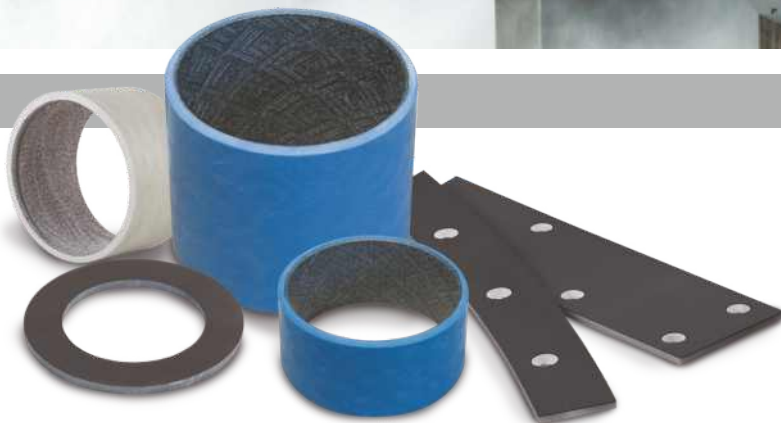
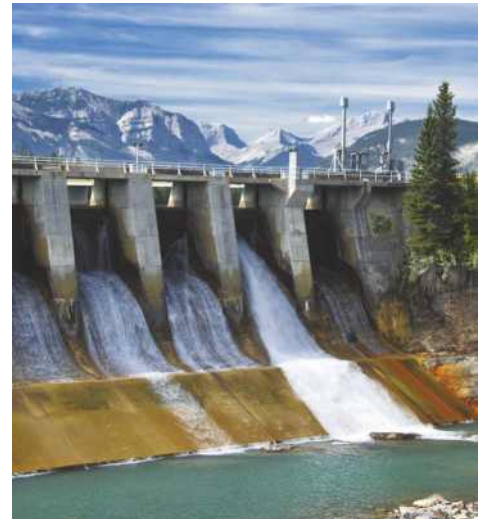


HPM™ / HPMB® / HPF™

Filament Wound Self-Lubricating Bearing Solutions



The Global Leader
in High Performance Bearing Solutions



an EnPro Industries company

GGB Bearing Technology

GGB's history as the global leader in plain bearing technologies dates back more than 115 years, beginning with the founding of Glacier Antifriction Metal Company in 1899. GGB introduced the industry-leading DU® bearing in 1956 and the DX® bearing in 1965. Since that time, 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 with the highest safety standards in the industry.

- **Safety:** GGB's deep-rooted culture of safety places a relentless focus on creating a secure, healthy work environment for all. A core value of GGB, safety is critically essential at all levels of business in order to achieve our goal of having the safest employees in the industry.
- **Excellence:** A world-class organization is built by fostering excellence throughout the company in all positions and functional areas. Our world-class manufacturing plants are certified in quality and excellence in the industry according to ISO 9001, TS 16949, ISO 14001, ISO 50001 and OHSAS 18001, allowing us to access the industry's best practices while aligning our quality management system with global standards.
- **Respect:** We believe that respect is consistent with the growth of individuals and groups. Our teams work together with mutual respect regardless of background, nationality or function, embracing the diversity of people and learning from one another.

Quality/Certification

Our world-class manufacturing plants in the United States, Brazil, China, Germany, France and Slovakia are certified in quality and excellence in the industry according to ISO 9001, TS 16949, ISO 14001, ISO 50001 and OHSAS 18001. 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: <http://www.ggbearings.com/en/company/certificates>.

The GGB Advantage

With a global manufacturing footprint, including cutting edge R&D facilities, flexible production platforms and extensive customer support networks, GGB offers unmatched technical expertise combined with razor sharp responsiveness and customized solutions.

Our global presence and local logistics networks ensure our customers receive only the highest quality bearing solutions, in a timely manner and with extensive engineering support. **We don't just make products, we build partnerships. That's the GGB Advantage.**

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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.

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

Wide Application Range

Laboratory and field tests have shown that GGB HPM™, HPMB®, and HPF™ bearings provide outstanding performance in a variety of dry or water-lubricated hydropower applications. These include use in:

- Wicket gates
- Servo-motors
- Operating ring sliding segments
- Linkages
- Guide vanes
- Intake gates
- Spillway gates
- Trash rakes
- Fish screens
- Ball and butterfly valves trunnions

Maintenance Free Operation

GGB HPM™, HPMB® and HPF™ bearings are self-lubricating composites, capable of operating in dry or water-lubricated 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.

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.

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.

Wide Range of Sizes and Shapes

GGB HPM™ and HPMB® bearings 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.

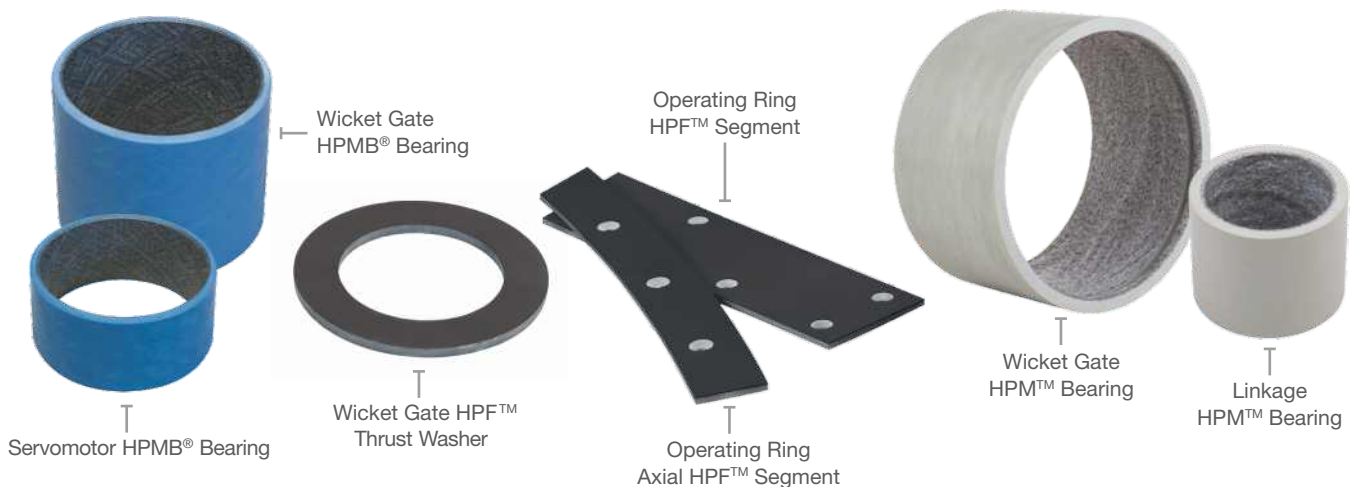


Fig. 1: Standard Shapes

Structure and Composition

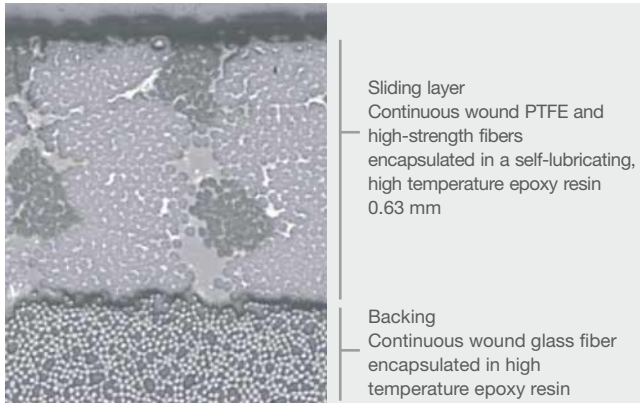


Fig. 2: HPM™ bearing microsection

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.



Fig. 3: HPMB® bearing microsection

HPMB®

This bearing consists of a self-lubricating filament wound material with a machinable liner, providing tight dimensional 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 carrying 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.

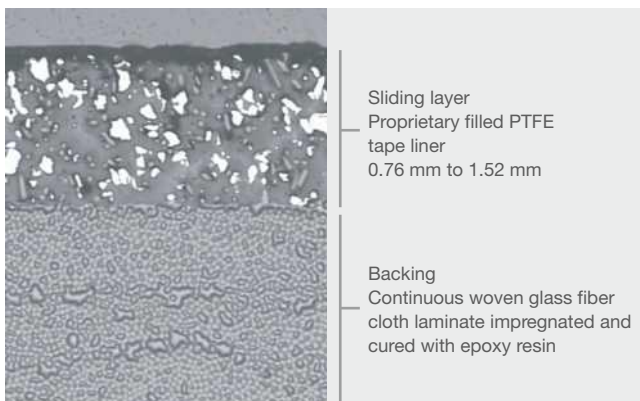


Fig. 4: HPF™ material microsection

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.

Properties

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 σ_c	345	345	380	MPa
Max. permissible static specific load $p_{sta,max}$	210	210	180	MPa
Max. permissible dynamic specific load $p_{dyn,max}$	140	140	140	MPa
Max. sliding speed, dry $v_{lim}^{*1)}$	0.13	0.13	2.5 m/s	m/s
Max. pv-value, dry	1.23	1.23	1.23	MPa x m/s
Max. operating temperature T_{max}	+160	+160	+140	°C
Min. operating temperature T_{min}	-196	-196	-196	°C
Friction coefficient, dry μ	0.03 - 0.12	0.03 - 0.12	0.02 - 0.10	-
Friction coefficient, in water μ	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
*1) For higher speeds please contact GGB application engineering				

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

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

Table 2: Chemical resistance

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 $0.8 \mu\text{m}$.

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	Comparable 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 STANDARD APPLICATIONS				
Material Number	DIN Designations	Comparable 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 STANDARD APPLICATIONS				
Material Number	DIN Designations	Comparable 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

Lubrication

HPM™, HPMB® and HPF™ self-lubricated bearings are specifically 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.

Lifetime Estimation

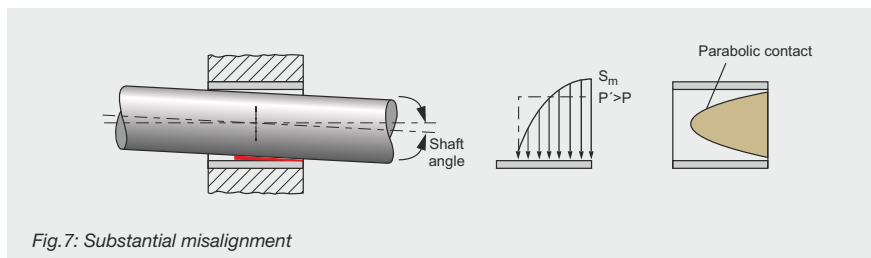
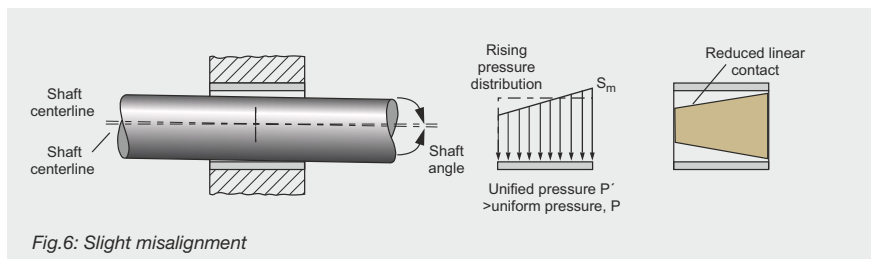
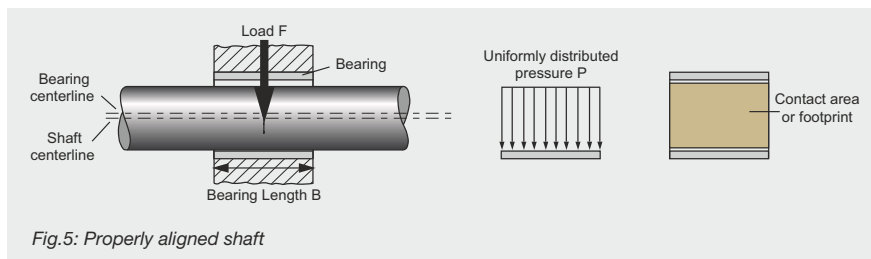
For estimates of life expectancy of HPM™, HPMB® and HPF™ products, please contact GGB applications and development engineering services.

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.



(7.1.1) [mm]

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

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

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

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.

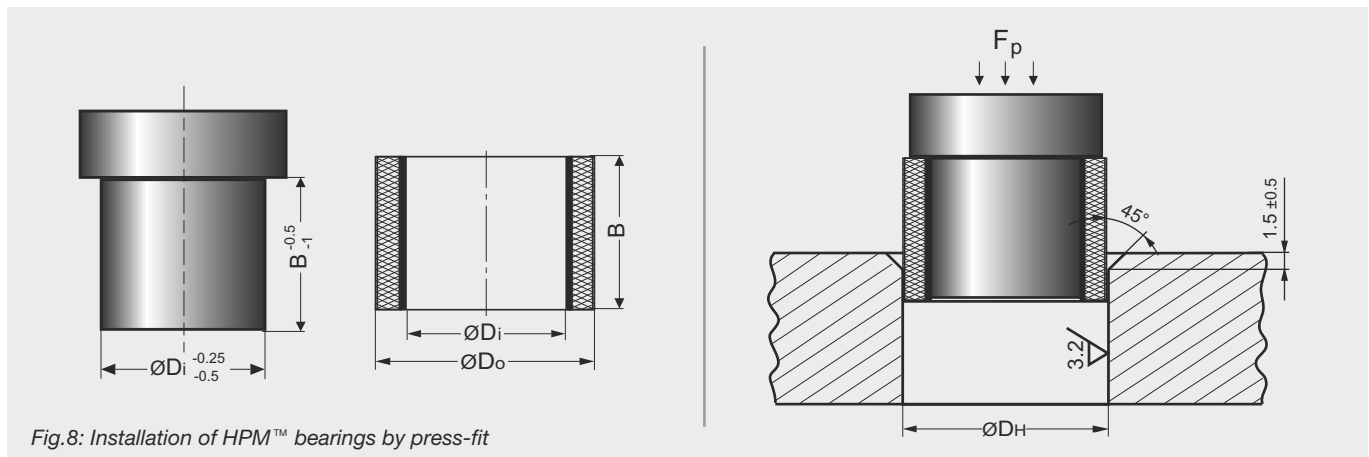
HPMB[®] bearings can be ID-machined either by GGB or the end user.

Installation

Installation of Cylindrical HPM[™] / HPMB[®] Bearings

Installation of 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.



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 9).

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.

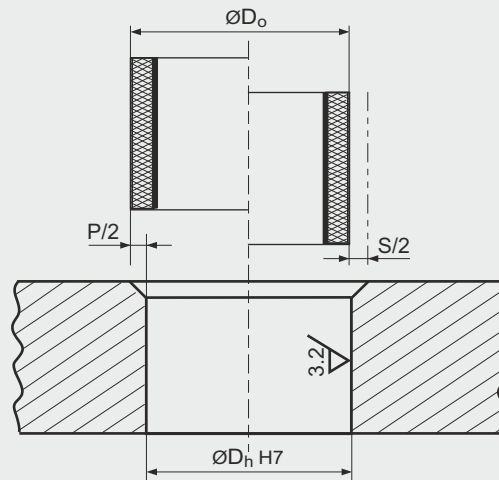


Fig.9: Press and shrinkage

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}	$12.6 \times 10^{-6} [1/K]$
ΔT_{CO_2}	$+15 - (-65) = 80 [K]$
ΔT_{IN_2}	$+15 - (-195) = 210 [K]$

(9.1.1) [mm]

$$S = 0.8 \cdot \alpha \cdot \Delta T \cdot D_o [\text{mm}]$$

(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 $-196\text{ }^{\circ}\text{C}$. 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.

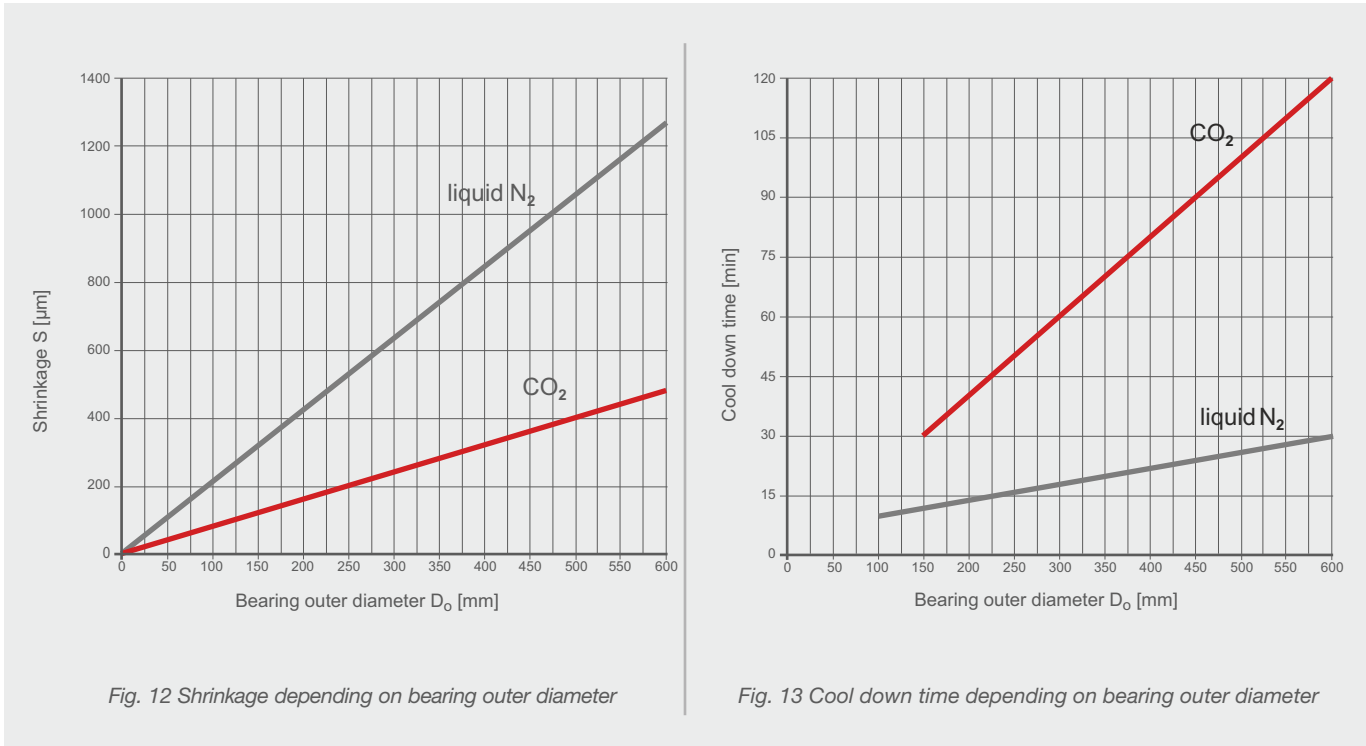
Details For the Use of Dry Ice

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.



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



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, pages 19 and 20).

Installation of HPF™ Sliding Plates

Sliding Plate Attachment with Countersunk Screws

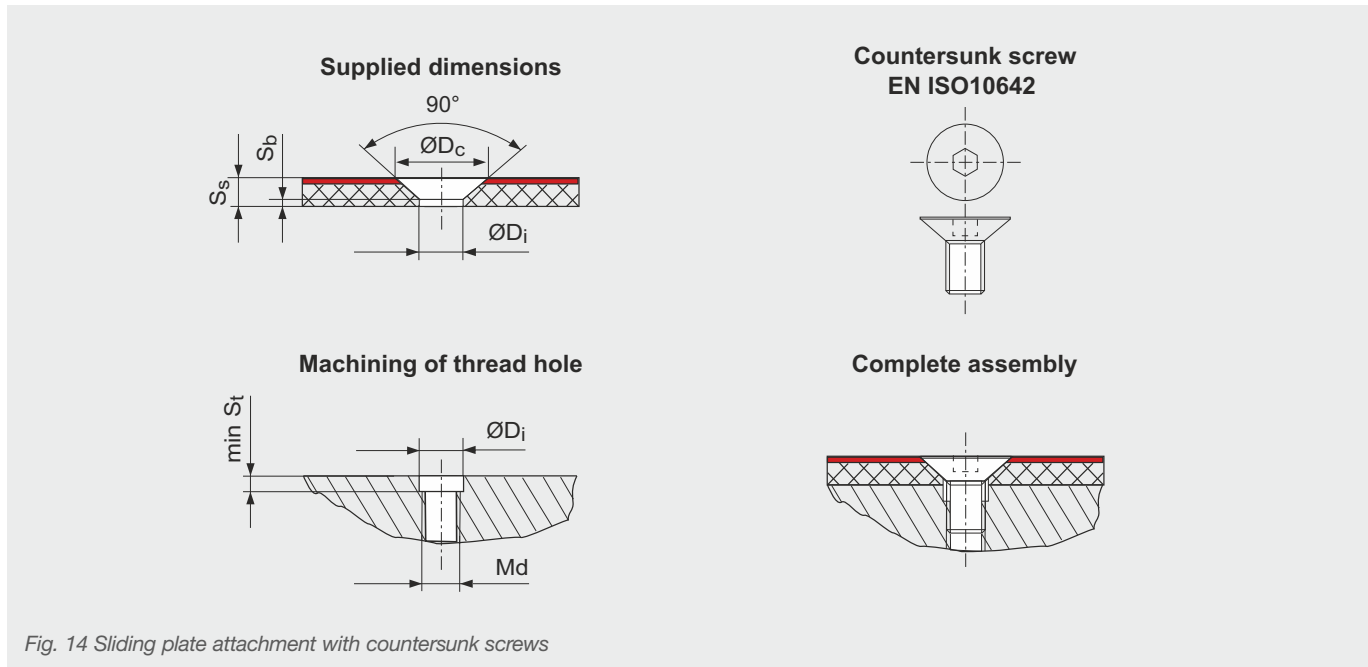


Fig. 14 Sliding plate attachment with countersunk screws

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 _i	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 15.

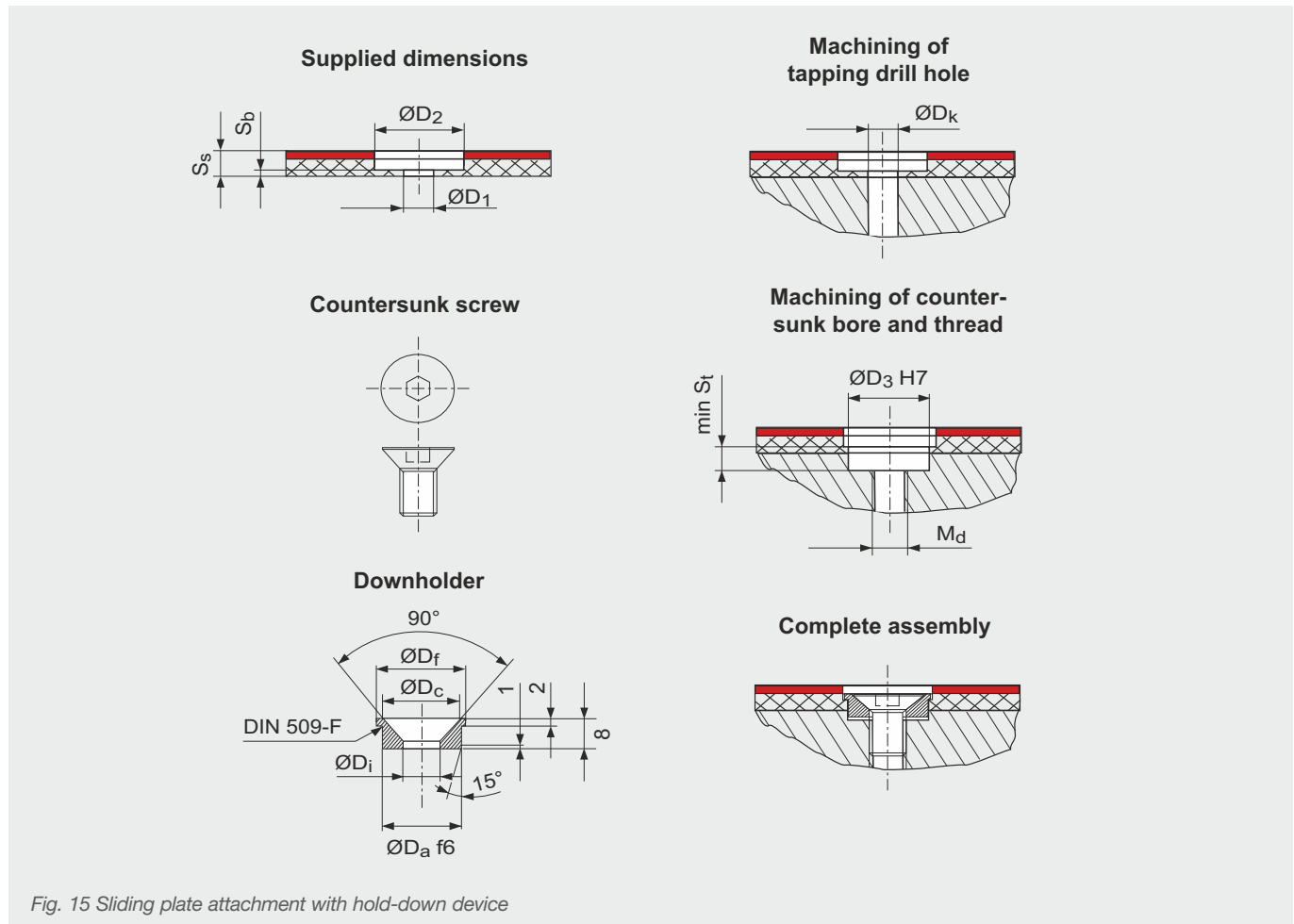
Additional Screw Securing

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



Preparation

Before installation, the sliding plate must be tightly fixed to the housing 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 the downholder together with countersunk screw - EN ISO 10642.

For number of screws and spacing, please refer to Fig. 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

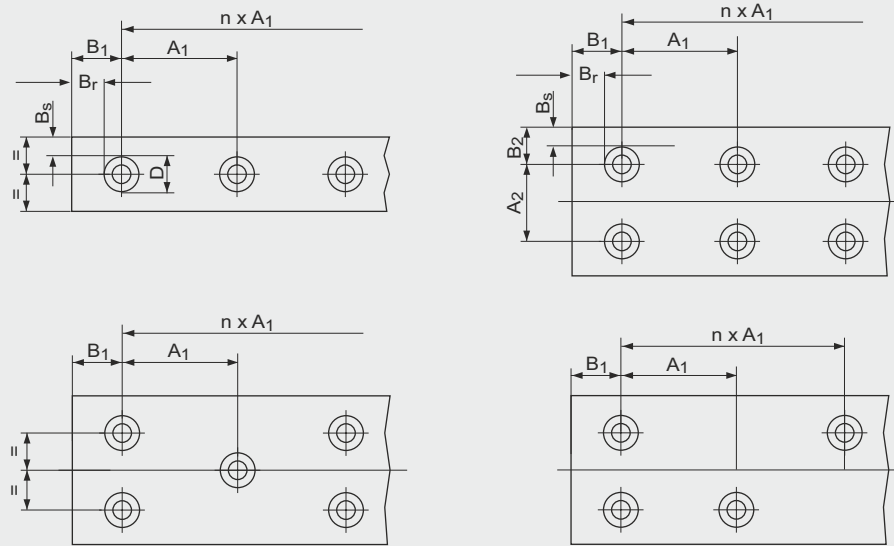


Fig. 16 Number of and spacing for screws in HPF™ sliding plates

Number of Screws

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

The following guidelines 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.

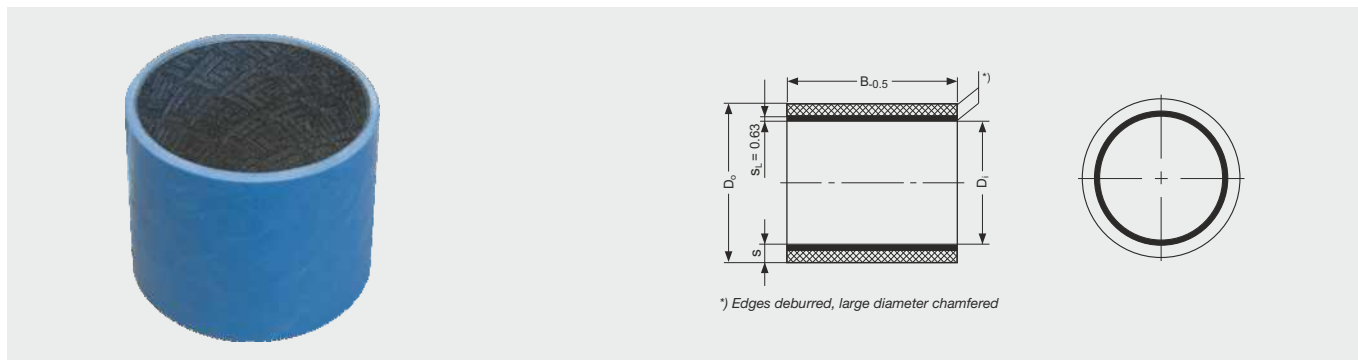
It's important to fix each corner of the sliding plate in order to avoid distortion in these areas.

Gluing of backing

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

Recommended Dimensions

Dimension Table for HPM™ and HPMB® Cylindrical Bushes



Order Specifications for Cylindrical Bushes

PART NUMBER FOR CYLINDRICAL BEARINGS	080	090	060	HPMB	-S-H8
Nominal Bush Inside Diameter D_i					
Nominal Bush Outside Diameter D_o					
Nominal Bush Width B					
Material Identification					
Bearing ID Tolerance after Installation for Precision Bearings (D8, E8 or H8).					
Example: 707580HPMB-S-H8 is an HPMB Cylindrical Bearing with 70 mm ID, 75 mm OD, 80 mm Width and H8 ID Tolerance					

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 _o	WALL THICKNESS	RECOMMENDED BUSH WIDTH B	
				MIN.	MAX.
1620xxHPMB-S-xx	16	20	2	10	20
2024xxHPMB-S-xx	20	24		15	25
2226xxHPMB-S-xx	22	26		15	25
2530xxHPMB-S-xx	25	30		15	30
2833xxHPMB-S-xx	28	33	2,5	20	35
3035xxHPMB-S-xx	30	35		20	40
3540xxHPMB-S-xx	35	40		25	45
4045xxHPMB-S-xx	40	45		25	50
4550xxHPMB-S-xx	45	50		30	55
5055xxHPMB-S-xx	50	55		30	65
5560xxHPMB-S-xx	55	60		35	70
6065xxHPMB-S-xx	60	65		40	75
6570xxHPMB-S-xx	65	70		40	80
7075xxHPMB-S-xx	70	75		45	90
7585xxxHPMB-S-xx	75	85	5	45	95
8090xxxHPMB-S-xx	80	90		50	100
8595xxxHPMB-S-xx	85	95		55	110
90100xxxHPMB-S-xx	90	100		55	115
95105xxxHPMB-S-xx	95	105		60	120
100110xxxHPMB-S-xx	100	110		60	130
110120xxxHPMB-S-xx	110	120		70	140
120130xxxHPMB-S-xx	120	130		75	155
130140xxxHPMB-S-xx	130	140		80	165
140150xxxHPMB-S-xx	140	150		85	180
150160xxxHPMB-S-xx	150	160	90	190	
160170xxxHPMB-S-xx	160	170	100	200	
180190xxxHPMB-S-xx	180	190	110	230	
200215xxxHPMB-S-xx	200	215	7.5	120	260
220235xxxHPMB-S-xx	220	235		135	280
240255xxxHPMB-S-xx	240	255		145	310
250265xxxHPMB-S-xx	250	265		150	320
260275xxxHPMB-S-xx	260	275		160	330

BEARING PART NUMBER	BUSH ID D _i	BUSH OD D _o	WALL THICKNESS	RECOMMENDED BUSH WIDTH B	
				MIN.	MAX.
280300xxHPMB-S-xx	280	300	10	170	360
300320xxHPMB-S-xx	300	320		180	390
320340xxHPMB-S-xx	320	340		200	410
340360xxHPMB-S-xx	340	360		210	440
350370xxHPMB-S-xx	350	370		210	450
360380xxHPMB-S-xx	360	380		220	460
380400xxxHPMB-S-xx	380	400		230	490
400425xxxHPMB-S-xx	400	425	12.5	240	520
420445xxxHPMB-S-xx	420	445		260	540
440465xxxHPMB-S-xx	440	465		270	570
450475xxxHPMB-S-xx	450	475		270	580
460485xxxHPMB-S-xx	460	485		280	590
480505xxxHPMB-S-xx	480	505		280	600
500525xxxHPMB-S-xx	500	525		300	600

Table 12: HPM™/HPMB® dimension table

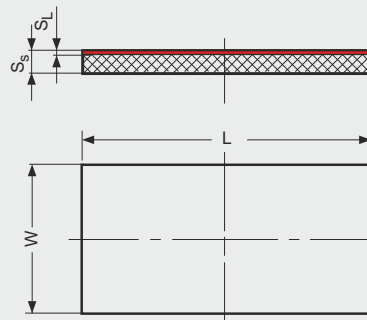
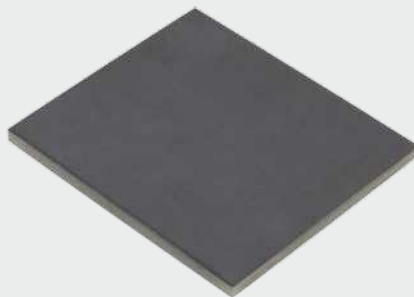
Tolerances

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	Basic Shaft
h8	h7			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™

Dimension Table for HPF™ Sliding Plates



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	Basic Hole		
		h8	d7, e7, f7		
Bearing inner Ø	D _i	Prior to installation			
		Clearance			
		Normal	Tight	-	
		D7 *1)	E7 *1)	H7 *1)	
		After installation			
		Clearance			
		Normal	Tight	-	
		D8	E8	H8	
Bearing Length	B	D _i ≤ 75 -0,5 D _i >75 ≤ 500 -1,0			

*1) Machined and measured in master die

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

All dimensions in mm

BearingPart Number	Plate Thickness	Usable Length	Usable Width	Sliding Layer Thickness
	S _s -0.25 ^{*1)}	L±3.0 ^{*1)}	W±1.0 ^{*1)}	S _L ^{*1)}
	max. min.	max. min.	max. min.	max. min.
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

ISO Tolerances

Bearing Tolerance, Clearance and Interference

BEARING Dimensions	TOLERANCE										CLEARANCE / INTERFERENCE									
	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 Dimensions	TOLERANCE										CLEARANCE / INTERFERENCE							
	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



Datasheet

DIMENSIONS (mm)

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

LOAD

Radial load F	static [N]	
	dynamic [N]	
Axial load F	static [N]	
	dynamic [N]	
Specific load p	radial [MPa]	
	axial [MPa]	

MOVEMENT

Rotational speed	N [1/min]	
Speed	U [ms]	
Length of stroke	L_s [mm]	
Frequency of stroke	[1/min]	
Oscillating cycle	ϕ [°]	
Oscillating freq.	N_{osz} [1/min]	

MATING SURFACE

Material		
Hardness	HB/HRC	
Surface finish	Ra [μ m]	

CUSTOMER INFORMATION

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

FITS & TOLERANCES

Shaft	D_J	
Bearing housing	D_H	

OPERATING ENVIRONMENT

Ambient temperature	T_{amb} [°]	
<input type="checkbox"/>	Housing with good heating transfer properties	
<input type="checkbox"/>	Light pressing or insulated housing with poor heat transfer properties	
<input type="checkbox"/>	Non metal housing with poor heat transfer properties	
<input type="checkbox"/>	Alternate operation in water and dry	

LUBRICATION

<input type="checkbox"/>	Dry	
<input type="checkbox"/>	Continuous lubrication	
<input type="checkbox"/>	Process fluid lubrication	
<input type="checkbox"/>	Initial lubrication only	
<input type="checkbox"/>	Hydrodynamic conditions	

Process fluid		
Lubricant		
Dynamic viscosity	η	

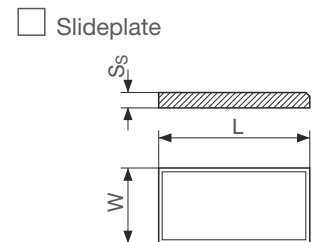
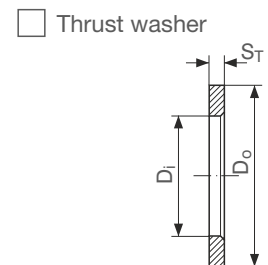
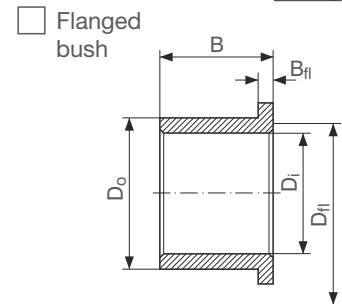
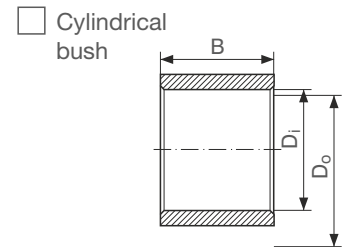
SERVICE HOURS PER DAY

Continuous operation		
Intermittent operation		
Operating time		
Days per year		

SERVICE LIFE

Required service life	L_H [h]	
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BEARING TYPE:



- Special parts (sketch)
- Rotational movement
- Steady load
- Rotating load
- Oscillating movement
- Linear movement

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	μ in	μ in	Surface roughness (DIN 4768, ISO/DIN 4287/1)

SYMBOL	UNIT SI	UNIT ANSI	DESIGNATION
S	mm	in	Bush wall thickness
S	μ m	μ in	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
v	m/s	ft/min	Sliding speed
v_{lim}	m/s	ft/min	Maximum sliding speed
α	-	-	Coefficient of friction
α_l	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 ² K	BTU-in/hr-ft ² ·°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

Product Information

GGB gives an assurance that 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 the material's suitability for the intended use. They have been developed from our own investigations as well as from generally accessible publications. They do not represent any assurance for the properties themselves.

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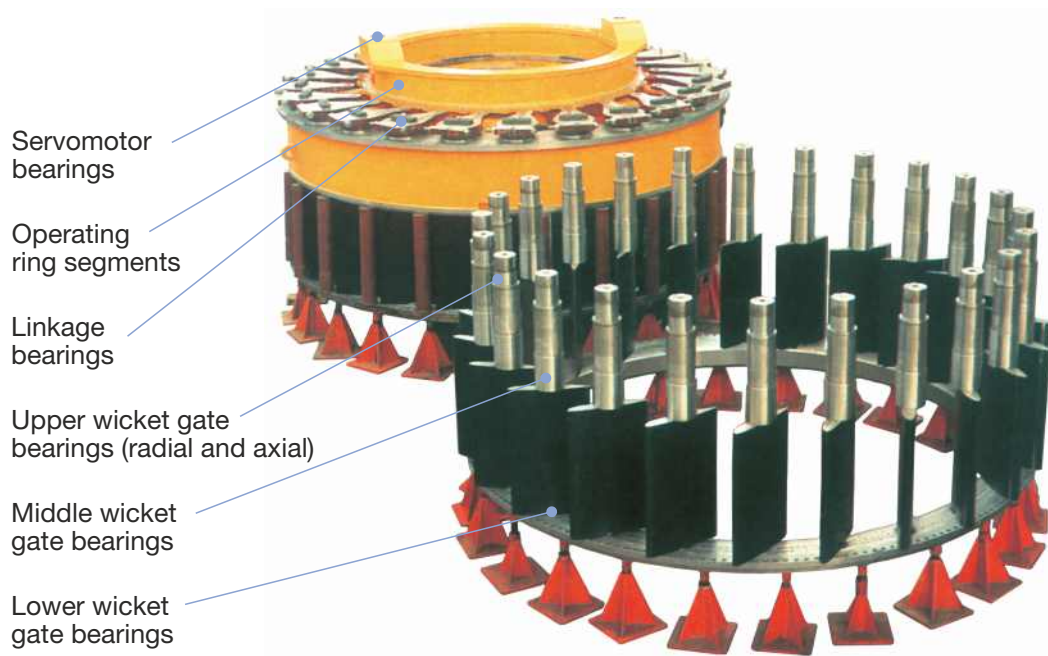
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Example Hydropower Applications – Francis Turbine



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

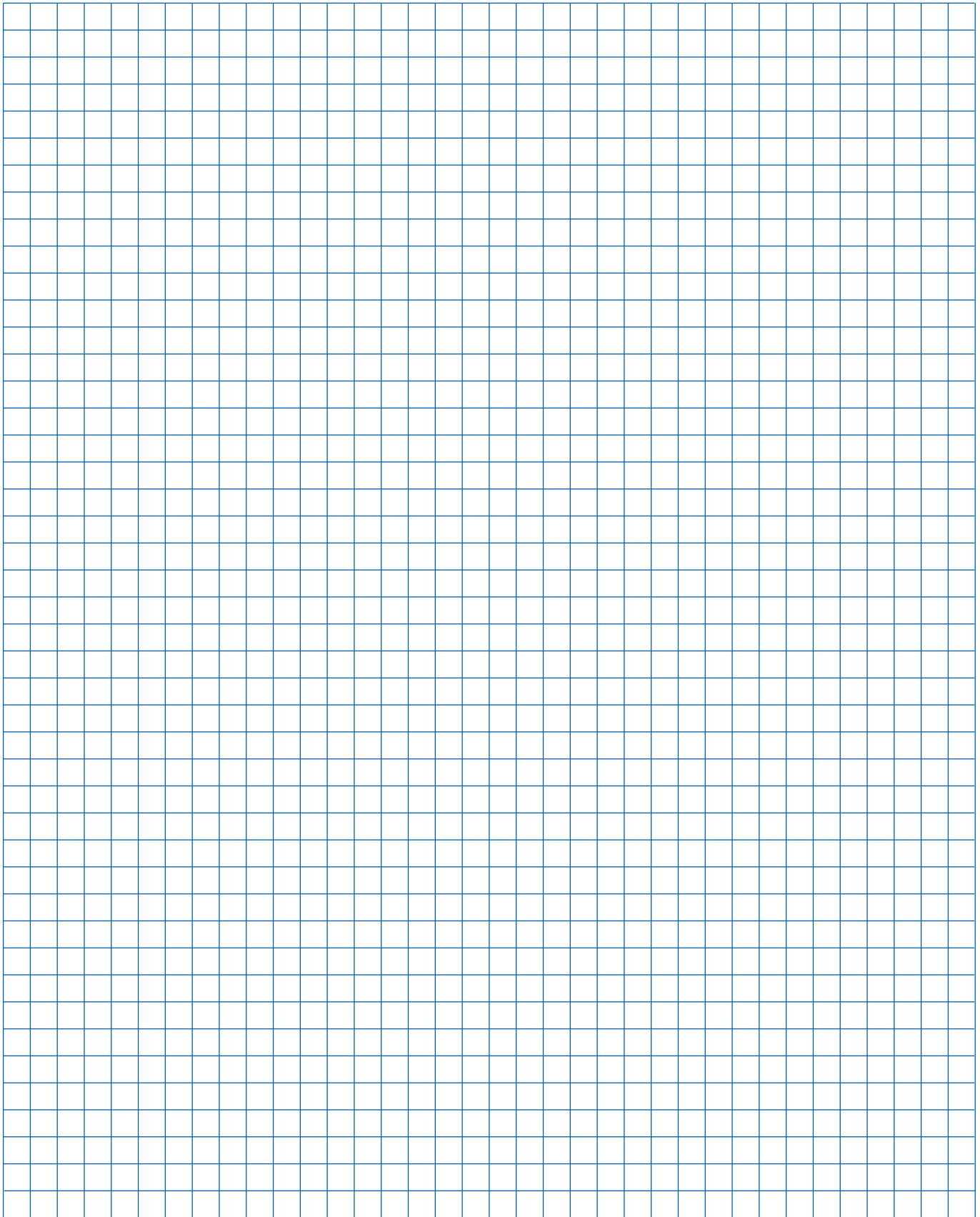
- Wicket gates (upper, intermediate, and lower)
- Servomotor
- Linkage
- Operating ring (radial and axial)

Pelton turbines

- Injector
- Delector

Valves

- Butterfly valve
- Ball valve





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