Carbon and Graphite
Materials for Plain Bearing Applications

Automotive & Mechanical Applications

Broad Base. Best Solutions.

SGL GROUP
THE CARBON COMPANY

Material Grade Recommendations for Plain Bearings

Base materials are carbon graphite, graphite and resin-bonded graphite, also used with special impregnations (antimony or resin) depending on the application. The range of uses includes wet, mixed and dry running.

Small-Batch Production

EK 20
Carbon graphite grade with good dry-running properties. Suitable for wet-running plain bearings.

EK 24
Carbon graphite grade with very good dry-running properties. Particularly suited for dry-running use and for use in media with poor lubricating properties.

EK 40
Graphite grade for dry-running plain bearings.

Large-Batch Production

EK 23
Carbon graphite grade, pressed-to-size, with good dry-running properties. Suitable for plain bearings running wet and dry.

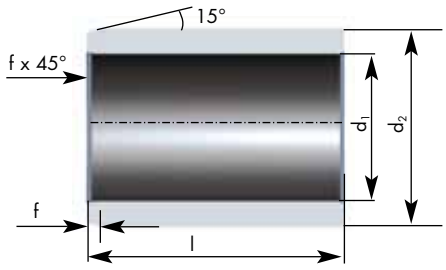
EK 25
Carbon graphite grade with very good dry-running properties. Particularly suited for dry-running use and for use in media with poor lubricating properties.

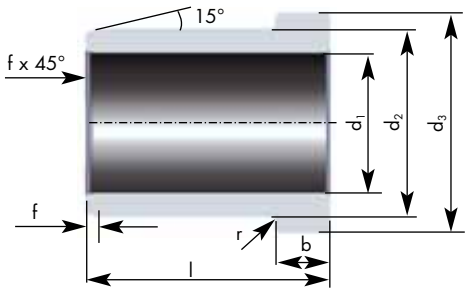
RIDURID® V 1640
Resin-bonded material for wet-running bearings.

Cylindrical bearing for pumps
in the chemical industry

Design Guideline / Calculations

Cylindrical Bearings, Flanged Bearings





d_1 = bearing bore (mm)
d_2 = bearing outside diameter (mm)
d_3 = flange diameter (mm)
s = bearing wall thickness (mm)
l = bearing length (mm)

F = radial or axial load (N)
p = specific radial or axial load (N/mm²)
b = flange thickness (mm)
v = sliding speed (m/s)
f = chamfer (mm)

Dry Running and Mixed Running

Bearing size	v (m/s) ≤ 1	projected bearing area	$l \times d_1 \geq \frac{F}{0.3\ (N/mm^2)}$ $l \leq 2\ d_1$
	v (m/s) ≤ 0.1	projected bearing area	$l \times d_1 \geq \frac{F}{1.5\ (N/mm^2)}$ $l \leq 2\ d_1$
Bearing clearance	0.3 ... 0.5 %	of shaft diameter at operating temperature (warm clearance)	
	0.3 ... 0.5 %	of shaft diameter at fitting temperature (cold clearance) if shrunk into a metal housing	
Coefficient of friction	0.10 ... 0.15	for mixed running	
	0.15 ... 0.25	for dry running	

Wet Running

Bearing size[1)]	v (m/s) ≤ 20	projected bearing area	$l \times d_1 \geq \frac{F}{0.3\ (N/mm^2)}$ $l \leq 2\ d_1$
	v (m/s) ≤ 15	projected bearing area	$l \times d_1 \geq \frac{F}{0.5\ (N/mm^2)}$ $l \leq 2\ d_1$
Bearing clearance[1)]	0.1 ... 0.3 %	of shaft diameter at operating temperature (warm clearance)	
	0.1 ... 0.3 %	of shaft diameter at fitting temperature (cold clearance) if shrunk into a metal housing	
Coefficient of friction	0.01 ... 0.05		

Information for Wet and Dry Running

Tolerances	Outside diameter	IT 6 / IT 7	
	Bore	IT 7 / IT 8	
Surface finish	Outside diameter		
	Ra = 6.3 µm ... 3.2 µm		
	Bore		
	Ra = 3.2 µm ... 0.8 µm		
Bearing design	Do not subject bearing to tension, shear or bending stress		
Fitting	Cold press fitting		
	Shrink fitting		
	Bonding		
Counterface materials (surface finish)	Generally hard materials, e.g. HRC > 50		
	Rz = 0.5...0.8 µm		

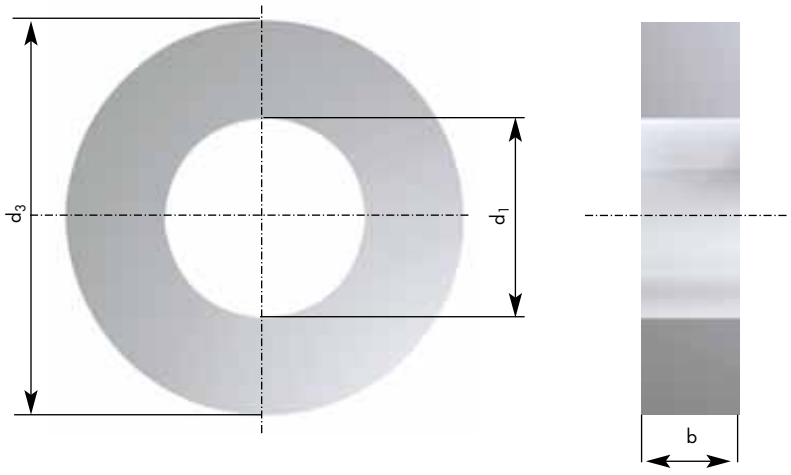
[1)] Observe the laws of hydrodynamics.

Method of Fitting	Recommended ISO Tolerances			Max. Operating Temperature °C/°F
	d_1	d_2	Housing diameter	
Cold press fitting	before F7 after H7...H8	s6	H7	about 150[1] / 302[1]
Shrink fitting	before D8 after E8...E9[2]	x8...z8	H7	about 300[2] / 572[2]

[1] For housing materials having a thermal expansion of $\alpha > 12 \cdot 10^{-6}$/K the maximum operating temperature is correspondingly reduced. Press fitting is effected with a stepped fitting pin with a tolerance of h5.
[2] We recommend that the bearing bore be finished to size after shrink fitting.
[3] For higher temperatures and for housing materials having a thermal expansion of $\alpha > 12 \cdot 10^{-6}$/K the special tolerances and/or a locking arrangement may be employed – please inquire about this.

Axial Bearings

The following information applies also to calculating the face surfaces of cylindrical and flanged bearings when loaded axially.



	Dry Running/Mixed Running	Wet Running
Bearing area A (mm²)	v (m/s) ≤ 1 $A \geq \frac{F}{0.3\ (N/mm^2)}$	v (m/s) ≤ 20 $A \geq \frac{F}{1.0\ (N/mm^2)}$
Coefficient of friction	0.1...0.25	0.01...0.05
Surface finish	Bearing surfaces fine-ground to lapped	Bearing surface lapped
Bearing design	Solid or split	Solid or split, lubricating grooves
Fitting	Cold press fitting, shrink fitting, bonded or screwed	Cold press fitting, shrink fitting, bonded or screwed
Counterface materials Surface finish	Usually hard materials, e.g. HRC > 50 Rz = 0.5...0.8 µm	Usually hard materials, e.g. HRC > 50 Rz = 0.5...0.8 µm

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Example: Cylindrical Bearing Calculation

Dry Running

Given values		
	Sliding speed	v = 0.5 m/s
	Load	P = 150 N
	Temperature	60 °C / 140 °F
Determining bearing size		
Projected bearing area	$l \times d_1 \geq \frac{P}{0.3} = \frac{150}{0.3} = 500\ mm^2$	
Bearing bore	$d_1 \geq \frac{l}{2}$	
we choose	$d_1 = l$	
	$d_1 = \sqrt{500} = 22.36$ mm	
rounded up	$d_1 = 23$ m	
Bearing length	$l = \frac{500}{23} = 21.7$ mm	
rounded up	l = 22 mm	
Bearing outside-Ø	$d_2 = d_1 + 2s$	
(see bearing design references page 6)	$s_{min} = 0.15 \times d_1 = 3.45$ mm	
	23 + 2 x 3.45 = 29.9 mm	
rounded up	$d_2 = 30$ mm	
Bearing dimensions	Ø 30/23 x 22 mm	
Bearing clearance		
Dry running	0.3 ... 0.5 % of shaft-Ø d	
Shaft diameter	d = 23 h6	
Bearing clearance (min.)	0.3 % x 23 = 0.069 mm (is added to nominal bore)	
Bearing tolerances	(see Fitting page 4)	
Bearing outside-Ø	chosen s6 (cold press fitting)	
Bearing bore	chosen F7	
Resulting in:	**Ø 30 s6/23.069 F7 x 22 mm**	

Example: Axial Bearing Calculation

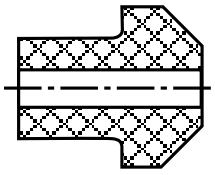
Wet Running

Given values		
	Shaft-Ø	20 mm
	Rubbing speed	v = 3 m/s
	Load	P = 500 N
	Medium	Water
	Temperature	30 °C / 86 °F
Determining bearing size		
Bearing bore	$d_1 = 20$ mm (given)	
Bearing outside-Ø d_3	By going back and calculating from the required area	
	$A = \frac{P}{1.0} = \frac{500}{1.0} = 500\ mm^2$	
this results in	$A = \frac{\pi (d_3^2 - d_1^2)}{4}$	
	$d_3 = \sqrt{\frac{A \times 4}{\pi} + d_1^2}$	
	$d_3 = \sqrt{\frac{500 \times 4}{\pi} + 20^2}$	
	$d_3 = 32$ mm	
Bearing outside-Ø chosen as	$d_3 = 35$ mm	
Bearing height (see bearing design references page 6)	$b > 0.1 d_3$	
chosen as	b = 5 mm	

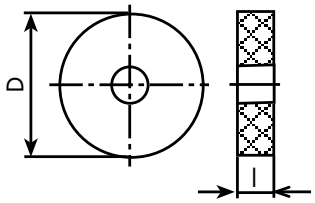
Bearing Design

In addition, we recommend following the design guidelines given below:

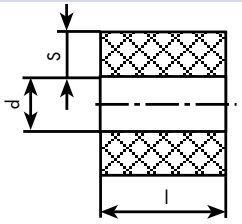
- bearings for dry running should have a smooth bore
- if bearings are running wet, bores should have spiral grooves or axial grooves according to the application.



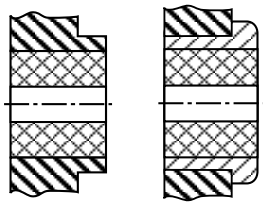
Avoid **sharp steps** in the bore and on the outside. Break sharp edges!



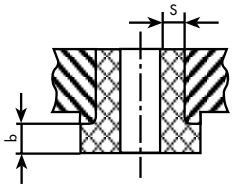
Dimension l ≥ 0.1 D;
if possible not below 3 mm



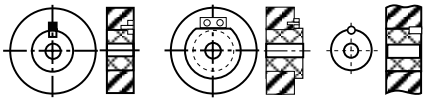
Cylinder strength
l ≤ 2d; s = 0.15 ... 0.2 x d;
s_{min} = 3 mm



Cylindrical bearings should be fully supported by the housing or by a special metal bushing.



Flange thickness should be at least equal to wall thickness. A transitional angle should be radiused. Housing thrust face for flange to be machined.
b ≥ s



Any arrangement such as a check plate or plain pin to **prevent rotation** should be provided in an unloaded area, not in the bore. Any keyway should be axial and milled out carefully to avoid breakage.

Counterface Materials, Surface Finish

Recommended are hard materials

- gray cast iron
- steel, alloy, non-alloy and nitrided (hard)
- hard metal
- aluminum oxide
- silicon carbide
- glass
- DLC-coated materials

Of limited use are

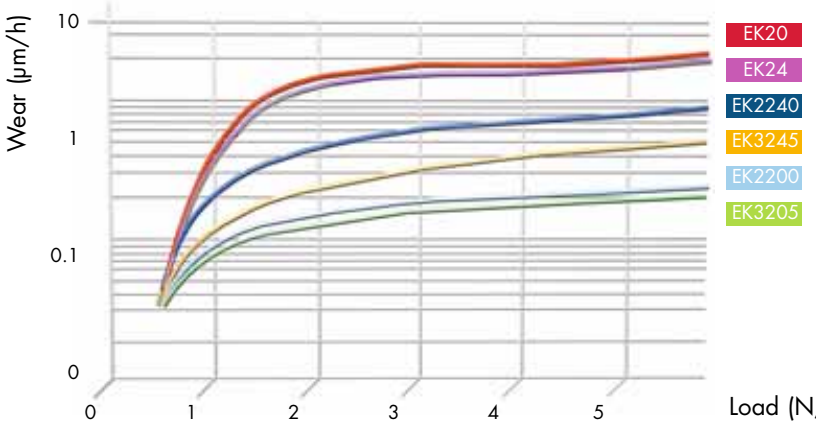
- steel, alloy and non-alloy (soft)
- light metal alloys
- chromium-plated materials
- non-ferrous metals
- carbon materials

In dry running conditions the surface finish should generally be of a higher standard than when a liquid film is present. In the latter case, even hydrodynamically poor media such as water or petrol will achieve some compensating effect and reduce friction between the micro-irregularities of the mating surfaces.

Surface Finish of Metallic Counterparts

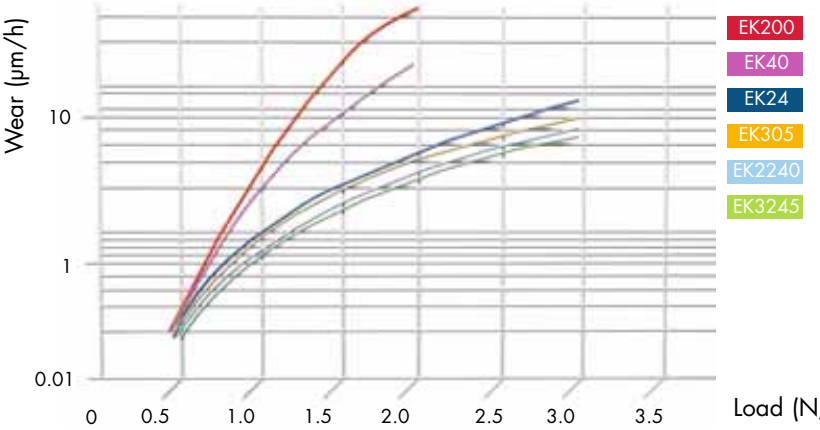
Load	v < 0.5 m/s p < 0.1 N/mm²	v < 1 m/s p < 0.2 N/mm²	v < 3 m/s p < 0.3 N/mm²
Rz µm	≈ 1	0.5 ... 0.8	< 0.5

Wear Rates



Load (N/mm²), Bearing Ø 30/20 x 20 mm

Wear rates of machined bearings of different carbon grades at a steady rubbing speed of 1 m/s and with increasing specific load when running wet.



Load (N/mm²), Bearing Ø 30/20 x 20 mm

Wear rates of machined bearings of different carbon grades at a steady rubbing speed of 1 m/s and with increasing specific load when running dry.

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