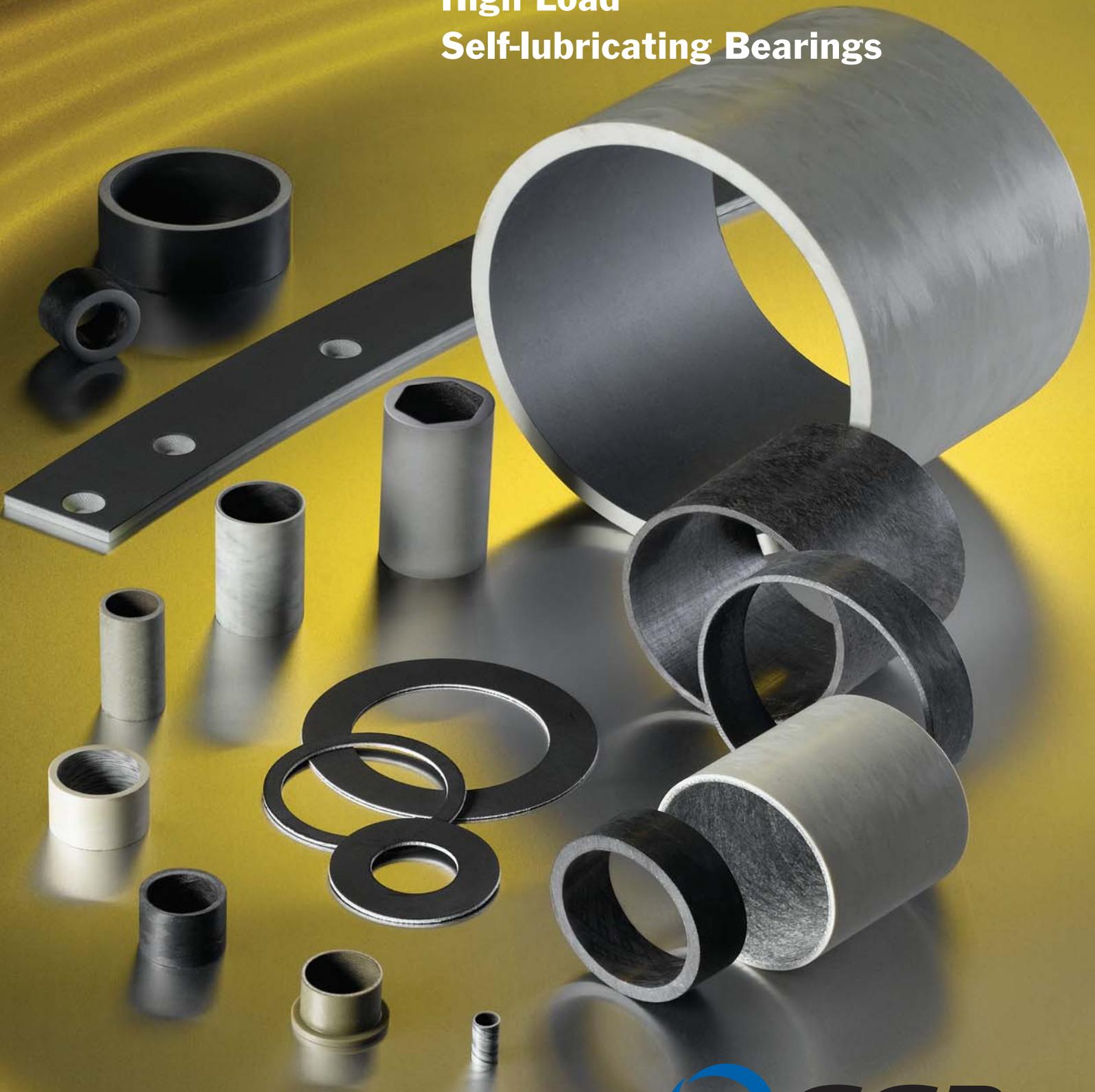


Filament Wound

High Load

Self-lubricating Bearings



Designer's Handbook



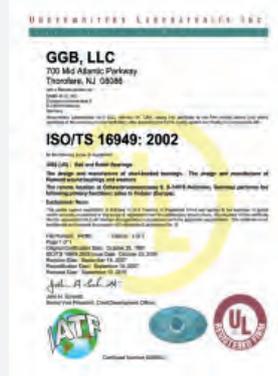
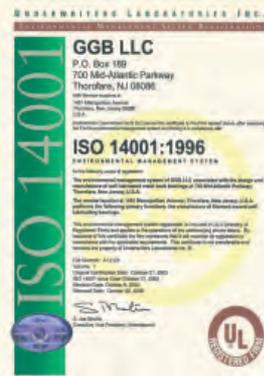
an EnPro Industries company

Quality

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

In addition GGB North America has been certified AS9100 revision B complying with the requirements of aerospace industry's quality management system for the manufacture of metal-backed bearings and filament wound bearings and washers.

AMERICA



FRANCE



CHINA



GERMANY



BRAZIL



SLOVAKIA



Formula Symbols and Designations

Formula Symbol	Unit ANSI	Unit SI	Designation
a_B	-	-	Bearing size factor
a_E	-	-	High load factor
a_M	-	-	Mating material factor
a_S	-	-	Surface finish factor
a_T	-	-	Temperature application factor
B	inch	mm	Nominal bush length
C_D	inch	mm	Installed diametral clearance
D_H	inch	mm	Housing Diameter
D_i	inch	mm	Nominal bush ID Nominal thrust washer ID
D_o	inch	mm	Nominal bush OD Nominal thrust washer OD
D_J	inch	mm	Shaft diameter
F	lbs.	N	Bearing load
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	psi	MPa	Specific load
p_{lim}	psi	MPa	Specific load limit
$p_{sta,max}$	psi	MPa	Maximum static load
$p_{dyn,max}$	psi	MPa	Maximum dynamic load
Q_{GF}	-	-	GAR-FIL cyclic life factor
Q_{GM}	-	-	GAR-MAX and HSG cyclic life factor
Q_{MLG}	-	-	MLG cyclic life factor
R_a	μ inch	μ m	Surface roughness (DIN 4768, ISO/DIN 4287/1)
S_m	psi	MPa	Calculated edge stress
S_S	inch	mm	Thickness of slideplate
S_T	inch	mm	Thickness of washer
s	inch	mm	Bush wall thickness
T	$^{\circ}$ F	$^{\circ}$ C	Temperature
T_{amb}	$^{\circ}$ F	$^{\circ}$ C	Ambient temperature
T_{max}	$^{\circ}$ F	$^{\circ}$ C	Maximum temperature
T_{min}	$^{\circ}$ F	$^{\circ}$ C	Minimum temperature

Formula Symbol	Unit ANSI	Unit SI	Designation
v	ft/min	m/s	Sliding speed
v_{lim}	ft/min	m/s	Maximum sliding speed
μ	-	-	Coefficient of friction
α_1	1/10 ⁶ K	1/10 ⁶ K	Coefficient of linear thermal expansion
σ_c	psi	MPa	Compressive Yield strength
λ_B	BTU-in/hr-ft ² · $^{\circ}$ F	W/mK	Thermal conductivity of bearing material
φ	$^{\circ}$	$^{\circ}$	Angular displacement

Unit Conversions

SI to ANSI Conversions

1 mm	0.0394 inch
1 m	3.2808 ft
1 Newton = 1N	0.225 lbs.
1 MPa = 1 N/mm ²	145 psi
1 m/s	196.85 ft/min
$^{\circ}$ C	($^{\circ}$ F-32)/1.8

ANSI to SI Conversions

1 inch	25.4 mm
1 ft	0.3048 m
1 Lb.	4.448 N
1 psi	0.0069 MPa = 0.0069 N/mm ²
1 ft/min	0.0051 m/s
$^{\circ}$ F	(1.8 x $^{\circ}$ C) +32

mm = millimeters

m = meters

ft = foot

in = inch

N = Newtons

W = Watts

MPa = MegaPascal = 10⁶ Pa

Lbs. = pounds

psi = pounds per square inch

hr = hour

ft/min = feet per minute

m/s = meters per second

$^{\circ}$ F = degrees Fahrenheit

$^{\circ}$ C = degrees Celsius

K = degrees Kelvin

BTU = British Thermal Units

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1 Introduction

The purpose of this handbook is to provide comprehensive technical information on the characteristics of GGB's family of filament wound, high load, self-lubricating bearings. The information given permits designers to establish the appropriate material required for a particular application. GGB North America (GGBNA) applications and development engineering services are available to assist with unusual design problems.

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.

GGBNA, is one of seven GGB manufacturing facilities world wide, and has remained the foremost supplier of self-lubricating plain bearings to America's industrial and automotive markets for almost 30 years. GGB is continually refining and extending its experimental and theoretical knowledge and, therefore, when using this brochure it is always worthwhile to contact GGB if additional information should be required.

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

1.1 General Characteristics and Advantages

To meet the need for high load, self-lubricating bearings that provide low wear rates in a wide variety of applications, GGB has developed a comprehensive family of filament wound, composite self-lubricating bearing materials. These bearings combine the excellent lubricating properties of filled PTFE (polytetrafluoroethylene) with the high

strength and stability of an oriented glass fiber wound structure. GGB's Filament wound bearings employ a tough, high strength composite structure consisting of epoxy-impregnated, wound glass fibers oriented to provide the radial and axial strength required to support high bearing loads.

GAR-MAX[®] and **HSG[™]** (High Strength GAR-MAX[®]) have a bearing surface liner of PTFE and high strength fibers twisted together and encapsulated by a high temperature epoxy resin that has been further enhanced with a self-lubricating additive.

MLG[™] has a bearing surface liner of PTFE and high strength fibers twisted together and encapsulated by a high temperature resin.

GAR-FIL[®] has a proprietary filled PTFE tape liner bonded to the backing.

HPM[™] has a bearing surface liner of PTFE and high strength fibers twisted together and encapsulated by a high temperature epoxy resin that has been further enhanced with PTFE.

HPF[™] has a bearing surface liner consisting of a proprietary filled PTFE tape liner bonded to the backing.

MEGALIFE[®] XT Thrust washers have a proprietary filled PTFE surface on both sides of the washers supported by a high strength composite inner core.

Wide Application Range

Laboratory and field testing have proven that GGB filament wound bearings provide outstanding performance in a wide variety of demanding dry or lubricated bearing applications. These include off-road vehicles, agricultural and automotive equipment, construction equipment, aerial

lifts, windmills, materials handling equipment, valves, textile equipment, mechanical and hydraulic presses, waste/recycling equipment, processing equipment, packing machinery, and many more.

Low Friction Operation

GGB self-lubricating filament wound 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. In fact, in low speed, high pressure type applications. GAR-FIL bearings offer one of the lowest coefficients of friction of any self-lubricated bearing material.

Outstanding Dimensional Stability

Unlike many conventional non metallic bearing materials, the high strength composite bearing structure of GGB filament wound bearings offer a thermal expansion rate similar to that of steel. This assures maximum dimensional stability

and positive housing retention, even at elevated temperatures. Furthermore, GGB filament wound bearings are dimensionally stable in water. Water absorption and swell are negligible.

Wide Range of Sizes and Shapes

GGB filament wound bearings are available in standard sizes from 12 mm to 150 mm [1/2" to 6"] ID with wall thicknesses of 2.5 mm and 5 mm [1/8" and 1/4"], including lengths up to 400 mm [16"].

On special order, ID sizes from 10 mm to over 500 mm [3/8" to over 20"] can be furnished with custom wall thickness and/or length as required.

MEGALIFE® XT thrust bearings are available in standard sizes with custom sizes available upon request.

Special shapes based on customer requirements are possible as shown below. Contact GGB for details.

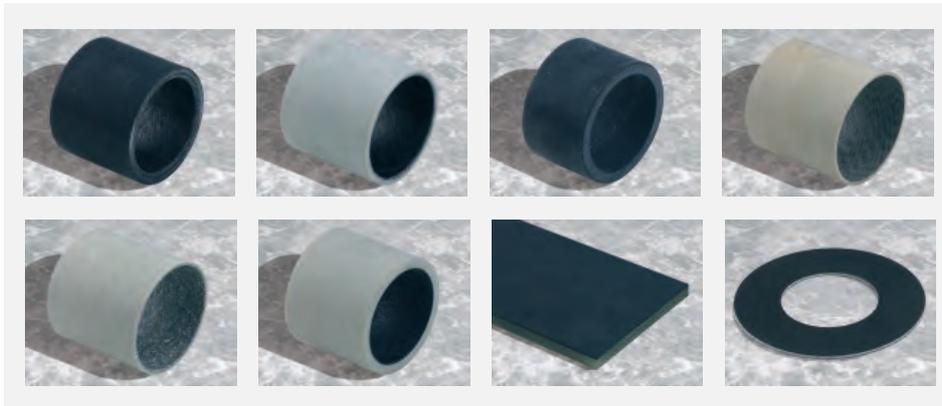


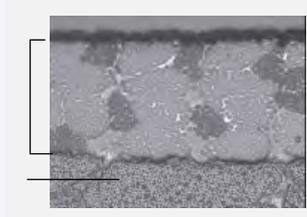
Fig. 1: Standard Shapes



Fig. 2: Examples for Special Shapes

2 Material Description

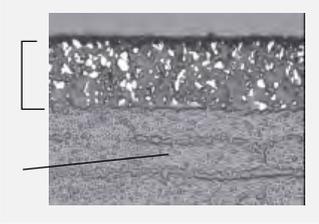
2.1 GAR-MAX[®]

Structure	Sliding Layer Microsection
<p>Sliding layer Continuous wound PTFE and high-strength fibers encapsulated in an internally lubricated, high temperature filled epoxy resin.</p> <p>Backing Continuous wound fiberglass encapsulated in a high temperature epoxy resin.</p>	 <p>Sliding Layer</p> <p>Backing</p>

Features	Possible Applications	Availability
<ul style="list-style-type: none"> • High load capacity • Excellent shock resistance • Excellent misalignment resistance • Excellent contamination resistance • Very good friction and wear properties • Good chemical resistance 	<ul style="list-style-type: none"> • Steering linkages • hydraulic cylinder pivots • king pin bearings • boom lifts, scissor lifts • cranes, hoists, lift gates • backhoes, trenchers • skid steer loaders • front end loaders... 	<p>Standard Cylindrical bearings: ID Range: 12 to 150 mm, metric series; 0.5 to 6 inch, inch series.</p> <p>Special order Bearing diameters to 500 mm [20 inches]; flanged bearings; hex and square bores; liner on OD</p>

Bearing Properties	SI Unit Value	ANSI Unit Value
Ultimate Compressive strength σ_c	414 MPa	60,000 psi
Maximum static load $p_{sta,max}$	207 MPa	30,000 psi
Maximum dynamic load $p_{dyn,max}$	138 MPa	20,000 psi
Maximum sliding speed v_{lim}	0.13 m/s	25 ft/min
Maximum pv factor	1.05 MPa·m/s	30,000 psi·ft/min
Maximum temperature T_{max}	163 °C	325 °F
Minimum temperature T_{min}	-196 °C	-320 °F

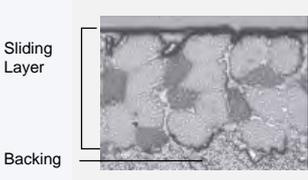
2.2 GAR-FIL®

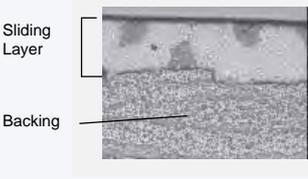
Structure	Sliding Layer Microsection
<p>Sliding layer Proprietary filled PTFE tape liner, 0.38 mm [.015] standard thickness.</p> <p>Backing Continuous wound fiberglass encapsulated in a high temperature epoxy resin.</p>	

Features	Possible Applications	Availability
<ul style="list-style-type: none"> • High load capacity • Good chemical resistance • Machinable bearing surface • High rotational speed capability • Very good friction and wear properties • Excellent contamination resistance 	<ul style="list-style-type: none"> • Valves • scissor lifts • pulleys • toggle linkages... 	<p>Standard Cylindrical bearings: ID Range: 12 to 150 mm, metric series; 0.5 to 6 inch, inch series.</p> <p>Special order Bearing diameters to 500 mm [20 inches]; special tape thicknesses; flanged bearings; hex and square bores; liner on OD</p>

Bearing Properties	SI Unit Value	ANSI Unit Value
Ultimate Compressive strength σ_c	379 MPa	55,000 psi
Maximum static load $p_{sta,max}$	138 MPa	20,000 psi
Maximum dynamic load $p_{dyn,max}$	138 MPa	20,000 psi
Maximum sliding speed v_{lim}	2.50 m/s	500 ft/min
Maximum pv factor	1.23 MPa·m/s	35,000 psi·ft/min
Maximum temperature T_{max}	204 °C	400 °F
Minimum temperature T_{min}	-196 °C	-320 °F

2.3 Special GAR-MAX[®] Products HSG[™] and MLG[™]

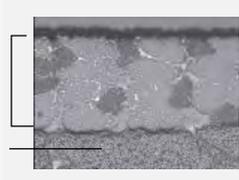
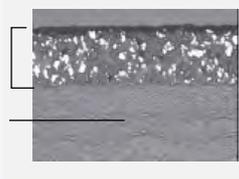
Structure	Sliding Layer Microsection	Features
HSG[™] - High Strength GAR-MAX		
<p>Sliding layer Continuous wound PTFE and high-strength fibers encapsulated in an internally lubricated, high temperature filled epoxy resin.</p> <p>Backing Continuous wound fiberglass encapsulated in a high temperature epoxy resin.</p>	 <p>Sliding Layer</p> <p>Backing</p>	<ul style="list-style-type: none"> • High static load capacity - twice as high as standard GAR-MAX • Excellent shock and misalignment resistance - better than standard GAR-MAX • Excellent contamination resistance • Very good friction and wear properties • Good chemical resistance

Structure	Sliding Layer Microsection	Features
MLG[™]		
<p>Sliding layer Continuous wound PTFE and high-strength fibers encapsulated in high temperature epoxy resin.</p> <p>Backing Continuous wound fiberglass encapsulated in a high temperature epoxy resin.</p>	 <p>Sliding Layer</p> <p>Backing</p>	<ul style="list-style-type: none"> • Value engineered filament wound bearing for lighter duty applications • High load capacity • Good misalignment resistance • Excellent shock resistance • Good friction and wear properties • Good chemical resistance

Bearing Properties	HSG [™]		MLG [™]	
	SI Unit Value	ANSI Unit Value	SI Unit Value	ANSI Unit Value
Ultimate Compressive strength σ_c	621 MPa	90,000 psi	414 MPa	60,000 psi
Maximum static load $p_{sta,max}$	414 MPa	60,000 psi	207 MPa	30,000 psi
Maximum dynamic load $p_{dyn,max}$	138 MPa	20,000 psi	138 MPa	20,000 psi
Maximum sliding speed v_{lim}	0.13 m/s	25 ft/min	0.13 m/s	25 ft/min
Maximum pv factor	1.05 MPa-m/s	30,000 psi-ft/min	1.05 MPa-m/s	30,000 psi-ft/min
Maximum temperature T_{max}	163 °C	320 °F	163 °C	320 °F
Minimum temperature T_{min}	-196 °C	-320 °F	-196 °C	-320 °F

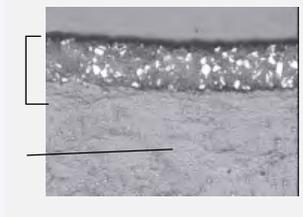
Possible applications and availability see 2.1 on Page 6

2.4 Hydropower Products HPM™ and HPF™

Structure	Sliding Layer Microsection	Features	Possible Applications
HPM™			
<p>Sliding layer Continuous wound PTFE and high-strength fibers encapsulated in a self-lubricating, high temperature epoxy resin.</p> <p>Backing Continuous wound fiberglass encapsulated in a high temperature epoxy resin.</p>	 <p>Sliding Layer</p> <p>Backing</p>	<ul style="list-style-type: none"> • Specifically developed for hydro-power applications • High load capacity • Excellent shock and edge loading capacity • Low friction, superior wear rate and bearing life • Excellent corrosion resistance • Dimensional stability - low water absorption, no swelling • Environmentally friendly 	<ul style="list-style-type: none"> • Servo-motor bearings • operating ring sliding segments • linkage bearings • wicket gate bearings • guide vane bearings • intake gate sliding segments • intake gate roller bearings • spillway gate bearings • trash rake bearings • fish screen bearings • trunnion bearings • blade bearings • injector bearings • deflector bearings • ball and butterfly trunnion bearings...
HPF™			
<p>Sliding layer Proprietary filled PTFE tape liner.</p> <p>Backing - Flat Material Continuous woven fiber glass cloth laminate impregnated and cured with epoxy resin.</p> <p>Backing - Cylindrical Bearings Continuous wound fiberglass encapsulated in a high temperature epoxy resin.</p>	 <p>Sliding Layer</p> <p>Backing</p>		

Bearing Properties	HPM™		HPF™		Availability
	SI Unit Value	ANSI Unit Value	SI Unit Value	ANSI Unit Value	
Ultimate Compressive strength σ_c	345 MPa	50,000 psi	379 MPa	55,000 psi	<p>HPM, Special order Cylindrical bearings to 500 mm (20 inches).</p> <p>HPF, Special order Cylindrical bearings, diameters up to 500 mm (20 inches); thrust bearings and wear plates.</p>
Maximum static load $p_{sta,max}$	138 MPa	20,000 psi	138 MPa	20,000 psi	
Maximum dynamic load $p_{dyn,max}$	138 MPa	20,000 psi	138 MPa	20,000 psi	
Maximum sliding speed v_{lim}	0.13 m/s	25 ft/min	2.5 m/s	500 ft/min	
Maximum pv factor	1.23 MPa·m/s	35,000 psi·ft/min	1.23 MPa·m/s	35,000 psi·ft/min	
Maximum temperature T_{max}					
- Cylindrical bearing material	163 °C	325 °F	204 °C	400 °F	
- Flat Material	-	-	140 °C	284 °F	
Minimum temperature T_{min}	-196 °C	-320 °F	-196 °C	-320 °F	

2.5 MEGALIFE[®] XT Thrust Bearings

Structure	Sliding Layer Microsection
<p>Sliding layer Proprietary filled PTFE tape liner on both sides.</p> <p>Core Continuously woven layer of filament fiberglass encapsulated in a high temperature epoxy resin.</p>	

Features	Possible Applications	Availability
<ul style="list-style-type: none"> • High load capacity • Excellent shock resistance • Excellent misalignment resistance • Good surface speed capability • Excellent contamination resistance • Very good friction and wear properties • Good chemical resistance 	<ul style="list-style-type: none"> • Pulley spacers • gear spacers • aerial lifts • fork lift masts • king pins • steering links • lift gates • cranes • backhoes • valve actuator linkages... 	<p>Standard Thrust bearings, standard sizes see pages 42-43.</p> <p>Special order For special sizes contact GGB.</p>

Bearing Properties	SI Unit Value	ANSI Unit Value
Ultimate Compressive strength σ_c	207 MPa	30,000 psi
Maximum static load $p_{sta,max}$	138 MPa	20,000 psi
Maximum dynamic load $p_{dyn,max}$	138 MPa	20,000 psi
Maximum sliding speed v_{lim}	0.50 m/s	100 ft/min
Maximum pv factor	1.23 MPa·m/s	35,000 psi·ft/min
Maximum temperature T_{max}	177 °C	350 °F
Minimum temperature T_{min}	-196 °C	-320 °F

2.6 Performance Comparison Chart

Material	Load Carrying Capability	Shock Loading Resistance	Speed Capability	Contamination Resistance	Misalignment Resistance	Machinability
GAR-MAX	1	2	3	1	2	4
GAR-FIL	1	3	1	2	4	1
HSG	1	1	3	1	1	4
MLG	1	2	3	2	3	4
HPM	1	2	3	1	2	4
HPF, Flat Material	1	3	1	2	4	1
HPF, Cylindrical Bearing	1	3	1	2	4	1
MEGALIFE XT	2	3	2	2	3	2

Table 1: Performance Comparison Chart

Ranking	
1	Excellent
2	Good
3	Fair
4	Not Recommended

3 Properties

3.1 Physical Properties

Table 2 shows the physical properties of GGB’s filament wound bearings.

High load capacity without lubrication

The ultimate compressive strength and maximum dynamic capacity of GGB filament wound bearings without

lubrication exceed those of most other bearing materials with lubrication.

Wide operating temperature range

GGB filament wound bearings can operate at much higher temperatures than lubricated bearings. This opens new application opportunities where metallic

bearings cannot function because of the limited temperature range of most greases and oils.

Thermal dimensional stability

GGB filament wound bearings have a thermal expansion rate similar to steel and cast iron. There is less chance of them losing their press fit or binding the shaft

when exposed to extremes of temperature. This is not the case with many other non-metallic bearings.

Weight savings

GGB filament wound bearings are 75% lighter than similarly sized bronze or steel bearings. This can result in a substantial

weight saving, especially with larger bearings.

Physical Properties	Units	GAR-MAX	GAR-FIL	HSG	MLG	HPM	HPF Flat Material	HPF Bearing Material	MEGA-LIFE XT
Ultimate Compressive Strength	MPa	414	379	621	414	345	379	379	207
	psi	60,000	55,000	90,000	60,000	50,000	55,000	55,000	30,000
Static Load Capacity	MPa	207	138	414	207	138	138	138	138
	psi	30,000	20,000	60,000	30,000	20,000	20,000	20,000	20,000
Maximum Dynamic Load Capacity	MPa	138	138	138	138	138	138	138	69
	psi	20,000	20,000	20,000	20,000	20,000	20,000	20,000	10,000
Max. Relative Surface Speed	m/s	0.13	2.50	0.13	0.13	0.13	2.50	2.50	0.50
	ft/min	25	500	25	25	25	500	500	100
Maximum pv Factor	MPa·m/s	1.05	1.23	1.05	1.05	1.23	1.23	1.23	1.23
	psi·ft/min	30,000	35,000	30,000	30,000	35,000	35,000	35,000	35,000
Max. Operating Temperature	°C	163	204	163	163	163	140	204	177
	°F	325	400	325	325	325	284	400	350
Min. Operating Temperature	°C	-196	-196	-196	-196	-196	-196	-196	-196
	°F	-320	-320	-320	-320	-320	-320	-320	-320
Thermal Expansion Rate - Hoop	10 ⁻⁶ /K	12.6	12.6	12.6	12.6	12.6	10.8*	12.6	12.6*
	10 ⁻⁶ /°F	7.0	7.0	7.0	7.0	7.0	6.0*	7.0	7.0*
Thermal Expansion Rate - Axial	10 ⁻⁶ /K	27.0	27.0	27.0	27.0	27.0	-	27.0	-
	10 ⁻⁶ /°F	15.0	15.0	15.0	15.0	15.0	-	15.0	-
Thermal Conductivity	W/mK	0.26	0.26	0.26	0.26	0.26	0.29	0.26	0.26
	BTU·in/hr·ft ² ·°F	1.8	1.8	1.8	1.8	1.8	2.0	1.8	1.8
Specific Gravity	-	1.87	1.96	1.87	1.87	1.87	1.9	1.96	1.85

* lengthwise

Table 2: Physical properties of GGB filament wound bearings

3.2 Performance Comparison

Table 3 presents the properties information in a convenient table to help you choose the best product for your application.

Material	Max. Dynamic Capacity (<0.025 m/s (5 sft/min))		Maximum Temperature		Thermal Expansion Rate - Hoop		Specific Gravity
	MPa	psi	°C	°F	10 ⁻⁶ /K	10 ⁻⁶ /°F	
Cast Bronze*	41	6,000	71	160	18.0	10.0	8.80
Porous Bronze**	28	4,000	71	160	18.0	10.0	7.50
Alloyed Bronze*	69	10,000	93	200	28.8	16.0	8.10
Steel-Backed Bronze*	24	3,500	93	200	14.4	8.0	8.00
Hardened Steel*	276	40,000	93	200	12.6	7.0	7.90
Zinc Aluminum*	38	5,500	93	200	27.0	15.0	5.00
Fabric-Reinforced Phenolic*	41	6,000	93	200	36.0	20.0	1.60
Reinforced PTFE	14	2,000	260	500	99.0	55.0	2.00
GAR-MAX	138	20,000	163	325	12.6	7.0	1.87
GAR-FIL	138	20,000	204	400	12.6	7.0	1.96
HSG	138	20,000	163	325	12.6	7.0	1.87
MLG	138	20,000	163	325	12.6	7.0	1.87
HPM	138	20,000	163	325	12.6	7.0	1.87
HPF, Flat Material	138	20,000	140	284	10.8***	6.0***	1.90
HPF, Cylindrical Bearing	138	20,000	204	400	12.6	7.0	1.96
MEGALIFE XT	69	10,000	177	350	12.6***	7.0***	1.85

*with lubrication; **oil impregnated; ***lengthwise

Table 3: Comparison of various bearing materials

Note

Actual performance depends on the interaction of many parameters that may vary with the specific application. For example, maximum values listed for loads, speeds, and temperature cannot be used

simultaneously. However, in certain applications, individual values can be exceeded. For conditions that do exceed the recommended design limits, contact our Engineering Department.

3.3 Chemical Resistance

GGB's filament wound bearings are resistant to a wide variety of chemicals including acids, bases, salt solutions, oils, fuels, alcohols, solvents and gases.

In fact GGB filament wound bearings offer greater chemical resistance than metallic bearings. However, GAR-FIL is resistant to the greater number of chemicals, and is used in a wide range of valves employed in the chemical processing industry as well as for fire-safe valves.

The chemical resistance of GGB's filament wound bearings to many common chemicals at 70 °F is shown in Table 4.

We recommend conducting a chemical resistance test prior to specifying a bearing that will be exposed to a chemical. 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.

	GAR-MAX	GAR-FIL	HSG	MLG	HPM	HPF
Acids 10%						
Acetic	Yes	Yes	Yes	Yes	Yes	Yes
Arsenic	No	Yes	No	No	No	Yes
Boric	Yes	Yes	Yes	Yes	Yes	Yes
Carbonic	No	No	No	No	No	No
Citric	Yes	Yes	Yes	Yes	Yes	Yes
Hydrochloric	Yes	Yes	Yes	Yes	Yes	Yes
Hydro-fluoric	No	No	No	No	No	No
Nitric	No	No	No	No	No	No
Sulfuric	Yes	Yes	Yes	Yes	Yes	Yes
Bases 10%						
Aluminum Hydroxide	Yes	Yes	Yes	Yes	Yes	Yes
Calcium Hydroxide	Yes	Yes	Yes	Yes	Yes	Yes
Magnesium Hydroxide	Yes	Yes	Yes	Yes	Yes	Yes
Potassium Hydroxide	Yes	Yes	Yes	Yes	Yes	Yes
Sodium Hydroxide	Yes	Yes	Yes	Yes	Yes	Yes
Salts						
Aluminum Chloride	Yes	Yes	Yes	Yes	Yes	Yes
Aluminum Nitrate	Yes	Yes	Yes	Yes	Yes	Yes
Aluminum Sulfate	Yes	Yes	Yes	Yes	Yes	Yes
Calcium Chloride	Yes	Yes	Yes	Yes	Yes	Yes
Ferric Chloride	Yes	Yes	Yes	Yes	Yes	Yes
Magnesium Carbonate	Yes	Yes	Yes	Yes	Yes	Yes
Magnesium Chloride	Yes	Yes	Yes	Yes	Yes	Yes
Magnesium Sulfate	Yes	Yes	Yes	Yes	Yes	Yes
Sodium Acetate	Yes	Yes	Yes	Yes	Yes	Yes
Sodium Bicarbonate	Yes	Yes	Yes	Yes	Yes	Yes
Sodium Bisulfate	Yes	Yes	Yes	Yes	Yes	Yes
Sodium Chloride	Yes	Yes	Yes	Yes	Yes	Yes
Sodium Nitrate	Yes	Yes	Yes	Yes	Yes	Yes
Zinc Sulfate	Yes	Yes	Yes	Yes	Yes	Yes
Alcohols						
Acetol	Yes	Yes	Yes	Yes	Yes	Yes
Allyl	No	No	No	No	No	No
Amyl	Yes	Yes	Yes	Yes	Yes	Yes
Butyl	No	No	No	No	No	No
Ethyl	Yes	Yes	Yes	Yes	Yes	Yes
Iso Butyl	Yes	Yes	Yes	Yes	Yes	Yes
Iso Propyl	Yes	Yes	Yes	Yes	Yes	Yes
Methyl	Yes	Yes	Yes	Yes	Yes	Yes
Propyl	Yes	Yes	Yes	Yes	Yes	Yes

	GAR-MAX	GAR-FIL	HSG	MLG	HPM	HPF
Solvents						
Acetone	Yes	Yes	Yes	Yes	Yes	Yes
Benzene	No	No	No	No	No	No
Carbon Tetrachloride	Yes	Yes	Yes	Yes	Yes	Yes
Methylene Chloride	No	No	No	No	No	No
Methyl Ethyl Ketone	Yes	Yes	Yes	Yes	Yes	Yes
Naphtha	Yes	Yes	Yes	Yes	Yes	Yes
Toluol	Yes	Yes	Yes	Yes	Yes	Yes
Trichlorethane	No	Yes	No	No	No	Yes
Oils						
Cottonseed	Yes	Yes	Yes	Yes	Yes	Yes
Crude Oil	Yes	Yes	Yes	Yes	Yes	Yes
Hydraulic Fluids	Yes	Yes	Yes	Yes	Yes	Yes
Linseed Oil	Yes	Yes	Yes	Yes	Yes	Yes
Motor Oil	Yes	Yes	Yes	Yes	Yes	Yes
Transmission Fluids	Yes	Yes	Yes	Yes	Yes	Yes
Fuels						
Diesel	Yes	Yes	Yes	Yes	Yes	Yes
Gasoline	Yes	Yes	Yes	Yes	Yes	Yes
Jet Fuel	Yes	Yes	Yes	Yes	Yes	Yes
Kerosene	Yes	Yes	Yes	Yes	Yes	Yes
Gases	Yes	Yes	Yes	Yes	Yes	Yes
Acetylene Bromine	No	No	No	No	No	No
Butane	Yes	Yes	Yes	Yes	Yes	Yes
Carbon Dioxide	Yes	Yes	Yes	Yes	Yes	Yes
Chlorine	No	Yes	No	No	No	Yes
Ethers	Yes	Yes	Yes	Yes	Yes	Yes
Fluorine	No	No	No	No	No	No
Hydrogen	Yes	Yes	Yes	Yes	Yes	Yes
Natural Gas	Yes	Yes	Yes	Yes	Yes	Yes
Nitrogen	Yes	Yes	Yes	Yes	Yes	Yes
Ozone	Yes	Yes	Yes	Yes	Yes	Yes
Propane	Yes	Yes	Yes	Yes	Yes	Yes
Sulfur Dioxide	Yes	Yes	Yes	Yes	Yes	Yes
Miscellaneous						
Anhydrous Ammonia	No	No	No	No	No	No
Detergents	Yes	Yes	Yes	Yes	Yes	Yes
Ethylene Glycol	Yes	Yes	Yes	Yes	Yes	Yes
Formaldehyde	Yes	Yes	Yes	Yes	Yes	Yes
Freon	Yes	Yes	Yes	Yes	Yes	Yes
Hydrogen Peroxide	No	No	No	No	No	No
Lime	Yes	Yes	Yes	Yes	Yes	Yes
Water	Yes	Yes	Yes	Yes	Yes	Yes
Sea water	Yes	Yes	Yes	Yes	Yes	Yes

Table 4: Chemical resistance

4 Data for Designers

4.1 Wear Rate

In the high load applications anticipated for filament wound bearings, radial displacement will result from a combination of many variables. These include adhesive wear, abrasion, deformation due to misalignment of the shaft, high interface temperatures, ingress of dirt, fluid contamination and mating surface conditions. With design pressures of less

than 69 MPa [10,000 psi], millions of cycles can be achieved with GAR-MAX, HSG, GAR-FIL, HPM and HPF bearings.

Fig. 3 and Fig. 4 show the rate of wear measured in continuous cycle testing for a GAR-MAX and GAR-FIL bearing operating at 103 MPa [15,000 psi].

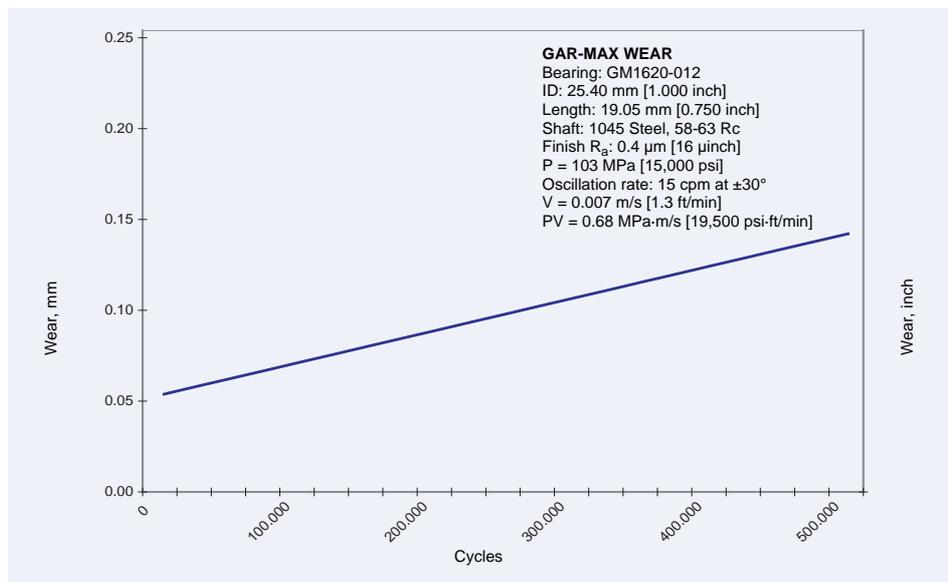


Fig. 3: Wear rate for GAR-MAX

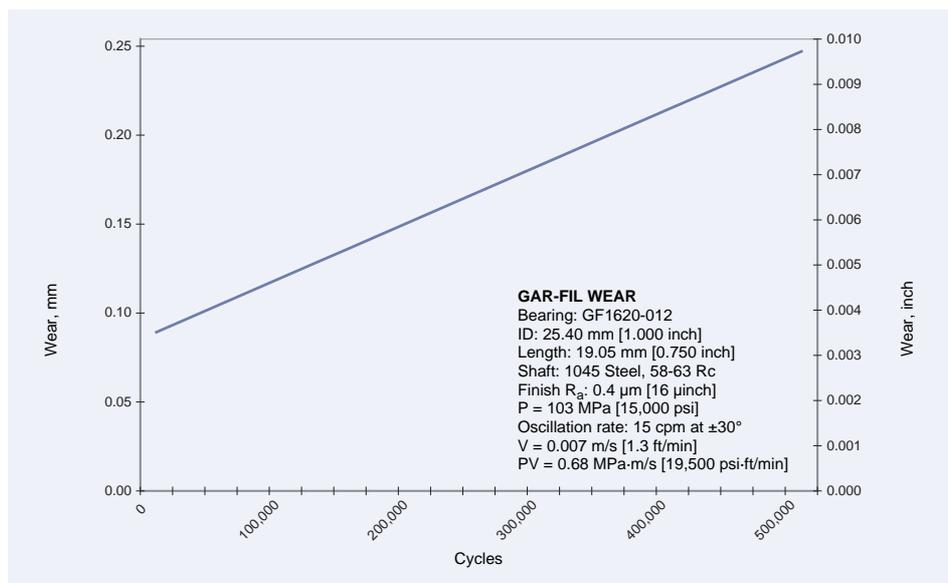


Fig. 4: Wear rate for GAR-FIL

4.2 Frictional Properties

The prime factors affecting the friction of filament wound bearings are pressure, velocity, temperature and mating surface conditions. Generally, the pressure is the most influential.

Fig. 5 shows how friction changes at various pressures. This information can be used to estimate the torque required to initiate motion in GGB filament wound bearings:

(4.2.1) [N·m]

$$\text{Torque} = \frac{\mu \cdot F \cdot D_i}{2000}$$

or

(4.2.2) [lbs·in]

$$\text{Torque} = \frac{\mu \cdot F \cdot D_i}{2}$$

Where	
μ	coefficient of friction
F	Applied load [Newtons] or [pounds]
D_i	Bearing nominal ID, [mm] or [inches]

This equation can be used to determine frictional losses that a bearing contributes to a system.

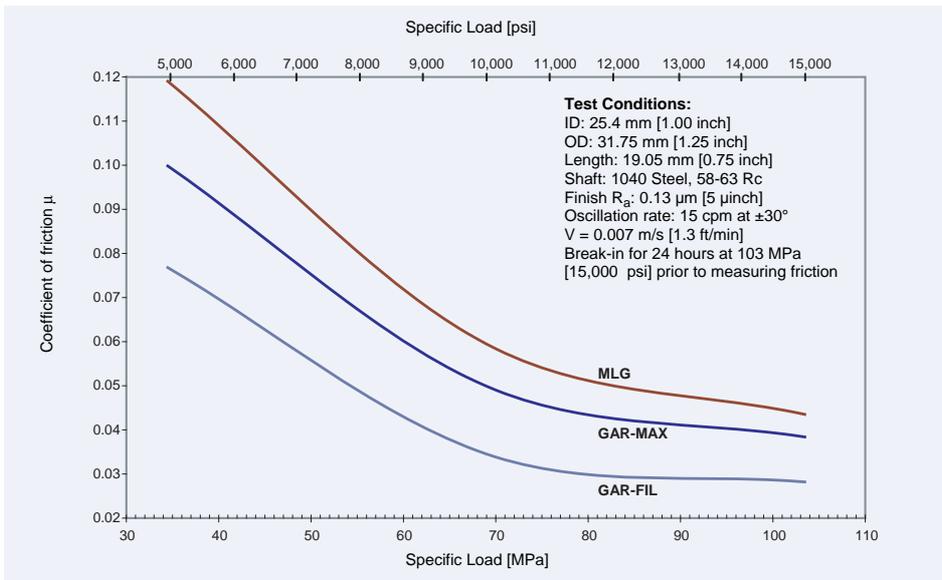


Fig. 5: Coefficient of friction vs specific load

With frequent starts and stops, the static coefficient of friction is approximately equal to or slightly less than the dynamic coefficient of friction as measured in laboratory testing. After progressively longer periods of sitting idle or dwell under load (e.g., of hours or days), the static coefficient of friction of the first movement

has been measured to be up to 200% higher, particularly before bedding-in. This phenomenon must be considered when designing long dwell period applications. Extremely low torque applications should be monitored or specifically tested for friction when prime mover torque requirements must be determined.

4.3 Operating Temperature

Operating temperature is an important consideration when specifying bearing materials since temperature will have a direct affect on bearing load capacity and wear resistance. GGB filament wound bearings consist of a rugged outer shell of filament wound fiberglass encapsulated in high temperature epoxy. This combination of materials permit GGB filament wound bearings to operate at higher temperatures than most other conventional plain

bearings as indicated in Table 3. At elevated temperatures GGB filament wound bearings have reduced load carrying capabilities due to the softening of the self-lubricating surfaces; however, GAR-MAX, HSG, MLG and HPM are not influenced by temperature to the same degree as GAR-FIL and HPF. GAR-FIL bearings have been used in low temperature (cryogenic) applications.

4.4 Load Capacity

The maximum unit load which can be supported by filament wound bearings will depend upon the type of loading. It will be highest under steady loads, whereas, dynamic loads or oscillating motion, which produce fatigue stresses in the bearing, will result in a reduction of load capacity. The maximum unit loads specified in Table 2 assume good alignment between the bearing and mating surface and running clearances listed in the standard product tables on pages 32 through 41.

The maximum static and dynamic loads given in Table 2 are based on bearings having a wall thickness of 2.5 mm [0.100 inch] or greater. Thin-walled bearings, those with a wall thickness between 1.5 mm [0.060 inch] and 2.5 mm [0.100 inch] have a reduced load capacity because of the reduced number of filament wound fiberglass crossovers that constitute the backing material. Wall thicknesses greater than 6.35 mm [0.250 inch] do not increase load capacity. Many applications for GAR-MAX and HSG bearings involve applied loads plus the presence of shock and impulse loading

along with additional loads due to structural bending. As an example, hydraulic cylinder pivots or clevis joints used in front end loaders, graders, and other types of off-highway vehicles require the consideration of misalignment and G-impact force. Experience gained in the application of GAR-MAX and HSG bearings on this type of equipment has led us to recommend the maximum specific load (pressures) shown in Table 5. Greater specific loads have shown surface distress in operation since the cumulative influence of misalignment and shock will increase the actual specific load.

The bearing length can also influence the distribution of load along the length of the bearing. A bearing that is heavily loaded and having a relatively long length will, due to shaft deflection, have disproportionately high unit loading at each end. For this reason, we do not recommend length-to-diameter ratios that are greater than 2.0. Conversely, very short bearings, those with length-to-diameter ratios less than 0.25 are not recommended because of potential bearing retention problems.

Application	Design Specific Load*		Impact [G]
	MPa	psi	
Dozer Yoke	34	5,000	3
Excavators	34	5,000	3
Back Hoes	34	5,000	3
Loader Linkage	34	5,000	3
Rollers	48	7,000	2
Bogie Wheel Pivots	48	7,000	2
Track Frame Pivots	48	7,000	2
Steer Cylinders	69	10,000	1
Control Linkage	69	10,000	1
Dump/Swing Cylinders	69	10,000	1

* Includes hydraulic check valve pressure but does not include impact, misalignment or vehicle driving force

Table 5: Specific application impact loading factors

4.5 Surface Velocity

GGB's filament wound bearings can operate over a wide range of operating velocities as shown in Table 2.

GAR-FIL and HPF bearings can operate without lubrication at speeds up to 2.5 m/s [500 ft/min] with a maximum pv value to 0.3 MPa·m/s [9,000 psi·ft/min]. This performance capability is due to the proprietary filled-PTFE liner. Since surface velocity influences the amount of heat generated in a plain bearing, additional clearance may be required at higher operating speeds. With GAR-FIL and HPF bearings, when operating over 0.25 m/s [50 ft/min], additional clearances are

required to accommodate for thermal expansion due to the heat generated.

GAR-MAX, HSG, MLG and HPM bearings, which have a maximum speed limit of 0.13 m/s [25 ft/min], are more suitable for high-load and low-speed applications. Since most GAR-MAX, HSG, MLG and HPM bearings are designed to operate at less than 0.05 m/s [10 ft/min], additional clearances are normally not required.

MEGALIFE XT thrust washers are limited to 0.50 m/s [100 ft/min].

4.6 pv Factor

The pv factor, which is the product of specific load (pressure) times surface velocity, is used as a guide in determining the useful life of plain bearings and is also an indication of heat generated within the bearing contact zone. The maximum pv factors listed in Table 2 are based on high-load and low-speed applications. The calculated unit load p , relative surface velocity v and operating temperature must be used along with the pv factor when selecting a bearing material for a given

application. These values are then compared against published maximum recommended values for load, speed, temperature and pv for the bearing material. For an application to be successful, each of the application values must not exceed the published maximum recommended values. To complete the bearing analysis, bearing life should be estimated using the method given in section 5.5.

4.7 Operating Clearances

Proper running clearance is a critical factor in bearing performance. In low speed oscillating pivot applications, the minimum possible recommended clearance can be as small as 0.013 mm [0.0005 inch] for filament wound bearings. The shaft or pin will fit nearly line-to-line during the assembly process. However, since little or no heat is generated during very slow oscillating operation, additional clearance is not required. For more dynamic applications involving continuous rotation at higher speeds or elevated ambient temperatures, minimum clearances may be as high as 0.005 mm/mm [0.005 inch/inch] of diameter.

GAR-MAX, HSG, MLG, and HPM bearings cannot be sized or machined on their ID due to the liner composition. However, GAR-FIL and HPF bearings can be sized or machined for close tolerance control. Standard GAR-FIL and HPF bearings are supplied with a 0.38 mm [0.015 inch] thick proprietary filled-PTFE tape liner that can be bored at assembly if necessary. GAR-FIL and HPF bearings can also be furnished with a thicker liner that allows for a greater amount of boring. For further information, contact GGB.

4.8 Dimensional Considerations

Before designing a special GGB filament wound bearing, there are several important considerations to keep in mind:

- **Wall Thickness**

Bearings with wall thicknesses less than 2.5 mm [0.100 inch] should be avoided since thin-walled bearings have reduced load capacity, approximately 50% less than our rated load capacity for GGB filament wound bearings. The minimum recommended wall thickness is 1.5 mm [0.060 inch]. Wall thicknesses greater than 6.35 mm [0.250 inch] do not increase load capacity.

- **Clearance**

As noted previously, the minimum running clearance applies only to low speed applications operating at ambient temperatures. For GAR-FIL and HPF bearings operating at surface speeds greater than 0.25 m/s [50 ft/min] or at elevated temperatures, additional clearance may be required.

- **Bearing Length**

In designing bearings, the shaft diameter is usually determined by the need for physical stability or stiffness; therefore, only the bearing length must be determined based upon operating pressure and required life. A short bearing should be limited to a length-to-diameter ratio of 0.25 as a minimum to insure sufficient retention in the housing. A long bearing is not recommended because of potential shaft deflection and misalignment problems as described in Section 5.7. A long heavily loaded bearing will have disproportionately high specific loading at each end due to shaft deflection. For this reason, we do not recommend length-to-diameter ratios greater than 2.0.

4.9 Shaft Material and Surface Finish

Since the shaft is considered to be an equal part of the bearing assembly, the importance of proper shaft specification cannot be overemphasized. Most steel alloys are acceptable as shaft materials. Hardened steel shafts offer better performance in high load applications or in the presence of abrasive contaminants by providing greater protection for the mating surface. When bearing operating pressures exceed a value of about 14 MPa [2,000 psi], minimum shaft hardness should be at least Brinell 480 HB [Rockwell C50]. Fully hardened shafts are usually not necessary. GGB filament wound bearings offer good embeddability in the presence of contaminants; however, we strongly recommend the use of seals. Hardened stainless steel or hard chrome

plating is recommended when corrosion resistance is required.

Equally important as material selection is shaft surface finish. A surface finish between 0.15 to 0.40 μm [6 to 16 μinches] will insure the most effective bearing performance by assuring maximum bearing wear resistance and lowest coefficient of friction. Rougher surface finishes can be used but there will be a reduction in bearing life. This is due to the rough shaft abrading the relatively soft polymer liner of the bearings.

We recommend that the ends of the shaft have chamfers or rounded edges to facilitate assembly and minimize the chance of scoring the bearing.

4.10 Housing Material

The running clearances given in section 7 for standard GGB filament wound bearings are based upon installation in rigid steel or cast iron housings at normal ambient temperature. If the housing is made from non-ferrous alloys, such as aluminum, and will be subjected to elevated operating temperatures, there will be a potential for reduced bearing retention due to the thermal expansion of the housing. In

applications where non-ferrous alloy housings are to be used at elevated temperatures, the interference between the bearing and housing bore may have to be increased to assure adequate retention of the bearing in the housing. To prevent shaft interference at assembly, the shaft diameter must be equally reduced to compensate for the additional interference fit. For further information contact GGB.

4.11 Lubrication

GGB filament wound bearings are recommended to be used dry. 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.

GAR-FIL and HPF bearings can be used when submerged in oil or other lubricating liquids. Liquidous lubricants will reduce the coefficient of friction and bearing wear. However, the lubricant must be constantly maintained and kept free of abrasive contaminants. Grease is not

recommended for GAR-FIL and HPF bearings.

HPM and HPF bearings are specifically designed for hydropower applications where they can be used both dry and submerged in water. We recommend that hardened stainless steel shafting, such as 440 stainless steel, be used to minimize the chance of shaft corrosion.

MEGALIFE XT washers and wear plates are typically used dry but can also be used in greased applications.

Liquid lubricants and greases attract contaminating particles that may migrate into the bearing. To minimize bearing contamination, the use of seals or wipers is highly recommended.

5 Performance

The following section describes how to estimate bearing life for GGB filament wound bearings. This method involves calculation of the pv factor which is then further modified by application factors for

unit loading, bearing length, operating temperature, mating surface material and bearing diameter. If you need additional assistance in estimating bearing life, feel free to contact GGB.

5.1 Design Factors

The main parameters when determining the size or estimating the service life for a GGB filament wound bearing are:

- Specific load limit, p_{lim}
- pv factor
- Length-to-diameter ratio
- Mating surface finish
- Mating surface material
- Temperature
- Other environmental factors, e.g., housing design, dirt, lubrication

5.2 Specific Load, p

The formula for calculating the specific load, p, for bearings is:

Bearing

(5.2.1) [MPa] or [psi]

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

Where	
p	Specific load, [MPa] or [psi]
F	Applied load [Newtons] or [pounds]
D_i	Nominal ID, [mm] or [inches]
B	Bearing length, [mm] or [inches]

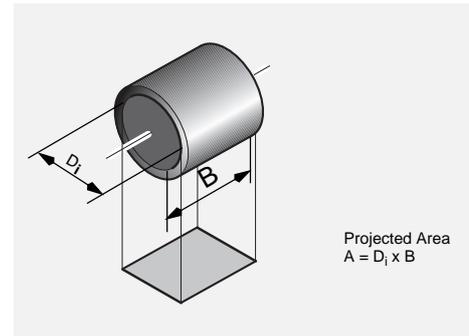


Fig. 6: Projected area for bearing

5.3 Sliding Speed, v

The formulae for calculating sliding speed are:

Bearings

(5.3.1) [m/s]

$$v = \frac{D_i \cdot \pi \cdot n}{60 \cdot 10^3}$$

or

(5.3.2) [ft/min]

$$v = \frac{D_i \cdot \pi \cdot n}{12}$$

Where	
v	Sliding speed, [m/s] or [ft/min]
n	Rotational speed, [1/min]

For oscillating applications

(5.3.3) [1/min]

$$n = \frac{4 \cdot \phi \cdot n_{osc}}{360}$$

Where	
n_{osc}	Oscillating movement frequency, [1/min]
ϕ	Angular displacement, [°]

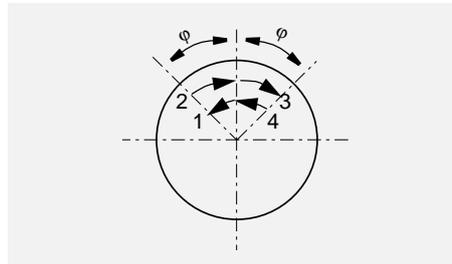


Fig. 7: Oscillating cycle, ϕ

5.4 pv Factor

The useful life of a GGB filament wound bearing is governed by the pv factor, the product of the specific load, p , and the sliding speed, v , as defined in 5.2 and 5.3 respectively.

The formula for calculating pv is:

(5.4.1) [MPa·m/s] or [psi·ft/min]

$$pv = p \cdot v$$

5.5 Estimating Bearing Life

Cyclic Bearing Life, L_Q

The cyclic bearing life of a GGB filament wound sleeve bearing is estimated by using the following formulae:

GAR-MAX and HSG

(5.5.1) [cycles]

$$L_Q = \frac{Q_{GM}}{pv} \cdot a_E \cdot a_T \cdot a_M \cdot a_S \cdot a_B$$

MLG

(5.5.2) [cycles]

$$L_Q = \frac{Q_{MLG}}{pv} \cdot a_E \cdot a_T \cdot a_M \cdot a_S \cdot a_B$$

GAR-FIL

(5.5.3) [cycles]

$$L_Q = \frac{Q_{GF}}{pv} \cdot a_E \cdot a_T \cdot a_M \cdot a_S \cdot a_B$$

Where	
L_Q	Estimated bearing life, [cycles]
Q_{GF}	GAR-FIL cyclic life factor, see Table 6
Q_{GM}	GAR-MAX and HSG cyclic life factor, see Table 6
Q_{MLG}	MLG cyclic life factor, see Table 6
pv	pv factor, p-v, [MPa·m/s] or [psi·ft/min]
a_E	High load factor
a_T	Temperature factor
a_M	Mating surface factor
a_S	Surface finish factor
a_B	Bearing size factor

Product	Factor	Cyclic Life Factors	
		MPa·m/s	psi·ft/min
GAR-MAX	Q_{GM}	$3.8 \cdot 10^6$	$11.0 \cdot 10^{10}$
HSG	Q_{GM}	$3.8 \cdot 10^6$	$11.0 \cdot 10^{10}$
MLG	Q_{MLG}	$1.4 \cdot 10^6$	$4.0 \cdot 10^{10}$
GAR-FIL	Q_{GF}	$2.4 \cdot 10^6$	$7.0 \cdot 10^{10}$

Table 6: Cyclic Life Factors

High Load Factor, a_E

The high load factor considers both the effect of the specific load and the bearing's B/D_i (length-to-diameter) ratio. Table 7 shows the specific load limit, P_{lim} , for various operating conditions. Fig. 8 shows a graph of the length factor, a_{B/D_i} , versus

B/D_i . Once the values for P_{lim} and a_{B/D_i} are selected, the high load factor, a_E , can be calculated as shown. If the calculated a_E value is negative, then the designer must consider a larger bearing in order to reduce the specific load, P .

(5.5.4)

$$a_E = \left(\frac{P_{lim} - p}{P_{lim}} \right)^{a_{B/D_i}}$$

Where	
P_{lim}	Specific load limit, see Table 7, [MPa] or [psi]
p	Specific load, [MPa] or [psi]
a_{B/D_i}	B/D_i factor taken from Fig. 8

Type of loading	Units	Specific Load Limit p_{lim}	
		GAR-MAX, HSG, MLG	GAR-FIL
Steady unidirectional loads relative to the bearing surface with rotation in one direction only.	MPa	138	138
	psi	20,000	20,000
Steady unidirectional loads with oscillating motion.	MPa	138	138
	psi	20,000	20,000
Dynamic loads, alternating or fluctuating, with rotating or oscillating motion.	MPa	103	103
	psi	15,000	15,000
Rotating load relative to bearing surface, e.g., fully rotational bearing on stationary shaft.	MPa	55 (<0.025 m/s)	14 (<0.125 m/s)
	psi	8,000 (<5 ft/min)	2,000 (<25 ft/min)

Table 7: Specific load limit, p_{lim}

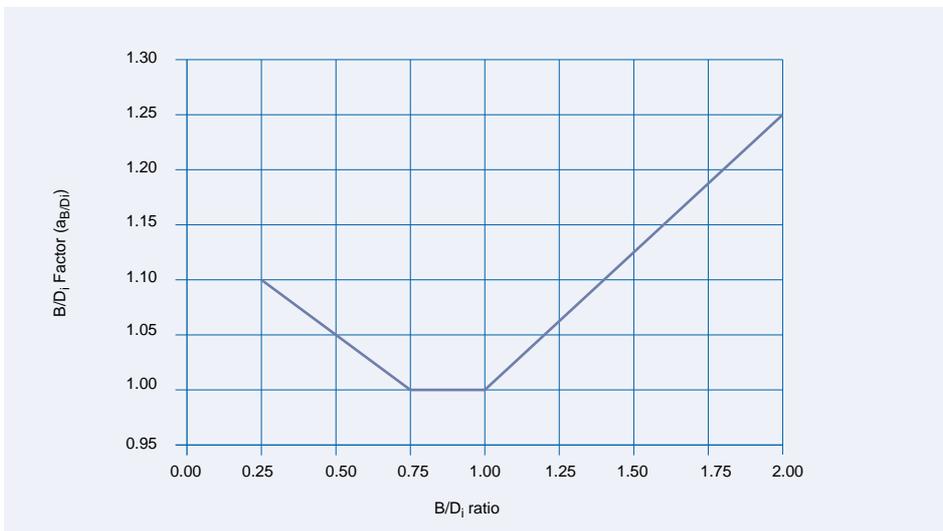


Fig. 8: B/D_i factor a_{B/D_i}

Type of Load

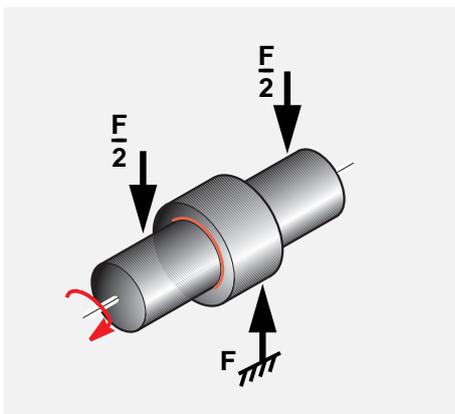


Fig. 9: Steady load, Bush stationary, Shaft rotating

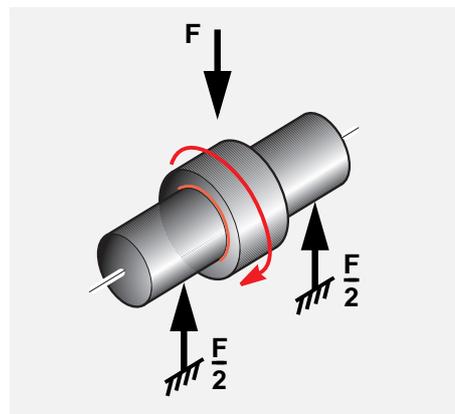


Fig. 10: Rotating load, shaft stationary, bush rotating

Temperature Factor - a_T

The effect of environmental temperature on the bearing life is given in Fig. 11. Elevated temperatures tend to soften the non-metallic bearing surface resulting in reduced wear resistance and load capacity. Since the bearing surface of GAR-FIL consists of a proprietary filled

PTFE material, bearing life will be influenced by temperature to a greater degree than GAR-MAX, HSG and MLG. When the operating temperature approaches the top limit of 205 °C [400 °F] for GAR-FIL or 163 °C [325 °F] for GAR-MAX, HSG and MLG, contact GGB.

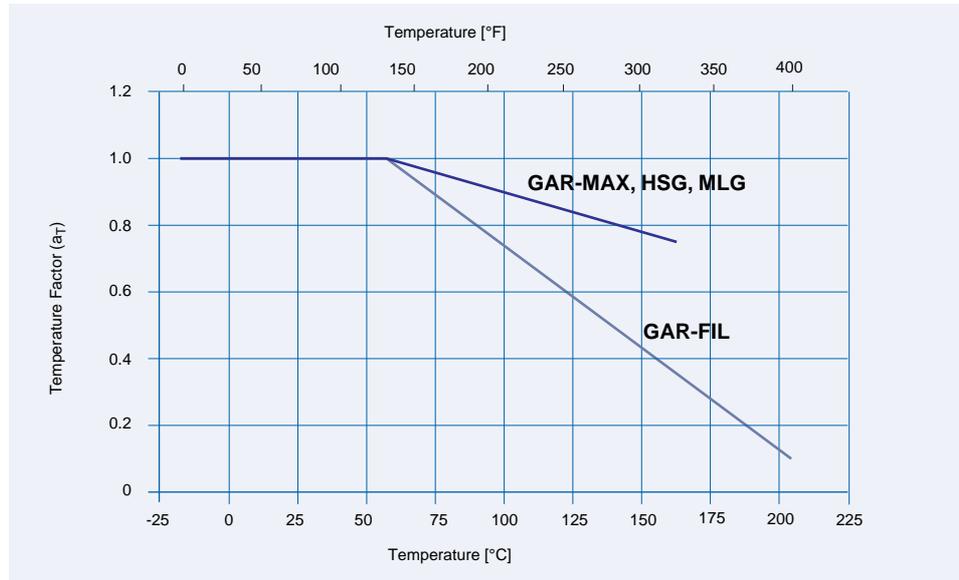


Fig. 11: Temperature factor a_T

Mating Material Factor - a_M

The effect of shaft material on self-lubricating bearing life is reflected in Table 8 which lists the mating surface material factors, a_M , for many commonly used shaft materials and shaft finishes.

When plated shafting is to be used, designers should specify that the plating possesses adequate strength and adhesion.

Material	Mating Surface Factor a_M
Steels	
Case-hardened Steel	1
Mild Steel	1
Nitrided Steel	1
Hardened Stainless Steel	1.2
Non-Ferrous Metals	
Bronze & Copper Based Alloys	0.1-0.4
Hard Anodized Aluminium, 0.025 mm (0.001 inch) thick	1.5
Plated Steel, 0.013 mm (0.0005 inch) minimum plating thickness	
Hard Chrome (polished after plating)	1.2
Tin Nickel	1.2
Tungsten Carbide Flame Plated	1.5
Zinc (Galvanized)	0.2

Table 8: Mating Surface Factor a_M

Mating Surface Factor - a_S

Shaft surface finish is a very important consideration when estimating bearing life. Fig. 12 shows a relationship of the mating surface factor, a_S , with respect to surface finish in micrometers [microinches]. To maximize bearing life, a surface finish of 0.15 to 0.40 μm [6 to 16 μinch] R_a is recommended. Rougher surface finishes will result in reduced bearing life because they will tend to rake through the soft

polymer liners and accelerate wear. On the other hand, very fine finishes do not permit the adequate transfer of the self-lubricating material onto the shaft surface and will also tend to reduce bearing life in dry applications. If rougher finishes are to be considered, testing should be conducted based on dynamics and operating pressures for the application.

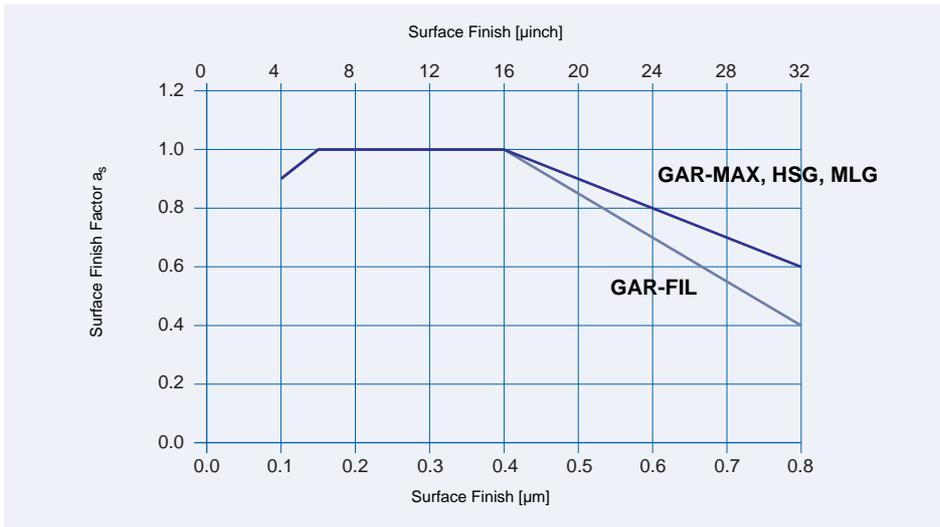


Fig. 12: Mating Surface Factor a_S

Bearing Size Factor - a_B

As the bearing size increases there is a relatively smaller angular contact area after initial bedding-in occurs. This reduction in contact area has the effect of

increasing the actual unit loading and consequently will result in reducing bearing life. The bearing size factor a_B versus shaft diameter is plotted in Fig. 14.

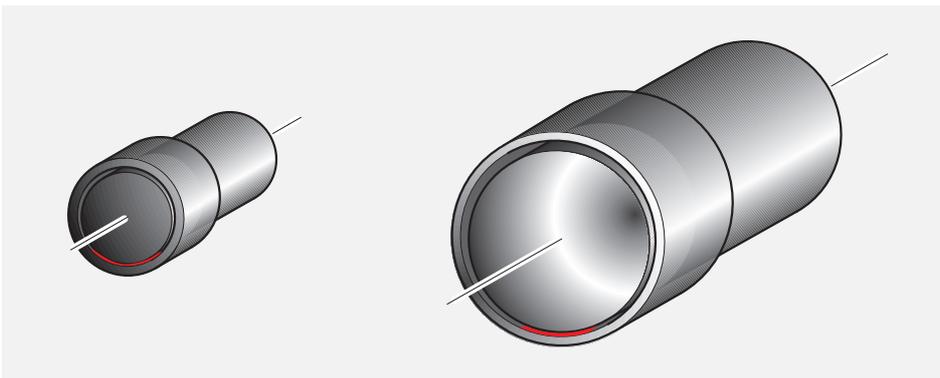


Fig. 13: Contact area between bearing and shaft



Fig. 14: Bearing Size Factor a_B

5.6 Worked Examples

GAR-MAX®

Given				
Load Details	Steady Load	Inside Diameter, D_i	2.25 inch	$\frac{B}{D_i} = \frac{2.00}{2.25} = 0.89$
	Shaft oscillating	Length, B	2.00 inch	
Shaft	Hardened Steel, $R_a = 20 \mu\text{inch}$	Bearing Load, F	60,000 pounds	
Environment	Ambient Temperature = 72 °F	Frequency, n_{osc}	15 cycles/min	
		Amplitude, ϕ	20°	

Calculation Constants and Application Factors

Specific Load Limit, p	20,000 psi	(Table 7, Page 25)
B/ D_i Factor, a_{B/D_i}	1.0	(Fig. 8, Page 25)
Temperature Factor, a_T	1.0	(Fig. 11, Page 26)
Mating Material Factor, a_M	1.0	(Table 8, Page 26)
Mating Surface Factor, a_S	0.9	(Fig. 12, Page 27)
Bearing Size Factor, a_B	0.96	(Fig. 14, Page 28)
Cyclic Life Factor, Q_{GM}	$11 \cdot 10^{10}$ psi-ft/min	(Table 6, Page 24)

Calculation	Reference	Value
Specific Load, p [MPa] or [psi]	(5.2.1), Page 22	$p = \frac{F}{D_i \cdot B} = \frac{60,000}{2.25 \cdot 2.00} = 13,333 \text{ psi}$
Sliding Speed, v [m/s] or [ft/min]	(5.3.1), Page 23	$v = \frac{D_i \cdot \pi \cdot n}{12} = \frac{2.25 \cdot \pi \cdot 3.333}{12} = 1.96 \text{ ft/min}$ $n = \frac{4 \cdot \phi \cdot n_{osc}}{360} = 3.333 \text{ rpm}$
pv Factor, pv [MPa-m/s] or [psi-ft/min]	(5.4.1), Page 23	$pv = p \cdot v = 13,333 \cdot 1.96 = 26,133 \text{ psi} \cdot \text{ft/min}$
High Load Factor, a_E	(5.5.4), Page 24	$a_E = \left(\frac{p_{lim} - p}{p_{lim}} \right)^{a_{B/D_i}} = \left(\frac{20,000 - 13,333}{20,000} \right)^{1.25} = 0.333$
Life, L_Q [cycles]	(5.5.1), Page 24	$L_Q = \frac{Q_{GM}}{pv} \cdot a_E \cdot a_T \cdot a_M \cdot a_S \cdot a_B = \frac{11 \cdot 10^{10}}{26,133} \cdot 0.333 \cdot 1.0 \cdot 1.0 \cdot 0.9 \cdot 0.96 = 1.2 \cdot 10^6 \text{ cycles}$

GAR-FIL®

Given				
Load Details	Steady Load	Inside Diameter, D_i	40 mm	$\frac{B}{D_i} = \frac{20}{40} = 0.5$
	Shaft oscillating	Length, B	20 mm	
Shaft	Hardened Steel, $R_a = 0.2 \mu\text{m}$	Bearing Load, F	50,000 Newtons	
Environment	Ambient Temperature = 75 °C	Frequency, n_{osc}	10 cycles/min	
		Amplitude, ϕ	30°	

Calculation Constants and Application Factors

Specific Load Limit, p	138 MPa	(Table 7, Page 25)
B/ D_i Factor, a_{B/D_i}	1.05	(Fig. 8, Page 25)
Temperature Factor, a_T	0.9	(Fig. 11, Page 26)
Mating Material Factor, a_M	1.2	(Table 8, Page 26)
Mating Surface Factor, a_S	1.0	(Fig. 12, Page 27)
Bearing Size Factor, a_B	0.98	(Fig. 14, Page 28)
Cyclic Life Factor, Q_{GF}	$2.4 \cdot 10^6$ N/mm ² -m/s	(Table 6, Page 24)

Calculation	Reference	Value
Specific Load, p [MPa] or [psi]	(5.2.1), Page 22	$p = \frac{F}{D_i \cdot B} = \frac{50,000}{40 \cdot 20} = 62.5 \text{ MPa}$
Sliding Speed, v [m/s] or [ft/min]	(5.3.1), Page 23	$v = \frac{D_i \cdot \pi \cdot n}{60 \cdot 10^3} = \frac{40 \cdot \pi \cdot 3.333}{60 \cdot 10^3} = 0.007 \text{ m/s}$ $n = \frac{4 \cdot \phi \cdot n_{osc}}{360} = 3.333 \text{ m/s}$
pv Factor, pv [MPa-m/s] or [psi-ft/min]	(5.4.1), Page 23	$pv = p \cdot v = 62.5 \cdot 0.007 = 0.438 \text{ MPa} \cdot \text{ft/min}$
High Load Factor, a_E	(5.5.4), Page 24	$a_E = \left(\frac{p_{lim} - p}{p_{lim}} \right)^{a_{B/D_i}} = \left(\frac{138 - 62.5}{138} \right)^{1.05} = 0.531$
Life, L_Q [cycles]	(5.5.1), Page 24	$L_Q = \frac{Q_{GF}}{pv} \cdot a_E \cdot a_T \cdot a_M \cdot a_S \cdot a_B = \frac{2.4 \cdot 10^6}{0.438} \cdot 0.531 \cdot 0.9 \cdot 1.2 \cdot 1.0 \cdot 0.98 = 3.1 \cdot 10^6 \text{ cycles}$

HSG™

Given				
Load Details	Dynamic Loads	Inside Diameter, D_i	6.00 inch	$\frac{B}{D_i} = \frac{4.00}{6.00} = 0.67$
	Shaft oscillating	Length, B	4.00 inch	
Shaft	Hardened Steel, $R_a = 16 \mu\text{inch}$	Bearing Load, F	180,000 pounds	
Environment	Ambient Temperature = 72 °F	Frequency, n_{osc}	6 cycles/min	
		Amplitude, ϕ	15°	

Calculation Constants and Application Factors

Specific Load Limit, p	15,000 psi	(Table 7, Page 25)
B/D _i Factor, a_{B/D_i}	1.02	(Fig. 8, Page 25)
Temperature Factor, a_T	1.0	(Fig. 11, Page 26)
Mating Material Factor, a_M	1.0	(Table 8, Page 26)
Mating Surface Factor, a_S	1.0	(Fig. 12, Page 27)
Bearing Size Factor, a_B	0.85	(Fig. 14, Page 28)
Cyclic Life Factor, Q_{GM}	$11 \cdot 10^{10}$ psi-ft/min	(Table 6, Page 24)

Calculation	Reference	Value
Specific Load, p [MPa] or [psi]	(5.2.1), Page 22	$p = \frac{F}{D_i \cdot B} = \frac{180,000}{6 \cdot 4} = 7,500$ psi
Sliding Speed, v [m/s] or [ft/min]	(5.3.1), Page 23	$v = \frac{D_i \cdot \pi \cdot n}{12} = \frac{6 \cdot \pi \cdot 1}{12} = 1.571$ ft/min $n = \frac{4 \cdot \phi \cdot n_{osc}}{360} = 1$ rpm
pv Factor, pv [MPa-m/s] or [psi-ft/min]	(5.4.1), Page 23	$pv = p \cdot v = 7,500 \cdot 1.571 = 11,783$ psi · ft/min
High Load Factor, a_E	(5.5.4), Page 24	$a_E = \left(\frac{p_{lim} - p}{p_{lim}} \right)^{a_{B/D_i}} = \left(\frac{15,000 - 7,500}{15,000} \right)^{1.02} = 0.493$
Life, L_Q [cycles]	(5.5.1), Page 24	$L_Q = \frac{Q_{GM}}{pv} \cdot a_E \cdot a_T \cdot a_M \cdot a_S \cdot a_B = \frac{11 \cdot 10^{10}}{11,783} \cdot 0.493 \cdot 1.0 \cdot 1.0 \cdot 1.0 \cdot 0.85 = 3.9 \cdot 10^6$ cycles

MLG™

Given				
Load Details	Steady Load	Inside Diameter, D_i	1.25 inch	$\frac{B}{D_i} = \frac{2.50}{1.25} = 2.0$
	Shaft oscillating	Length, B	2.50 inch	
Shaft	Mild Steel, $R_a = 32 \mu\text{inch}$	Bearing Load, F	40,000 pounds	
Environment	Ambient Temperature = 120 °F	Frequency, n_{osc}	20 cycles/min	
		Amplitude, ϕ	30°	

Calculation Constants and Application Factors

Specific Load Limit, p	20,000 psi	(Table 7, Page 25)
B/D _i Factor, a_{B/D_i}	1.25	(Fig. 8, Page 25)
Temperature Factor, a_T	1.0	(Fig. 11, Page 26)
Mating Material Factor, a_M	1.0	(Table 8, Page 26)
Mating Surface Factor, a_S	0.6	(Fig. 12, Page 27)
Bearing Size Factor, a_B	0.99	(Fig. 14, Page 28)
Cyclic Life Factor, Q_{MLG}	$4 \cdot 10^{10}$ psi-ft/min	(Table 6, Page 24)

Calculation	Reference	Value
Specific Load, p [MPa] or [psi]	(5.2.1), Page 22	$p = \frac{F}{D_i \cdot B} = \frac{40,000}{1.25 \cdot 2.50} = 12,800$ psi
Sliding Speed, v [m/s] or [ft/min]	(5.3.1), Page 23	$v = \frac{D_i \cdot \pi \cdot n}{12} = \frac{1.25 \cdot \pi \cdot 6.667}{12} = 1.571$ ft/min $n = \frac{4 \cdot \phi \cdot n_{osc}}{360} = 6.667$ rpm
pv Factor, pv [MPa-m/s] or [psi-ft/min]	(5.4.1), Page 23	$pv = p \cdot v = 12,800 \cdot 2.182 = 27,930$ psi · ft/min
High Load Factor, a_E	(5.5.4), Page 24	$a_E = \left(\frac{p_{lim} - p}{p_{lim}} \right)^{a_{B/D_i}} = \left(\frac{20,000 - 12,800}{20,000} \right)^{1.25} = 0.279$
Life, L_Q [cycles]	(5.5.1), Page 24	$L_Q = \frac{Q_{MLG}}{pv} \cdot a_E \cdot a_T \cdot a_M \cdot a_S \cdot a_B = \frac{4 \cdot 10^{10}}{27,930} \cdot 0.279 \cdot 1.0 \cdot 1.0 \cdot 0.6 \cdot 0.99 = 2.3 \cdot 10^5$ cycles

5.7 Misalignment

Bearings operating with proper shaft alignment are uniformly loaded along their length as shown in Fig. 15. In the right side of Fig. 15 is a top view of the contact area. Shaft misalignment reduces the contact area and shifts the bearing pressure distribution to one end of the bearing, as illustrated in Fig. 16. With substantial

misalignment the contact area reduces to a parabolic shape as shown in Fig. 17. The concentrated edge pressure due to the excessive misalignment can cause bearing failure. When the edge pressure produces stresses that approach or exceed the compressive strength of the material, fracture may occur.

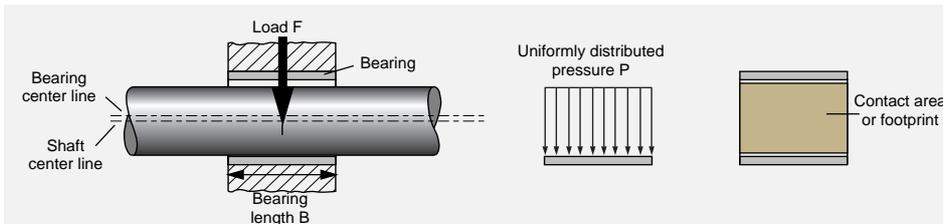


Fig. 15: Properly aligned shaft

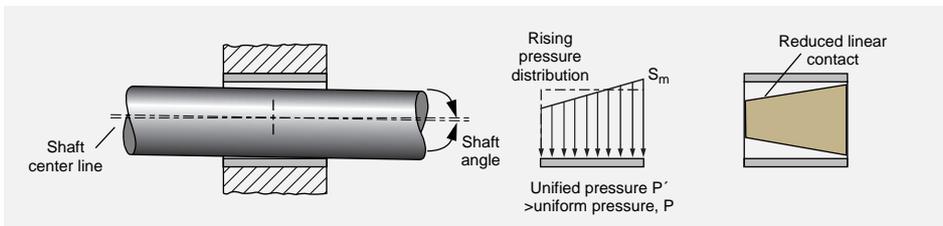


Fig. 16: Slight misalignment

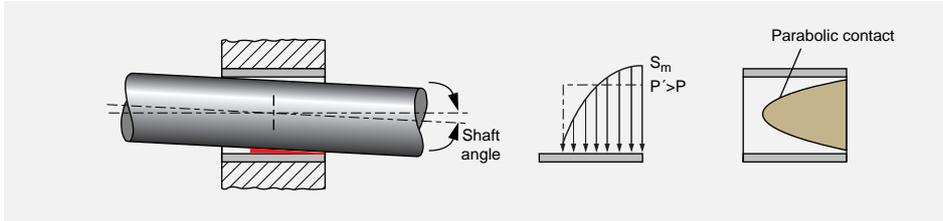


Fig. 17: Substantial misalignment

If it is known from experience that misalignment and/or shaft deflections are minimal, less than 0.2 %, (0.002 mm/mm of length [0.002 inch/inch of length]), for highly loaded, very low speed applications, then the following misalignment considerations can be ignored.

Misalignment tests were conducted on GAR-MAX bearings to determine the maximum edge stresses that may occur under varying amounts of misalignment. Fig. 18 and Fig. 19 show the relationship of the calculated edge stress, S_m , relative

to the applied unit load, P , for two levels of misalignment (0.6% and 1.0%) and two length-to-diameter ratios ($B/D_i = 0.5$ and $B/D_i = 1.0$). For static loading, or static combined with shock loading, if the edge stress, S_m , exceeds the acceptable maximum of 345 MPa [50,000 psi] for GAR-MAX and MLG or 517 MPa [75,000 psi] for HSG, then a redesign of the bearing is required.

GAR-FIL is not recommended for applications when significant misalignment is anticipated.

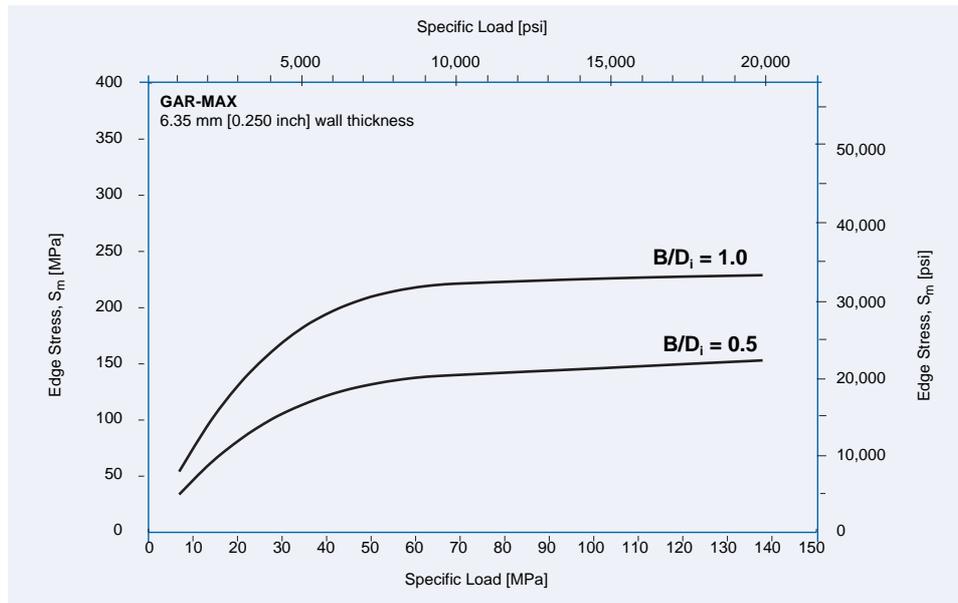


Fig. 18: Edge Stress for 0.6% Misalignment

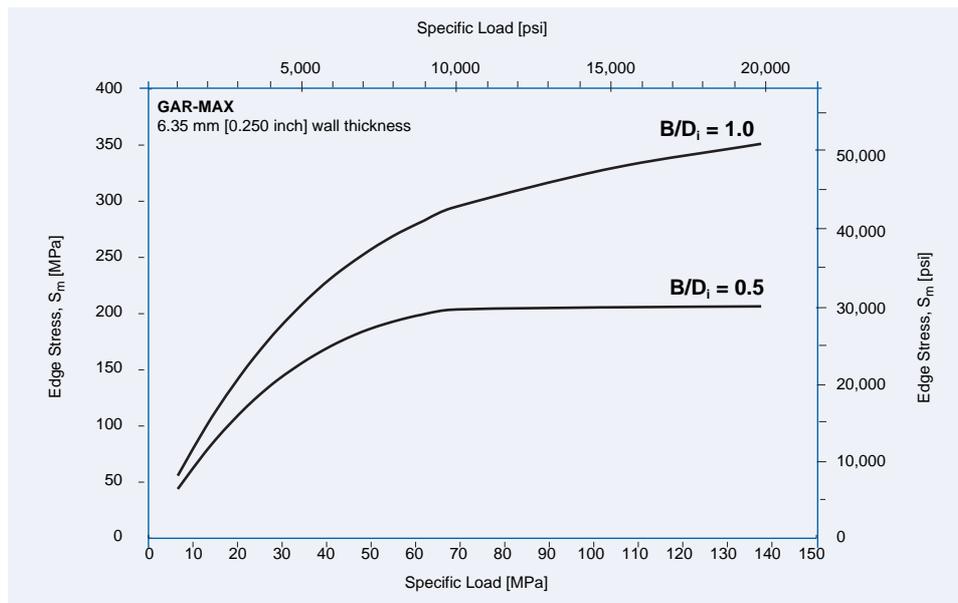


Fig. 19: Edge Stress for 1.0% Misalignment

6 Installation and Machining

6.1 Installation

The retention of GGB filament wound bearings in metal housings is excellent due to the high material stiffness and a thermal expansion rate similar to steel. The press fits used for bronze bearings are adequate for filament wound bearings in most cases.

The bearing will close in by an amount equal to the measure of interference with the housing. This close-in must be considered when calculating the installed bore and corresponding shaft diameter.

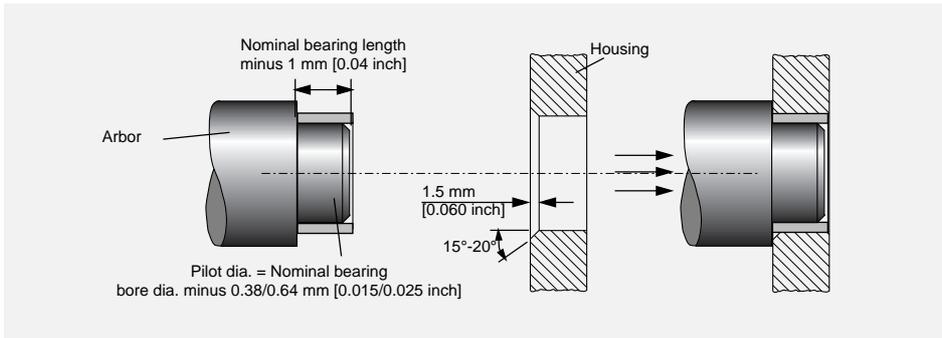


Fig. 20: Fitting of bearings

6.2 Machining

Length

Abrasive cut-off wheels produce the best results when cutting lengths of GGB filament wound bearings. When using a lathe to cut off lengths, we recommend using a carbide tool due to the abrasive

nature of the fiberglass/epoxy outer shell. Water mist or exhaust dust collectors should be used to minimize dust in the work area.

Outer Diameter

Grinding is the preferred method of altering the OD; however, carbide lathe tools can also be used.

Inner Diameter

Only GAR-FIL and HPF bearings can be sized on the ID. We recommend specifying 0.76 mm [0.030 inch] or thicker tape liner when ordering bearings that will be bored. When lathe boring a GAR-FIL or HPF

bearing you should first install the bearing into a rigid housing and bore using high speed and low feed rate. GAR-FIL and HPF bearings can also be reamed and broached.

Deburring

Emery cloth is effective in removing burrs from the OD of GGB filament wound bearings. To remove frayed fibers from the ID of GAR-MAX, HSG, MLG and HPM

bearings, a small hand held grinder is preferred. The ID of GAR-FIL or HPF bearings can be deburred by a sharp cutting tool or emery cloth.

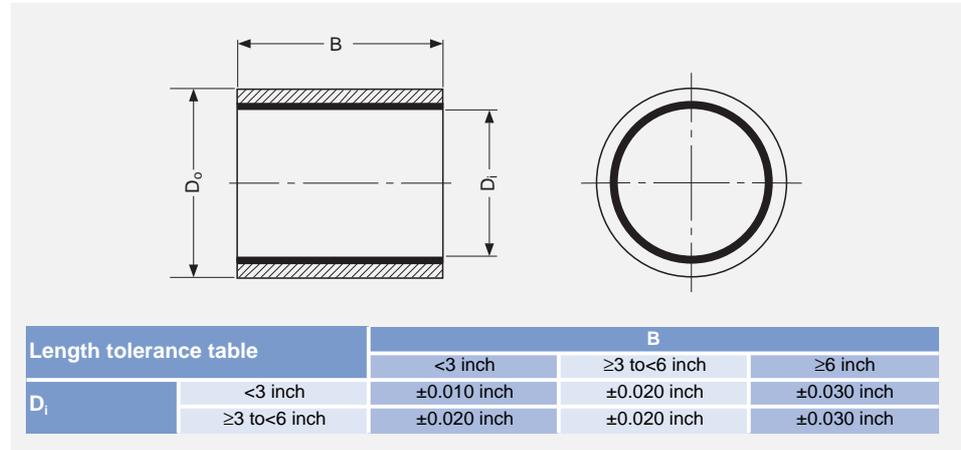
Drilling

Carbide drills should be used for drilling GGB filament wound bearings. When drilling GAR-MAX, HSG, MLG and HPM bearings, the ID must be supported with a mandrel, and a flat tipped drill or end mill should be used.

7 Standard Products

7.1 GF, GM, HSG, MLG (inch sizes)

1/8" wall series



To order, specify bearing material prefix and size number plus suffix for desired length (in multiples of 1/16"). e.g. GM2428-032 is a 1.5" ID x 1.75" OD x 2" long GAR-MAX bearing.

Bearing Part Number GF, GM, HSG, MLG	Nominal Size ID x OD D _i x D _o	Bearing ID D _i	Bearing OD D _o	Recommended Sizes		Running Clearance C _D
				Shaft Dia. D _J	Housing Dia. D _H	
0812-xxx	1/2 x 3/4	0.5040	0.7535	0.5000	0.7500	0.0005
		0.5070	0.7515	0.4995	0.7505	0.0065
1014-xxx	5/8 x 7/8	0.6290	0.8785	0.6250	0.8750	0.0005
		0.6320	0.8765	0.6245	0.8755	0.0065
1216-xxx	3/4 x 1	0.7540	1.0035	0.7500	1.0000	0.0005
		0.7570	1.0015	0.7495	1.0005	0.0065
1418-xxx	7/8 x 1 1/8	0.8790	1.1285	0.8750	1.1250	0.0005
		0.8820	1.1265	0.8745	1.1255	0.0065
1620-xxx	1 x 1 1/4	1.0040	1.2535	1.0000	1.2500	0.0005
		1.0070	1.2515	0.9995	1.2505	0.0065
1822-xxx	1 1/8 x 1 3/8	1.1290	1.3785	1.1250	1.3750	0.0005
		1.1320	1.3765	1.1245	1.3755	0.0065
2024-xxx	1 1/4 x 1 1/2	1.2540	1.5035	1.2500	1.5000	0.0005
		1.2570	1.5015	1.2495	1.5005	0.0065
2226-xxx	1 3/8 x 1 5/8	1.3790	1.6285	1.3750	1.6250	0.0005
		1.3820	1.6265	1.3745	1.6255	0.0065
2428-xxx	1 1/2 x 1 3/4	1.5040	1.7535	1.5000	1.7500	0.0005
		1.5070	1.7515	1.4995	1.7505	0.0065
2630-xxx	1 5/8 x 1 7/8	1.6290	1.8785	1.6250	1.8750	0.0005
		1.6320	1.8765	1.6245	1.8755	0.0065
2832-xxx	1 3/4 x 2	1.7550	2.0035	1.7500	2.0000	0.0015
		1.7580	2.0015	1.7495	2.0005	0.0075
3034-xxx	1 7/8 x 2 1/8	1.8800	2.1285	1.8750	2.1250	0.0015
		1.8830	2.1265	1.8745	2.1255	0.0075
3236-xxx	2 x 2 1/4	2.0055	2.2545	2.0000	2.2500	0.0010
		2.0095	2.2525	1.9995	2.2510	0.0085
3438-xxx	2 1/8 x 2 3/8	2.1305	2.3795	2.1250	2.3750	0.0010
		2.1345	2.3775	2.1245	2.3760	0.0085
3640-xxx	2 1/4 x 2 1/2	2.2555	2.5045	2.2500	2.5000	0.0010
		2.2595	2.5025	2.2495	2.5010	0.0085
3842-xxx	2 3/8 x 2 5/8	2.3805	2.6295	2.3750	2.6250	0.0010
		2.3845	2.6275	2.3740	2.6260	0.0090
4044-xxx	2 1/2 x 2 3/4	2.5060	2.7545	2.5000	2.7500	0.0015
		2.5100	2.7525	2.4990	2.7510	0.0095

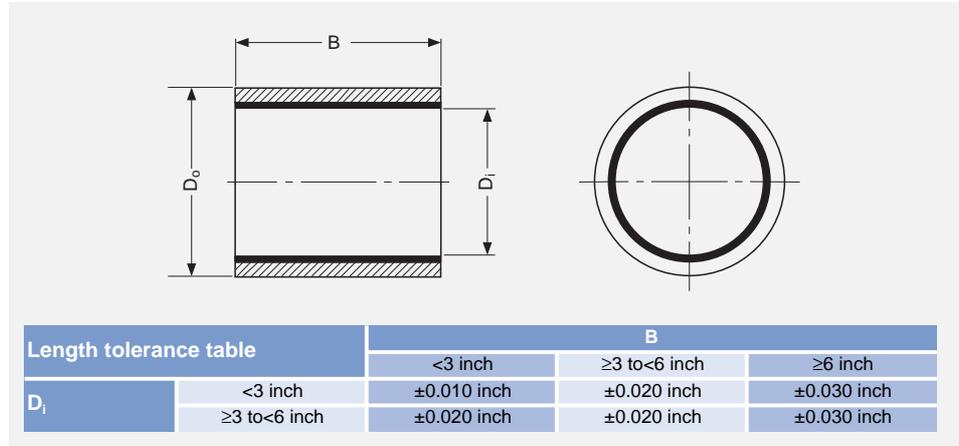
Bearing Part Number GF, GM, HSG, MLG	Nominal Size ID x OD D _i x D _o	Bearing ID D _i	Bearing OD D _o	Recommended Sizes		Running Clearance C _D
				Shaft Dia. D _J	Housing Dia. D _H	
4448-xxx	2 ³ / ₄ x 3	2.7560 2.7600	3.0050 3.0030	2.7500 2.7490	3.0000 3.0015	0.0010 0.0095
4852-xxx	3 x 3 ¹ / ₄	3.0065 3.0105	3.2550 3.2530	3.0000 2.9990	3.2500 3.2515	0.0015 0.0100
5256-xxx	3 ¹ / ₄ x 3 ¹ / ₂	3.2565 3.2605	3.5055 3.5035	3.2500 3.2490	3.5000 3.5020	0.0010 0.0100
5660-xxx	3 ¹ / ₂ x 3 ³ / ₄	3.5065 3.5105	3.7555 3.7535	3.5000 3.4990	3.7500 3.7520	0.0010 0.0100
6064-xxx	3 ³ / ₄ x 4	3.7565 3.7605	4.0055 4.0035	3.7500 3.7490	4.0000 4.0020	0.0010 0.0100
6468-xxx	4 x 4 ¹ / ₄	4.0090 4.0140	4.2570 4.2540	4.0000 3.9990	4.2500 4.2520	0.0020 0.0130
6872-xxx	4 ¹ / ₄ x 4 ¹ / ₂	4.2590 4.2640	4.5070 4.5040	4.2500 4.2490	4.5000 4.5020	0.0020 0.0130
7276-xxx	4 ¹ / ₂ x 4 ³ / ₄	4.5090 4.5140	4.7570 4.7540	4.5000 4.4990	4.7500 4.7520	0.0020 0.0130
7680-xxx	4 ³ / ₄ x 5	4.7590 4.7640	5.0070 5.0040	4.7500 4.7490	5.0000 5.0020	0.0020 0.0130
8084-xxx	5 x 5 ¹ / ₄	5.0090 5.0140	5.2570 5.2540	5.0000 4.9990	5.2500 5.2520	0.0020 0.0130
8488-xxx	5 ¹ / ₄ x 5 ¹ / ₂	5.2590 5.2640	5.5070 5.5040	5.2500 5.2490	5.5000 5.5020	0.0020 0.0130
8892-xxx	5 ¹ / ₂ x 5 ³ / ₄	5.5090 5.5140	5.7570 5.7540	5.5000 5.4990	5.7500 5.7520	0.0020 0.0130
9296-xxx	5 ³ / ₄ x 6	5.7590 5.7640	6.0070 6.0040	5.7500 5.7490	6.0000 6.0020	0.0020 0.0130
96100-xxx	6 x 6 ¹ / ₄	6.0120 6.0180	6.2590 6.2550	6.0000 5.9985	6.2500 6.2520	0.0030 0.0165

All Dimensions in Inches.

Additional sizes available - please consult
GGB Customer Service.

GF, GM, HSG, MLG (inch sizes)

1/4" wall series



To order, specify bearing material prefix and size number plus suffix for desired length (in multiples of 1/16"). e.g. GM2432-032 is a 1.5" ID x 2" OD x 2" long GAR-MAX bearing.

Bearing Part Number GF, GM, HSG, MLG	Nominal Size ID x OD D _i x D _o	Bearing ID D _i	Bearing OD D _o	Recommended Sizes		Running Clearance C _D
				Shaft Dia. D _J	Housing Dia. D _H	
0816-xxx	1/2 x 1	0.5040 0.5070	1.0035 1.0015	0.5000 0.4995	1.0000 1.0005	0.0005 0.0065
1018-xxx	5/8 x 1 1/8	0.6290 0.6320	1.1285 1.1265	0.6250 0.6245	1.1250 1.1255	0.0005 0.0065
1220-xxx	3/4 x 1 1/4	0.7540 0.7570	1.2535 1.2515	0.7500 0.7495	1.2500 1.2505	0.0005 0.0065
1422-xxx	7/8 x 1 3/8	0.8790 0.8820	1.3785 1.3765	0.8750 0.8745	1.3750 1.3755	0.0005 0.0065
1624-xxx	1 x 1 1/2	1.0040 1.0070	1.5035 1.5015	1.0000 0.9995	1.5000 1.5005	0.0005 0.0065
1826-xxx	1 1/8 x 1 5/8	1.1290 1.1320	1.6285 1.6265	1.1250 1.1245	1.6250 1.6255	0.0005 0.0065
2028-xxx	1 1/4 x 1 3/4	1.2540 1.2570	1.7535 1.7515	1.2500 1.2495	1.7500 1.7505	0.0005 0.0065
2230-xxx	1 3/8 x 1 7/8	1.3790 1.3820	1.8785 1.8765	1.3750 1.3745	1.8750 1.8755	0.0005 0.0065
2432-xxx	1 1/2 x 2	1.5040 1.5070	2.0035 2.0015	1.5000 1.4995	2.0000 2.0005	0.0005 0.0065
2634-xxx	1 5/8 x 2 1/8	1.6290 1.6320	2.1285 2.1265	1.6250 1.6245	2.1250 2.1255	0.0005 0.0065
2836-xxx	1 3/4 x 2 1/4	1.7550 1.7580	2.2545 2.2525	1.7500 1.7495	2.2500 2.2510	0.0005 0.0070
3038-xxx	1 7/8 x 2 3/8	1.8800 1.8830	2.3795 2.3775	1.8750 1.8745	2.3750 2.3760	0.0005 0.0070
3240-xxx	2 x 2 1/2	2.0055 2.0095	2.5045 2.5025	2.0000 1.9995	2.5000 2.5010	0.0010 0.0085
3442-xxx	2 1/8 x 2 5/8	2.1305 2.1345	2.6295 2.6275	2.1250 2.1245	2.6250 2.6260	0.0010 0.0085
3644-xxx	2 1/4 x 2 3/4	2.2555 2.2595	2.7545 2.7525	2.2500 2.2495	2.7500 2.7510	0.0010 0.0085
3846-xxx	2 3/8 x 2 7/8	2.3805 2.3845	2.8795 2.8775	2.3750 2.3740	2.8750 2.8760	0.0010 0.0090
4048-xxx	2 1/2 x 3	2.5060 2.5100	3.0050 3.0030	2.5000 2.4990	3.0000 3.0015	0.0010 0.0095
4452-xxx	2 3/4 x 3 1/4	2.7560 2.7600	3.2550 3.2530	2.7500 2.7490	3.2500 3.2515	0.0010 0.0095

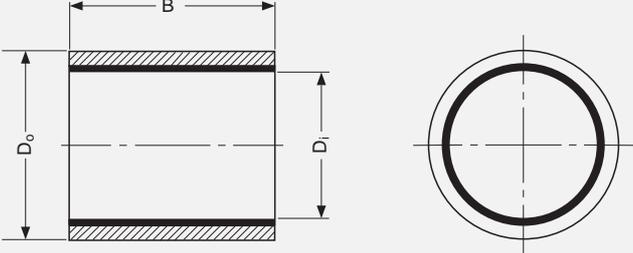
Bearing Part Number GF, GM, HSG, MLG	Nominal Size ID x OD D _i x D _o	Bearing ID D _i	Bearing OD D _o	Recommended Sizes		Running Clearance C _D
				Shaft Dia. D _J	Housing Dia. D _H	
4856-xxx	3 x 3 ¹ / ₂	3.0065 3.0105	3.5055 3.5035	3.0000 2.9990	3.5000 3.5020	0.0010 0.0100
5260-xxx	3 ¹ / ₄ x 3 ³ / ₄	3.2565 3.2605	3.7555 3.7535	3.2500 3.2490	3.7500 3.7520	0.0010 0.0100
5664-xxx	3 ¹ / ₂ x 4	3.5065 3.5105	4.0055 4.0035	3.5000 3.4990	4.0000 4.0020	0.0010 0.0100
6068-xxx	3 ³ / ₄ x 4 ¹ / ₄	3.7565 3.7605	4.2555 4.2535	3.7500 3.7490	4.2500 4.2520	0.0010 0.0100
6472-xxx	4 x 4 ¹ / ₂	4.0090 4.0140	4.5070 4.5040	4.0000 3.9990	4.5000 4.5020	0.0020 0.0130
6876-xxx	4 ¹ / ₄ x 4 ³ / ₄	4.2590 4.2640	4.7570 4.7540	4.2500 4.2490	4.7500 4.7520	0.0020 0.0130
7280-xxx	4 ¹ / ₂ x 5	4.5090 4.5140	5.0070 5.0040	4.5000 4.4990	5.0000 5.0020	0.0020 0.0130
7684-xxx	4 ³ / ₄ x 5 ¹ / ₄	4.7590 4.7640	5.2570 5.2540	4.7500 4.7490	5.2500 5.2520	0.0020 0.0130
8088-xxx	5 x 5 ¹ / ₂	5.0090 5.0140	5.5070 5.5040	5.0000 4.9990	5.5000 5.5020	0.0020 0.0130
8492-xxx	5 ¹ / ₄ x 5 ³ / ₄	5.2590 5.2640	5.7570 5.7540	5.2500 5.2490	5.7500 5.7520	0.0020 0.0130
8896-xxx	5 ¹ / ₂ x 6	5.5090 5.5140	6.0070 6.0040	5.5000 5.4990	6.0000 6.0020	0.0020 0.0130
92100-xxx	5 ³ / ₄ x 6 ¹ / ₄	5.7590 5.7640	6.2570 6.2540	5.7500 5.7490	6.2500 6.2520	0.0020 0.0013
96104-xxx	6 x 6 ¹ / ₂	6.0120 6.0180	6.5090 6.5050	6.0000 5.9985	6.5000 6.5020	0.0030 0.0165

All Dimensions in Inches.

Additional sizes available - please consult
GGB Customer Service.

7.2 GF, GM, HSG, MLG (metric sizes)

2.5 mm wall series



Length tolerance table		B		
		<75 mm	≥75 to <150 mm	≥150 mm
D _i	<75 mm	-0.50 mm	-1.00 mm	-1.50 mm
	≥75 to <150 mm	-1.00 mm	-1.00 mm	-1.50 mm

To order, specify bearing ID, OD and length size number (in millimeters) plus material suffix. e.g. 253020GM is a 25 mm ID x 30 mm OD x 20 mm long GAR-MAX bearing.

Bearing Part Number	Nominal Size ID x OD D _i x D _o	Bearing ID D _i	Bearing OD D _o	Recommended Sizes		Running Clearance C _D
				Shaft Dia. [h8] D _J	Housing Dia. [H7] D _H	
1217xx	12 x 17	12.110 12.190	17.090 17.040	12.000 11.973	17.000 17.018	0.020 0.195
1520xx	15 x 20	15.110 15.190	20.090 20.040	15.000 14.973	20.000 20.021	0.020 0.198
1621xx	16 x 21	16.110 16.190	21.090 21.040	16.000 15.973	21.000 21.021	0.020 0.198
1823xx	18 x 23	18.110 18.190	23.090 23.040	18.000 17.973	23.000 23.021	0.020 0.198
2025xx	20 x 25	20.110 20.190	25.090 25.040	20.000 19.967	25.000 25.021	0.020 0.204
2227xx	22 x 27	22.110 22.190	27.090 27.040	22.000 21.967	27.000 27.021	0.020 0.204
2530xx	25 x 30	25.110 25.190	30.090 30.040	25.000 24.967	30.000 30.021	0.020 0.204
2833xx	28 x 33	28.115 28.195	33.095 33.045	28.000 27.967	33.000 33.025	0.020 0.208
3035xx	30 x 35	30.115 30.195	35.095 35.045	30.000 29.967	35.000 35.025	0.020 0.208
3540xx	35 x 40	35.115 35.195	40.095 40.045	35.000 34.961	40.000 40.025	0.020 0.214
4045xx	40 x 45	40.115 40.195	45.095 45.045	40.000 39.961	45.000 45.025	0.020 0.214
4550xx	45 x 50	45.125 45.225	50.100 50.050	45.000 44.961	50.000 50.025	0.025 0.239
5055xx	50 x 55	50.125 50.225	55.100 55.055	50.000 49.961	55.000 55.030	0.025 0.239
5560xx	55 x 60	55.140 55.240	60.115 60.065	55.000 54.954	60.000 60.030	0.025 0.251
6065xx	60 x 65	60.140 60.240	65.115 65.065	60.000 59.954	65.000 65.030	0.025 0.251
6570xx	65 x 70	65.140 65.240	70.115 70.065	65.000 64.954	70.000 70.030	0.025 0.251
7075xx	70 x 75	70.145 70.245	75.115 75.065	70.000 69.954	75.000 75.030	0.030 0.256
7580xx	75 x 80	75.165 75.265	80.125 80.070	75.000 74.954	80.000 80.030	0.040 0.271

Bearing Part Number GF, GM, HSG, MLG	Nominal Size ID x OD D _i x D _o	Bearing ID D _i	Bearing OD D _o	Recommended Sizes		Running Clearance C _D
				Shaft Dia. [h8] D _J	Housing Dia. [H7] D _H	
8085xx	80 x 85	80.165 80.265	85.125 85.075	80.000 79.954	85.000 85.035	0.040 0.271
8590xx	85 x 90	85.165 85.265	90.125 90.075	85.000 84.946	90.000 90.035	0.040 0.279
9095xx	90 x 95	90.175 90.275	95.135 95.085	90.000 89.946	95.000 95.035	0.040 0.279
95100xx	95 x 100	95.175 95.300	100.135 100.085	95.000 94.946	100.000 100.035	0.040 0.304
100105xx	100 x 105	100.175 100.300	105.135 105.085	100.000 99.946	105.000 105.035	0.040 0.304
110115xx	110 x 115	110.175 110.300	115.135 115.080	110.000 109.946	115.000 115.035	0.040 0.309
120125xx	120 x 125	120.205 120.330	125.165 125.105	120.000 119.946	125.000 125.040	0.040 0.319
130135xx	130 x 135	130.205 130.330	135.165 135.090	130.000 129.937	135.000 135.040	0.040 0.343
140145xx	140 x 145	140.205 140.330	145.165 145.090	140.000 139.937	145.000 145.040	0.040 0.343
150155xx	150 x 155	150.205 150.330	155.165 155.090	150.000 149.937	155.000 155.040	0.040 0.343

All Dimensions in Millimeters.

Additional sizes available - please consult
GGB Customer Service.

GF, GM, HSG, MLG (metric sizes)

5 mm wall series

Length tolerance table		B		
		<75 mm	≥75 to <150 mm	≥150 mm
D _i	<75 mm	-0.50 mm	-1.00 mm	-1.50 mm
	≥75 to <150 mm	-1.00 mm	-1.00 mm	-1.50 mm

To order, specify bearing ID, OD and length size number (in millimeters) plus material suffix. e.g. 253520GM is a 25 mm ID x 35 mm OD x 20 mm long GAR-MAX bearing.

Bearing Part Number GF, GM, HSG, MLG	Nominal Size ID x OD D _i x D _o	Bearing ID D _i	Bearing OD D _o	Recommended Sizes		Running Clearance C _D
				Shaft Dia. [h8] D _J	Housing Dia. [H7] D _H	
1222xx	12 x 22	12.110 12.190	22.090 22.040	12.000 11.973	22.000 22.021	0.020 0.198
1525xx	15 x 25	15.110 15.190	25.090 25.040	15.000 14.973	25.000 25.021	0.020 0.198
1626xx	16 x 26	16.110 16.190	26.090 26.040	16.000 15.973	26.000 26.021	0.020 0.198
1828xx	18 x 28	18.110 18.190	28.090 28.040	18.000 17.973	28.000 28.021	0.020 0.198
2030xx	20 x 30	20.110 20.190	30.090 30.040	20.000 19.967	30.000 30.021	0.020 0.204
2232xx	22 x 32	22.115 22.195	32.095 32.045	22.000 21.967	32.000 32.025	0.020 0.208
2535xx	25 x 35	25.115 25.195	35.095 35.045	25.000 24.967	35.000 35.025	0.020 0.208
2838xx	28 x 38	28.115 28.195	38.095 38.045	28.000 27.967	38.000 38.025	0.020 0.208
3040xx	30 x 40	30.115 30.195	40.095 40.045	30.000 29.967	40.000 40.025	0.020 0.208
3545xx	35 x 45	35.115 35.195	45.095 45.045	35.000 34.961	45.000 45.025	0.020 0.214
4050xx	40 x 50	40.115 40.195	50.095 50.045	40.000 39.961	50.000 50.025	0.020 0.214
4555xx	45 x 55	45.130 45.230	55.105 55.055	45.000 44.961	55.000 55.030	0.025 0.244
5060xx	50 x 60	50.130 50.230	60.105 60.055	50.000 49.961	60.000 60.030	0.025 0.244
5565xx	55 x 65	55.140 55.240	65.115 65.065	55.000 54.954	65.000 65.030	0.025 0.251
6070xx	60 x 70	60.140 60.240	70.115 70.065	60.000 59.954	70.000 70.030	0.025 0.251
6575xx	65 x 75	65.140 65.240	75.115 75.065	65.000 64.954	75.000 75.030	0.025 0.251
7080xx	70 x 80	70.145 70.245	80.115 80.065	70.000 69.954	80.000 80.030	0.030 0.256
7585xx	75 x 85	75.165 75.265	85.125 85.075	75.000 74.954	85.000 85.035	0.040 0.271

Bearing Part Number	Nominal Size ID x OD D _i x D _o	Bearing ID D _i	Bearing OD D _o	Recommended Sizes		Running Clearance C _D
				Shaft Dia. [h8] D _J	Housing Dia. [H7] D _H	
8090xx	80 x 90	80.165 80.265	90.125 90.075	80.000 79.954	90.000 90.035	0.040 0.271
8595xx	85 x 95	85.165 85.265	95.125 95.075	85.000 84.946	95.000 95.035	0.040 0.279
90100xx	90 x 100	90.175 90.275	100.135 100.085	90.000 89.946	100.000 100.035	0.040 0.279
95105xx	95 x 105	95.175 95.300	105.135 105.085	95.000 94.946	105.000 105.035	0.040 0.304
100110xx	100 x 110	100.175 100.300	110.135 110.085	100.000 99.946	110.000 110.035	0.040 0.304
110120xx	110 x 120	110.175 110.300	120.135 120.085	110.000 109.946	120.000 120.035	0.040 0.304
120130xx	120 x 130	120.205 120.330	130.165 130.090	120.000 119.946	130.000 130.040	0.040 0.334
130140xx	130 x 140	130.205 130.330	140.165 140.090	130.000 129.937	140.000 140.040	0.040 0.343
140150xx	140 x 150	140.205 140.330	150.165 150.090	140.000 139.937	150.000 150.040	0.040 0.343
150160xx	150 x 160	150.205 150.330	160.165 160.090	150.000 149.937	160.000 160.040	0.040 0.343

All Dimensions in Millimeters.

Additional sizes available - please consult
GGB Customer Service.

7.3 MEGALIFE XT, Thrust Bearings, Inch sizes

To order, specify MWXT size number plus suffix for desired thickness (062, 080, 125). e.g. MWXT1632-080 is a 1" ID x 2" OD x 0.080" thick **MEGALIFE XT** thrust bearing.

Part Number	Nominal Size ID x OD	Nominal Thickness
MWXT0816-xxx	1/2 x 1	0.062, 0.080
MWXT1020-xxx	5/8 x 1 1/4	0.062, 0.080, 0.125
MWXT1224-xxx	3/4 x 1 1/2	0.062, 0.080, 0.125
MWXT1428-xxx	7/8 x 1 3/4	0.062, 0.080, 0.125
MWXT1632-xxx	1 x 2	0.062, 0.080, 0.125
MWXT1834-xxx	1 1/8 x 2 1/8	0.062, 0.080, 0.125
MWXT2036-xxx	1 1/4 x 2 1/4	0.062, 0.080, 0.125
MWXT2238-xxx	1 3/8 x 2 3/8	0.062, 0.080, 0.125
MWXT2440-xxx	1 1/2 x 2 1/2	0.062, 0.080, 0.125
MWXT2642-xxx	1 5/8 x 2 5/8	0.062, 0.080, 0.125
MWXT2844-xxx	1 3/4 x 2 3/4	0.062, 0.080, 0.125
MWXT3248-xxx	2 x 3	0.062, 0.080, 0.125
MWXT3652-xxx	2 1/4 x 3 1/4	0.062, 0.080, 0.125
MWXT4060-xxx	2 1/2 x 3 3/4	0.062, 0.080, 0.125
MWXT4464-xxx	2 3/4 x 4	0.062, 0.080, 0.125
MWXT4872-xxx	3 x 4 1/2	0.062, 0.080, 0.125

All Dimensions in Inches.

Additional sizes available - please consult GGB Customer Service.

7.4 MEGALIFE XT, Thrust Bearings, Metric sizes

To order, specify MWXTM size number plus suffix for desired thickness (15; 20; 30).

e.g. MWXTM2244-20 is a 22 mm ID x 44 mm OD x 2 mm thick **MEGALIFE XT** thrust bearing.

Part Number	Nominal Size ID x OD	Nominal Thickness
MWXTM1224-xx	12 x 24	1.5, 2.0 mm
MWXTM1530-xx	15 x 30	1.5, 2.0, 3.0 mm
MWXTM1836-xx	18 x 36	1.5, 2.0, 3.0 mm
MWXTM2040-xx	20 x 40	1.5, 2.0, 3.0 mm
MWXTM2244-xx	22 x 44	1.5, 2.0, 3.0 mm
MWXTM2550-xx	25 x 50	1.5, 2.0, 3.0 mm
MWXTM3055-xx	30 x 55	1.5, 2.0, 3.0 mm
MWXTM3560-xx	35 x 60	1.5, 2.0, 3.0 mm
MWXTM4065-xx	40 x 65	1.5, 2.0, 3.0 mm
MWXTM4570-xx	45 x 70	1.5, 2.0, 3.0 mm
MWXTM5075-xx	50 x 75	1.5, 2.0, 3.0 mm
MWXTM5580-xx	55 x 80	1.5, 2.0, 3.0 mm
MWXTM6085-xx	60 x 85	1.5, 2.0, 3.0 mm
MWXTM6595-xx	65 x 95	1.5, 2.0, 3.0 mm
MWXTM70100-xx	70 x 100	1.5, 2.0, 3.0 mm
MWXTM75115-xx	75 x 115	1.5, 2.0, 3.0 mm

All Dimensions in Millimeters.

Additional sizes available - please consult GGB Customer Service.

8 Data Sheet for bearing design

8 Data Sheet for bearing design

Company:

Project:

Application:

Date:

Existing Design New Design
 Quantity Annual

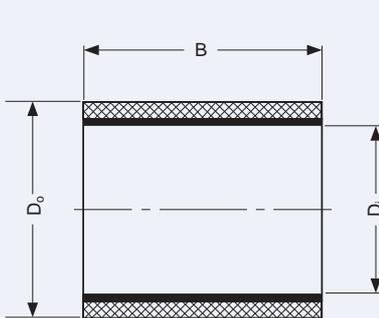
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Tel.:

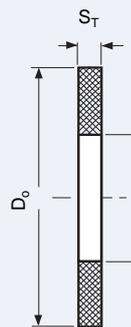
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Email:

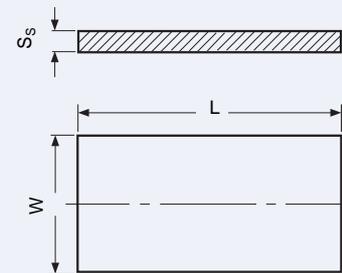
Drawing attached YES NO



Cylindrical Bush



Thrust Washer



Slideplate

Steady load Rotating load Rotational movement Oscillating movement Linear movement

Dimensions in mm

Inside Diameter D_i
 Outside Diameter D_o
 Length B
 Flange Diameter D_{fl}
 Flange Thickness S_{fl}
 Length of slideplate L
 Width of slideplate W
 Thickness of slideplate S_s

Load

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

Movement

Rotational speed N [1/min]
 Speed v [m/s]
 Length of Stroke L_s [mm]
 Frequency of Stroke [1/min]
 Angular displacement ϕ [°]
 Oscillating frequency n_{osz} [1/min]

Service hours per day

Continuous operation [h]
 Intermittent operation [h]

Fits and Tolerances

Housing (\emptyset , tolerance) D_H
 Shaft (\emptyset , tolerance) D_J

Mating surface

Material
 Hardness HB/HRC
 Surface roughness R_a [μm]

Operating Environment

Temperature - ambient T_{amb}
 Temperature - min/max T_{min}/T_{max}

Housing material

Assembly with good heat transfer properties

Assembly with poor heat transfer properties

Dry operation With lubricant

If grease, type with technical datasheet

If oil, type with technical datasheet

- Oil splash

- Oil bath

- Oil circulation

Service life

Required service life L_H [h]

9 Other GGB Bearing Materials

Whatever your application requires, GGB offers the solution with its wide range of bearing materials:

Solid Polymer Materials - Thermoplastic materials processed by injection moulding. These engineering polymers include polyamid-based EP™, polyoxymethylene-based EP12™, polybutyleneterephthalate-based EP22™, polyphenylensulfide-based EP43™ and EP44™, polyether-etherketone-based EP63™ and EP64™, and polyamidimid-based EP73™ and EP79™. EP™, EP22™, EP43™ and EP63™ are available in standard cylindrical and flanged bearings. EP22™ and EP43™ are also available as rod stock for prototype or small serial production. All EP materials are available by special order.

DP4™ - compliant with ELV directive 2000/53/EC and 2002/95/EC. DP4 (steel backing + porous bronze sinter + PTFE + fillers) bearing material is suitable for lubricated and dry applications. Standard sizes, special sizes and shapes made to order.

DP4B™ - compliant with ELV directive 2000/53/EC and 2002/95/EC. DP4B (bronze backing + porous sinter bronze + PTFE + fillers) bearing material is suitable for lubricated and dry applications. Standard sizes, special sizes and shapes made to order. Bronze backing provides improved corrosion resistance and is antimagnetic.

DU® - self-lubricating metal-polymer bearing material (steel backing + porous bronze sinter + PTFE + Pb) for dry and lubricated applications with very good wear and friction performance. Available in stock sizes. Special sizes and shapes made to order.

DU®B - self-lubricating, corrosion resistant bearing material (bronze backing + porous bronze sinter + PTFE + Pb) for dry and lubricated applications. The bronze backing provides improved corrosion resistance and is antimagnetic. Available in standard sizes, special sizes made to order.

DX® - marginally lubricated metal-polymer (steel backing + porous bronze sinter + POM) for grease and oil lubricated applications. Available in stock sizes. Special sizes and shapes made to order.

HX™ - marginally lubricated metal-polymer (steel backing with + bronze sinter + PEEK + PTFE + fillers) for grease and oil lubricated applications. Standard sizes, special sizes and shapes made to order.

...and many more.

Visit us on the internet:
www.ggbearings.com



9 Other GGB Bearing Materials

Your notes:

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.

Unless expressly declared in writing, GGB gives no warranty that the products described are suited to 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 the technical data without prior announcement.

Edition 2009 (This edition replaces earlier editions which hereby lose their validity).

Declaration on lead contents of GGB products/compliance with EU law

Since July 1, 2006 it has been prohibited under Directive 2002/95/EC (restriction of the use of certain hazardous substances in electrical and electronic equipment; ROHS Directive) to put products on the market that contain lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB) or polybrominated diphenyl ethers (PBDE).

Certain applications listed in the annex to the ROHS Directive are exempted. A maximum concentration value of 0.01% by weight and per homogeneous material, for cadmium and of 0.1% by weight and per homogeneous material, for lead, mercury, hexavalent chromium, PBB and PBDE shall be tolerated.

According to Directive 2000/53/EC on end-of life vehicles, since July 1, 2003 it has been prohibited to put on the market materials and components that contain lead, mercury, cadmium or hexavalent chromium. Due to an exceptional provision, lead-containing bearing shells and bushes could still be put on the market up until July 1, 2008. This general exception expired on July 1, 2008. A maximum concentration value of up to 0.1% by weight and per homogeneous material, for lead, hexavalent chromium and mercury shall be tolerated.

All products of GGB, with the exception of DU, DUB, DB, SY and SP satisfy these requirements of Directives 2002/95/EC (ROHS Directive) and 2000/53/EC (End-of-life Vehicle Directive).

All products manufactured by GGB are also compliant with REACH Regulation (EC) No. 1 907/2006 of December 18, 2006.

GAR-MAX®, **GAR-FIL®**, **HSG™**, **MLG™**, **HPM™**, **HPF™** and **MEGALife® XT** are trademarks of GGB.

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