

GLYCODUR® Dry bearings



Naturally lead free.

Naturally free from
materials causing
environmental pollution.

Naturally maintenance-free.

Naturally certified.

For our nature.

GLYCODUR®

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1

Sliding bearing material

1.1 Composition

GLYCODUR® dry sliding bearings are available in two standard versions, GLYCODUR® F and GLYCODUR® A.

Both versions have different sliding layers (see illustrations on page 5) according to DIN ISO 3547 type P1 and P2.

GLYCODUR® F

GLYCODUR® F sliding bearings have a copper-plated steel base, to which a 0.2 to 0.4 mm porous tin bronze layer is sintered. The pores of this layer are filled during a rolling process with polytetrafluoroethylene (PTFE) and other friction and wear reducing additives. A 5 to 30 µm top layer made of the same material forms the running-in layer.

GLYCODUR® F sliding bearings combine in optimal manner the mechanical properties of the sintered bronze with the sliding and lubrication properties of a PTFE mixture. The structure of this composite material results in good dimensional stability and good thermal conductivity.

GLYCODUR® A

GLYCODUR® A dry sliding bearings also have a copper-plated steel base and a 0.2 to 0.4 mm sintered tin bronze layer. The principal characteristic of these bearings is the polyoxymethylene (POM) top layer, which is solidly joined to the sintered bronze.

This surface layer is relatively thick, 0.3 mm, and features pockets for lubrication grease. GLYCODUR® A sliding bearings are therefore to some extent unaffected by misalignments including related edge loads.

GLYCODUR® AB

GLYCODUR® AB sliding bearings have a similar composition to GLYCODUR® A sliding bearings, but they have a 0.35 mm top layer made of POM. This allows the final machining of the sliding surface on

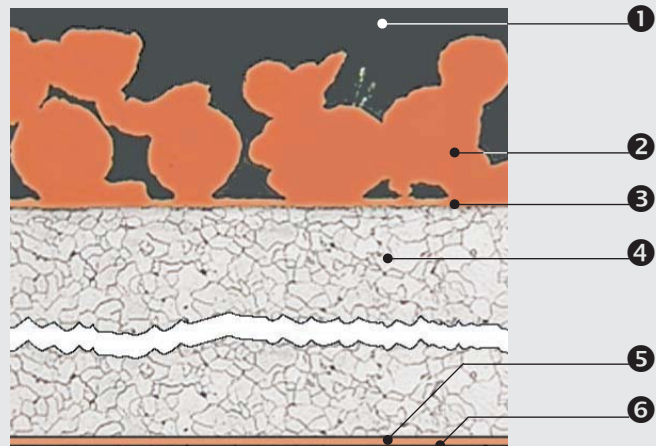
installed bushings by boring or turning, or in exceptional cases by reaming, in order to eliminate possible misalignments, or to achieve small operating clearance.

GLYCODUR®

Sliding bearing material

GLYCODUR® F

DIN ISO 3547
Type P1

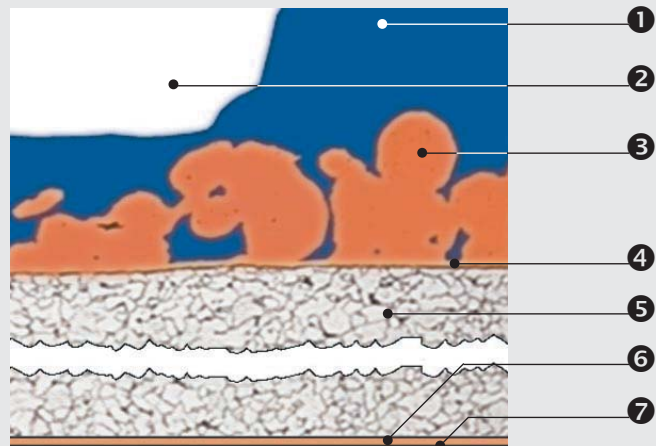


- ① Polytetrafluorethylene (PTFE)
- ② Tin bronze
- ③ Copper layer
- ④ Sheet steel backing
- ⑤ Copper layer
- ⑥ Tin layer

Figure 1.1.1 –
Microsection GLYCODUR® F

GLYCODUR® A

DIN ISO 3547
Type P2



- ① Polyoxymethylene (POM)
- ② Lubrication indentation
- ③ Tin bronze
- ④ Copper layer
- ⑤ Sheet steel backing
- ⑥ Copper layer
- ⑦ Tin layer

Figure 1.1.2 –
Microsection GLYCODUR® A

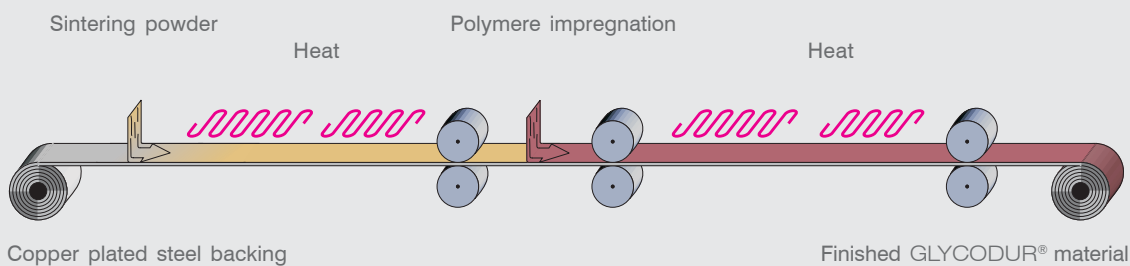


Figure 1.1.3 –
Scheme production process
GLYCODUR®

1.2 Characteristics summary of GLYCODUR® materials

Properties – mating surface requirements	GLYCODUR® F
Construction	Steel backing with sintered layer of tin bronze. Pore filling and covering layer (5 to 30 µm/ 0.0002 to 0.00118 in) of PTFE with friction reducing additives
Permissible static specific bearing load	250 MPa (36 250 psi)
Permissible dynamic specific load	80 MPa (11 600 psi)
Maximum sliding velocity	2 m/s (400 fpm)
Operating temperature	-200 to +260 °C (-330 to +500°F)
Coefficient of friction	0.03 to 0.25
Stick-slip	negligible
Wear layer thickness	0.2 mm (0.0079 in)
Lubrication	not required
Ability to support edge loads (e.g. resulting fr. misalignm.)	fair
Ability to embed dirt and foreign particles	fair
Ability to carry alternating loads	good
Ability to accommodate linear movement	fair
Machining of sliding surface after mounting	calibration

Properties – mating surface requirements	GLYCODUR® A/AB
Construction	Steel backing with sintered layer of tin bronze. Pore filling and covering layer (0.3 and 0.35 mm/ 0.0118 and 0.0138 in, resp.) of polyoxymethylene (POM)
Permissible static specific bearing load	250 MPa (36 250 psi)
Permissible dynamic specific load	120 MPa (17 400 psi)
Maximum sliding velocity	2.5 m/s (500 fpm)
Operating temperature	-40 to +110 °C (-40 to +230 °F) (+130 °C [+270 °F] for short periods)
Coefficient of friction	0.02 to 0.20
Stick-slip	negligible
Wear layer thickness	0.3 (0.35) mm (0.0118 [0.0138] in)
Lubrication	initial lubrication required
Ability to support edge loads (e.g. resulting fr. misalignm.)	good
Ability to embed dirt and foreign particles	good
Ability to carry alternating loads	fair
Ability to accommodate linear movement	good
Machining of sliding surface after mounting	drilling, turning, (reaming)

1.3 Characteristics summary of GLYCODUR® special materials

Designation	Overlay	Properties, applications	Max. tempe- rature	Lubrication	Friction	Wear resistance	Load capacity
PTFE based materials according to DIN ISO 3547 type P1							
GLYCO® 92 (GLYCODUR® F)	PTFE, MoS ₂	General dry running applications, shock absorbers, hydraulics	260 °C (500 °F)	Dry	●	●	●
				Oil	●●●	●	●
GLYCO® 97	PTFE, MoS ₂ , BN	Optimised dry bearing material, good formability	260 °C (500 °F)	Dry	●●	●●●	●●
				Oil	–	–	–
GLYCO® 298	PTFE, MoS ₂ , Additives	Optimised material for shock absorbers	260 °C (500 °F)	Dry	–	–	–
				Oil	●●●	●●●	●●
Thermoplastic based materials according to DIN ISO 3547 type P2							
GLYCO® 94 (GLYCODUR® A) (GLYCODUR® AB)	POM	With initial lubrication for industrial and automotive applications	110 °C (230 °F)	Dry	–	–	–
		With stock allowance		Grease	●●●	●●●	●●●
				Oil	–	–	–
GLYCO® 193 GLYCO® 193M	PPS, PTFE, Additives	Shock absorbers, pumps, dry applications	220 °C (428 °F)	Dry	●●●	●●●	●●●
		With stock allowance		Grease	●●●	●●●	●●●
				Oil	●	●●●	●●●
GLYCO® 95	PEEK, PTFE, C-fibres, graphite	With initial lubrication for high wear resitance	250 °C (480 °F)	Dry	–	–	–
				Grease	●●●	●●●	●●●
				Oil	●	●●●	●●●
Mesh material							
GLYCO® 90	PTFE, Additives	Hinges (clearance free bearings)	260 °C (500 °F)	Dry	●	●●●	●●●
				Grease	●	●●●	●●●
				Oil	●	●●●	●●●

– Limited applicable ● Standard ●● Superior ●●● Excellent

Please check availability.

Flanged bushings are available in the following materials:

- GLYCO® 92 (GLYCODUR® F)
- GLYCO® 97
- GLYCO® 90

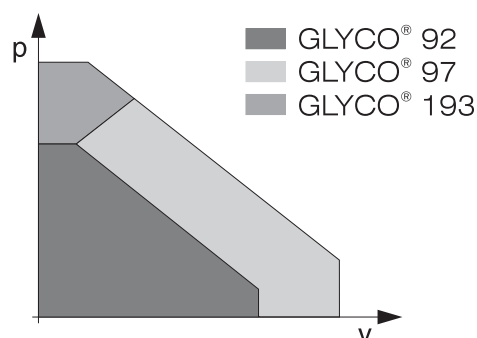


Figure 1.3.1 – pv areas, dry running (qualitative)

1.4 Friction

The friction in GLYCODUR® bearings mainly depends on the bearing load, the sliding velocity and the operating temperature. The surface roughness of the mating surface and, above all with GLYCODUR® A bearings, the lubrication conditions are also important. The coefficient of friction for GLYCODUR® F bearings is between 0.03 and 0.25 depending on the operating conditions. The coefficient of friction for

GLYCODUR® A bearings is similar, but lubrication has a stronger effect in this case. The lower coefficients of friction are typically obtained under high specific bearing loads and low sliding velocities (see diagram).

Under extremely unfavorable conditions, as well as with low loads the indicated value may even be exceeded.

GLYCODUR® bearings show negligible “stick-slip”.

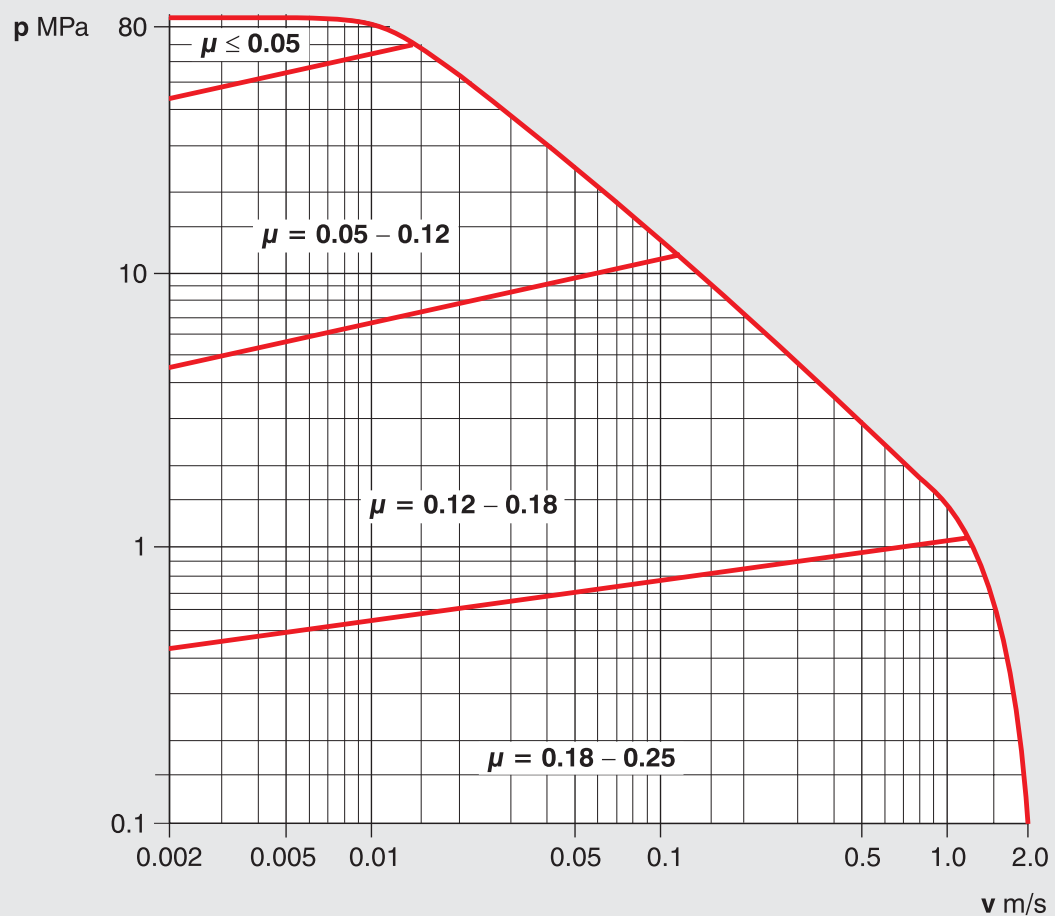


Figure 1.4.1 – Guidelines for friction coefficients for GLYCODUR® F bearings

1.5 Running-in characteristics

During the running-in phase of GLYCODUR® F bearings one part of the polytetrafluoroethylene top layer will be transferred to the mating surface.

For this reason, the characteristically low operating values for wear and friction will be obtained with GLYCODUR® F bearings after they have been run in.

1.6 Electrical properties

The sliding layer, made of POM, enables GLYCODUR® A sliding bearings to function as electrical insulators. In order

to avoid electrostatic charging, affected components must be appropriately grounded.

1.7 Chemical properties

The chemical properties of GLYCODUR® sliding bearings are mainly determined by the steel backing layer and the tin bronze sinter layer, because the sliding layers are resistant to many chemicals. The top layer of GLYCODUR® F bearings is virtually inert, due to the PTFE material used, it can be attacked by molten alkaline metals or by free fluorides at elevated temperatures. The POM top layer of GLYCODUR® A bearings is resistant to organic substances. The tin bronze sintered structure is resistant to seawater, water vapor, atmospheric effects, salt solutions and sulfuric acids at room temperature, but is not resistant to oxidising acids and media containing ammonium hydroxides.

All exposed surfaces on the steel backing are tin plated; but in most applications there is only limited protection against corrosion. If the bearings are exposed to corrosive media, or a risk of contact corrosion between the steel backing of the bearing and the housing material, the backing may be protected by a Ni, Cr, or Zn layer. Further details are available upon request. Under dry sliding conditions, there is no lubricant to provide protection against corrosion. Special attention must be paid to the corrosion properties of the mating material.

1.8 Machinability

With the exception of the sliding surface, GLYCODUR® materials can be machined by all conventional methods.

Bushings GLYCODUR® F /
GLYCODUR® A

If narrower bushings are required for certain applications, these can be obtained simply by turning or parting off a standard bushing; lubrication holes may also be added later by drilling. In any case, burrs protruding into the sliding surface after machining must be carefully removed.

GLYCODUR® F and GLYCODUR® A bushings are supplied ready for installation. Any subsequent machining of the bore, i.e. the sliding surface, should only be undertaken in exceptional cases, as this will reduce the service life of the bushings.

In some cases the bore can be calibrated using a mandrel when using GLYCODUR® F bushings (Fig. 1.8.1). When installing a GLYCODUR® F bushing with an exterior diameter D in a steel housing with the exterior diameter D_G , the adjacent diagram will show the approximate values for the required d_K of the calibration mandrel ($= d + \Delta d_K$). This diagram shows the required oversize Δd_K of the calibration mandrel as a function of the desired expansion Δd of the bushing bore for various nominal diameters d of the bushing bore; it is valid for the ratio $D_G / D = 2$. No approximate values are given for bushings mounted into light alloy housings, because the influence of the housing design and the material is too strong. In such cases the required mandrel diameter must be determined by tests.

The exposed steel surfaces resulting from machining should be protected against corrosion.

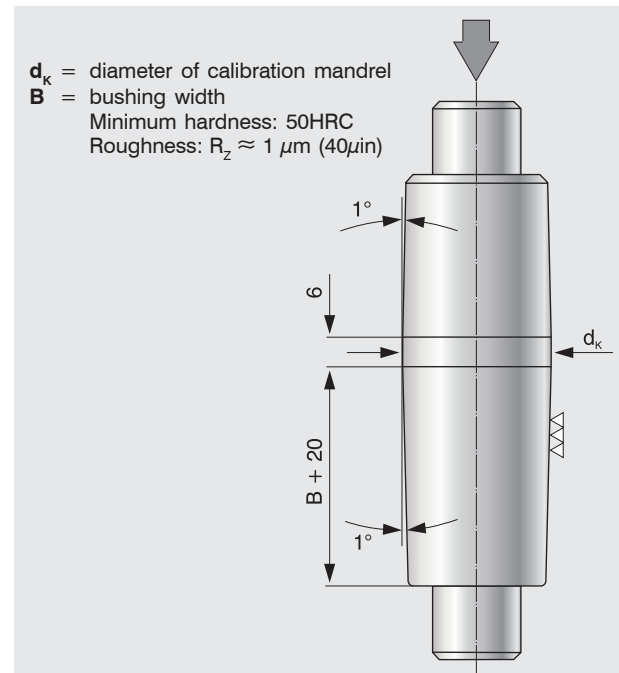


Figure 1.8.1 – Calibration mandrel

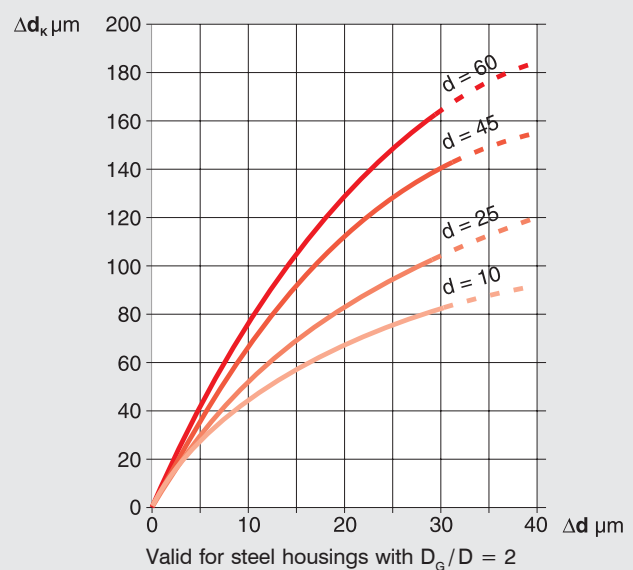


Figure 1.8.2 – Calibration behaviour of
GLYCODUR® F bushings

2.1 Design and service life estimate

Many years of goal-oriented research and development work have resulted in excellent sliding materials that cover a wide range of applications featuring maintenance-free or low maintenance operation.

The type and design of bearing to be used for a given application has to be chosen with respect to the type of load acting upon the bearing, the operating temperature which can be expected and the requirements regarding lubrication and maintenance. The following points serve as a guide for initial consideration for designing a bearing and estimating its service life.

The load capacity and wear characteristics of a GLYCODUR® bearing depend on the individual operating conditions, therefore all subsequent information and calculations are approximate values only.

To determine the required size of a bearing we recommend starting with the bearing load capacity, the prevailing loads, the service life requirements and with the operational safety.

The service life of a GLYCODUR® bearing is indicated by the number of angular movements/revolutions or as operating hours. When operating in the mixed or dry friction range, the service life is deter-

mined by the increase of the bearing clearance and/or on the increasing friction caused by progressive wear of the sliding surfaces, plastic deformation of the sliding material or fatigue in the sliding surface.

Depending on the application and the sliding material, the permissible wear or the permissible increase in friction will be different.

This means that under the same operating conditions the service life, which can be obtained in practice, will be different. This is due to the fact that depending on the application, the bearing has to meet different demands. It has also been proven that the service life, which will be obtained in practice under identical operating conditions, varies.

This applies to field as well as laboratory tests. The effective or actual service life is largely determined by the actual operating conditions. Apart from magnitude and type of load, several other factors such as contamination, corrosion, high frequency load and movement cycles, shocks, etc. have to be considered. Some of these factors may only be evaluated with extreme difficulty.

The **nominal service life** is an approximate value only, which will be achieved or exceeded by the majority of bearings.

2

Determination
of bearing
size

2.2 Selection of pv range

When determining the bearing size, the pv diagrams below may be used to give an indication of whether a given bearing can be used under the actual operating conditions (load, sliding velocity). If the check reveals that operating data is within area **I**, then the service life G_h can be determined by using the equa-

tion shown on page 13. However if the area **II** is obtained, then we recommend contacting one of our experts, or verifying the suitability of the bearing by an advance test. If necessary, the bearing size should be modified in such a way that the value for the product $p \times v$ reaches area **I**.

GLYCODUR® F

pv areas of application:

- I** Basic rating, service life equation valid.
- II** Possible area of application at optimum conditions, e. g. heat dissipation.

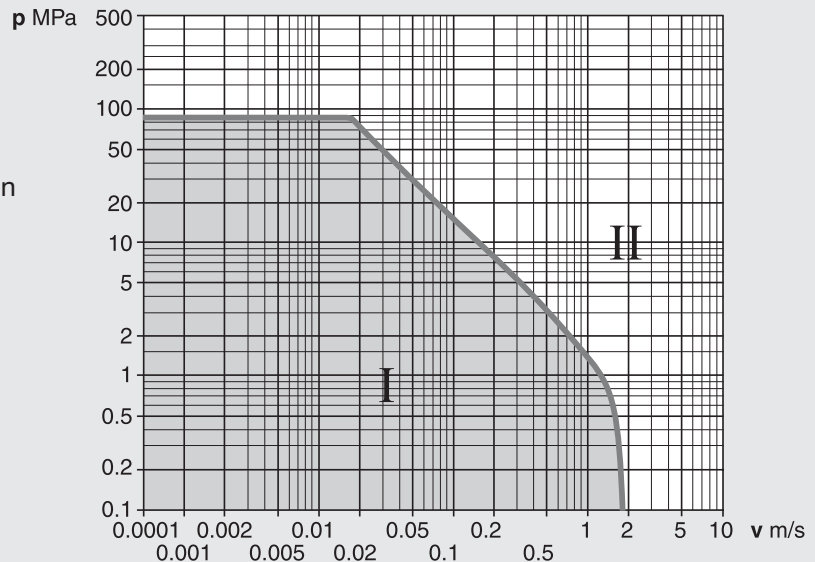


Figure 2.2.1 –
pv operating areas
GLYCODUR® F

GLYCODUR® A

pv areas of application:

- I** Basic rating, service life equation valid.
- II** Possible area of application at optimum conditions, e. g. heat dissipation.

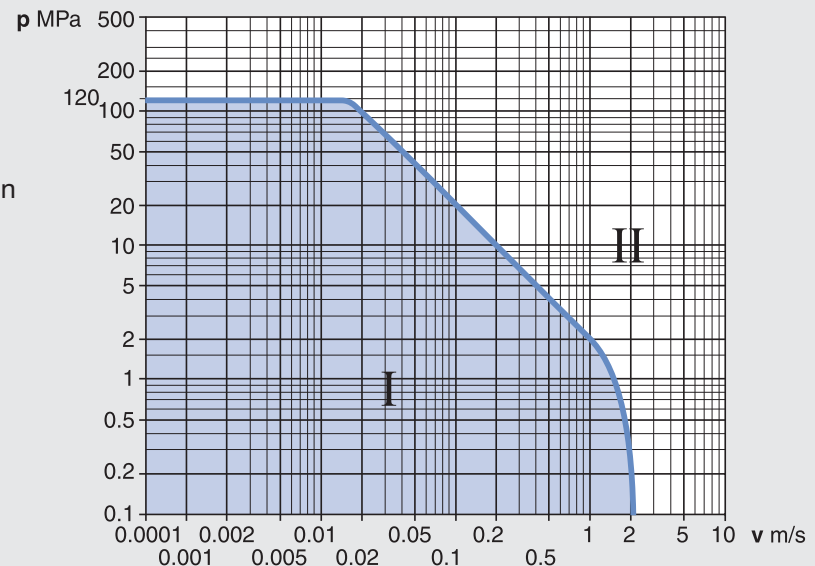


Figure 2.2.2 –
pv operating areas
GLYCODUR® A

2.3 Calculation procedure for the nominal service life

Many factors have an effect on the service life of a GLYCODUR® dry sliding bearing, e.g. load, sliding velocity, operating temperature, roughness of the mating surface etc. A calculation of the service life can therefore only be an approximation. The approximate values for the nominal service life determined by the equation below will be reached by

the majority of the bearings, and even exceeded in many cases. This has been confirmed by rig tests and historical results of actual operation.

For GLYCODUR® sliding bearings the relation between the nominal service life and the influencing factors indicated results from the equation:

$$G_h = c_1 \times c_2 \times c_3 \times c_4 \times c_5 \times \frac{K_M}{(pv)^n}$$

See calculation example on page 18 (chapter 2.14).

Where:

G_h nominal service life, operating hours

p specific bearing load, MPa

v sliding velocity, m/s

c₁ load factor (page 16)

c₂ velocity factor (page 15)

c₃ temperature factor (page 17)

c₄ roughness factor (page 18)

c₅ load distribution factor (page 16)

K_M constant depending on material and bearing type:

	GLYCODUR® F	GLYCODUR® A
Bushings	480	1900
Thrust washers	300	1900

n an exponent:

	GLYCODUR® F	GLYCODUR® A
pv ≤ 1	1	1
pv > 1	1	3

If the product **pv** of GLYCODUR® F falls below the limit value of 0.025 at very low loads and/or sliding velocities, and of

GLYCODUR® A below the limit value of 0.1, then **pv** = 0.025 or **pv** = 0.1 have to be used in the service life equation.

2.4 Specific surface load p

The specific surface load can be determined by dividing the total bearing

load by the bearing projected area (inner diameter × width).

$$p = K \times \frac{F}{C}$$

Where :

p = specific load MPa

F = dynamic bearing load N

C = dynamic load capacity N

K = specific load characteristic value MPa

GLYCODUR® F	80
GLYCODUR® A	120

The factor **K** mainly considers, that the bearing diameter and the operating clearance are increasing with increasing service

life, thus reducing the contact surface between bearing and shaft.

2.5 Sliding velocity v

The sliding velocity for bushings and thrust washers results in:

$$v = 5.82 \times 10^{-7} \times d \times \beta \times f$$

Where:

v = sliding velocity m/s

d = bore diameter of bushing mm
= mean diameter of thrust washer mm (dimension J in bearing tables, pages 36/42)

f = angular frequency or rotational frequency min⁻¹

β = half turning angle in degrees (see illustration)
= 90° in case of rotational movement

Drawing turning angle

The complete oscillation = 4β:
i.e. from point 0 to 4

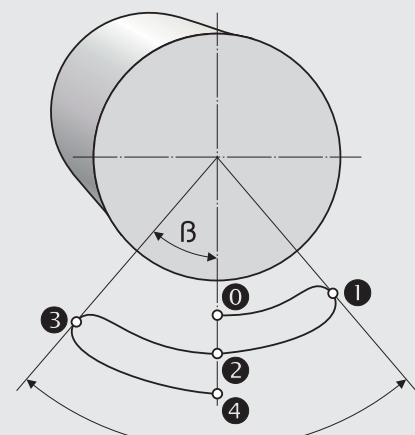


Figure. 2.5.1 – Drawing turning angle

2.6 Sliding velocity factor c_2

Increasing sliding velocity will lead to increased heat generation in the sliding surface; the wear rate increases.

Therefore, the velocity factor c_2 has to be considered when designing the bearing.

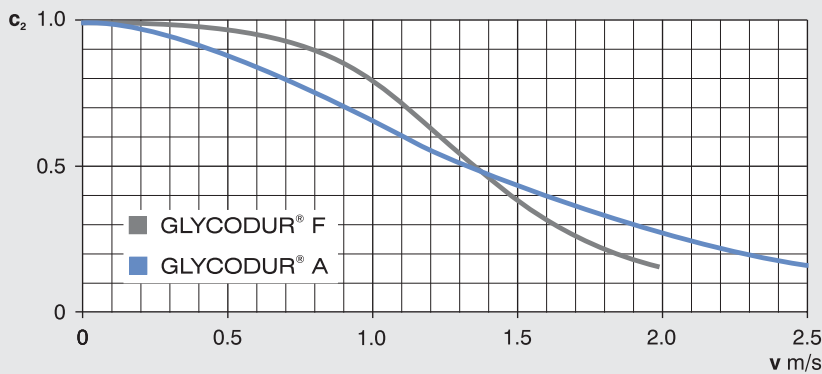


Figure 2.6.1 – Sliding velocity factor

2.7 Load capacity C and C_0

The dynamic load capacity C and the static load capacity C_0 express the load capacity of a bearing.

The basic dynamic load rating C is used for calculations when the GLYCODUR® bearing is subjected to dynamic stress. It represents the load (constant in magnitude and direction) under which a basic rating service life (expressed as a sliding distance) will be obtained for continuous oscillating movement at a defined sliding velocity and at room temperature. It presupposes that the load acting on bushings and flanged bushings is in a radial direction only and that the load acting on thrust washers is purely axial and acts concentrically.

Dynamic load refers primarily to angular and rotational movements. In addition, micro sliding movements occur, resulting from vibrations or high frequency load changes. Often, the load types mentioned represent a combination of all types.

While angular and rotational movements under load will mainly cause wear, other cases may result in material fatigue. Indication of load capacities is always dependent upon basic definitions.

Therefore, load capacity figures from different manufacturers, cannot simply be compared with each other.

The static load capacity C_0 indicates the maximum load which a bushing, flange bushing or thrust washer can support at room temperature in the static condition, without permanent deformation occurring in the sliding layer that may impair the bearing's function. At higher temperatures the static load capacity has to be reduced, depending on the sliding material combination, by the temperature factor c_3 (see page 17), which also applies to dynamically loaded bearings. In addition, the permissible temperature application ranges have to be observed for the individual sliding materials.



2.8 Load factor c_1

It is of further importance, that the specific surface load factor is included in the static load capacity. Increasing load will

reduce the absolute value of the static load capacity by the load factor c_1 .

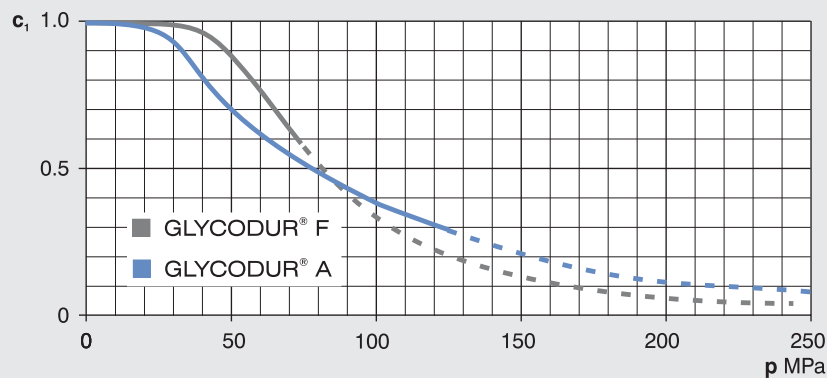


Figure 2.8.1 –
Load factor GLYCODUR®

2.9 Load distribution factor c_5

Beyond the above-mentioned points, the type of load distribution has an effect on the determination of the service life. This is taken into consideration by the load distribution factor c_5 .

- $c_5 = 1.0$ for a point-focal load
(the load is always at the same point of the bearing's perimeter)
- $c_5 = 1.5$ for a circumferential load
(the load zone travels around the entire bearing perimeter)

2.10 Operating temperature

GLYCODUR® A bearings can be used in the temperature range from -40 to +110 °C (-40 to +230 °F); temperatures up to +130 °C (+266 °F) are also permissible for a short period. GLYCODUR® F bearings cover a much larger

temperature range between -200 to +260 °C (-328 to +500 °F). This large range results from the special material combination used for the sliding layer with its excellent heat conductivity.

Determination of bearing size

2.11 Temperature factor c_3

Beginning with a certain limit value of the operating temperature, the service life of GLYCODUR® A and GLYCODUR® F

bearings will be substantially reduced. This is allowed for in the calculation by a temperature factor c_3 .

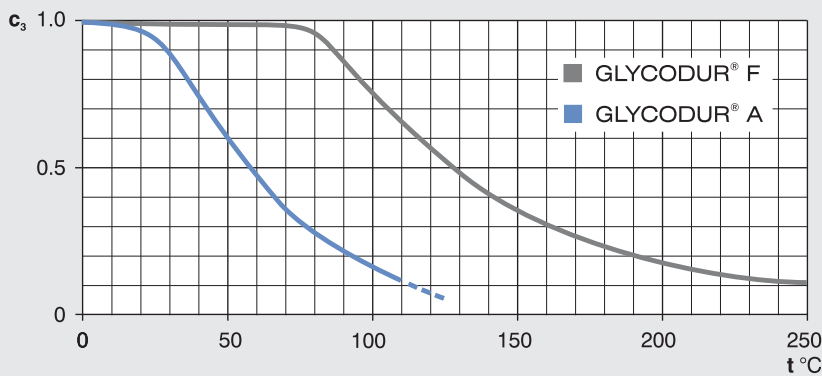


Figure 2.11.1 – Temperature factor GLYCODUR®

2.12 Roughness of the mating surface

When deciding on the material to be used and the surface roughness of the mating surfaces, the conditions under which the bearing system is to operate are of considerable importance.

In most cases soft carbon steels with polished surfaces will be adequate.

Roughness measuring units R_a and R_z in accordance to DIN ISO 4288

	R_a	R_z
GLYCODUR® F	0.4 μm	3 μm
GLYCODUR® A	0.8 μm	6 μm

For demanding applications, hardened mating surfaces with a minimum surface hardness of 50 HRC or featuring a surface treatment e.g. by hard chrome plating, nickel plating etc. are of great advantage.

In these cases, R_a should not exceed 0.3 μm (12 μin) and R_z should not exceed 2 μm (80 μin). Improved surface finishes will improve the running characteristics; poor surface finishes will increase wear.

2.13 Roughness factor c_4

This will be taken into account by the roughness factor c_4 , when designing the bearing.

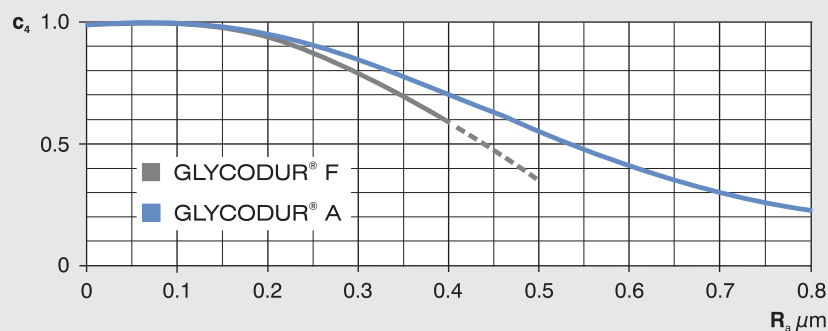


Figure 2.13.1 – Roughness factor GLYCODUR®

2.14 Calculation examples for determining the nominal service life

Calculation procedure

The suspension of a vehicle is to be equipped with paired GLYCODUR® plain bushings.

Design data:

Bolt diameter: $d = 20 \text{ mm}$
Mean roughness of pin: $R_a = 0.3 \mu\text{m}$

Operating data:

Radial load at the linkage point: $F_r = 13\,750 \text{ N}$
Half angle of oscillation: $\beta = 0.6^\circ$ (Fig. 2.5.1)
Oscillating frequency: $f = 250 \text{ min}^{-1}$
Operating temperature: $t = 30^\circ\text{C}$

Based on the design criteria bearing **PG 202320 F** with a dynamic load capacity $C = 30500 \text{ N}$ is selected. It is necessary to check whether the bearing can be used

at the given operating conditions and to determine the nominal service life. For the first check consider the p_v diagram (page 12):

Determination of bearing size

Specific bearing load:

$$p = K \times \frac{F}{C} = 80 \times \frac{13750}{2 \times 30500} \approx 18 \text{ MPa}$$

(with K according to table on page 14)

Sliding velocity:

$$v = 5.82 \times 10^{-7} \times d \times \beta \times f = 5.82 \times 10^{-7} \times 20 \times 0.6 \times 250 = 0.0017 \text{ m/s}$$

(with β page 14)

These values are within the permissible area **I** in the **pv** diagram for GLYCODUR® F bearings.

The following factors result:

Load factor c₁	= 1 (page 16)
Velocity factor c₂	= 1 (page 15)
Temperature factor c₃	= 1 (page 17)
Roughness factor c₄	= 0.8 (page 18)
Load distribution factor c₅	= 1* (page 16)
K_M	= 480
n	= 1 (as pv = 0.05 < 1)

* Due to the small oscillation angle a practical point-focal load has been assumed.

Nominal service life:

$$G_h = 1 \times 1 \times 1 \times 0.8 \times 1 \times \frac{480}{(18 \times 0.0017)^1} \approx 12550 \text{ Operating hours}$$

3

3.1

Summary of bearing installation requirements

GLYCODUR® F

Standard	
Recommended housing tolerance for bushings	H7
Recommended shaft tolerance for bushings	f7 up to 75 mm Ø (3 in resp.) h8 over 75 mm Ø (3 in resp.)
Required surface finish for the mating surface	$R_z \leq 3 \mu\text{m}$ ($R_z \leq 120 \mu\text{in}$) $R_a \leq 0.4 \mu\text{m}$ ($R_a \leq 16 \mu\text{in}$)
Permissible surface treatment of the mating surface	grinded (drawn)
Higher requirements	
Surface treatment	chrome plated, nickel plated, etc.
Surface hardness	50HRC
Surface roughness	$R_z \leq 2 \mu\text{m}$ ($R_z \leq 80 \mu\text{in}$) $R_a \leq 0.3 \mu\text{m}$ ($R_a \leq 12 \mu\text{in}$)

Table 3.1.1 –
Bearing installation
requirements
GLYCODUR® F

GLYCODUR® A / AB

Standard	
Recommended housing tolerance for bushings	H7
Recommended shaft tolerance for bushings	h8
Required surface finish for the mating surface	$R_z \leq 6 \mu\text{m}$ ($R_z \leq 240 \mu\text{in}$) $R_a \leq 0.8 \mu\text{m}$ ($R_a \leq 32 \mu\text{in}$)
Permissible surface treatment of the mating surface	drawn
Higher requirements	
Surface treatment	chrome plated, nickel plated, etc.
Surface hardness	50HRC
Surface roughness	$R_z \leq 2 \mu\text{m}$ ($R_z \leq 80 \mu\text{in}$) $R_a \leq 0.3 \mu\text{m}$ ($R_a \leq 12 \mu\text{in}$)

Table 3.1.2 –
Bearing installation
requirements
GLYCODUR® A/AB

3.2 Junction Design

The journal, which is the sliding partner for GLYCODUR® bearings, must always be wider than the bearing itself to avoid step formations in the sliding area of the bearing. This is particularly important if axial displacement can occur between the shaft and housing due to shaft elongation.

The housing bore for the bearings should always receive a chamfer so that the bushing can be pressed more easily into the housing, particularly since slitted bushings often show an open split line. The shaft ends also need a chamfer to avoid damage to the sliding layer when inserting them into the bushings. In both cases the angle of the chamfer should be 10 to 15° (fig. 3.2.1).

If an axial positioning for the GLYCODUR® bushings is provided, the diameter of the housing shoulders should be no smaller than $d + 0.8 \text{ mm}$.

For the dry running GLYCODUR® F bearings an exact alignment is especially important. If misalignment cannot be avoided, constructive measures are needed to avoid inadmissibly high edge loads.

Such measures could for example consist of a larger chamfer on the housing bore or by using a broader bushing which protudes on both sides over the housing (fig. 3.2.2).

If misalignments have to be compensated for and the operating conditions

allow the use of GLYCODUR®A bushings, then those with a machining allowance (GLYCODUR®AB) should be used. These bushings can be bored or reamed after installation.

If the shafts are to be located radially as well as axially the loads must be compensated for by using flanged bushings or bushings in combination with thrust washers (fig. 3.2.3). The use of flanged bushings and thrust washers is advantageous even by small axial loads, particularly where no suitable thrust surface is available due to material or machining reasons.

When using flanged bushings it is important to chamfer the housing bore so that it does not come into contact with the flange of the bushing (fig. 3.2.4). Thrust washers are usually radially located in a turned recess in the housing and secured by a dowel pin or grub screw as shown in fig. 3.2.3. The necessary measures for this type of fastening can be found in the bearings table on pages 36/42.

If a recess cannot be provided in the housing then the thrust washers can also be secured by using dowel pins, screws (fig. 3.2.5) or by bonding. To avoid damage, the heads of the pins or screws should be recessed by at least 0.3 mm below the sliding bearing surface, the thrust washer should be supported under its entire surface.

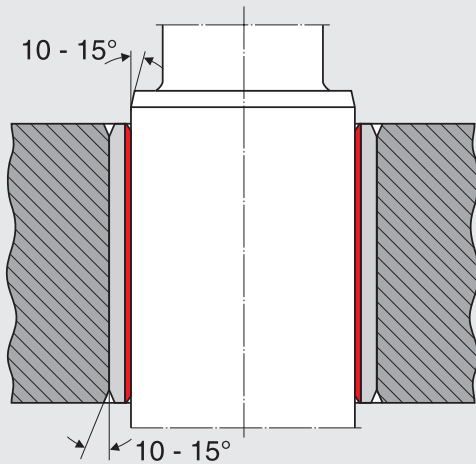


Figure 3.2.1 – Chamfers in shaft and housing bore

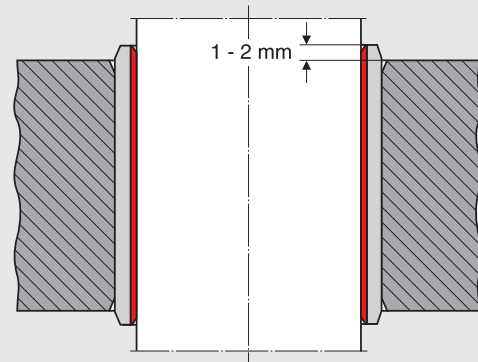


Figure 3.2.2 – Avoidance of misalignments by using a larger GLYCODUR® bushing

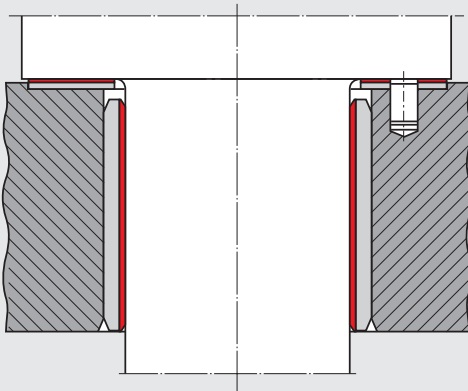


Figure 3.2.3 – Combination of a GLYCODUR® thrust washer with a cylindrical bushing

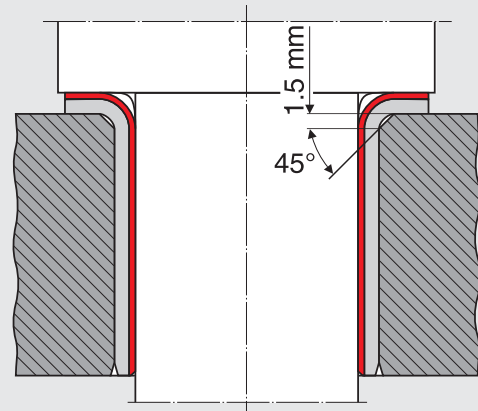


Figure 3.2.4 – Chamfer in housing bore when using a GLYCODUR® flanged bushing

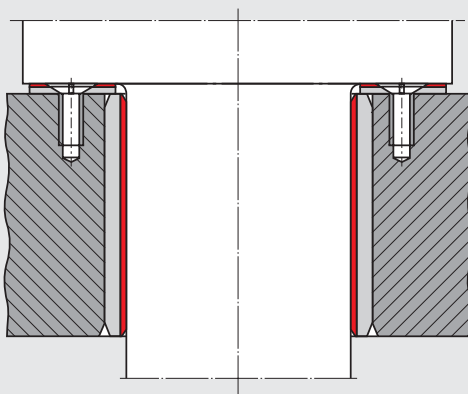


Figure 3.2.5 – Fixing of GLYCODUR® thrust washers

3.3 Seals

GLYCODUR® bearings, particularly GLYCODUR® A bearings, are, to a large part, insensitive to dirt. Foreign particles normally contained in the air are embedded without any problems in the sliding surface and therefore have no effect on the running properties of the bearings. Where however the bearings are exposed to higher dirt contamination, sealing of the bearings should be provided. The efficiency of the insulation has a decisive effect on the service life of the bearings. When selecting suitable seals it is necessary to take into consideration the design, available space and acceptable expense. Simple and effective sealing can be accomplished if the bordering parts can be used (fig. 3.3.1). Even under heavy operating conditions, shaft seals provide adequate protection for GLYCODUR® bearings (fig. 3.3.2). Special insulation made of rubber, plastic or similar substances should be used under extreme operating conditions (fig. 3.3.3). These seals have however a limited service life under extremely rough operating conditions, for example under sandy conditions. If possible under the relevant operating conditions, additional protection can be obtained by periodic lubrication.

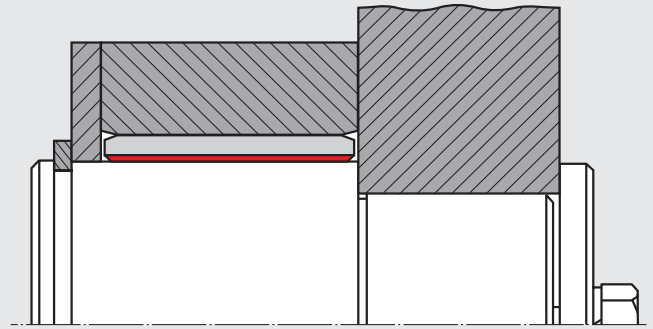


Figure 3.3.1 –
Sealing of a bearing by adjacent parts

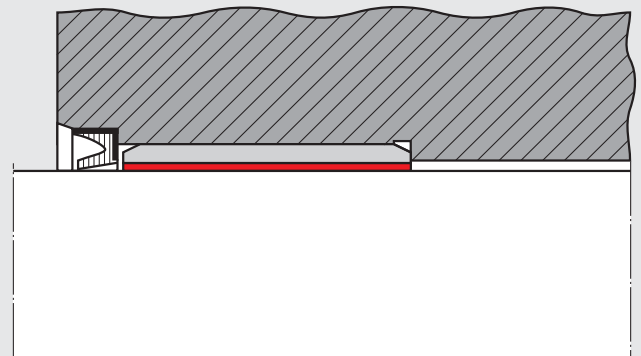


Figure 3.3.2 –
Sealing of a bearing by shaft seal

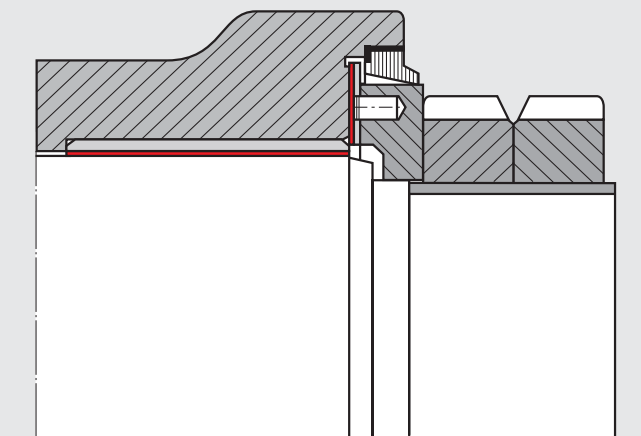


Figure 3.3.3 – Special seal

3.4 Installation

A fundamental prerequisite for the correct functioning of GLYCODUR® bearings in daily operation is cleanliness and care when installing.

The housing and other components of the bearings should be cleaned and deburred before installation. Unmachined surfaces on the inside of cast housings should be free of moulding sand before installation. The preferred way to install GLYCODUR® bushings and flange bushings is to use a mandrel (fig. 3.4.1). By using an O-ring the bearing can be easily hold on the mandrel. The installation is made easier if a small amount of oil or grease is used on the bearing seat.

When installing larger bushings we advice the use of mounting ring (fig 3.4.2), the use of which aligns and centers the bushing which, furthermore, cannot tilt during insertion. Using a solid lubricating paste containing molybdenum disulfide (MoS_2) can reduce scuffing tendencies and lower the insertion force.

Bushings and flange bushings which will be subjected to very high loads during

operation should be mounted with the joint positioning 90° to the loaded area so that the service life is not reduced.

GLYCODUR® bearings can be also be fixed by gluing in or on the housing. It must be guaranteed that the adhesive selected can withstand the anticipated operating temperatures and meets the requirements with regard to expansion behaviour, strength and tempering. If there is no operational experience, it is recommended to contact the manufacturers of the adhesive directly. When using adhesives, care must be taken that none comes into contact with the sliding surface.

Furthermore, the mating surface must be cleaned and checked for damage prior to installation. When inserting the shaft into the bearing care must be taken that the gliding surface is not damaged by sharp edges or burrs, etc..

When mounting thrust washers it is important that they are positioned the correct way around, i.e. steel back against the housing wall.

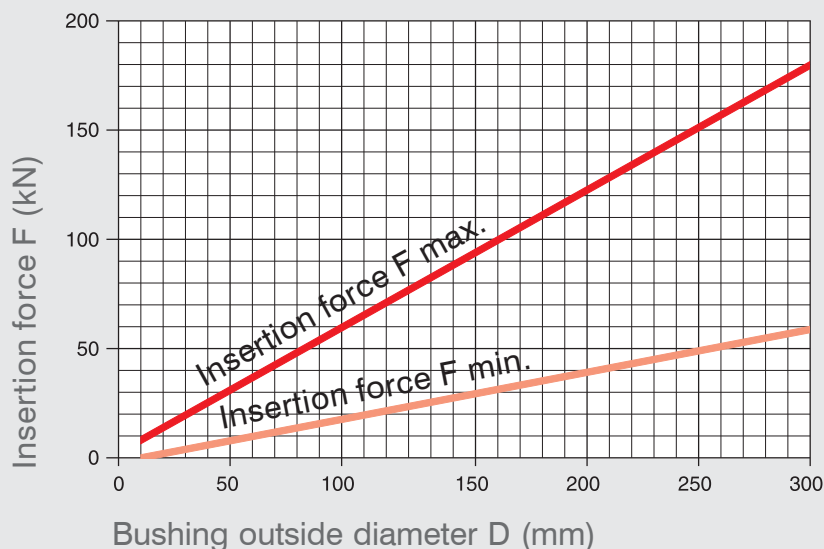


Figure 3.4.3 –
Approximate values for press in forces of GLYCODUR® bushings

Calculated for a steel ring $D_e/D = 1.5$ dry pressed in.

Ratio bushing width to bushing inner diameter 1 ($B/d = 1$).

In case of deviating bushing widths, the insertion force will be determined by multiplication with the new B/d ratio.

Sliding bearing installation

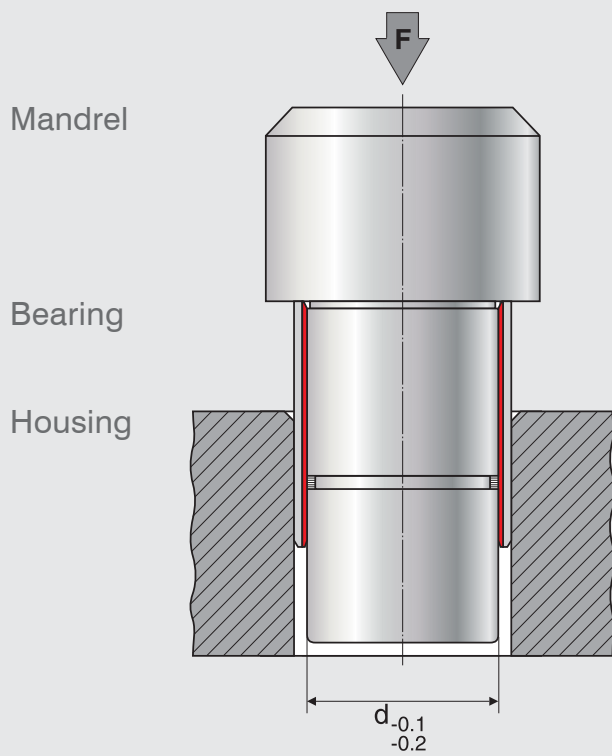


Figure 3.4.1 – Installation with mandrel

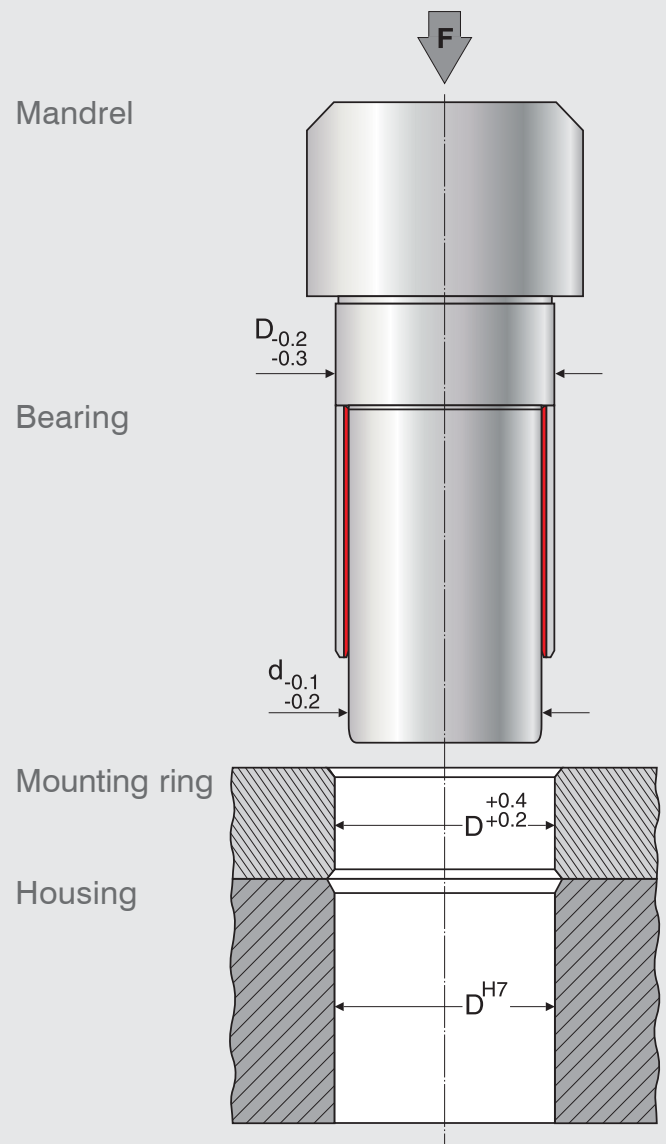


Figure 3.4.2 – Installation with mandrel and mounting ring

3.5 Lubrication and maintenance

GLYCODUR® F bearings have good dry sliding properties and do not need to be lubricated. The presence or supply of oil, or other fluids may be advantageous, other liquids not normally used for lubrication, e.g. water, kerosene or paraffin. Lubrication enhances the removal of heat from the bearing and the formation of a load carrying hydro-dynamic lubricant films result in a considerably enhanced wear characteristic and thus a considerable extension of the service life.

If grease is applied periodically for reasons of sealing or protection of the mating surface against corrosion, this will extend the service life of the bearings. A single application of grease to GLYCODUR® F bearings during installation may have a negative effect on the service life; as the grease will form a paste like mixture with the wear particles produced during running-in, which will increase the bearing wear.

Age resistant lithium-based greases are preferred for lubrication, but at operating temperatures over 80 °C (170 °F) silicone

greases should be used. Greases containing solid lubricant additives (e.g. molybdenum disulfide) are unsuitable.

GLYCODUR® A bearings have to be lubricated initially with grease. Saponified lithium greases (e.g. Klüber Poly lub GLY801) are specifically suited for these bearings, due to their good adhesion, or saponified aluminum greases with good moistening power. It is not necessary to relubricate after the initial application, but the presence or continuous supply of lubricating fluid or grease does considerably extend the service life.

For this reason, GLYCODUR® A bushings from 10 mm (0.3937 in) bore diameter and 12 mm (0.4724 in) width are delivered with a lubrication hole as standard. The nominal diameter of the lubrication holes are given in the table below. The size and position of the holes is in accordance with the specifications in ISO 3547. The recommendations regarding the grease to be used are the same as for GLYCODUR® F bearings.

Bearing bore diameter d		Nominal diameter of lubrication hole
over	incl.	
-	22 mm/0.866 in	3 mm/0.118 in
22 mm/0.866 in	40 mm/1.575 in	4 mm/0.157 in
40 mm/1.575 in	50 mm/1.969 in	5 mm/0.197 in
50 mm/1.969 in	100 mm/3.937 in	6 mm/0.236 in
100 mm/3.937 in		8 mm/0.315 in

4.1 Bushing tolerances

The tolerances for the outside diameter of the metric GLYCODUR® bushings correspond to the values given in ISO 3547 Part 1. To check these tolerances the method outlined in ISO 3547 Part 2 should be followed.

The values for the maximum and the minimum wall thickness for metric bushings can be found in the tables on pages 30 (following) and 38 (following). The tolerance for the bushing width **B** is a uniform ± 0.25 mm (± 0.01 in).

4

Tolerances

4.2 Flanged bushing tolerances

GLYCODUR® flanged bushings are manufactured to the same tolerances as the plain bushings.

A deviation of ± 0.5 mm (0.02 in) applies to the flange diameter **D₁** when mounted.

4.3 Housing, shafts and bearing clearance

GLYCODUR® plain and flanged bushings can be located by means of interference fits. For “ready to fit” bushings and flanged bushings in metric sizes, it is recommended to machine the housing for bearings up to 4 mm bore diameter to an H6 tolerance and to an H7 tolerance for larger bearings (pages 30 and 38).

After the installation, the bore diameter of the bushings and the bearing clearance will be within the limits indicated in the tables on pages 30 (following) and 38 (following), provided the shaft was also manufactured to the tolerances indicated in these tables. The values for bearing clearance apply to room temperature; if the operating temperature is increased, the bearing clearance is reduced by 0.0016 mm (6.3×10^{-5} in) for each 20 °C (68 °F) temperature increase for GLYCODUR® F bearings, and by 0.005 mm

(20×10^{-5} in) for GLYCODUR® A bearings.

The bearing clearance can be reduced or increased within the recommended limits by matching shaft and housing bore to each other during installation.

In certain applications for example, or if the bearing load is low or where minimum running resistance is called for, it is recommended to select the maximum values for bearing clearance indicated in the tables.

The recommended tolerances and indicated approximate values apply to housings made of steel, or cast iron. For light alloy housings a higher degree of interference fit due to the difference in thermal expansion may be required. Otherwise, the bushings could become loose.



If it is impossible to use an interference fit because of mounting difficulties or because the force needed for pressing in is too high, it is possible to secure the bushing in the housing bore by gluing. In special cases where adhesive is used it may be necessary to modify the shaft tolerance to avoid improper bearing

clearance. Thrust washers are generally secured in machined recesses in the housing. Appropriate diameters and tolerances for the recesses are given in the tables on pages 36 and 42.

When determining housing and shaft tolerances attention should be paid to ISO 3547 and ISO 6525.

5.1

Special parts

Special parts on request.

5

Special parts



6

6.1 GLYCODUR® F bushing tolerances for shaft, housing and bearing clearance

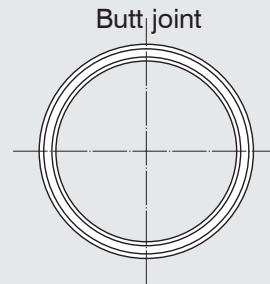
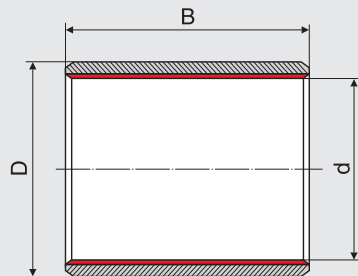
GLYCODUR® F

Dimensions bushings				Diameter limits				Bore diameter of mounted bushing		Bearing clearance	
Bore diameter	Outside diameter	Wall thickness		Shaft (f7 for d ≤ 75 mm) (h8 for d > 75 mm)		Housing bore (H7)					
d	D	max.	min.	max.	min.	max.	min.	max.	min.	min.	max.
mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	μm	μm
3	4.5	0.750	0.730	3.000 _(h6)	2.994 _(h6)	4.508 _(H6)	4.500 _(H6)	3.048	3.000	0	54
4	5.5	0.750	0.730	4.000 _(h6)	3.992 _(h6)	5.508 _(H6)	5.500 _(H6)	4.048	4.000	0	56
5	7	1.007	0.981	4.990	4.978	7.015	7.000	5.053	4.986	-4	75
6	8	1.007	0.981	5.990	5.978	8.015	8.000	6.053	5.986	-4	75
7	9	1.007	0.981	6.987	6.972	9.015	9.000	7.053	6.986	-1	81
8	10	1.007	0.981	7.987	7.972	10.015	10.000	8.053	7.986	-1	81
10	12	1.007	0.981	9.987	9.972	12.018	12.000	10.056	9.986	-1	84
12	14	1.007	0.981	11.984	11.966	14.018	14.000	12.056	11.986	2	90
13	15	1.007	0.981	12.984	12.966	15.018	15.000	13.056	12.986	2	90
14	16	1.007	0.981	13.984	13.966	16.018	16.000	14.056	13.986	2	90
15	17	1.007	0.981	14.984	14.966	17.018	17.000	15.056	14.986	2	90
16	18	1.007	0.981	15.984	15.966	18.018	18.000	16.056	15.986	2	90
17	19	1.007	0.981	16.984	16.966	19.021	19.000	17.059	16.986	2	93
18	20	1.007	0.981	17.984	17.966	20.021	20.000	18.059	17.986	2	93
20	23	1.507	1.475	19.980	19.959	23.021	23.000	20.071	19.986	6	112
22	25	1.507	1.475	21.980	21.959	25.021	25.000	22.071	21.986	6	112
24	27	1.507	1.475	23.980	23.959	27.021	27.000	24.071	23.986	6	112
25	28	1.507	1.475	24.980	24.959	28.021	28.000	25.071	24.986	6	112
28	32	2.007	1.971	27.980	27.959	32.025	32.000	28.083	27.986	6	124
30	34	2.007	1.971	29.980	29.959	34.025	34.000	30.083	29.986	6	124
32	36	2.007	1.971	31.975	31.950	36.025	36.000	32.083	31.986	11	133
35	39	2.007	1.971	34.975	34.950	39.025	39.000	35.083	34.986	11	133
37	40	1.507	1.475	36.975	36.950	40.025	40.000	37.075	36.986	11	125
40	44	2.007	1.971	39.975	39.950	44.025	44.000	40.083	39.986	11	133
45	50	2.508	2.462	44.975	44.950	50.025	50.000	45.101	44.984	9	151

Dimension and tolerance tables

Dimensions bushings				Diameter limits				Bore diameter of mounted bushing		Bearing clearance	
Bore diameter	Outside diameter	Wall thickness		Shaft (f7 for d ≤ 75 mm) (h8 for d > 75 mm)		Housing bore (H7)					
d	D	max.	min.	max.	min.	max.	min.	max.	min.	min.	max.
mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	μm	μm
50	55	2.508	2.462	49.975	49.950	55.030	55.000	50.106	49.984	14	166
55	60	2.508	2.462	54.970	54.940	60.030	60.000	55.106	54.984	14	166
60	65	2.508	2.462	59.970	59.940	65.030	65.000	60.106	59.984	14	166
65	70	2.508	2.462	64.970	64.940	70.030	70.000	65.106	64.984	14	166
70	75	2.508	2.462	69.970	69.940	75.030	75.000	70.106	69.984	14	166
75	80	2.508	2.462	74.970	74.940	80.030	80.000	75.106	74.984	14	166
80	85	2.490	2.440	80.000	79.954	85.035	85.000	80.155	80.020	20	201
85	90	2.490	2.440	85.000	84.946	90.035	90.000	85.155	85.020	20	209
90	95	2.490	2.440	90.000	89.946	95.035	95.000	90.155	90.020	20	209
95	100	2.490	2.440	95.000	94.946	100.035	100.000	95.155	95.020	20	209
100	105	2.490	2.440	100.000	99.946	105.035	105.000	100.155	100.020	20	209
105	110	2.490	2.440	105.000	104.946	110.035	110.000	105.155	105.020	20	209
110	115	2.490	2.440	110.000	109.946	115.035	115.000	110.155	110.020	20	209
115	120	2.490	2.440	115.000	114.946	120.035	120.000	115.155	115.020	20	209
120	125	2.465	2.415	120.000	119.946	125.040	125.000	120.210	120.070	70	264
125	130	2.465	2.415	125.000	124.937	130.040	130.000	125.210	125.070	70	273
130	135	2.465	2.415	130.000	129.937	135.040	135.000	130.210	130.070	70	273
135	140	2.465	2.415	135.000	134.937	140.040	140.000	135.210	135.070	70	273
140	145	2.465	2.415	140.000	139.937	145.040	145.000	140.210	140.070	70	273
150	155	2.465	2.415	150.000	149.937	155.040	155.000	150.210	150.070	70	273
160	165	2.465	2.415	160.000	159.937	165.040	165.000	160.210	160.070	70	273
180	185	2.465	2.415	180.000	179.937	185.046	185.000	180.216	180.070	70	279
200	205	2.465	2.415	200.000	199.928	205.046	205.000	200.216	200.070	70	288
210	215	2.465	2.415	210.000	209.928	215.046	215.000	210.216	210.070	70	288
220	225	2.465	2.415	220.000	219.928	225.046	225.000	220.216	220.070	70	288
250	255	2.465	2.415	250.000	249.928	255.052	255.000	250.222	250.070	70	294
280	285	2.465	2.415	280.000	279.919	285.052	285.000	280.222	280.070	70	303
300	305	2.465	2.415	300.000	299.919	305.052	305.000	300.222	300.070	70	303

6.2 Dimension table for GLYCODUR® F bushings



Dimensions			Basic load rates		Mass	Designation
d	D	B	dyn. C	stat. C ₀		
mm	mm	mm	N	N	g	
3	4.5	3	720	2240	0.2	PG 030403 F/4.5
	4.5	5	1200	3750	0.3	PG 030405 F/4.5
	4.5	6	1430	4500	0.4	PG 030406 F/4.5
4	5.5	3	965	3000	0.2	PG 040503 F/5.5
	5.5	4	1270	4000	0.3	PG 040504 F/5.5
	5.5	6	1930	6000	0.6	PG 040506 F/5.5
	5.5	10	3200	10000	0.8	PG 040510 F/5.5
5	7	5	2000	6200	0.7	PG 050705 F
	7	8	3200	10000	1.1	PG 050708 F
	7	10	4000	12500	1.4	PG 050710 F
6	8	6	2900	9000	1	PG 060806 F
	8	8	3800	12000	1.3	PG 060808 F
	8	10	4800	15000	1.6	PG 060810 F
7	9	7	3900	12250	1.3	PG 070907 F
8	10	6	3800	12000	1.2	PG 081006 F
	10	8	5100	16000	1.7	PG 081008 F
	10	10	6400	20000	2.1	PG 081010 F
	10	12	7650	24000	2.5	PG 081012 F
10	12	8	6400	20000	2	PG 101208 F
	12	10	8000	25000	2.5	PG 101210 F
	12	12	9650	30000	3	PG 101212 F
	12	15	12000	37500	3.8	PG 101215 F
	12	20	16000	50000	5.1	PG 101220 F
12	14	8	7650	24000	2.4	PG 121408 F
	14	10	9650	30000	3	PG 121410 F
	14	12	11600	36000	3.6	PG 121412 F
	14	15	14300	45000	4.5	PG 121415 F
	14	20	19300	60000	6	PG 121420 F
	14	25	24000	75000	7.6	PG 121425 F
13	15	10	10400	32500	3.2	PG 131510 F
14	16	10	11200	34500	3.5	PG 141610 F
	16	12	13400	41500	4.2	PG 141612 F
	16	15	16600	52000	5.2	PG 141615 F
	16	20	22400	70000	7	PG 141620 F
	16	25	28000	88000	8.7	PG 141625 F
15	17	10	12000	37500	3.7	PG 151710 F
	17	12	14300	45000	4.4	PG 151712 F
	17	15	18000	56000	5.6	PG 151715 F
	17	20	24000	75000	7.4	PG 151720 F
	17	25	30000	93000	9.3	PG 151725 F

Dimensions			Basic load rates		Mass	Designation
d	D	B	dyn. C	stat. C ₀		
mm	mm	mm	N	N	g	
16	18	10	12900	40000	3.9	PG 161810 F
	18	12	15300	48000	4.7	PG 161812 F
	18	15	19300	60000	5.9	PG 161815 F
	18	20	25500	80000	7.9	PG 161820 F
	18	25	32000	100000	9.9	PG 161825 F
17	19	12	16300	51000	5	PG 171912 F
18	20	15	21600	67000	6.6	PG 182015 F
	20	20	29000	90000	8.8	PG 182020 F
	20	25	36000	112000	11	PG 182025 F
20	23	10	14600	45500	7.4	PG 202310 F
	23	15	22800	71000	11	PG 202315 F
	23	20	30500	96500	15	PG 202320 F
	23	25	39000	120000	19	PG 202325 F
	23	30	46500	146000	23	PG 202330 F
22	25	10	17000	52000	8.3	PG 222510 F
	25	15	25000	78000	12	PG 222515 F
	25	20	34000	106000	16	PG 222520 F
	25	25	42500	134000	21	PG 222525 F
	25	30	51000	160000	25	PG 222530 F
24	27	15	27500	85000	13	PG 242715 F
	27	20	36500	116000	18	PG 242720 F
	27	25	46500	146000	22	PG 242725 F
	27	30	56000	176000	26	PG 242730 F
25	28	15	28500	88000	14	PG 252815 F
	28	20	38000	120000	18	PG 252820 F
	28	25	48000	150000	23	PG 252825 F
	28	30	58500	183000	28	PG 252830 F
	28	40	78000	245000	37	PG 252840 F
	28	50	98000	310000	47	PG 252850 F
28	32	15	33000	102000	21.3	PG 283220 F
	32	20	43000	134000	28	PG 283220 F
	32	25	54000	170000	35	PG 283225 F
	32	30	65500	204000	42	PG 283230 F
30	34	15	34000	106000	22	PG 303415 F
	34	20	46500	143000	30	PG 303420 F
	34	25	58500	180000	37	PG 303425 F
	34	30	69500	220000	45	PG 303430 F
	34	40	95000	300000	60	PG 303440 F
32	36	20	49000	153000	31	PG 323620 F
	36	30	75000	232000	48	PG 323630 F
	36	40	100000	315000	64	PG 323640 F

Dimension and tolerance tables

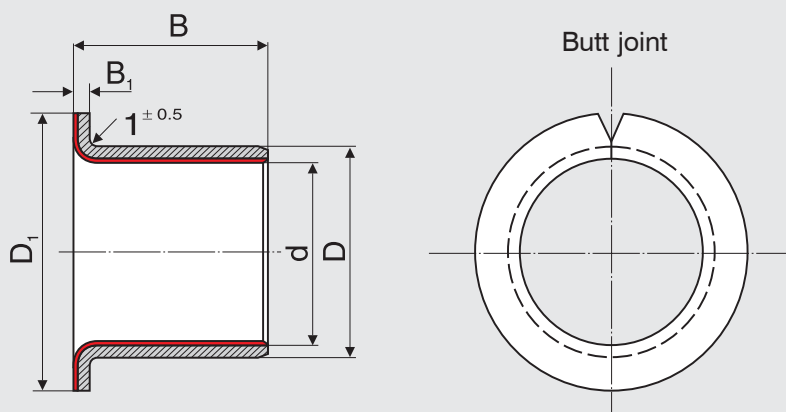
Dimensions			Basic load rates		Mass	Designation
d	D	B	dyn. C	stat. C ₀		
mm	mm	mm	N	N	g	
35	39	20	54000	166000	34	PG 353920 F
	39	30	81500	255000	52	PG 353930 F
	39	40	110000	345000	68	PG 353940 F
	39	50	137000	430000	87	PG 353950 F
37	40	20	57000	176000	27	PG 374020 F
40	44	20	61000	193000	39	PG 404420 F
	44	30	93000	290000	59	PG 404430 F
	44	40	125000	390000	78	PG 404440 F
	44	50	156000	490000	98	PG 404450 F
45	50	20	69500	216000	65	PG 455020 F
	50	30	106000	325000	83	PG 455030 F
	50	40	140000	440000	110	PG 455040 F
	50	50	176000	550000	140	PG 455050 F
50	55	20	76500	240000	62	PG 505520 F
	55	30	116000	365000	93	PG 505530 F
	55	40	156000	490000	125	PG 505540 F
	55	50	200000	620000	155	PG 505550 F
	55	60	236000	735000	185	PG 505560 F
55	60	20	85000	265000	67	PG 556020 F
	60	30	129000	400000	100	PG 556030 F
	60	40	173000	540000	135	PG 556040 F
	60	50	216000	680000	170	PG 556050 F
	60	60	260000	815000	200	PG 556060 F
60	65	20	91500	290000	75	PG 606520 F
	65	30	140000	440000	110	PG 606530 F
	65	40	190000	585000	145	PG 606540 F
	65	60	285000	880000	220	PG 606560 F
	65	70	335000	1040000	255	PG 606570 F
65	70	30	153000	475000	120	PG 657030 F
	70	50	255000	800000	200	PG 657050 F
	70	70	360000	1120000	275	PG 657070 F
70	75	40	220000	680000	170	PG 707540 F
	75	50	275000	865000	210	PG 707550 F
	75	70	390000	1220000	300	PG 707570 F
75	80	50	300000	930000	230	PG 758050 F
	80	60	355000	1100000	270	PG 758060 F
	80	80	475000	1500000	365	PG 758080 F
80	85	40	250000	780000	200	PG 808540 F
	85	60	375000	1180000	290	PG 808560 F
	85	100	630000	1960000	485	PG 8085100 F
85	90	30	196000	610000	150	PG 859030 F
	90	60	400000	1250000	305	PG 859060 F
	90	100	670000	2080000	510	PG 8590100 F
90	95	60	425000	1320000	325	PG 909560 F
	95	100	710000	2240000	540	PG 9095100 F

Dimensions			Basic load rates		Mass	Designation
d	D	B	dyn. C	stat. C ₀		
mm	mm	mm	N	N	g	
95	100	60	450000	1400000	340	PG 9510060 F
	100	100	750000	2360000	570	PG 95100100 F
100	105	50	390000	1220000	305	PG 10010550 F
	105	60	475000	1460000	360	PG 10010560 F
	105	115	915000	2850000	690	PG 100105115 F
105	110	60	490000	1530000	375	PG 10511060 F
	110	115	950000	3000000	725	PG 105110115 F
110	115	60	520000	1630000	395	PG 11011560 F
	115	115	1000000	3150000	760	PG 110115115 F
115	120	50	450000	1400000	340	PG 11512050 F
	120	70	630000	1960000	480	PG 11512070 F
120	125	50	475000	1460000	358	PG 12012550 F
	125	60	560000	1760000	430	PG 12012560 F
	125	100	950000	3000000	715	PG 120125100 F
125	130	100	980000	3100000	745	PG 125130100 F
130	135	60	610000	1900000	465	PG 13013560 F
	135	100	1020000	3200000	775	PG 130135100 F
135	140	60	640000	2000000	480	PG 13514060 F
	140	80	850000	2650000	645	PG 13514080 F
140	145	60	655000	2040000	500	PG 14014560 F
	145	100	1100000	3450000	835	PG 140145100 F
150	155	60	710000	2200000	535	PG 15015560 F
	155	80	950000	3000000	715	PG 15015580 F
	155	100	1200000	3750000	890	PG 150155100 F
160	165	80	1000000	3150000	780	PG 16016580 F
	165	100	1270000	3900000	970	PG 160165100 F
180	185	80	1140000	3550000	870	PG 18018580 F
	185	100	1430000	4400000	1100	PG 180185100 F
200	205	100	1600000	4900000	1200	PG 200205100 F
210	215	100	1660000	5200000	1250	PG 210215100 F
220	225	100	1730000	5400000	1350	PG 220225100 F
250	255	100	1960000	6100000	1500	PG 250255100 F
280	285	80	1760000	5500000	1350	PG 28028580 F
300	305	100	2360000	7350000	1800	PG 300305100 F

6.3 Dimension table for GLYCODUR® F flanged bushings

Dimensions					Basic load rates				Mass	Designation
d	D	D ₁	B	B ₁	rad. dyn. C	stat. C ₀	ax. dyn. C _a	stat. C _{0a}		
mm	mm	mm	mm	mm	N	N	N	N	g	
5	7	11.5	4	1	800	2500	2850	9000	1.1	PBG 050704 F
6	8	12	4	1	965	3000	2750	8650	1.3	PBG 060804 F
	8	12	8	1	2900	9000	2750	8650	1.9	PBG 060808 F
8	10	15	5.5	1	2240	6950	5100	16000	2.1	PBG 081005.5 F
	10	15	7.5	1	3550	11000	5100	16000	2.5	PBG 081007.5 F
	10	15	9.5	1	4800	15000	5100	16000	2.9	PBG 081009.5 F
10	12	18	7	1	4000	12500	8000	25000	3.1	PBG 101207 F
	12	18	9	1	5600	17600	8000	25000	3.6	PBG 101209 F
	12	18	12	1	8000	25000	8000	25000	4.3	PBG 101212 F
	12	18	17	1	12000	37500	8000	25000	5.6	PBG 101217 F
	12	18	20	1	14400	45000	8000	25000	6.1	PBG 101220 F
12	14	20	7	1	4800	15000	9150	28500	3.6	PBG 121407 F
	14	20	9	1	6700	20800	9150	28500	4.2	PBG 121409 F
	14	20	12	1	9650	30000	9150	28500	5.1	PBG 121412 F
	14	20	15	1	12500	39000	9150	28500	6.1	PBG 121415 F
	14	20	17	1	14300	45000	9150	28500	6.6	PBG 121417 F
13	15	21	17	1	15600	48750	9500	29800	6.8	PBG 131517 F
14	16	22	12	1	11000	34500	10000	31500	5.8	PBG 141612 F
	16	22	17	1	16600	52000	10000	31500	7.5	PBG 141617 F
15	17	23	9	1	8300	26000	10400	32500	5.1	PBG 151709 F
	17	23	12	1	12000	37500	10400	32500	6.2	PBG 151712 F
	17	23	17	1	18000	56000	10400	32500	7.6	PBG 151717 F
16	18	24	12	1	12200	38000	8500	26500	6.2	PBG 161812 F
	18	24	15	1	16600	52000	8500	26500	7.1	PBG 161815 F
	18	24	17	1	18600	58500	8500	26500	8.1	PBG 161817 F
18	20	26	12	1	13700	42500	9300	29000	7.3	PBG 182012 F
	20	26	22	1	28000	88000	9300	29000	12	PBG 182022 F
20	23	30	11.5	1.5	14300	45000	17300	54000	13	PBG 202311.5 F
	23	30	15	1.5	20000	62000	17300	54000	16	PBG 202315 F
	23	30	16.5	1.5	22000	69500	17300	54000	17	PBG 202316.5 F
	23	30	21.5	1.5	30500	95000	17300	54000	21	PBG 202321.5 F
25	28	35	11.5	1.5	17300	54000	20400	64000	16	PBG 252811.5 F
	28	35	16.5	1.5	28000	85000	20400	64000	21	PBG 252816.5 F
	28	35	21.5	1.5	37500	116000	20400	64000	25	PBG 252821.5 F
30	34	42	16	2	30500	95000	29000	91500	35	PBG 303416 F
	34	42	26	2	54000	170000	29000	91500	50	PBG 303426 F
35	39	47	16	2	35500	110000	33500	104000	43	PBG 353916 F
	39	47	26	2	63000	196000	33500	104000	61	PBG 353926 F
40	44	53	20	2	51200	160000	41000	124400	44.7	PBG 404420 F
	44	53	26	2	70400	220000	41000	124400	61.9	PBG 404426 F

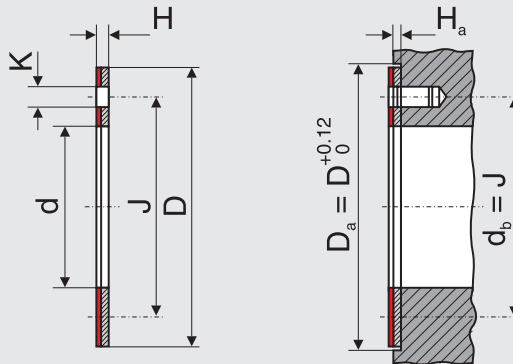
Dimension and tolerance tables



6.4 GLYCODUR® F flanged bushing tolerances

Flange thickness	Deviation	
	high	low
	mm	mm
$B_1 = 1$	+0.05	-0.05
$B_1 = 1.5$	+0.05	-0.10
$B_1 = 2$	+0.05	-0.10

6.5 Dimension and tolerance tables for GLYCODUR® F thrust washers



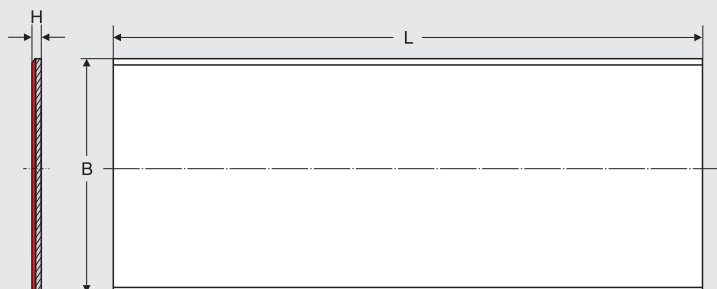
Dimensions						Basic load rates		Mass	Designation
d	D	H	J	K	H _a	dyn. C	stat. C ₀		
mm	mm	mm	mm	mm	mm	N	N	g	
10	20	1.5	15	1.75	1	24000	75000	2.3	PXG 102001.5 F
12	24	1.5	18	1.75	1	28000	85000	3.8	PXG 122401.5 F
14	26	1.5	20	2.25	1	30000	93000	4.2	PXG 142601.5 F
16	30	1.5	23	2.25	1	40000	126000	5.4	PXG 163001.5 F
18	32	1.5	25	2.25	1	44000	137000	6.1	PXG 183201.5 F
20	36	1.5	28	3.25	1	56000	176000	7.8	PXG 203601.5 F
22	38	1.5	30	3.25	1	60000	186000	8.4	PXG 223801.5 F
26	44	1.5	35	3.25	1	78000	245000	11	PXG 264401.5 F
28	48	1.5	38	4.25	1	93000	290000	13	PXG 284801.5 F
32	54	1.5	43	4.25	1	116000	365000	16	PXG 325401.5 F
38	62	1.5	50	4.25	1	150000	465000	21	PXG 386201.5 F
42	66	1.5	54	4.25	1	163000	510000	23	PXG 426601.5 F
48	74	2	61	4.25	1.5	200000	620000	37	PXG 487402 F
52	78	2	65	4.25	1.5	208000	655000	39	PXG 527802 F
62	90	2	76	4.25	2	265000	825000	85	PXG 629002 F

Table 6.5.1 –
GLYCODUR® F thrust washer dimensions

Dimensions	Deviations	
	high	low
	mm	mm
Bore diameter d	+0.250	0
Outside diameter D	0	-0.250
Hole pitch diameter J	+0.120	-0.120
Hole diameter K	+0.125	-0.125
Height H	0	-0.050

Table 6.5.2 –
GLYCODUR® F thrust washer tolerances

6.6 Dimension table for GLYCODUR® F strip material



Dimensions				Mass	Designation
B	B ¹⁾	L ²⁾	H		
mm	mm	mm	mm	kg	
200	182	500	0.75	0.54	PLG 2005000.75 F
200	182	500	1.00	0.73	PLG 2005001.0 F
250	232	500	1.50	1.39	PLG 2505001.5 F
250	232	500	2.00	1.89	PLG 2505002.0 F
225	207	500	2.50	2.14	PLG 2255002.5 F
200	200	500	3.06	2.35	PLG 2005003.06 F

¹⁾ Effective strip width (width of sliding layer)

²⁾ Other lengths to order

6.7 GLYCODUR® F strip material tolerances

Dimensions		Deviations	
		high	low
		mm	mm
Width B		+0.500	0
Length L		+3	0
Height	H ≤ 2.5	0	-0.040
	H = 3.06	+0.020	-0.020

7

7.1 GLYCODUR® A bushing tolerances for shaft, housing and bearing clearance

GLYCODUR® A

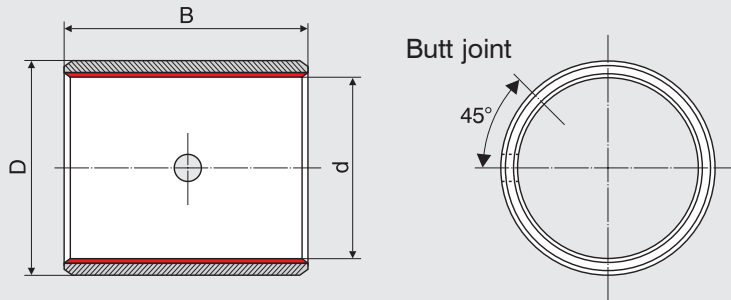
Dimensions bushings				Diameter limits				Bore diameter of mounted bushing		Bearing clearance	
Bore diameter	Outside diameter	Wall thickness		Shaft (h8)		Housing bore (H7)					
d	D	max.	min.	max.	min.	max.	min.	max.	min.	min.	max.
mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	μm	μm
6	8	0.980	0.955	6.000	5.982	8.015	8.000	6.105	6.040	40	123
7	9	0.980	0.955	7.000	6.978	9.015	9.000	7.105	7.040	40	127
8	10	0.980	0.955	8.000	7.978	10.015	10.000	8.105	8.040	40	127
10	12	0.980	0.955	10.000	9.978	12.018	12.000	10.108	10.040	40	130
12	14	0.980	0.955	12.000	11.973	14.018	14.000	12.108	12.040	40	135
13	15	0.980	0.955	13.000	12.973	15.018	15.000	13.108	13.040	40	135
14	16	0.980	0.955	14.000	13.973	16.018	16.000	14.108	14.040	40	135
15	17	0.980	0.955	15.000	14.973	17.018	17.000	15.108	15.040	40	135
16	18	0.980	0.955	16.000	15.973	18.018	18.000	16.108	16.040	40	135
18	20	0.980	0.955	18.000	17.973	20.021	20.000	18.111	18.040	40	138
20	23	1.475	1.445	20.000	19.967	23.021	23.000	20.131	20.050	50	164
22	25	1.475	1.445	22.000	21.967	25.021	25.000	22.131	22.050	50	164
24	27	1.475	1.445	24.000	23.967	27.021	27.000	24.131	24.050	50	164
25	28	1.475	1.445	25.000	24.967	28.021	28.000	25.131	25.050	50	164
28	32	1.970	1.935	28.000	27.967	32.025	32.000	28.155	28.060	60	188
30	34	1.970	1.935	30.000	29.967	34.025	34.000	30.155	30.060	60	188
32	36	1.970	1.935	32.000	31.961	36.025	36.000	32.155	32.060	60	194
35	39	1.970	1.935	35.000	34.961	39.025	39.000	35.155	35.060	60	194
37	40	1.475	1.445	37.000	36.961	40.025	40.000	37.135	37.050	50	174
40	44	1.970	1.935	40.000	39.961	44.025	44.000	40.155	40.060	60	194
45	50	2.460	2.415	45.000	44.961	50.025	50.000	45.195	45.080	80	234
50	55	2.460	2.415	50.000	49.961	55.030	55.000	50.200	50.080	80	239
55	60	2.460	2.415	55.000	54.954	60.030	60.000	55.200	55.080	80	246
60	65	2.460	2.415	60.000	59.954	65.030	65.000	60.200	60.080	80	246
65	70	2.450	2.385	65.000	64.954	70.030	70.000	65.260	65.100	100	306

GLYCODUR® A

Dimension and tolerance tables

Dimensions bushings				Diameter limits				Bore diameter of mounted bushing		Bearing clearance	
Bore diameter	Outside diameter	Wall thickness		Shaft (h8)		Housing bore (H7)					
d	D	max.	min.	max.	min.	max.	min.	max.	min.	min.	max.
mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	μm	μm
70	75	2.450	2.385	70.000	69.954	75.030	75.000	70.260	70.100	100	306
75	80	2.450	2.385	75.000	74.954	80.030	80.000	75.260	75.100	100	306
80	85	2.450	2.385	80.000	79.954	85.035	85.000	80.265	80.100	100	311
85	90	2.450	2.385	85.000	84.946	90.035	90.000	85.265	85.100	100	319
90	95	2.450	2.385	90.000	89.946	95.035	95.000	90.265	90.100	100	319
95	100	2.450	2.385	95.000	94.946	100.035	100.000	95.265	95.100	100	319
100	105	2.450	2.385	100.000	99.946	105.035	105.000	100.265	100.100	100	319
105	110	2.450	2.385	105.000	104.946	110.035	110.000	105.265	105.100	100	319
110	115	2.450	2.385	110.000	109.946	115.035	115.000	110.265	110.100	100	319
115	120	2.450	2.385	115.000	114.946	120.035	120.000	115.265	115.100	100	319
120	125	2.450	2.385	120.000	119.946	125.040	125.000	120.270	120.100	100	324
125	130	2.450	2.385	125.000	124.937	130.040	130.000	125.270	125.100	100	333
130	135	2.450	2.385	130.000	129.937	135.040	135.000	130.270	130.100	100	333
135	140	2.450	2.385	135.000	134.937	140.040	140.000	135.270	135.100	100	333
140	145	2.450	2.385	140.000	139.937	145.040	145.000	140.270	140.100	100	333
150	155	2.450	2.385	150.000	149.937	155.040	155.000	150.270	150.100	100	333
160	165	2.450	2.385	160.000	159.937	165.040	165.000	160.270	160.100	100	333
180	185	2.450	2.385	180.000	179.937	185.046	185.000	180.276	180.100	100	339
190	195	2.450	2.385	190.000	189.928	195.046	195.000	190.276	190.100	100	348
200	205	2.450	2.385	200.000	199.928	205.046	205.000	200.276	200.100	100	348
210	215	2.450	2.385	210.000	209.928	215.046	215.000	210.276	210.100	100	348
220	225	2.450	2.385	220.000	219.928	225.046	225.000	220.276	220.100	100	348
250	255	2.450	2.385	250.000	249.928	255.052	255.000	250.282	250.100	100	363
280	285	2.450	2.385	280.000	279.919	285.052	285.000	280.282	280.100	100	363
300	305	2.450	2.385	300.000	299.919	305.052	305.000	300.282	300.100	100	363

7.2 Dimension table for GLYCODUR® A bushings



Dimensions			Basic load rates		Mass	Designation
d	D	B	dyn. C	stat. C ₀		
mm	mm	mm	N	N	g	
8	10	8	7650	16000	1.3	PG 081008 A
	10	10	9650	20000	1.6	PG 081010 A
	10	12	11600	24000	1.9	PG 081012 A
10	12	10	12000	25000	1.9	PG 101210 A
	12	12	14300	30000	2.3	PG 101212 A
	12	15	18000	37500	2.9	PG 101215 A
	12	20	24000	50000	3.9	PG 101220 A
12	14	10	14300	30000	2.3	PG 121410 A
	14	12	17300	36000	2.8	PG 121412 A
	14	15	21600	45000	3.5	PG 121415 A
	14	20	29000	60000	4.6	PG 121420 A
13	15	10	15600	32500	2.4	PG 131510 A
14	16	15	25000	52000	4	PG 141615 A
	16	20	33500	70000	5.3	PG 141620 A
15	17	10	18000	37500	2.8	PG 151710 A
	17	12	21600	45000	3.4	PG 151712 A
	17	15	27000	56000	4.3	PG 151715 A
	17	25	45000	93000	7.1	PG 151725 A
16	18	15	29000	60000	4.5	PG 161815 A
	18	20	38000	80000	6	PG 161820 A
	18	25	48000	100000	7.5	PG 161825 A
18	20	15	32500	67000	5	PG 182015 A
	20	20	43000	90000	6.7	PG 182020 A
	20	25	54000	112000	8.4	PG 182025 A
20	23	15	34000	71000	9.7	PG 202315 A
	23	20	46500	96500	13	PG 202320 A
	23	25	58500	120000	16	PG 202325 A
	23	30	69500	146000	19	PG 202330 A
22	25	15	37500	78000	11	PG 222515 A
	25	20	51000	106000	14	PG 222520 A
	25	30	76500	160000	21	PG 222530 A
25	28	15	42500	88000	12	PG 252815 A
	28	20	57000	120000	16	PG 252820 A
	28	25	72000	150000	20	PG 252825 A
	28	30	88000	183000	24	PG 252830 A

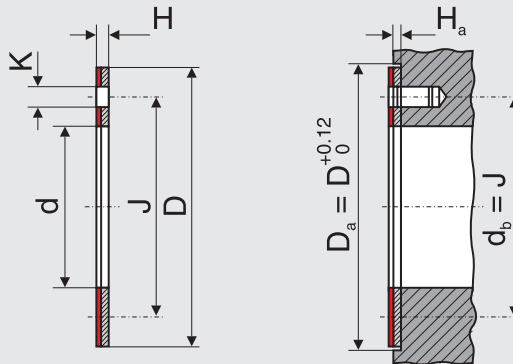
Dimensions			Basic load rates		Mass	Designation
d	D	B	dyn. C	stat. C ₀		
mm	mm	mm	N	N	g	
28	32	25	81500	170000	32	PG 283225 A
	32	30	98000	204000	38	PG 283230 A
30	34	20	69500	143000	27	PG 303420 A
	34	30	106000	220000	41	PG 303430 A
	34	40	140000	300000	54	PG 303440 A
32	36	20	73500	153000	29	PG 323620 A
	36	30	112000	232000	43	PG 323630 A
	36	40	150000	315000	57	PG 323640 A
35	39	20	80000	166000	31	PG 353920 A
	39	30	122000	255000	47	PG 353930 A
	39	50	208000	430000	78	PG 353950 A
37	40	20	85000	176000	23	PG 374020 A
	40	30	129000	270000	35	PG 374030 A
40	44	20	91500	193000	36	PG 404420 A
	44	30	140000	290000	53	PG 404430 A
	44	40	190000	390000	66	PG 404440 A
	44	50	236000	490000	89	PG 404450 A
45	50	20	104000	216000	52	PG 455020 A
	50	30	156000	325000	78	PG 455030 A
	50	40	212000	440000	105	PG 455040 A
	50	50	265000	550000	130	PG 455050 A
50	55	30	176000	365000	86	PG 505530 A
	55	40	236000	490000	115	PG 505540 A
	55	60	355000	735000	170	PG 505560 A
55	60	20	127000	265000	63	PG 556020 A
	60	25	160000	335000	78	PG 556025 A
	60	30	193000	400000	94	PG 556030 A
	60	40	260000	540000	125	PG 556040 A
	60	50	325000	680000	155	PG 556050 A
	60	60	425000	880000	205	PG 606560 A
60	65	30	212000	440000	100	PG 606530 A
	65	40	280000	585000	135	PG 606540 A
	65	60	425000	880000	205	PG 606560 A
65	70	50	380000	800000	185	PG 657050 A
	70	70	540000	1120000	255	PG 657070 A

Dimension and tolerance tables

Dimensions			Basic load rates		Mass	Designation
d	D	B	dyn. C	stat. C ₀		
mm	mm	mm	N	N	g	
70	75	50	415000	865000	195	PG 707550 A
	75	70	585000	1220000	275	PG 707570 A
75	80	40	355000	735000	170	PG 758040 A
	80	60	530000	1100000	255	PG 758060 A
	80	80	710000	1500000	340	PG 758080 A
80	85	40	375000	780000	180	PG 808540 A
	85	60	560000	1180000	270	PG 808560 A
	85	80	750000	1560000	360	PG 808580 A
	85	100	950000	1960000	450	PG 8085100 A
85	90	30	290000	610000	145	PG 859030 A
	90	60	600000	1250000	285	PG 859060 A
90	95	60	640000	1320000	300	PG 909560 A
	95	100	1060000	2240000	505	PG 9095100 A
95	100	30	325000	680000	160	PG 9510030 A
	100	60	670000	1400000	320	PG 9510060 A
100	105	30	345000	720000	170	PG 10010530 A
	105	50	585000	1220000	280	PG 10010550 A
	105	60	710000	1460000	335	PG 10010560 A
	105	80	950000	1960000	445	PG 10010580 A
	105	115	1370000	2850000	640	PG 100105115 A
105	110	60	735000	1530000	350	PG 10511060 A
110	115	60	780000	1630000	370	PG 11011560 A
	115	115	1500000	3150000	705	PG 110115115 A
115	120	50	670000	1400000	320	PG 11512050 A
120	125	60	850000	1760000	400	PG 12012560 A
	125	100	1430000	3000000	665	PG 120125100 A

Dimensions			Basic load rates		Mass	Designation
d	D	B	dyn. C	stat. C ₀		
mm	mm	mm	N	N	g	
125	130	100	1500000	3100000	695	PG 125130100 A
130	135	60	915000	1900000	435	PG 13013560 A
135	140	60	950000	2000000	450	PG 13514060 A
140	145	60	980000	2040000	465	PG 14014560 A
	145	100	1660000	3450000	775	PG 140145100 A
150	155	60	1060000	2200000	500	PG 15015560 A
	155	80	1430000	3000000	665	PG 15015580 A
160	165	80	1500000	3150000	710	PG 16016580 A
	165	100	1900000	3900000	885	PG 160165100 A
180	185	80	1700000	3550000	795	PG 18018580 A
	185	100	2120000	4400000	995	PG 180185100 A
190	195	60	1340000	2800000	630	PG 19019560 A
	195	100	2240000	4650000	1050	PG 190195100 A
200	205	100	2360000	4900000	1100	PG 200205100 A
210	215	100	2500000	5200000	1150	PG 210215100 A
220	225	100	2600000	5400000	1200	PG 220225100 A
250	255	100	3000000	6100000	1400	PG 250255100 A
280	285	80	2650000	5500000	1250	PG 28028580 A
300	305	100	3550000	7350000	1650	PG 300305100 A

7.3 Dimension and tolerance tables for GLYCODUR® A thrust washers



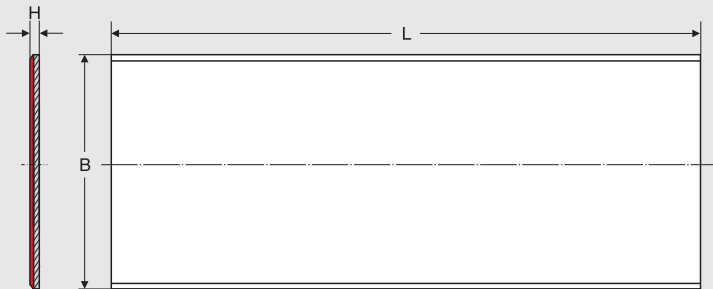
Dimensions						Basic load rates		Mass	Designation
d	D	H	J	K	H _a	dyn. C	stat. C ₀		
mm	mm	mm	mm	mm	mm	N	N	g	
12	24	1.5	18	1.75	1	40500	85000	3.2	PXG 122401.5 A
14	26	1.5	20	2.25	1	45000	93000	3.6	PXG 142601.5 A
18	32	1.5	25	2.25	1	65500	137000	5.3	PXG 183201.5 A
20	36	1.5	28	3.25	1	85000	176000	6.7	PXG 203601.5 A
22	38	1.5	30	3.25	1	90000	186000	7.2	PXG 223801.5 A
26	44	1.5	35	3.25	1	118000	245000	9.4	PXG 264401.5 A
28	48	1.5	38	4.25	1	140000	290000	11	PXG 284801.5 A
32	54	1.5	43	4.25	1	176000	365000	14	PXG 325401.5 A
38	62	1.5	50	4.25	1	224000	465000	18	PXG 386201.5 A
42	66	1.5	54	4.25	1	240000	510000	19	PXG 426601.5 A
48	74	2	61	4.25	1.5	300000	620000	34	PXG 487402 A
52	78	2	65	4.25	1.5	315000	655000	36	PXG 527802 A

Table 7.3.1 –
GLYCODUR® A thrust washer dimensions

Dimensions	Deviations	
	high	low
	mm	mm
Bore diameter d	+0.250	0
Outside diameter D	0	-0.250
Hole pitch diameter J	+0.120	-0.250
Hole diameter K	+0.125	-0.125
Height H	0	-0.050

Table 7.3.2 –
GLYCODUR® A thrust washer tolerances

7.4 Dimension table for GLYCODUR® A strip material



Dimensions				Mass	Designation
B	B ¹⁾	L ²⁾	H		
mm	mm	mm	mm	kg	
200	182	500	1.00	0.57	PLG 2005001.0 A
250	232	500	1.50	1.14	PLG 2505001.5 A
250	232	500	2.00	1.63	PLG 2505002.0 A
225	207	500	2.50	1.90	PLG 2255002.5 A
200	182	500	3.06	2.11	PLG 2005003.06 A

¹⁾ Effective strip width (width of sliding layer)

²⁾ Other lengths to order

7.5 GLYCODUR® A strip material tolerances

Dimensions		Deviations	
		high	low
		mm	mm
Width B		+0.500	0
Length L		+3	0
Height	H ≤ 2.5	0	-0.100
	H = 3.06	+0.050	-0.050

Automotive

King pins, starter pinions, brake rod linkages, brake shafts, brake shoes, suspension struts, foot pedals, accelerator linkages, fans, drive shafts, clutch release levers, steering rods, steering columns, swing axles, shock absorbers, support joints, throttle valves etc.

Railroad vehicles, railroad installations

Automatic doors, level crossing barriers, brakes, pantographs, driving controls, load switches, relay boxes, signaling equipment, wagons, switch points etc.

Aerospace

Brakes, electronic equipment, landing gears, engines, radar equipment, control systems etc.

Construction machinery, conveyers

Lifts, excavator drives, excavator controls, excavator arms, concrete mixers, fork lift trucks, hydraulic cylinders, track tensioning pulleys, crane drives, crane control equipment, crane jibs, mortar vehicles, pallet lift trucks, pneumatic lifts, caterpillar graders, escalators, moving walkways, vibrating screens, slides, shuttering cleaners, heavy-duty trailers, cable winches, conveyers of all kinds etc.

Domestic appliances, hospital equipment

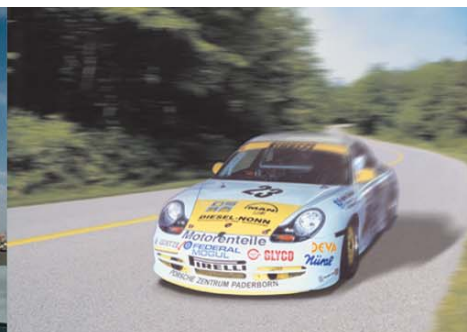
Dental equipment, dish washers, ironing machines, air conditioning equipment, hospital beds, refrigerators, sewing machines, operating tables, x-ray equipment, vacuum cleaners, washing machines etc.

Agricultural machinery, food processing machinery

Bottle filling machines, bakery equipment, timber chain saws, filtration machines, meat processing equipment, hay balers, potato harvesters, wine-making equipment, loaders, unloaders, combine harvesters, mills, planting machines, root crop harvesters, balers, tractors, tractor seats, automatic packing equipment, weighing equipment etc.

Paper and textile

Cutting machines, printing machines, doubling machines, folding machines, yarn and wool machinery, vulcanization machines, carders, button machines, paper cutting and processing machines, sorting devices, spinning machines, stuffers, knitting machines, looms etc.



Pumps and valves

Axial and radial piston pumps, metering pumps, firefighting pumps, compressors, ball cocks, mixing valves, oil burners, pumps for chemicals, regulating valves, submersible pumps, vacuum pumps, gear pumps etc.

Other applications

Waste disposal equipment and systems, magnetic brakes, hardening plants, awnings, smelting furnaces, steel and steel/hydraulic engineering equipment, continuously variable gears, drying plants etc.

GLYCODUR®



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General sales conditions

1. General - Area of Application

1.1 Our sales conditions apply exclusively; we are not acknowledging General Terms and Conditions (T&C) of the customer contrary to or deviating from these Sales Conditions, unless otherwise agreed upon in writing. General Terms and Conditions of the customer also do not apply should the customer at some time in the business relationship refer to those T&C and we did not oppose to them. We fulfill deliveries only under our T&C. These General Sales Conditions apply to all, also future business transactions covering sales of goods, work and service performances with us, including the phase of preparation of contract. Already with our quotation or the answer to an inquiry our General Sales Conditions are included in the legal relationship to the customer. Our Sales Conditions apply towards enterprises within the meaning of Section 14 German Civil Code (§ 14 BGB), if the contract pertains to the operation of the enterprise. In respect to consumers they apply unless statutory regulations mandatorily prevail.

1.2 "Customer" in the sense of these Sales Conditions is each recipient of our products, work or services ("Products") based upon contractual agreement. Terms define primarily according to the definition of the respective actual Technical Standards as DIN/ISO 8402.

1.3 All agreements made between us and the customer for the purpose of fulfillment of a contract must be made in writing. Verbal side agreements are not valid unless confirmed by us in writing. Amendments of the contract or annulment require the written form. This also applies for provisions about the abandonment of the written form.

1.4 We are entitled to process and to share for our own purposes also personal data originating from the business relationship. The Customer is herewith informed thereof pursuant to Sections 28 ff Federal Law on Data Protection (§ 28 ff BDSG).

2. Quotations, Order

2.1 Our quotation remains without engagement until final order confirmation.

2.2 The order of the customer is a binding quotation. We are entitled to accept this quotation within two weeks by sending an order confirmation or to provide the products ordered to the customer within an agreed upon period.

2.3 Each order applies only for the market for which it is destined. We have to be informed of the destination market. In the event the customer cannot deliver to a country of destination, e.g. due to an embargo, he - upon request - has to return to us the delivered products. In the case of any deviation hereof the customer shall compensate us for any costs and damages and shall indemnify us from any those claims.

2.4 In the event the order is based on our specifications of products and/or materials or if reference is made to them, the respective specifications for these products and materials apply; respective information will be provided to the customer upon request. If products deviating from those specified in the purchase order are approved by the customer, these are deemed as owed. Further information, e.g. in brochures, pamphlets, catalogues, etc., will not become part of the contract, unless expressly agreed upon. They do not constitute any legally binding declarations and particularly do not constitute the acceptance of assured qualities, of otherwise independent guaranties or specific instructions for any application. This also applies for the use of standard - or conformity certificates.

2.5 The customer exclusively decides on the fitness of the products for the intended purpose to be delivered by us for the cases of application and construction chosen by him. A purpose for the application of our products ordered by the customer shall only become part of the contract if agreed upon in writing. This also applies insofar as we were participating in the development of the products created by the customer or contributed advice and recommendations. Article 2.4 applies accordingly.

2.6 The customer solely decides about the readiness of our products for their purposes. In the relationship towards us the customer is debarred from the objection of delivery of products not tested or insufficiently tested.

2.7 The customers assures the retraceability of the products delivered by us. Rights to refuse performance of the customer are insofar excluded. We may request at any time the proof of keeping documentation.

2.8 The customer has to point out to us the use of the products delivered by us as a part requiring safety or as a part requiring special documentation. He is liable to us for each damage originating from the non-fulfillment of this obligation. Our products may not be used in aviation or in nuclear plants without our consent.

2.9 We reserve the copyrights as well as property rights in any illustrations, drawings, calculations and other documents, models or patterns. This also applies to such written documentation which are designated to be "confidential". Before handing them to third parties customer needs our express written consent.

3. Prices and Payment Conditions

3.1 Only prices confirmed by us are binding. In the event deliveries and partial deliveries are - as per agreement - carried out later than two months after date of order confirmation, then the sales price stated by us at the time of delivery is valid. Insofar as the order confirmation does not state otherwise, our prices are "ex works" including loading at the factory, however, excluding packing, freight, transfer, insurance, customs, assembly and the respective valid value added tax. The value added tax will be shown separately on the invoice on the date of invoicing in its legal amount.

3.2 Unless stipulated otherwise our accounts receivables are payable net within 30 days after invoice date. Discounts we only grant if so agreed. We may request pre-payment or security prior to delivery. Upon default of the customer we are entitled to at least 8 % p.a. above the base rate of the European Central Bank valid on the due date. The customer is entitled to prove that either no or a lower damage has incurred.

3.3 Payments may only be made in the currency determined by us. All payment obligations resulting from the legal relationship with us are according to our option deemed to be agreed in EURO.

3.4 The acceptance of bills of exchange and cheques will be effected only upon special agreement and only on account of payment. Discount and collection charges are for account of the customer.

3.5 The set-off of counterclaims by the customer is excluded, unless the counterclaim is undisputed or has become res indicata and results from the same legal transaction. The customer is only entitled to exercise a right of retention insofar as his counterclaim is based on the same contractual relationship. The customer is not entitled to a right of retention because of partial performance pursuant to Section 320 Subsection 2 German Civil Code (§320 Abs.2 BGB). The assignment or pledge of existing claims towards us require our written consent.

3.6 The duties of the customer out of a contract concluded with us continue to be in effect, if the product manufactured by customer is included into the product delivered by us and may not be marketed for reasons not within our responsibility.

3.7 Deviating from Sections 366, 367 German Civil Code (§§ 366, 367 BGB) we are at all times entitled to determine which claims are fulfilled by the payments of customer.

4. Delivery Time and Default in Delivery

4.1 Only delivery times which have been confirmed by us in writing are binding. They only bind us if the customer has made all order specifications and has made participative actions. Transactions to be performed at a fixed date require a separate written agreement.

4.2 In case of force majeure or other unpredictable, extraordinary circumstances and circumstances not due to anyone's fault (interruption of operation, strike, lockout, interventions by authorities, difficulties in supplying energy, belated or defective supply of raw material, semi-finished or finished products necessary for the production of the delivery items, etc.) the delivery time will be extended by the duration of this impediment plus an appropriate allowance for setting up if, for this reason, we are prevented from timely fulfillment of our obligation. This also applies if these circumstances occur at our subcontractor. In important cases we will inform the customer of begin and end of such circumstances as soon as possible. If the impediment lasts longer than six months we and the customer may withdraw from the contract.

Should, due to the circumstances delivery or performance become impossible or unreasonable, then we are discharged from our delivery obligation. In case the delivery time is extended or we are discharged from the delivery obligation, the customer may not derive any claims for damage hereof. Insofar as we become discharged of the delivery obligation we grant back any possible advance performances of the customer.

4.3 Claims for compensation of damages by the customer due to belated delivery, also after expiration of a grace period granted to us, are limited to damages which are predictable and typical for contract.

4.4 Unless otherwise agreed, work-contractual acceptances have to be carried out by the customer at our premises at his own cost. If the customer fails to carry out this acceptance, the products are deemed to be unconditionally accepted upon leaving our premises.

4.5 For deliveries of our products within logistic systems - e.g. just-in-time - a written agreement is required.

4.6 Delivery periods start with the date of order confirmation, however, not before the timely and proper fulfillment of the obligations of the customer, i.e. especially not before the provision of documents, approvals, releases to be obtained by customer, as well as before receipt of an agreed advance payment.

4.7 The delivery time is deemed to be met if our product at the expiration of the delivery period has left the factory or the distribution centre or the readiness for dispatch has been announced. This does not apply if by contract an acceptance is agreed upon or if an assembly obligation has been stipulated.

4.8 In the event the dispatch is delayed upon the request of the customer, then we will charge him – commencing 1 month after notice of readiness for dispatch – the costs for the storage. However, we are entitled, after setting and expiration of an adequate grace period and after adequate advance notice, to otherwise dispose of the delivery item and to make delivery to the customer with an appropriate extended period.

4.9 We are entitled at any time, for the fulfillment of our delivery obligation, to carry out a contractual delivery by an affiliated entity, or to have manufactured the ordered product by an affiliated entity.

5. Delivery, Transfer of Risk and Transportation.

5.1 Partial deliveries are permissible to a reasonable extent.

5.2 With the dispatch of the products, the notification of readiness of dispatch or with the occurrence of default in taking delivery by the customer – whichever happens first – the transfer risk including the risk of accidental loss of the goods sold passes on to the customer.

5.3 Packaging and means of transport as well as dispatch may be selected by us, if the customer does not make a timely decision confirmed by us prior to expiration of the delivery time. The costs of the change shall be borne by the customer.

5.4 If dispatch is delayed as a consequence of circumstances within the responsibility of the customer, then the transfer risk passes on to the customer as of the date of readiness of dispatch.

5.5 Upon request of the customer the delivery will be insured at his expense against theft, breakage, transportation, fire and water damages as well as against other risks that may be insured. The date of transfer of risk pursuant to article 5.2 remains unaffected hereof.

6. Retention of Title

6.1 We reserve the right of retention of title on the delivered products up to the receipt of all payments resulting from the business relationship with the customer and his affiliated entities. He is not authorized to provide as security to third parties products owed by us. In case of violation of the contract, especially payment delay, we are - after setting an adequate period - entitled to take back the product. The taking back of the product by us – unless expressly otherwise provided – is not deemed a rescission from the contract. After taking back our product we are entitled to its exploitation; the proceeds of the exploitation is to be set off against the obligations of the customer – less appropriate exploitation costs.

In the event we pledge the products we are entitled to exploitation under set-off against our claims.

6.2 The customer is obligated to handle our products properly and to store them with the care specifically required for the products. Especially he is obligated to insure these at his own expense against fire, water and theft at replacement value. Replacement claims against the insurer are to be assigned to us. We hereby accept the assignment. The customer instructs the insurer to perform payment only to us. Insofar as maintenance and inspection are necessary, the customer shall carry these services out in time at his own expense.

6.3 Upon pledges or other encumbrances of third parties on our products the customer has to notify us immediately in writing, to enable us to file action pursuant to Section 771 Code of Civil Procedure (§ 771 ZPO). He has to take all measures necessary for abolition and defense of such encumbrances and claims and to support us in securing our rights in every manner, also in our name. Insofar as third parties are not in a position to retribute to us the court and out-of-court costs of an action pursuant to Section 771 Code of Civil Procedure (§ 771 ZPO), the customer is liable for the loss incurred.

6.4 The customer is entitled to process our products in the ordinary course of business and/or to resell them in that scope; however, he already at this time assigns to us all receivables in the amount of the final invoice amount (including value added tax) of our claim accruing from the resale against his buyers or third parties, and irrespective of the fact, whether our products have been sold without or after processing. The customer remains also after assignment authorized to collect this receivable. Our entitlement to collect the receivable ourselves remains unaffected hereof. However, we agree not to collect the receivable as long as the customer fulfills his payment obligations from the proceeds collected, is not in default with payments and especially no filings for insolvency proceedings exist or payments have been stopped. In such case we may demand that the customer informs us of the assigned receivables and name their debtors, of all information necessary for the collection, hands over all documents pertaining to the case and informs the debtors (third parties) of the assignment. Furthermore, all receivables out of bills of exchange which were drawn on receivables resulting from the resale of our property (customer bills of exchange). We may – at any time – demand the surrender of the bills of exchange and request endorsement by the customer. We are entitled at any time to inform third parties of the assignment of the receivables of the customer to us. Any assignments are herewith accepted.

6.5 The process or transformation of our products by the customer is always carried out for us. In the event our product is processed with other objects not owed by us, then we acquire the co-ownership in the new object in the ratio of the value of our products (final invoice amount including value added tax) to the other processed objects at the time of

processing. For the object created due to processing the same applies as for the purchase item delivered without reserve.

6.6 We agree to release the securities due to us upon request of customer insofar as the realizable value of our securities exceeds the claims to be secured by more than 10 %; it is our option to choose the securities to be released.

7. Liability for Defects

7.1 We furnish the assured deliveries according to the contractual agreement.

7.2 Insofar as our delivery within the period of the statute of limitations shows a material defect (hereinafter: Defect), the cause of which already existed at the time of transfer of risk, then the customer – in our discretion – may claim subsequent fulfillment by repair or new delivery of respective products at the place of delivery.

7.3 In the event the subsequent fulfillment fails, then the customer – at his discretion – is entitled, irrespective of any claims for damages and claims for reimbursement of expenditures pursuant to article 7.9 through 7.14, to reduce the purchase price or – insofar as our failure to comply with our duty is essential – to withdraw from the contract.

7.4 Preconditions of any warranty claim are

- especially the proper storage, handling and usage of our products for applications we were informed of as well as the application of only suitable operation equipment when applying our products. The customer is solely responsible for the correctness and completeness of the specifications in the purchase order and the respective documentation handed over to us. Drawings and technical stipulations or documentation handed over by the customer do not constitute any assured qualities or otherwise extended bases for claims against us, unless prior expressly agreed upon with us in writing.

- that no own processing or subsequent improvement was carried out by the customer

- that the customer has fulfilled his legally owed inspection obligations and requirements to make a complaint in respect of a defect. Defects have to be evidenced insofar stating their kind and extent within 10 days after receipt of the delivery item at the place of destination.

7.5 In order to carry out all subsequent improvements and replacement deliveries deemed necessary to us in our fair judgment the customer has, after coordinating with us, to grant the necessary time and opportunity. Otherwise we are released from the damage consequences which would exist because of non-fulfillment. Also, in the event of considerable defects we are entitled to subsequent improvement or replacement delivery.

7.6 The statute of limitations for claims of defects expires in one year. This does not apply insofar as these are based upon an intentional conduct within our responsibility and insofar as the law pursuant to Sections 438 I No. 2, 479 I, 634 a I No. 2 German Civil Code (§§ 438 I Nr.2, 479 I, 634 a I Nr.2 BGB) imperatively provides for longer time periods. The statute of limitations commences with the delivery of the products unless otherwise agreed upon in writing.

7.7 If we should become exposed to no-fault liability claims of third parties under local or foreign law, which are caused by products delivered by us, then the customer has to hold us harmless and indemnify us in any case from all claims and costs of legal defense against such claims of product liability. This also applies for each recourse claim against us, no matter who lodges, asserts or acquires such claim. Compensation claims in case of defectiveness and cause of damage of the products delivered by us can be asserted by the customer, even in case of joint and several liability, only if we are responsible for the defect. The customer shall make available to us at our disposal all information required for prosecution of our rights, also such from his areas. The customer shall support us in the exonerating evidence encumbered on us by third parties by surrender of documents pursuant to article 2.8.

7.8 The customer agrees to hold sufficient insurance coverage against liability cases especially arising from liability with or without fault. He has to inform his insurer of the obligations from these conditions.

7.9 According to the legal stipulations we are liable insofar as the customer asserts claims for damage or claims for reimbursement of expenditures (hereinafter: damage compensation claims) based on intention or gross negligence, including those of intention or gross negligence of our representatives or persons employed in the performance of our obligation. Further are we liable pursuant to legal provisions if we culpably violated an essential contractual obligation as well as in cases of injury of life, body or health and insofar as we have assumed guarantees.

7.10 The compensation for damages for the violation of an essential contractual duty is limited to the predictable, typical damage, insofar as no intent or gross negligence exists and insofar as no liability has been assumed for injury of life, body or health or from assumed guarantees. Insofar claims for these damages become statute barred in one year.

7.11 Further damage compensation claims as designated in these General Sales Conditions are excluded.

7.12 The imperative stipulations of the Product Liability Law remain unaffected.

7.13 Claims for reimbursement of expenses of the customer are limited to the value of the interest, which the customer has in the fulfillment of contract.

7.14 Insofar as our liability is excluded or limited, this applies also for the personal liability of our employees, staff members, co-workers representatives and persons employed in the performance of our obligation.

7.15 Claims are excluded if they are not asserted in court within three months after written refusal by us.

8. Tools and Inventor's Rights

8.1 Tools being manufactured in connection with the manufacture of our products for the customer and all rights therein and thereof, belong to us, irrespective of cost contribution by the customer. Each transfer of rights on them to the customer is excluded.

8.2 In the event of orders, the execution of which requires development work from us, the customer does not acquire an inventor's right in the developed objects or procedures, in our know-how as well as in the equipment for the manufacture of these objects, also if he has contributed a part of the development and/or manufacturing costs. Rights pursuant to the Employee Invention Act remain unaffected.

9. Secrecy, Place of Performance, Place of Jurisdiction and Applicable Law

9.1 The customer shall treat confidential any knowledge and information from the business relationship with us which are not evident or have permissibly become evident. This also especially applies to knowledge about our know-how and our manufacturing methods and processes acquired upon auditing us or including us in the co-development of his products. The customer shall impose this on third parties engaged by him as own obligation. The customer is liable to us for all damages arising from the violation of this obligation excluding the continuation of offense, as one offense. The obligation to preservation of confidentiality is considered an independent legal duty surviving any termination of the business relationship with us.

9.2 Place of performance for the delivery is the place of manufacturing, resp. our distribution center. Place of performance for the payment is our business seat.

9.3 All legal relationships between us and customer are subject to German law, excluding the United Nations Conventions on Contracts for the International Sales of Goods (CISG). Should claims be asserted against us abroad, we may assert claims against the customer at the place of jurisdiction of the main claim.

10. Concluding Terms

10.1 If orders and correspondence are not made out in German language, relevant for the interpretation of the contents of contract are the documents in German language.

10.2 Should one or several stipulations of these conditions be or will be ineffective, then the effectiveness of the remaining stipulations will not be effected thereof. The customer is obligated to cooperate in agreeing on a valid provision which is legally and economically as close as possible to the original.

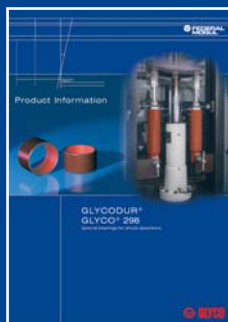
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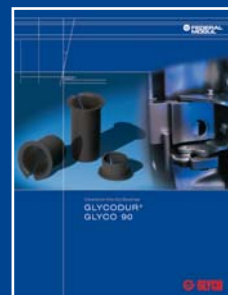




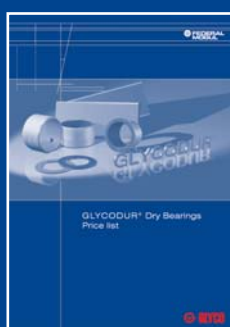
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