VSK Shaft Sealing System

CARBON AND GRAPHITE BEARING

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Description Dry	Chain Grate Stoker	lue Gas Damper	10 Ton Furnace Charging Machine	Submersible Pump Motor	Vertical Centrifugal Pump	Aircraft Fuel Pump
Wet Bearing lb/in2	Dry	Dry	Dry	Wet	Wet	Wet

Note: Tandem / Jointed bearing in 2/3 lengths recommended for length more than 80-100mm

1. INTRODUCTION

Carbon is self-lubricating, chemically inert, dimensionally stable, non-hygroscopic and highly resistant to wear characteristic which make it ideal for those hostile environments where conventional typical cannot be used.
Typical of these are where.

1. Oil Contamination cannot be tolerated
2. Temperatures exceed the limits of normal lubricants
3. operation is in a non-lubricating fluid VSK Carbon bearings are capable of sustaining PV'S (9kg/cm2 X m/s) of 1.5 at temperature of 500°C. in an oxidizing atmosphere and well above 350 PV in non-lubricating liquids.

2. MATERIAL

Carbon grades

The selection of the appropriate grade of carbon is dependent upon the bearing operating conditions and is usually from one of the following four categories :

1. Amorphous carbon / graphite maximum temperature 300°C

2. Amorphous carbon / graphite Resin impregnated maximum temperature 200°C

3. Amorphous carbon / graphite Antimoy impregnated maximum temperature 300°C

4. Electrographite maximum temperature 500°C oxidizing atmosphere 2000°C non-oxidizing atmosphere.

Shaft materials

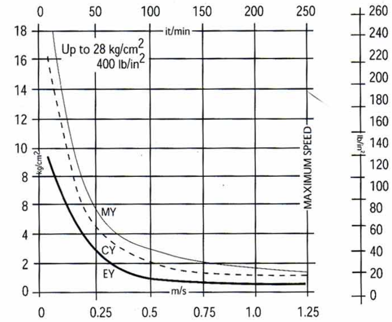
The shaft to run against a carbon bearing should be hard and corrosion resistant such as austenitic iron, hardened stainless steel, thick chrome plates or satellite. Non-ferrous metals and mild steel should be avoided.

A shaft surface finish of between 0.25-0.50 microns Ra is recommended although for lightly loaded applications, 2 microns Ra may be accepted.

3 OPERATING LIMITS

Dry-running

The PV curves shown provide a guide for the continuous operation of Carbon Bearings. For short period or intermittent operations, these recommendations may be exceeded by a generous margin.



METRIC

Max. PV	$\left(\frac{kg}{cm^2} \times \frac{m}{s}\right)$
Carbon Graphite	1.1
Electro Graphite	0.55
Metal Graphite	1.45

IMPERIAL

Max. PV	$\left(\frac{lb}{in^2} \times \frac{ft}{min}\right)$
Carbon Graphite	3000
Electro Graphite	1500
Metal Graphite	4000

PV CURVES – for continuous dry operation and steady loads.

Wet Running

Carbons Bearing running in liquids of high lubricity are capable of achieving performances approximating to those of conventional metal bearings. In more mobile liquids such as Water, Petrol and kerosene the special characteristics of carbon, allied to careful design, permit operations at PV's of 350 kg/cm^2 m/s and above.

Friction

The coefficient of friction is not a physical property of a material and depends on the nature and operating conditions of a rubbing pair. It will vary with the environment, load, speed, surface finish, etc.

In dry operations, a carbon Bearing running against a hard well finished shaft may be expected to show a coefficient of friction varying between 0.10 under light and 0.25 under heavy loads.

The characteristics of the liquid will determine the coefficient of friction in a fully lubricated application whilst under boundry layer condition it will probably be within the range of 0.01 to 0.10.

SK
Shaft Sealing System

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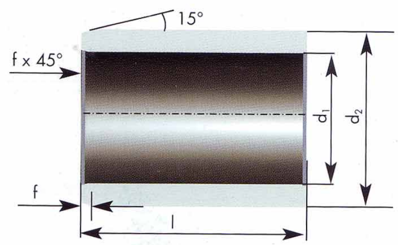
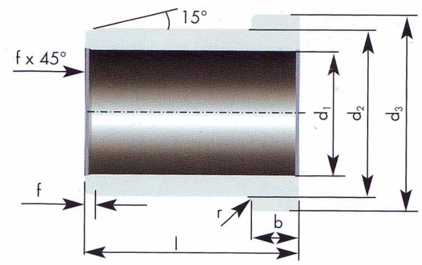
Design Guideline / Calculations
Cylindrical Bearings, Flanged Bearings





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/mm^2)
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 temerature (warm clearance)		
	0.3 ... 0.5 %	of shaft diameter at fitting temerature (cold clearance) if shrunk into 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 temerature (warm clearance)		
	0.1 ... 0.3 %	of shaft diameter at fitting temerature (cold clearance) if shrunk into metal housing		
Coefficient of friction	0.01 ... 0.05			

Information for wet and Dry Running

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

Observe the laws of hydrodynamics.

Fitting

Method of filling	Recommended ISO Tolerances			Max. Operating Temperature °C / °F
	d1	d2	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)]

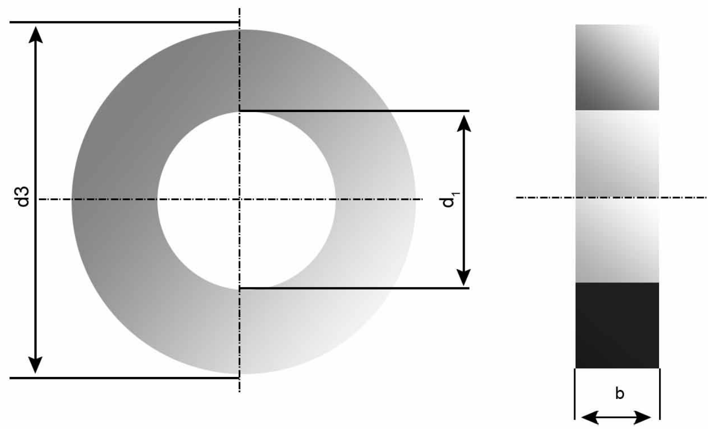
1. For Housing material having a thermal expansion of a > 12 - 10^6 / k the maximum operating temperature is correspondingly reduced. Press fitting is effected with a stepped fitting pin with a tolarance of h5.

2. We recommend that the bearing bore is finished to size after shrink fitting.

3. For higher temperature and for housing materials have a thermal expansion of a > 12 - 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 and mixed Running	Wet Running
Bearing area A (mm^2)	V (m/s) ≤ 1	V (m/s) ≤ 20
	$A \geq \frac{F}{0.3\ (N/mm^2)}$	$A \geq \frac{F}{1.0\ (N/mm^2)}$
Coefficient of friction	0.1... 0.25	0.1... 0.05
Surface finish	Bearing surface 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

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	$d_1 \geq \frac{1}{2}$
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 (see bearing design)	$d_2 = d_1 + 2s$ $s_{min} = 0.15 \times d_1 = 3.45$ 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 tolarance	(see Fitting)
Bearing outside Ø	chosen s6 (cold press fitting)
bearing bore	chosen F7
Resulting in	**Ø 30 s6 / 23.069 F7 x 22 mm**

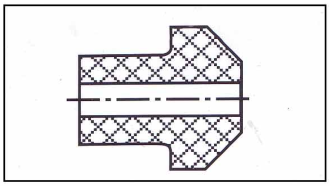
Example : Axial bearing calculation

Wet Running	
Given values	
	shaft Ø 20mm 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
	$A = \frac{P}{1.0} = \frac{500}{1.0} = 500mm^2$
this result 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 and design)	$b > 0.1\ d_3$
Chosen as	b = 5 mm

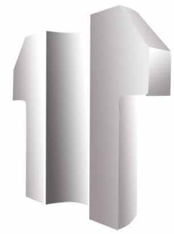
Bearing design

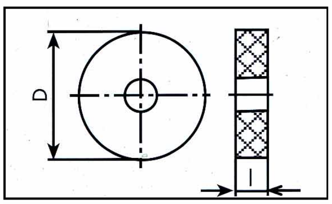
In addition, we recommend following the design guidelines given below :

- 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.

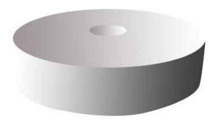


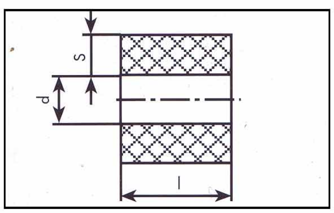
Avoid **sharp steps** in the bore and on the out-side. break sharp edges



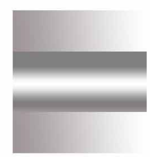


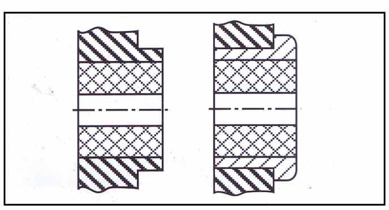
Dimension l ≥ 0.1 D ;
if possible not below 3mm



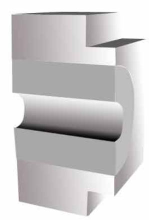


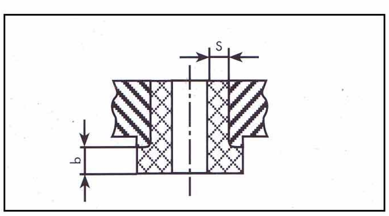
Cylinder Strength
1 ≤ 2d ; s = 0.15 ... 0.2 x d;
s_{min} = 3mm



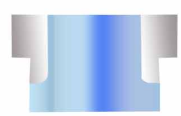


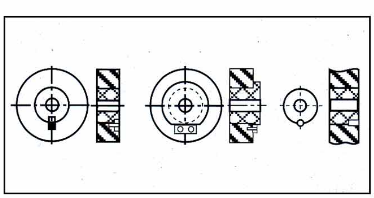
Cylinder bearing should be fully supported by the housing or by a special metal bush-ing.





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





Any arrangement such as 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.