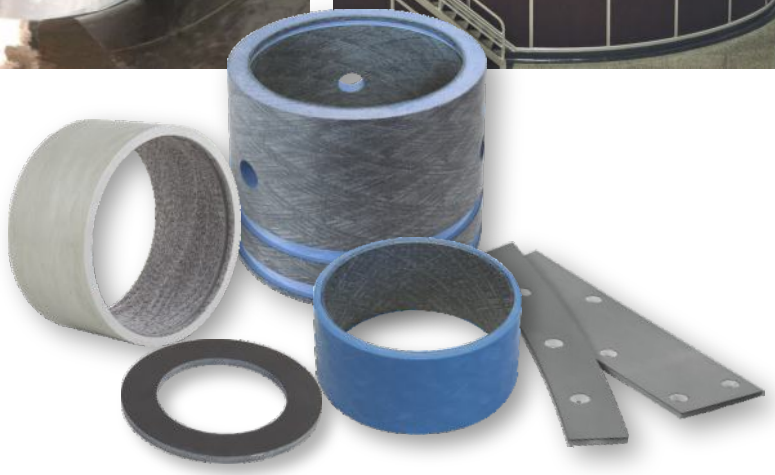
GGB



HPM / HPMB® / HPF®

FIBER REINFORCED COMPOSITE SELF-LUBRICATING BEARING SOLUTIONS FOR HYDROPOWER APPLICATIONS





The Tribological Solution Provider for Industrial Progress, Regardless of Shape or Material

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.

GGB is an Enpro company (NYSE: NPO).

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

GGB - Who We Are

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

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

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

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, OHSAS 18001, and AS9100D/EN9100. This allows us to access the industry's best practices while aligning our management system with global standards.

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

RESPECT

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

Table of Contents

1 Introduction

GGB is the world´s largest manufacturer of polymer plain bearings for low maintenance and maintenance-free applications. This includes an extensive product portfolio, including metal-polymer bearings, thermoplastic materials, filament wound composite materials and mono-metallic materials.

The purpose of this handbook is to provide comprehensive technical information on the characteristics of GGB's HPM, HPMB® and HPF®, high load, self-lubricating bearings for hydropower applications. The information given permits designers to establish the appropriate bearing material required for a particular application. GGB applications and development engineering services are available to provide additional design assistance.

1.1 GENERAL CHARACTERISTICS AND ADVANTAGES

HPM bearings are self-lubricating, glass-fiber reinforced bearings, which are produced by means of a special winding technology. The core structure guarantees high strength, while the sliding layer contains special non-abrasive fibers and solid lubricants that ensure excellent tribological properties in wet environments or in the event of high edge loads.

HPMB® bearings are self-lubricating, glass-fiber reinforced bearings, which are produced by means of a special winding technology. Added benefit of HPMB material is the machinability of the liner with a single point tool, either by GGB or by the customer prior to or post installation. Post installation machining offers the tightest tolerance control.

HPF® sliding plates are made of a composite material consisting of a self-lubricating surface layer and a composite backing, offering outstanding tribological characteristics.

The HPM, HPMB® and HPF® materials offer the following characteristics:

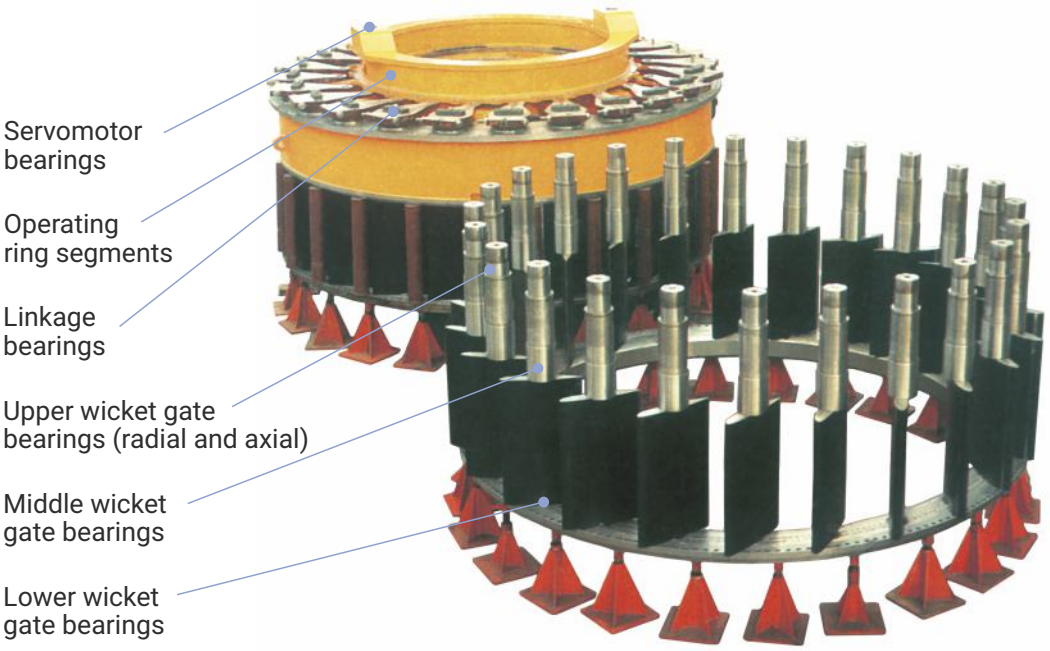
- Maintenance free operation – no additional lubrication required
- Low friction and wear rate – superior bearing life
- Resistant to impact, shock and edge loadings
- Dimensionally stable with low water absorption – suitable for use in sea water
- High static and dynamic load capacity
- Suitable for rotating, oscillating and linear movements
- Excellent corrosion resistance
- Environmentally friendly – compliant with EU RoHS legislation
- 75% lower weight than equivalent size metallic bearings
- HPM bearings can be machined by GGB to the required inner diameter

The HPMB® material offers added characteristics:

- Easily machinable bearing liner with commonly available single point tools by GGB or a customer

2 Example Hydropower Applications

FRANCIS TURBINE



APPLICATIONS

Gates
- Sliding gates
- Radial gates
- Spillway gates
- Trash rakes
- Fish screens

Kaplan turbines
- Runner hub
- Servomotor
- Wicket gates (outer and inner)
- Linkage
- Blade

Francis turbines
- Wicket gates (upper, intermediate, and lower)
- Servomotor
- Linkage
- Operating ring (radial and axial)

Pelton turbines
- Injector
- Delector

Valves
- Butterfly valve
- Ball valve

MAINTENANCE FREE OPERATION

GGB **HPM, HPMB®** and **HPF®** bearings are self-lubricating composites, capable of operating in dry or waterlubricated conditions, eliminating the need of periodic re-greasing. This benefit eliminates the need of complex greasing systems, reduces operating costs in the long run, and offers an environmentally-friendly solution.

GGB **HPM, HPMB®** and **HPF®** bearings are designed with a minimum of twenty years operation in a water turbine.

LOW FRICTION OPERATION

GGB self-lubricating **HPM, HPMB®** and **HPF®** bearings are particularly effective in applications where the relative motion is not sufficient to promote circulation of the oil or grease used with more conventional bearings. The natural lubricity of the PTFE used in the bearing surfaces assures low friction in dry applications.

OUTSTANDING DIMENSIONAL STABILITY

Due to negligible water absorption GGB **HPM, HPMB®** and **HPF®** bearings do not require additional running clearance due to the water exposure. The flexible nature of the liner allows bearings to tolerate misalignment conditions without damage, which gives GGB **HPM, HPMB®** and **HPF®** undisputed benefit over metallic bearings in water turbines.

Unlike many conventional metallic and composite bearing materials, the high-strength composite structure of GGB **HPM, HPMB®** and **HPF®** bearings offer a thermal expansion rate similar to that of steel and cast iron. This ensures safe housing retention irrespective of the operating temperature and a reduced risk of loss of bearing clearance at elevated temperatures in comparison to bronze and some competing non-metallic bearing types.

WIDE RANGE OF SIZES AND SHAPES

GGB **HPM** and **HPMB®** bearings are are available in sizes from 16 mm to 500 mm inner diameter, with wall thicknesses of 2.0 mm to 12.5 mm, and lengths up to 600 mm.

GGB **HPF®** sliding plates are available in standard thicknesses of 6, 8 and 10 mm. Different/other **HPF®** plate thicknesses are available by request.

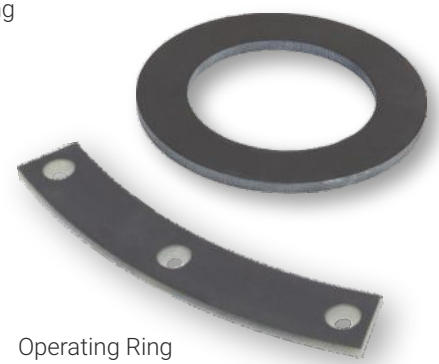
Wicket Gate HPM Bearing

Linkage HPM Bearing

Wicket Gate
HPMB® bearing

Servomotor HPMB® Bearing

Wicket Gate
HPF® Thrust Washer



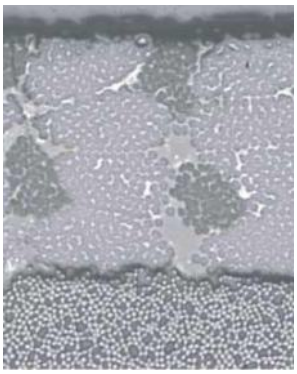
Operating Ring
Axial HPF® Segment

3 Structure and Composition

HPM

The sliding layer is composed of continuously wound PTFE and high strength fibers in an epoxy resin matrix with structurally embedded solid lubricants, designed to ensure good tribological properties.

The outer layer is a glass-fiber reinforced resin matrix that provides a very high load carrying capacity.



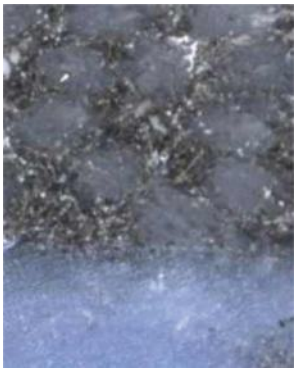
Sliding layer
Continuous wound PTFE and high-strength fibers encapsulated in a self-lubricating, high temperature epoxy resin
0.63 mm

Backing
Continuous wound glass fiber encapsulated in high temperature epoxy resin

HPMB®

This bearing consists of a self-lubricating filament wound material with a machinable liner, providing tight imensional control and class-leading tribological properties. The sliding layer is composed of continuously wound PTFE and high strength fibers in an epoxy resin matrix with structurally embedded solid lubricants. The outer layer is a glass-fiber reinforced resin matrix that provides a very high load arrying capacity.

HPMB® material can be machined on the inner diameter to the depth up to 1 mm on diameter in standard configuration, and to the depth up to 3 mm on diameter upon request.



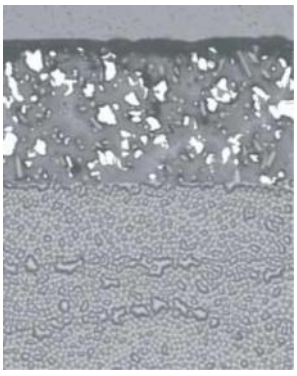
Sliding layer
0.5 mm to 1.5 mm
machining allowance

Backing
Continuous wound glass fiber encapsulated in high temperature epoxy resin

HPF®

The material surface layer consists of a proprietary filled PTFE tape material which is securely bonded to the composite backing.

The composite backing consists of continuous woven glass cloth laminate impregnated and cured with epoxy resin.



Sliding layer
Proprietary filled PTFE tape liner
0.76 mm to 1.52 mm

Backing
Continuous woven glass fiber cloth laminate impregnated and cured with epoxy resin

4 Properties

4.1 PHYSICAL AND MECHANICAL PROPERTIES

SLIDING LAYER PROPERTIES	HPM	HPMB®	HPF®	UNIT
Specific gravity	1.87	1.87	1.90	-
Water absorption (24 hrs)	0.15	0.15	0.05	%
Coefficient of thermal expansion α_1	12.6	12.6	Lengthwise: 10.8	10^{-6}/K
Youngs Modulus E	10 000 - 14 000	10 000 - 14 000	12 000 - 14 000	MPa
Compressive strength δ_c	345	345	380	MPa
Max. permissible static specific load $p_{sta, max}$	210	210 1	80	MPa
Max. permissible dynamic specific load $p_{dyn, max}$	140	140	140	MPa
Max. sliding speed, dry U_{lim} *1)	0.13	0.13	2.5	m/s
Max. pU-value, dry	1.23	1.23	1.23	MPa x m/s
Max. operating temperature T_{max}	+160	+160	+140	°C
Min. operating temperatureT_{min}	- 196	- 196	- 196	°C
Coefficient of friction f, dry	0.03 - 0.12	0.03 - 0.12	0.02 - 0.10	-
Coefficient of friction f, in water	0.03 - 0.12	0.03 - 0.12	0.02 - 0.08	-
Mating material				
Optimal shaft surface finish ground R_a	0.20 - 0.80	0.20 - 0.80	0.20 - 0.80	µm
Min. shaft hardness	>180	>180	>180	HB

Table 1: HPM / HPMB® / HPF® sliding layer and bearing properties

*1) For higher speeds please contact GGB application engineering

4.2 CHEMICAL RESISTANCE

GGB's HPM, HPMB® and HPF® products are resistant to a wide variety of chemicals including acids, bases, salt solutions, oils, fuels, alcohols, solvents and gases. The chemical resistance of the bearings to many common chemicals at 20 °C is shown in Table 2.

Chemical resistance testing is recommended prior to use in the field. An effective test (ASTM D 543) is to submerge a sample bearing in the subject chemical at the maximum anticipated operating temperature for seven days. If there is a change in the weight, dimensions, or compressive strength of the bearing, then the bearing is not resistant to the chemical.

	HPM/HPMB®	HPF®
ACIDS 10%		
Acetic	Yes	Yes
Arsenic	No	Yes
Boric	Yes	Yes
Carbonic	No	No
Citric	Yes	Yes
Hydrochloric	Yes	Yes
Hydro-luoric	No	No
Nitric	No	No
Sulfuric	Yes	Yes
BASES 10%		
Aluminum Hydroxide	Yes	Yes
Calcium Hydroxide	Yes	Yes
Magnesium Hydroxide	Yes	Yes
Potassium Hydroxide	Yes	Yes
Sodium Hydroxide	Yes	Yes
ALCOHOLS		
Acetol	Yes	Yes
Allyl	No	No
Amyl	Yes	Yes
Butyl	No	No
Ethyl	Yes	Yes
Iso Butyl	Yes	Yes
Iso Propyl	Yes	Yes
Methyl	Yes	Yes
Propyl	Yes	Yes
GASES		
Acetylene Bromine	No	No
Butane	Yes	Yes
Carbon Dioxide	Yes	Yes
Chlorine	No	Yes
Ethers	Yes	Yes
Fluorine	No	No
Hydrogen	Yes	Yes
Natural Gas	Yes	Yes
Nitrogen	Yes	Yes
Ozone	Yes	Yes
Propane	Yes	Yes
Sulfur Dioxide	Yes	Yes
FUELS		
Diesel	Yes	Yes
Gasoline	Yes	Yes
Jet Fuel	Yes	Yes
Kerosene	Yes	Yes
OILS		
Cottonseed	Yes	Yes
Crude Oil	Yes	Yes
Hydraulic Fluids	Yes	Yes
Linseed Oil	Yes	Yes
Motor Oil	Yes	Yes
Transmission Fluids	Yes	Yes
SOLVENTS		
Acetone	Yes	Yes
Benzene	No	No
Carbon Tetrachloride	Yes	Yes
Methylene Chloride	No	No
Methyl Ethyl Ketone	Yes	Yes
Naphtha	Yes	Yes
Toluol	Yes	Yes
Trichlorethane	No	Yes
SALTS		
Aluminum Chloride	Yes	Yes
Aluminum Nitrate	Yes	Yes
Aluminum Sulfate	Yes	Yes
Calcium Chloride	Yes	Yes
Ferric Chloride	Yes	Yes
Magnesium Carbonate	Yes	Yes
Magnesium Chloride	Yes	Yes
Magnesium Sulfate	Yes	Yes
Sodium Acetate	Yes	Yes
Sodium Bicarbonate	Yes	Yes
Sodium Bisulfate	Yes	Yes
Sodium Chloride	Yes	Yes
Sodium Nitrate	Yes	Yes
Zinc Sulfate	Yes	Yes
MISCELLANEOUS		
Anhydrous Ammonia	No	No
Detergents	Yes	Yes
Ethylene Glycol	Yes	Yes
Formaldehyde	Yes	Yes
Freon	Yes	Yes
Hydrogen Peroxide	No	No
Lime	Yes	Yes
Water	Yes	Yes
Seawater	Yes	Yes

Table 2: Chemical resistance

5 Mating Materials

A mating material hardness of at least 180 HB is recommended for use with GGB HPM, HPMB® and HPF® bearings. In abrasive environments, a hardened mating surface should be used. HPM and HPMB® bearings can embed contaminants; however, the use of seals is strongly recommended.

For optimal life expectancy the surface roughness when using HPM, HPMB® or HPF® should be R_a = 0.2 to 0.8 µm.

Rougher surfaces may be acceptable depending on the operating conditions. For effect on bearing service life, contact GGB application engineering.

The corrosion resistance of the mating material should be determined according to the operating conditions. The adjacent table provides an overview of some possible mating materials.

MATING MATERIALS FOR STANDARD APPLICATIONS				
MATERIAL NUMBER	DIN DESIGNATIONS	COMPARABALE STANDARDS		
		USA AISI	GB B.S. 9 70	F AFNOR
1.0543	ZSt60-2	Grade 65	55C	A60-2
1.0503	C45	1045	080M46	CC45
1.7225	42CrMo4	4140	708M40	42CD4

Table 3: Recommended mating materials for standard applications

MATING MATERIALS FOR CORROSIVE ENVIRONMENTS				
MATERIAL NUMBER	DIN DESIGNATIONS	COMPARABALE STANDARDS		
		USA AISI	GB B.S. 9 70	F AFNOR
1.4021	X 20Cr13	420	420S37	220c13
1.4024	X 15Cr13	410	-	-
1.4057	42CrMo4	431	432S29	Z15CN16.02
1.4112	X 90CrMoV18	440B	-	(Z70CV17)
1.4122	X 35CrMo17-1	-	-	-

Table 4: Recommended mating materials for corrosive environments

MATING MATERIALS FOR SEAWATER APPLICATIONS				
MATERIAL NUMBER	DIN DESIGNATIONS	COMPARABALE STANDARDS		
		USA AISI	GB B.S. 9 70	F AFNOR
1.4460	X 4CrNiMo27-5-3	329	-	-
1.4462	X 2CrNiMoN22-5-3	UNS531803	318513	Z3CND24-08
2.4856	Inconel 625	-	-	-

Table 5: Recommended mating materials for seawater applications

6 Lubrication

HPM, HPMB® and HPF® self-lubricated bearings are pecifically designed for hydropower applications, where they can be used both dry and immersed in water.

However, grease can be used to protect and/or to purge the bearing zone of corrosion or contaminants. In applications where high cyclic vibrations are present, hydrostatic erosion of liner fibers by the grease may occur over long periods of time. This should be monitored to assure liner integrity over the operating life of the equipment.

7 Lifetime Estimation

For estimates of life expectancy of HPM, HPMB® and HPF® products, please contact GGB applications and development engineering services.

MISALIGNMENT

Bearings operating without misalignment are uniformly loaded along their length, as shown in Fig. 5.

The projected contact area between the shaft and the bearing is shown to the right of Fig. 5. Shaft misalignment reduces the contact area and shifts the bearing pressure distribution to one end of the bearing, as illustrated in Fig. 6.

With substantial misalignment, the contact area reduces to a parabolic shape, as shown in Fig. 7. The concentrated edge pressure due to the excessive misalignment can cause bearing damage. If the edge pressure produces stresses that approach or exceed the compressive strength of the material, fracture may occur.

For highly loaded, very low-speed applications, misalignment and/or shaft deflections less than 0.2% (2 mm/m) of length is permissible.

(7.1.1) [mm]

$$S_D = \frac{B \cdot 0.2}{100}$$

The related deflection is proportional to bearing length. If misalignment and/or shaft deflections exceed this value, please contact GGB.

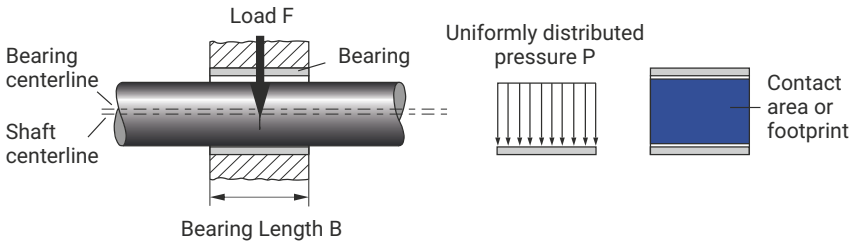


Fig.5: Properly aligned shaft

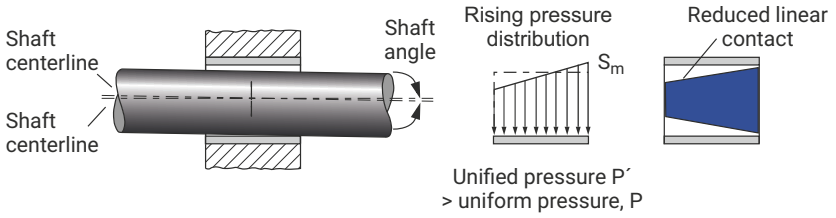


Fig.6: Slight misalignment

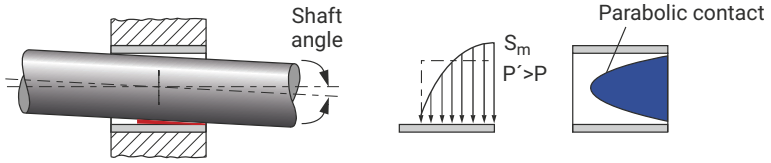


Fig.7: Substantial misalignment

8 Machining of HPMB® Bearings

The HPMB® bearing's liner is easily machined with commonly available single-point tools. In standard form, maximum allowable machining depth is 1 mm (on diameter), which can be increased up to 3 mm (on diameter) by special request.

HPMB® may be machined in a single pass to the required final inside diameter and it shall be machined dry.

Documented machining parameters include carbide inserts with a cutting radius 3 - 10 mm to machine the liner with a surface speed of 1.25 – 3.5 m/s and a traverse speed of 0.13 mm/revolution.

It is highly recommended that HPMB® bearings only be used in the ID-machined condition, with a minimum recommended machining depth of 0.2 mm on diameter.

HPMB® bearings can be ID-machined either by GGB or the end user.

9 Installation of HPM/HPMB® Bearings

INSTALLATION OF CYLINDRICAL HPM/ HPMB® BEARINGS BY PRESS-FIT

Radial bearings less than 200 mm in diameter should be pressed into the housing by using a hydraulic- or screw-press together with a pressing mandrel, as shown in Fig. 8.

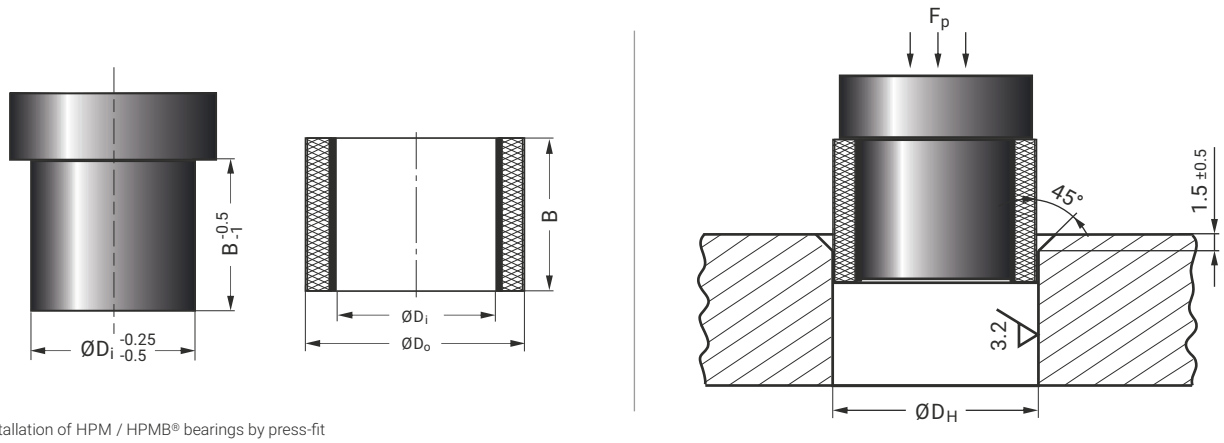


Fig.8: Installation of HPM / HPMB® bearings by press-fit

NOTE:

- The press-in force must be applied evenly.
- Installation by using a hammer will damage the bearing and is not recommended.
- The retention of GGB filament wound bearings in housings is excellent due to their high material stiffness and thermal expansion rate similar to that of steel.
- In most cases the press fits used for bronze bearings are sufficient for HPM and HPMB® bearings.
- The bearing will deform, reducing the bore by an amount equal to the interference fit with the housing. This deformation has been considered when calculating the installed bore and corresponding shaft diameter given in the recommended tolerances for installation of HPM and HPMB® bearings by press-fit.
- For diameters larger than 200 mm, installation by cooling is recommended (see installation of HPM and HPMB® precision bearings by cooling on page 13).

INSTALLATION OF HPM/ HPMB® PRECISION BEARINGS BY COOLING

HPM and HPMB® precision radial bearings with diameters larger than 200 mm are best installed by cooling. This technique allows easy assembly of interference fit without additional pressing tools or excessive force, and avoids any damage to the material.

The standard recommended cooling medium is liquid nitrogen. However, for precision bearings larger than 250 mm (H7/r7), using dry ice is also possible, due to its easier handling and availability.

NOTE:

- The installation method relies on shrinking the bearing by cooling to temporarily reduce the interference fit and thereby facilitate installation.
- Thermal expansion of the housing by heating will not achieve the same results, may result in damage to the bearing and must not be attempted.

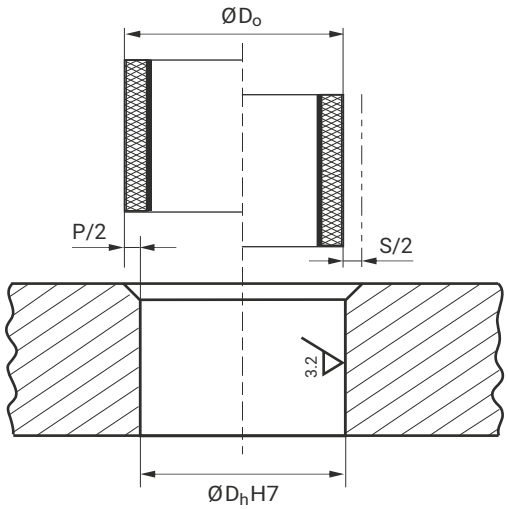


Fig.9: Press and shrinkage

Calculation of shrinkage

The shrinkage is calculated in accordance with DIN 7190. The values for ΔT depend on the cooling material used.

To ensure a sufficient shrinkage a safety factor of 0.8 is applied.

As the theoretical minimum temperatures might not be reached, especially for dry ice, a reduced ΔT value will be used for the calculation.

WITH	
D_o	Bearing outer diameter [mm]
α_{HPM}	12.6 x 10^{-6} [1/K]
ΔT_{CO_2}	+15-(-65) = 80 [K]
ΔT_{IN_2}	+15-(-195) = 210 [K]

(9.1.1) [mm]

$$S = 0.8 \cdot \alpha \cdot \Delta T \cdot D_o$$

(9.1.2) [mm]

$$S_{CO_2} = 0.8 \cdot 12.6 \cdot 10^{-6} \cdot 80 \cdot D_o$$

(9.1.3) [mm]

$$S_{IN_2} = 0.8 \cdot 12.6 \cdot 10^{-6} \cdot 210 \cdot D_o$$

Depending on the bearing size, the necessary cooling time may vary between 30 minutes and 2 hours (Fig. 12). The use of liquid nitrogen, especially for smaller bearings, offers a more effective cooling rate due to its lower temperature of -196 °C. When using liquid nitrogen, the end of the cooling process is indicated when no more bubbles are evident (end of boiling).

PREPARATION

The bearing must be cleaned and dried before starting the cooling process.

DETAILS FOR THE USE OF LIQUID NITROGEN

Special open insulated thermos containers for handling liquid nitrogen should be used. These are available from specialized trade suppliers (Fig. 10).

Safety instructions associated with dry ice or liquid nitrogen must be adhered to.

DETAILS FOR THE USE OF DRY ICE

A closed wooden container insulated with expanded polystyrene is generally adequate for cooling (Fig. 11). To minimize the amount of dry ice required, fill some of the space in the bore and edges with insulating material, while ensuring that any remaining space is large enough to be filled with the necessary quantity of dry ice. The dry ice should be finely crushed so that all bearing surfaces (including front faces) can be covered.

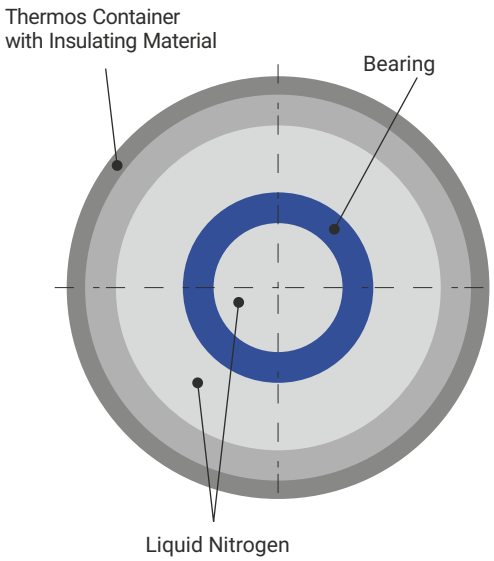


Fig.10: Thermos container for liquid nitrogen (top view)

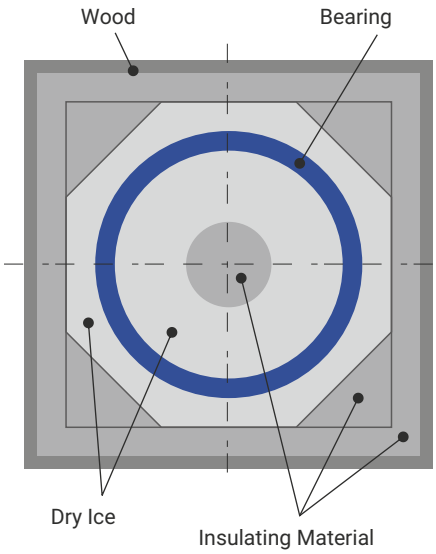


Fig.11: Wooden container for dry ice (top view)

The maximum shrinkage depending on the bearing diameter is shown in Fig. 12.

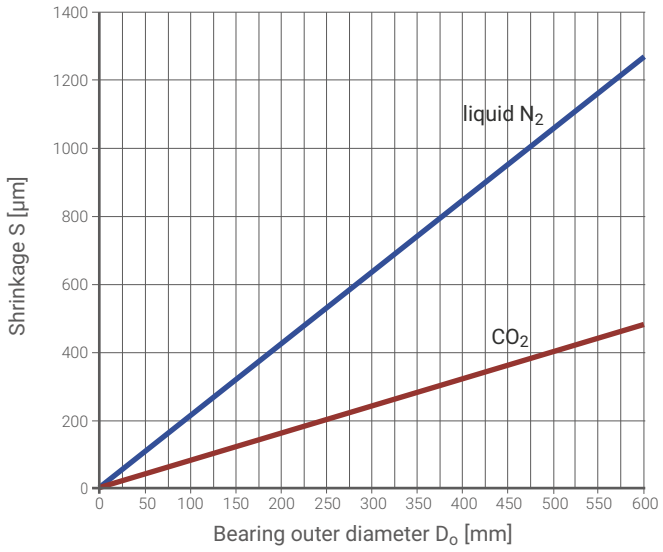


Fig. 12 Shrinkage depending on bearing outer diameter

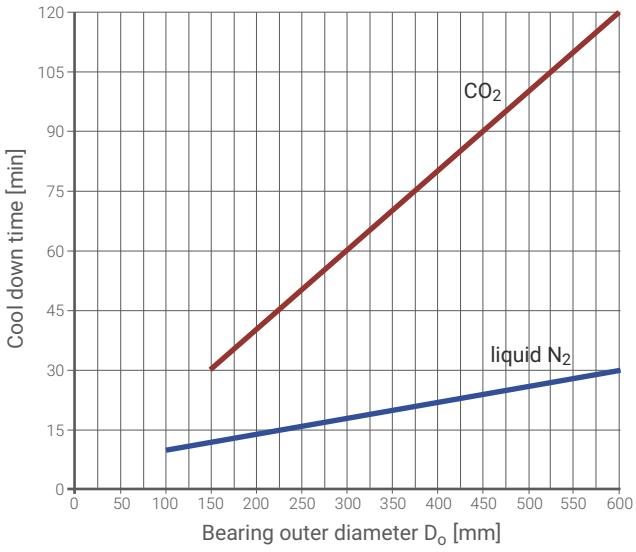


Fig. 13 Cool down time depending on bearing outer diameter

INSTALLATION

Before removing the bearing from the cooling medium, the effective shrinkage of the outer diameter should be measured. The measurement must be done quickly in order to avoid cooling and shrinking the measuring equipment.

When the necessary shrinkage of the bearing has been achieved, it must be installed immediately. The installation should be possible without additional press-in force.

The bearing and housing bore should be cleaned carefully before installation. The housing bore may be slightly greased or oiled (recommended for bearing diameters larger than 250 mm). In practice, petroleum jelly has proven particularly effective.

The retention of GGB HPM™ and HPMB® bearings in housings is excellent due to the high material stiffness and a thermal expansion coefficient similar to steel.

The press its used for bronze bearings are sufficient for HPM and HPMB® bearings in most cases. The bearing will close-in by an amount equal to the interference fit with the housing. This close-in has been considered when calculating the installed bore and corresponding shaft diameter (**Table 13 and 14, page 24**).

10 Installation of HPF® Sliding Plates

SLIDING PLATE ATTACHMENT WITH COUNTERSUNK SCREWS

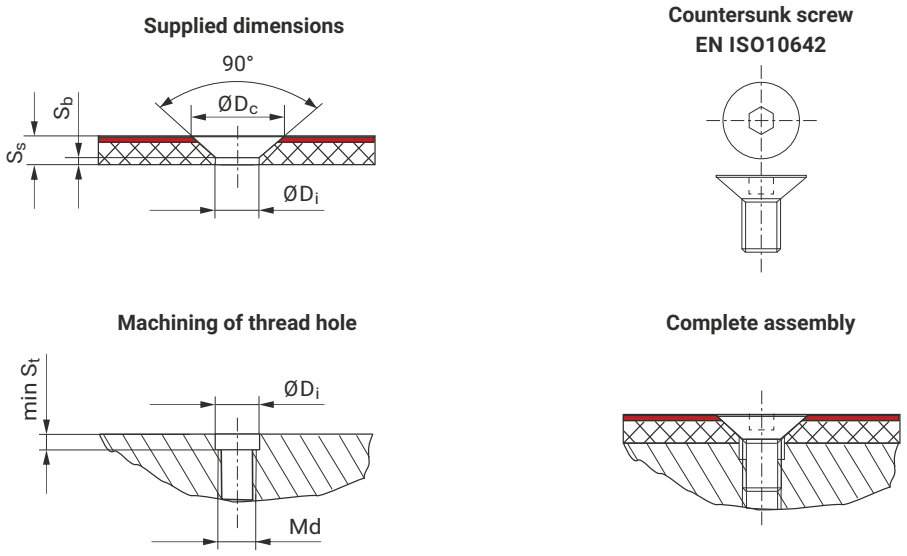


Fig. 14 Sliding plate attachment with countersunk screws

PREPARATION

Before installation, the sliding plate has to be tightly fixed with the housing part using suitable clamping tools (e.g. clamping tongs).

The tapping drill hole, countersunk bore and thread should be machined as shown in Fig. 15.

EN ISO10642 (DIN 7991)	BORE IN SLIDING PLATE		
d	D_j	D_C	$S_{b\ min}$
M6	6.4	14	1.5
M8 Thin plate	8.4	18.5	0.5
M8 Standard	8.4	18.5	1.5
M10	10.5	23	1.5

Table 6: Specifications for drill hole and countersunk bore

EN ISO10642 (DIN 7991)	THREAD HOLE	PLATE THICKNESS
d	$S_{t\ min}$	$S_{s\ min}$
M6	0.0	6
M8 Thin plate	1.5	6
M8 Standard	0.5	7
M10	1.0	8

Table 7: Specifications for thread hole

INSTALLATION

The plate should be fixed by using countersunk screws, type EN ISO 10642. For the number of screws and spacing please refer to Figure 16, page 21.

ADDITIONAL SCREW SECURING

If required, screws may be secured with metal adhesives, e.g. “Loctite 603.” The manufacturer’s instructions must be adhered to.

GLUING OF BACKING

Gluing the backing of the sliding material to the supporting structure should only be carried out if absolutely necessary.

SLIDING PLATE ATTACHMENT WITH HOLD-DOWN DEVICES

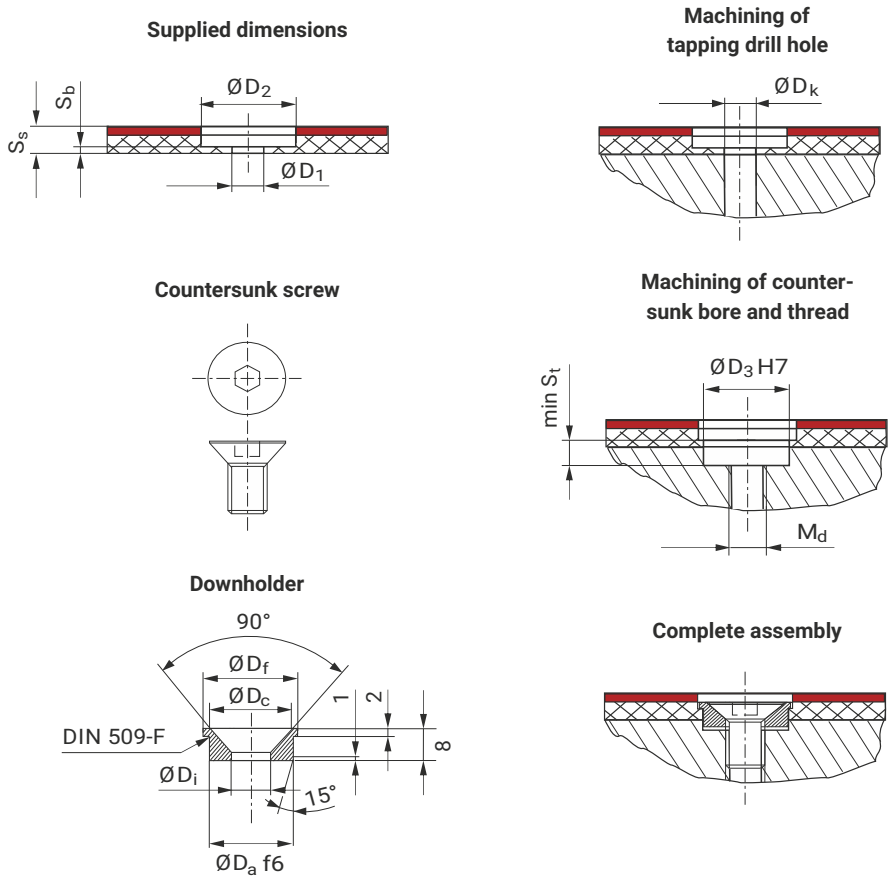


Fig. 15 Sliding plate attachment with hold-down device

PREPARATION

Before installation, the sliding plate has to be tightly fixed with the housing part using suitable clamping tools (e.g. clamping tongs).

The tapping drill hole, countersunk bore and thread should be machined as shown in Fig. 15.

EN ISO10642 (DIN 7991)	BORE IN SLIDING PLATE		THICKNESS	
d	D_1	D_2	$S_{b\ min}$	$S_{s\ min}$
M6	5	19	1.5	≥4
M8	6.5	23	1.5	≥4
M10	8.5	27	1.5	≥4

Table 8: Specifications for drill hole and countersunk bore

EN ISO10642 (DIN 7991)	BORE IN SLIDING PLATE		
d	D_k	D_3	$S_{t\ min}$
M6	5	14 H7	7
M8	6.8	18 H7	7
M10	8.5	23 H7	7

Table 9: Specifications for thread hole

INSTALLATION

The plate should be fixed by using countersunk screws, type EN ISO 10642. For the number of screws and spacing please refer to Figure 16.

EN ISO10642 (DIN 7991)	DOWNHOLDER (BRASS OR STAINLESS STEEL)			
d	D_1	D_a	$S_{b\ min}$	$S_{s\ min}$
M6	6.4	14 f6	14	16
M8	8.4	18 f6	18	21
M10	10.5	23 f6	23	27

Table 10: Specifications for downholder

ADDITIONAL SCREW SECURING

If required, screws may be secured with metal adhesives, e.g. “Loctite 603.” The manufacturer’s instructions must be adhered to.

GLUING OF BACKING

Gluing the backing of the sliding material to the supporting structure should only be carried out if absolutely necessary.

NUMBER OF SCREWS AND HOLE SPACING

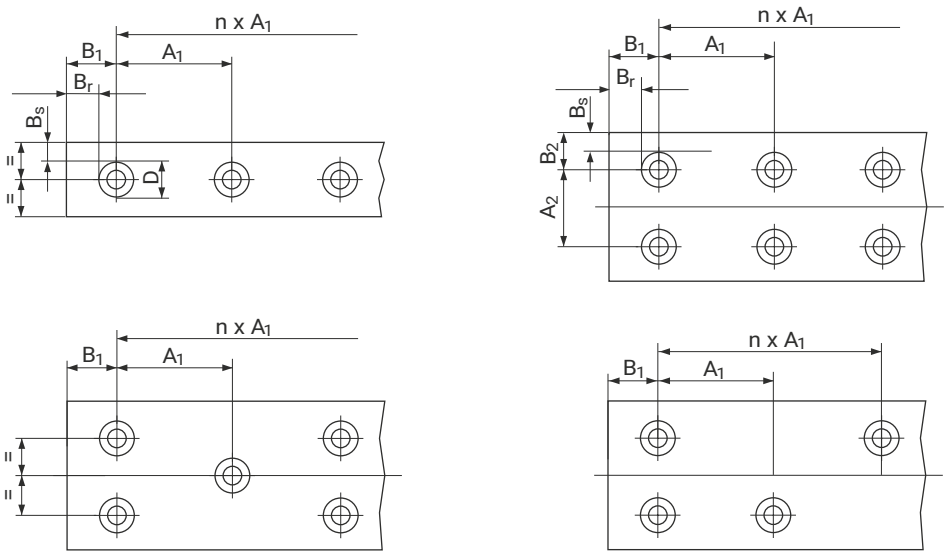


Fig. 16 Number of and spacing for screws in HPF sliding plates

NUMBER OF SCREWS

The number and size of screws required depends on the axial forces and shear loads expected.

The guidelines opposite are based on experience in the field for recommended screw sizes M6 to M10:

THREAD HOLE	
B_r , B_S	10, 30 mm
B_1 , B_2	~1, 1.5 x D
A_1 , A_2	60, 150 mm

Table 11: Guidelines for screw sizes M6 to M10

HOLE SPACING

The holes should be equally distributed, as shown in the example drawings in Fig. 16.

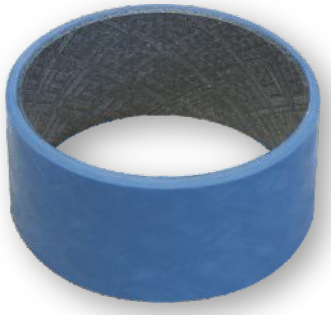
It's important to fix each corner of the sliding plate in order to avoid distortion in these areas.

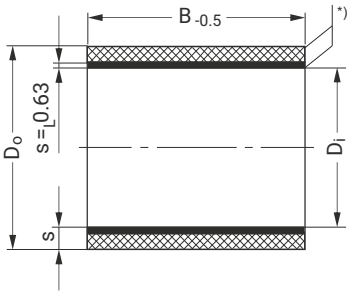
GLUING OF BACKING

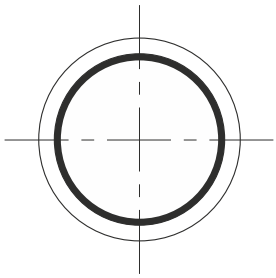
Gluing the backing of the sliding material to the supporting structure should only be carried out if absolutely necessary.

11 Recommended Dimensions

DIMENSION TABLE FOR HPM AND HPMB® CYLINDRICAL BUSHES







*) Edges deburred, large diameter chamfered

ORDER SPECIFICATIONS FOR CYLINDRICAL BUSHES

PART NUMBER FOR CYLINDRICAL BEARINGS	080	090	060	HPMB	-S
Nominal Bush Inside Diameter D_i					
Nominal Bush Outside Diameter D_O					
Nominal Bush Width B					
Material Identification					
Customer Specific					

Example:
707580HPMB-S is an HPMB cylindrical bearing with D_i 70 mm, D_O 75 mm and 80 mm width

DIMENSIONS

NOTE:

- Further sizes available upon request.
- In addition to the recommended wall thickness, bearings with greater or smaller wall thicknesses can be manufactured upon request.
- The bearing length can be freely chosen within the recommended maximum and minimum bearing lengths.
- All dimensions in mm.

BEARING PART NUMBER	BUSH ID D_i	BUSH OD D_0	WALL THICKNESS	RECOMMENDED BUSH WIDTH B MIN.	MAX.
1620xxHPMB-S	16	20	2	10	20
2024xxHPMB-S	20	24		15	25
2226xxHPMB-S	22	26		15	25
2530xxHPMB-S	25	30		15	30
2833xxHPMB-S	28	33	2.5	20	35
3035xxHPMB-S	30	35		20	40
3540xxHPMB-S	35	40		25	45
4045xxHPMB-S	40	45		25	50
4550xxHPMB-S	45	50		30	55
5055xxHPMB-S	50	55		30	65
5560xxHPMB-S	55	60		35	70
6065xxHPMB-S	60	65		40	75
6570xxHPMB-S	65	70		40	80
7075xxHPMB-S	70	75		45	90
7585xxHPMB-S	75	85	5	45	95
8090xxHPMB-S	80	90		50	100
8595xxHPMB-S	85	95		55	110
90100xxxHPMB-S	90	100		55	115
95105xxxHPMB-S	95	105		60	120
100110xxxHPMB-S	100	110		60	130
110120xxxHPMB-S	110	120		70	140
120130xxxHPMB-S	120	130		75	155
130140xxxHPMB-S	130	140		80	165
140150xxxHPMB-S	140	150		85	180
150160xxxHPMB-S	150	160		90	190
160170xxxHPMB-S	160	170		100	200
180190xxxHPMB-S	180	190		110	230
200215xxxHPMB-S	200	215	7.5	120	260
220235xxxHPMB-S	220	235		135	280
240255xxxHPMB-S	240	255		145	310
250265xxxHPMB-S	250	265		150	320
260275xxxHPMB-S	260	275		160	330
280300xxxHPMB-S	280	300	10	170	360
300320xxxHPMB-S	300	320		180	390
320340xxxHPMB-S	320	340		200	410
340360xxxHPMB-S	340	360		210	440
350370xxxHPMB-S	350	370		210	450
360380xxxHPMB-S	360	380		220	460
380400xxxHPMB-S	380	400		230	490
400425xxxHPMB-S	400	425	12.5	240	520
420445xxxHPMB-S	420	445		260	540
440465xxxHPMB-S	440	465		270	570
450475xxxHPMB-S	450	475		270	580
460485xxxHPMB-S	460	485		280	590
480505xxxHPMB-S	480	505		280	600
500525xxxHPMB-S	500	525		300	600

Table 12: HPM/HPMB dimension table

TOLERANCES FOR HPM AND HPMB® CYLINDRICAL BUSHES

RECOMMENDED TOLERANCES / MACHINED HPM				
Housing Ø	D_h	**H7**		
		Standard	**Machined** *1)	
Bearing outer Ø	D_o	s9	<120 s9 ≥120 r9	
Shaft Ø	D_s	Basic Shaft h8	Basic Shaft h7	Basic Hole d7, e7, f7
Bearing inner Ø	D_i	**Prior to installation**		
		c10	Clearance	
			Normal Tight	–
			D9 **E9**	**H9**
		After installation		
		f12	Clearance	
			Normal Tight	**–**
			D10 **E10**	**H10**
Bearing Length	B	Di ≤ 75 -0.5 Di >75 ≤ 120 -1.0	Di ≤ 75 -0.5 Di >75 ≤ 500 -1.0	

*1) For HPM precision bearings available please contact GGB application engineering

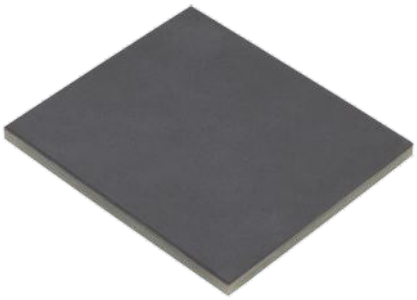
Table 13: Recommended Tolerances Machined HPM

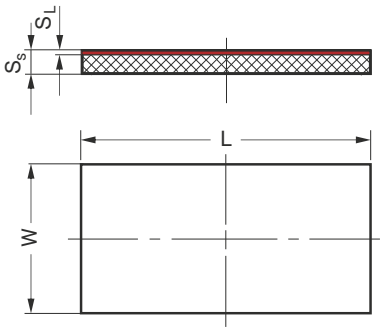
RECOMMENDED TOLERANCES / HPMB® MACHINED PRECISION BEARINGS				
Housing Ø	D_h	**H7**		
		Precision		
Bearing outer Ø	D_o	<120 s7 ≥120 r7		
Shaft Ø	D_s	Basic Shaft h8		Basic Hole d7, e7, f7
Bearing inner Ø	D_i	**Prior to installation**		
		Clearance		
		Normal	Tight	–
		D7 *2)	**E7** *2)	**H7** *2)
		After installation		
		Clearance		
		Normal	Tight	**–**
		D8	**E8**	**H8**
Bearing Length	B	Di ≤ 75 -0.5 Di >75 ≤ 500 -1.0		

*2) Machined and measured in master die

Table14: Recommended tolerances for installation of HPMB bearings by press-fit

DIMENSION TABLE FOR HPF® SLIDING PLATES





BEARING PART NUMBER	PLATE THICKNESS S_s -0.25 *1)	USABLE LENGTH L ±3.0 *1)	USABLE WIDTH W ±1.0 *1)	SLIDING LAYER THICKNESS S_L *1)
S30300HPF	3.0	1200	600	0.76
S50300HPF	5.0			
S60300HPF	6.0			
S80300HPF	8.0			
S100300HPF	10.0			

*1) Special dimensions possible on demand

All dimensons in mm

12 ISO Tolerances

BEARING TOLERANCE, CLEARANCE AND INTERFERENCE

BEARING	TOLERANCE										CLEARANCE / INTERFERENCE									
Dimensions	D8		E8		F8		F12		H7		H8		C10		D9		D10		E10	
mm	µm	µm	µm	µm	µm	µm	µm	µm	µm	µm	µm	µm	µm	µm	µm	µm	µm	µm	µm	µm
> 0 ≤ 3	20	34	14	28	6	20	6	106	0	10	0	14	60	100	20	45	20	60	14	54
> 3 ≤ 6	30	48	20	38	10	28	10	130	0	12	0	18	70	118	30	60	30	78	20	68
> 6 ≤ 10	40	62	25	47	13	35	13	163	0	15	0	22	80	138	40	76	40	98	25	83
> 10 ≤ 14	50	77	32	59	16	43	16	196	0	18	0	27	95	165	50	93	50	120	32	102
> 14 ≤ 18	50	77	32	59	16	43	16	196	0	18	0	27	95	165	50	93	50	120	32	102
> 18 ≤ 24	65	98	40	73	20	53	20	230	0	21	0	33	110	194	65	117	65	149	40	124
> 24 ≤ 30	65	98	40	73	20	53	20	230	0	21	0	33	110	194	65	117	65	149	40	124
> 30 ≤ 40	80	119	50	89	25	64	25	275	0	25	0	39	120	220	80	142	80	180	50	150
> 40 ≤ 50	80	119	50	89	25	64	25	275	0	25	0	39	130	230	80	142	80	180	50	150
> 50 ≤ 65	100	146	60	106	30	76	30	330	0	30	0	46	140	260	100	174	100	220	60	180
> 65 ≤ 80	100	146	60	106	30	76	30	330	0	30	0	46	150	270	100	174	100	220	60	180
> 80 ≤ 100	120	174	72	125	36	90	36	386	0	35	0	54	170	310	120	207	120	260	72	212
> 100 ≤ 120	120	174	72	125	36	90	36	386	0	35	0	54	180	320	120	207	120	260	72	212
> 120 ≤ 140	145	208	85	148	43	106	43	443	0	40	0	63	200	360	145	245	145	305	85	245
> 140 ≤ 160	145	208	85	148	43	106	43	443	0	40	0	63	210	370	145	245	145	305	85	245
> 160 ≤ 180	145	208	85	148	43	106	43	443	0	40	0	63	230	390	145	245	145	305	85	245
> 180 ≤ 200	170	242	100	172	50	122	50	510	0	46	0	72	240	425	170	285	170	355	100	285
> 200 ≤ 225	170	242	100	172	50	122	50	510	0	46	0	72	260	445	170	285	170	355	100	285
> 225 ≤ 250	170	242	100	172	50	122	50	510	0	46	0	72	280	465	170	285	170	355	100	285
> 250 ≤ 280	190	271	110	191	56	137	56	576	0	52	0	81	300	510	190	320	190	400	110	320
> 280 ≤ 315	190	271	110	191	56	137	56	576	0	52	0	81	330	540	190	320	190	400	110	320
> 315 ≤ 355	210	299	125	214	62	151	62	632	0	57	0	89	360	590	210	350	210	440	125	355
> 355 ≤ 400	210	299	125	214	62	151	62	632	0	57	0	89	400	630	210	350	210	440	125	355
> 400 ≤ 450	230	327	135	232	68	165	68	698	0	63	0	97	440	690	230	385	230	480	135	385
> 450 ≤ 500	230	327	135	232	68	165	68	698	0	63	0	97	480	730	230	385	230	480	135	385
> 500 ≤ 560	260	370	145	255	76	186	76	776	0	70	0	110	60	100	260	435	260	540	145	425
> 560 ≤ 630	260	370	145	255	76	186	76	776	0	70	0	110	70	118	260	435	260	540	145	425
> 630 ≤ 710	290	514	160	285	80	205	80	880	0	80	0	125	80	138	290	490	290	610	160	480
> 710 ≤ 800	290	514	160	285	80	205	80	880	0	80	0	125	95	165	290	490	290	610	160	480
> 800 ≤ 900	320	460	170	310	86	226	86	986	0	90	0	140	95	165	320	550	320	680	170	530
> 900 ≤ 1000	320	460	170	310	86	226	86	986	0	90	0	140	110	194	320	550	320	680	170	530
> 1000 ≤ 1120	350	515	195	360	98	263	98	1148	0	105	0	165	110	194	350	610	350	770	195	615
> 1120 ≤ 1250	350	515	195	360	98	263	98	1148	0	105	0	165	120	220	350	610	350	770	195	615
> 1250 ≤ 1400	390	585	220	415	110	305	110	1360	0	125	0	165	130	230	390	700	390	890	220	720
> 1400 ≤ 1600	390	585	220	415	110	305	110	1360	0	125	0	165	140	260	390	700	390	890	220	720
> 1600 ≤ 1800	430	660	240	470	120	350	120	1620	0	150	0	230	150	270	430	800	430	1030	240	840
> 1800 ≤ 2000	430	660	240	470	120	350	120	1620	0	150	0	230	170	310	430	800	430	1030	240	840
> 2000 ≤ 2240	480	760	260	540	130	410	130	1880	0	175	0	280	180	320	480	920	480	1180	260	960
> 2240 ≤ 2500	480	760	260	540	130	410	130	1880	0	175	0	280	200	360	480	920	480	1180	260	960
> 2500 ≤ 2800	520	850	290	620	145	475	145	2245	0	210	0	330	210	370	520	1060	520	1380	290	1150
> 2800 ≤ 3150	520	850	290	620	145	475	145	2245	0	210	0	330	230	390	520	1060	520	1380	290	1150

SHAFT TOLERANCE, CLEARANCE AND INTERFERENCE

SHAFT	TOLERANCE										CLEARANCE / INTERFERENCE							
Dimensions	d7		e7		f7		h7		h8		r7		s7		r9		s9	
mm	µm	µm	µm	µm	µm	µm	µm	µm	µm	µm	µm	µm	µm	µm	µm	µm	µm	µm
> 0 ≤ 3	-30	-20	-24	-14	-16	-6	-10	0	-14	0	10	20	14	24	10	35	14	39
> 3 ≤ 6	-42	-30	-32	-20	-22	-10	-12	0	-18	0	15	27	19	31	15	45	19	49
> 6 ≤ 10	-55	-40	-40	-25	-28	-13	-15	0	-22	0	19	34	23	38	19	55	23	59
> 10 ≤ 14	-68	-50	-50	-32	-34	-16	-18	0	-27	0	23	41	28	46	23	66	28	71
> 14 ≤ 18	-68	-50	-50	-32	-34	-16	-18	0	-27	0	23	41	28	46	23	66	28	71
> 18 ≤ 24	-86	-65	-61	-40	-41	-20	-21	0	-33	0	28	49	35	56	28	80	35	87
> 24 ≤ 30	-86	-65	-61	-40	-41	-20	-21	0	-33	0	28	49	35	56	28	80	35	87
> 30 ≤ 40	-105	-80	-75	-50	-50	-25	-25	0	-39	0	34	59	43	68	34	96	43	105
> 40 ≤ 50	-105	-80	-75	-50	-50	-25	-25	0	-39	0	34	59	43	68	34	96	43	105
> 50 ≤ 65	-130	-100	-90	-60	-60	-30	-30	0	-46	0	41	71	53	83	41	115	53	127
> 65 ≤ 80	-130	-100	-90	-60	-60	-30	-30	0	-46	0	43	73	59	89	43	117	59	133
> 80 ≤ 100	-155	-120	-107	-72	-71	-36	-35	0	-54	0	51	86	71	106	51	138	71	158
> 100 ≤ 120	-155	-120	-107	-72	-71	-36	-35	0	-54	0	54	89	79	114	54	141	79	166
> 120 ≤ 140	-185	-145	-125	-85	-83	-43	-40	0	-63	0	63	103	92	132	63	163	92	192
> 140 ≤ 160	-185	-145	-125	-85	-83	-43	-40	0	-63	0	65	105	100	140	65	165	100	200
> 160 ≤ 180	-185	-145	-125	-85	-83	-43	-40	0	-63	0	68	108	108	148	68	168	108	208
> 180 ≤ 200	-216	-170	-146	-100	-96	-50	-46	0	-72	0	77	123	122	168	77	192	122	237
> 200 ≤ 225	-216	-170	-146	-100	-96	-50	-46	0	-72	0	80	126	130	176	80	195	130	245
> 225 ≤ 250	-216	-170	-146	-100	-96	-50	-46	0	-72	0	84	130	140	186	84	199	140	255
> 250 ≤ 280	-242	-190	-162	-110	-108	-56	-52	0	-81	0	94	146	158	210	94	224	158	288
> 280 ≤ 315	-242	-190	-162	-110	-108	-56	-52	0	-81	0	98	150	170	222	98	228	170	300
> 315 ≤ 355	-267	-210	-182	-125	-119	-62	-57	0	-89	0	108	165	190	247	108	248	190	330
> 355 ≤ 400	-267	-210	-182	-125	-119	-62	-57	0	-89	0	114	171	208	265	114	254	208	348
> 400 ≤ 450	-293	-230	-198	-135	-131	-68	-63	0	-97	0	126	189	232	295	126	281	232	387
> 450 ≤ 500	-293	-230	-198	-135	-131	-68	-63	0	-97	0	132	195	252	315	132	287	252	407
> 500 ≤ 560	-330	-260	-215	-145	-146	-76	-70	0	-110	0	150	220	280	350	150	325	280	455
> 560 ≤ 630	-330	-260	-215	-145	-146	-76	-70	0	-110	0	155	225	310	380	155	330	310	485
> 630 ≤ 710	-370	-290	-240	-160	-160	-80	-80	0	-124	0	175	255	340	420	175	375	340	540
> 710 ≤ 800	-370	-290	-240	-160	-160	-80	-80	0	-124	0	185	265	380	460	185	385	380	580
> 800 ≤ 900	-410	-320	-260	-170	-176	-86	-90	0	-140	0	210	300	430	520	210	440	430	660
> 900 ≤ 1000	-410	-320	-260	-170	-176	-86	-90	0	-140	0	220	310	470	560	220	450	470	700
> 1000 ≤ 1120	-455	-350	-300	-195	-203	-98	-105	0	-165	0	250	355	520	625	250	510	520	780
> 1120 ≤ 1250	-455	-350	-300	-195	-203	-98	-105	0	-165	0	260	365	580	685	260	520	580	840
> 1250 ≤ 1400	-515	-390	-345	-220	-235	-110	-125	0	-195	0	300	425	640	765	300	610	640	950
> 1400 ≤ 1600	-515	-390	-345	-220	-235	-110	-125	0	-195	0	330	455	720	845	330	640	720	1030
> 1600 ≤ 1800	-580	-430	-390	-240	-270	-120	-150	0	-230	0	370	520	820	970	370	740	820	1190
> 1800 ≤ 2000	-580	-430	-390	-240	-270	-120	-150	0	-230	0	400	550	920	1070	400	770	920	1290
> 2000 ≤ 2240	-655	-480	-435	-260	-305	-130	-175	0	-280	0	440	615	1000	1175	440	880	1000	1440
> 2240 ≤ 2500	-655	-480	-435	-260	-305	-130	-175	0	-280	0	460	635	1100	1275	460	900	1100	1540
> 2500 ≤ 2800	-730	-520	-500	-290	-355	-145	-210	0	-330	0	550	760	1250	1460	550	1090	1250	1790
> 2800 ≤ 3150	-730	-520	-500	-290	-355	-145	-210	0	-330	0	580	790	1400	1610	580	1120	1400	1940

13 Bearing Application Data Sheet

Please complete the form below and share it with your GGB sales engineer or send it to: **usa@ggbearings.com**

DATA FOR BEARING DESIGN CALCULATION

Application: _____

_____

Project/No.: _____ Quantity: _____ ☐ New Design ☐ Existing Design

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

DIMENSIONS [MM]

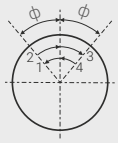
Inside diameter	D_i	
Outside diameter	D_o	
Length	B	
Flange Diameter	D_{fl}	
Flange thickness	B_{fl}	
Wall thickness	S_T	
Length of slideplate	L	
Width of slideplate	W	
Thickness of slideplate	S_S	

LOAD

☐ Static load
☐ Dynamic load

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

MOVEMENT

Rotational speed	N [1/min]	
Speed	U [m/s]	
Length of stroke	L_S [mm]	
Frequency of stroke	[1/min]	
Oscillating cycle 	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

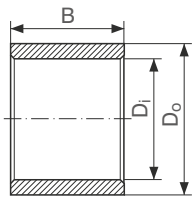
Continuous operation		
Intermittent operation		
Operating time		
Days per year		

SERVICE LIFE

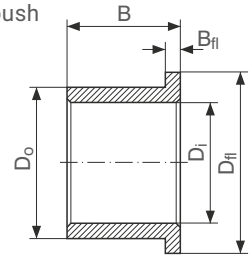
Required service life	L_H [h]	

BEARING TYPE

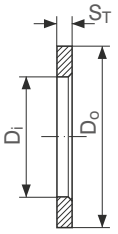
☐ Cylindrical bush



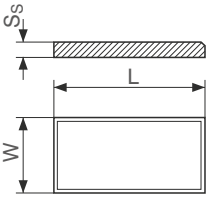
☐ Flanged bush



☐ 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 SI	UNIT ANSI	DESIGNATION
a_B	-	-	Bearing size factor
a_E	-	-	High load factor
a_M	-	-	Mating material factor
a_S	-	-	Surface inish factor
a_T	-	-	Temperature application factor
B	mm	in	Nominal bush length
C_D	mm	in	Installed diametrical clearance
D_H	mm	in	Housing diameter
D_i	mm	in	Nominal bush ID Nominal thrust washer ID
D_o	mm	in	Nominal bush OD Nominal thrust washer OD
D_J	mm	in	Shaft diameter
E	MPa	lbf/in^2	Young's Modulus
F	N	lbf	Bearing load
L_Y	-	-	Bearing service life, years
L_Q	-	-	Bearing service life, cycles
n	1/min	1/min	Rotational speed
n_{osc}	1/min	1/min	Rotational speed for oscillating motion
p	MPa	lbf/in^2	Specific load
p_{lim}	MPa	lbf/in^2	Specific load limit
$p_{sta,max}$	MPa	lbf/in^2	Maximum static load
$p_{dyn,max}$	MPa	lbf/in^2	Maximum dynamic load
R_a	µin	µin	Surface roughness (DIN 4768, ISO/DIN 4287/1)

SYMBOL	UNIT SI	UNIT ANSI	DESIGNATION
S	mm	in	Bush wall thickness
S	µm	µin	Shrinkage
S_D	mm	in	Related deflection
S_L	mm	in	Thickness of sliding layer
S_S	mm	in	Thickness of sliding plate
S_T	mm	in	Thickness of washer
T	°C	°F	Temperature
T_{amb}	°C	°F	Ambient temperature
T_{max}	°C	°F	Maximum temperature
T_{min}	°C	°F	Minimum temperature
t_h	min/hr	min/hr	Operating time
t_d	hr/day	hr/day	Operating time
t_y	days/year	days/year	Operating time
U	m/s	ft/min	Sliding speed
U_{lim}	m/s	ft/min	Maximum sliding speed
α	-	-	Coefficient of friction
α_1	1/10^{6}K	1/10^{6}K	Coefficient of linear Thermal expansion
σ_x	MPa	lbf/in^2	Compressive Yield strength
λ_B	W/m°K	BTU·in/hr·f t2·°F	Thermal conductivity of bearing material
φ	°	°	Angular displacement
$\Delta\sigma_\alpha$	mm	in	Allowable wear

UNIT CONVERSIONS	
SI to ANSI Conversions	
1 mm	0.0394 in
1 m	3.2808 ft
1 Newton = 1N	0.225 ft
1 MPa = 1 N/mm^2	145 lbf/in^2
1 m/s	196.85 ft/min
°C	(°F-32)/1.8
ANSI to SI Conversions	
1 in	25.4 mm
1 ft	0.3048
1 lbf	4.448 N
1 lbf/in^2	0.0069 MPa = 0.0069 N/mm^2

mm = millimeters
m = meters
ft = foot
in = inch
N = Newtons
W = Watts
MPa = MegaPascal = N/mm^2
lbf = pounds force

min = minute
hr = hour
m/s = meters per second
°F = degrees Fahrenheit
°C = degrees Celcius
°K = degrees Kelvin
BTU = British Thermal Units

14 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. We have established internal processes that monitor any changes to existing standards and regulations, and we work collaboratively with customers and distributors to ensure all requirements are strictly followed. This includes RoHS and REACH guidelines.

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

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

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

THE TRIBOLOGICAL SOLUTION PROVIDER FOR INDUSTRIAL PROGRESS, REGARDLESS OF SHAPE OR MATERIAL

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HB305ENG06-21USA