75							
MB6560HX				60,25 59,75							
MB6570HX				70,25 69,75							
MB7040HX	70	75		40,25 39,75		69,900 69,854		75,030 75,000	70,030 70,000		
MB7050HX				50,25 49,75							
MB7065HX				65,25 64,75							
MB7070HX				70,25 69,75							
MB7080HX				80,25 79,75							
MB7540HX	75	80		40,25 39,75		74,900 74,854		80,030 80,000	75,030 75,000		9,5
MB7560HX				60,25 59,75							
MB7580HX				80,25 79,75							
MB8040HX	80	85		40,50 39,50		79,900 79,854		85,035 85,000	80,030 80,000		
MB8060HX				60,50 59,50							
MB8080HX				80,50 79,50							
MB80100HX				100,50 99,50							
MB8530HX	85	90		30,50 29,50		84,880 84,826		90,035 90,000	85,035 85,000	0,209 0,120	
MB8540HX				40,50 39,50							
MB8560HX				60,50 59,50							
MB8580HX				80,50 79,50							
MB85100HX				100,50 99,50							
MB9040HX	90	95		40,50 39,50		89,880 89,826		95,035 95,000	90,035 90,000		
MB9060HX				60,50 59,50							
MB9090HX				90,50 89,50							
MB90100HX				100,50 99,50							
MB9560HX	95	100		60,50 59,50		94,880 94,826		100,035 100,000	95,035 95,000		
MB95100HX				100,50 99,50							
MB10050HX	100	105		50,50 49,50		99,880 99,826		105,035 105,000	100,035 100,000		
MB10060HX				60,50 59,50							
MB10080HX				80,50 79,50							
MB10095HX				95,50 94,50							
MB100115HX				115,50 114,50							

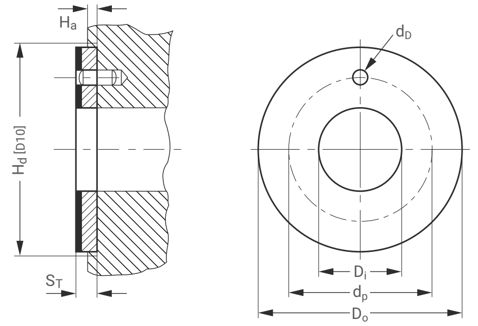
All dimensions in mm

9 Standard Products

PART NO.	NOMINAL DIAMETER D_i	NOMINAL DIAMETER D_o	WALL THICKNESS S_3 max. min.	WIDTH B max. min.	SHAFT Ø D_{Jm} [d8]	SHAFT Ø D_{Jm} [d8] max. min.	HOUSING Ø D_H [H7]	HOUSING Ø D_H [H7] max. min.	BUSH Ø $D_{i,a,m}$ ASSEMBLY IN H7 HOUSING max. min.	CLEARANCE C_{Dm} max. min.	OIL HOLE Ø d_L
MB10560HX	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
MB105110HX				110,50 109,50							
MB105115HX				115,50 114,50							
MB11060HX	110	115		60,50 59,50		109,880 109,826		115,035 115,000	110,035 110,000		
MB110115HX				115,50 114,50							
MB11550HX	115	120		50,50 49,50		114,880 114,826		120,035 120,000	115,035 115,000		
MB11570HX				70,50 69,50							
MB12060HX	120	125	2,619 2,564	60,50 59,50		119,880 119,826		125,040 125,000	120,035 120,000		
MB120100HX				100,50 99,50							
MB125100HX	125	130		100,50 99,50		124,855 124,792		130,040 130,000	125,040 125,000	0,248 0,145	
MB13050HX	130	135		50,50 49,50		129,855 129,792		135,040 135,000	130,040 130,000		No hole
MB13060HX				60,50 59,50							
MB130100HX				100,50 99,50							
MB13560HX	135	140		60,50 59,50		134,855 134,792		140,040 140,000	135,040 135,000		
MB13580HX				80,50 79,50							
MB14060HX	140	145		60,50 59,50		139,855 139,792		145,040 145,000	140,040 140,000		
MB140100HX				100,50 99,50							
MB15060HX	150	155		60,50 59,50		149,855 149,792		155,040 155,000	150,040 150,000		
MB15080HX				80,50 79,50							
MB150100HX				100,50 99,50							

All dimensions in mm

9.3 HI-EX® THRUST WASHERS



PART NO.	INSIDE DIAMETER D_i max. min.	OUTSIDE DIAMETER D_o max. min.	THICKNESS S_T max. min.	DOWEL HOLE Ø d_D max. min.	DOWEL HOLE PCD Ø d_P max. min.	RECESS DEPTH H_a max. min.
WC08HX	10,25 10,00	20,00 19,75	1,58 1,49	No hole	No hole	1,20 0,95
WC10HX	12,25 12,00	24,00 23,75		1,875 1,625	18,12 17,88	
WC12HX	14,25 14,00	26,00 25,75		2,375 2,125	20,12 19,88	
WC14HX	16,25 16,00	30,00 29,75			22,12 21,88	
WC16HX	18,25 18,00	32,00 31,75			25,12 24,88	
WC18HX	20,25 20,00	36,00 35,75		3,375 3,125	28,12 27,88	
WC20HX	22,25 22,00	38,00 37,75			30,12 29,88	
WC22HX	24,25 24,00	42,00 41,75			33,12 32,88	
WC24HX	26,25 26,00	44,00 43,75			35,12 34,88	
WC25HX	28,25 28,00	48,00 47,75		4,375 4,125	38,12 37,88	
WC30HX	32,25 32,00	54,00 53,75			43,12 42,88	
WC35HX	38,25 38,00	62,00 61,75			50,12 49,88	
WC40HX	42,25 42,00	66,00 65,75			54,12 53,88	
WC45HX	48,25 48,00	74,00 73,75	2,60 2,51		61,12 60,88	1,70 1,45
WC50HX	52,25 52,00	78,00 77,75			65,12 64,88	
WC60HX	62,25 62,00	90,00 89,75			76,12 75,88	

All dimensions in mm

9.4 HI-EX® STRIP

HI-EX® Strip sizes are available as Non-Standard products, on request.

10 Test Methods

10.1 MEASUREMENT OF WRAPPED BUSHES

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

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

Test A of ISO 3547 Part 2

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

TEST A OF ISO 3547 PART 2 ON PM2015HX	
Checking block and setting mandrel $d_{ch,1}$	23,062 mm
Test force F_{ch}	4500 N
Limits for Δz	0 and -0,065 mm
Bush Outside diameter D_o	23,035 to 23,075 mm

Table 7 : Test A of ISO 3547 Part 2

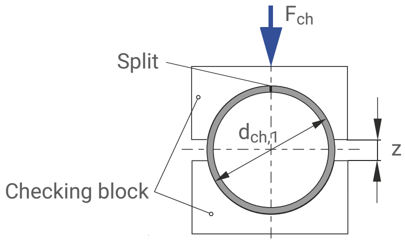


Fig.34 : Test A, data for drawing

Test B (alternatively to Test A)

Check external diameter with GO and NOGO ring gauges.

Test C

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

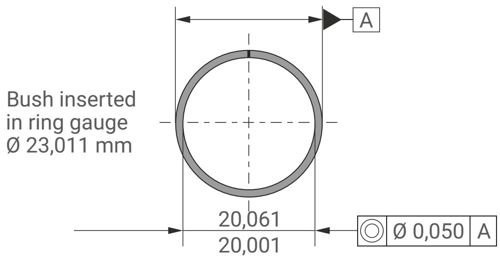


Fig.35 : Test C, data for drawing

Measurement of Wall Thickness (alternatively to Test C)

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

Test D

Check external diameter by precision measuring tape.

11 Bearing Application Data Sheet

Not sure which GGB part fits your application requirements?
Please complete the form below and share it with your GGB sales person or distributor representative.

DATA FOR BEARING DESIGN CALCULATION

Application: ____

____

Project/No.: ____________________ Quantity: __________ ☐ New Design ☐ Existing Design

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

DIMENSIONS [MM]

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

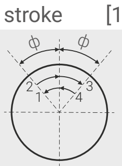
LOAD

☐ Static load
☐ Dynamic load

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

MOVEMENT

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



MATING SURFACE

Material		
Hardness	HB/HRC	
Surface finish	Ra [µm]	

FITS & TOLERANCES

Shaft	D_J	
Bearing housing	D_H	

OPERATING ENVIRONMENT

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

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

LUBRICATION

☐ Dry
☐ Continuous lubrication
☐ Process fluid lubrication
☐ Initial lubrication only
☐ Hydrodynamic conditions

Process fluid		
Lubricant		
Dynamic viscosity	η[mPas]	

SERVICE HOURS PER DAY

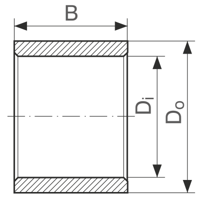
Continuous operation	
Intermittent operation	
Operating time	
Days per year	

SERVICE LIFE

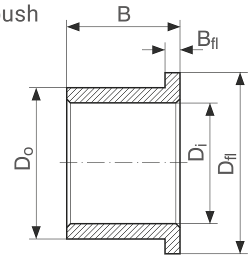
Required service life	L_H [h]	

BEARING TYPE

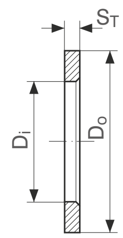
☐ Cylindrical bush



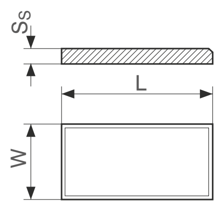
☐ Flanged bush



☐ Thrust washer



☐ Slideplate



☐ Special parts (sketch)

CUSTOMER INFORMATION

Company ____

Street ____

City / State / Province / Post Code ____

Telephone ____________________ Fax ____________________

Name ____

Email Address ____________________ Date ____________________

FORMULA SYMBOLS AND DESIGNATIONS

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 length
C	1/min	Dynamic load frequency
C_D	mm	Installed diametrical clearance
C_{Dm}	mm	Diametral clearance machined
C_i	mm	ID chamfer length
C_o	mm	OD chamfer length
C_T	-	Total number of dynamic load cycles
D_H	mm	Housing Diameter
D_i	mm	Nominal bush and thrust washer ID
$D_{i,a}$	mm	Bush ID when assembled in housing
$D_{i,a,m}$	mm	Bush ID assembled and machined
D_J	mm	Shaft diameter
D_{Jm}	mm	Shaft diameter for machined bushes
D_o	mm	Nominal bush and 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 (e.g. for thrust washers)
L	mm	Strip length
L_H	h	Bearing service life
L_{RG}	h	Relubrication interval

SYMBOL	UNIT	DESIGNATION
N	1/min	Rotational speed
N_{osc}	1/min	Oscillating movement frequency
p	N/mm^2	Specific load
p_{lim}	N/mm^2	Specific load limit
$p_{sta,max}$	N/mm^2	Maximum static load
$p_{dyn,max}$	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
Z_T	-	Total number of cycles
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/mm^2	Compressive yield strength
λ	W/mK	Thermal conductivity
φ	°	Angular displacement
η	Ns/mm^2	Dynamic viscosity

Product Information

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

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

Unless expressly declared in writing, GGB gives no warranty that the products described are suited for any particular purpose or specific operating circumstances. GGB accepts no liability for any losses, damages, or costs however they may arise through direct or indirect use of these products.

GGB's sales and delivery terms and conditions, included as an integral part of quotations, stock and price lists, apply absolutely to all business conducted by GGB. Copies can be made available on request.

Products are subject to continual development. GGB retains the right to make specification amendments or improvements to technical data without prior announcement. Edition 2021 (this edition replaces earlier editions which hereby lose their validity).

STATEMENT REGARDING LEAD CONTENT IN GGB PRODUCTS & EU DIRECTIVE COMPLIANCE

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

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

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

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

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