FEROGLIDE

Self lubricating bearings

TECHNICAL MANUAL

Contents

FEROGLIDE

OPERATING PARAMETERS

Many factors affect the design criteria of FEROGLIDE bearings. Those of primary concern include applied load (or bearing pressure), surface velocity, operating mode, surface temperature, mating surface finish, the tolerances on the mating housing and shaft and the final running clearance.

All performance values referred to in this section are based on dry operation. When operating in a fluid environment, FEROGLIDE bearings may have a higher pressure velocity (PV) limit. Under dry running conditions the maximum allowable surface velocity will be dependant on the applied load as well as other operating parameters, but in general terms should be kept below 10m/min.

Bearing Load Limits

Due to the nature of the FEROGLIDE liner materials, the applied load is taken up by the metal backing. The bearing pressure on any FEROGLIDE bearing is generally taken as the applied load, divided by the projected bearing support area, which is the bearing length multiplied by the shaft diameter.

$p = P/d \times L$

E.g. 500 kg load on a bearing 50 mm long with a shaft 45 mm diameter

Bearing Load = P = 500 [kgs] x 9.81 [m/sec] = 4905 N
Bearing Area = [d x L] = 45 mm x 50 mm = 2250 mm^2

Therefore the bearing pressure = p = 4905/2250 N/mm^2 =2.18 N/mm^2 or 2.18 MPa

Types of Bearing Load

1) Static where there is little or no shaft movement and dynamic motion
2) Dynamic where there is oscillating or linear motion and the movement is 10 m/min or less. For continuous rotation we recommend that you contact TENMAT LTD for additional advice.

Static Pressure Limit (constant pressure*) the following table 1 is for maximum load with little or no dynamic movement of the shaft.

*Where repeated impact loading is applied, these values should be reduced to meet fatigue life requirements

Table 1

Maximum Static Pressure N/mm^2	Maximum Static Pressure PSI	Backing metal
210	29 800	Mild Steel
240	34 000	Bronze [RG7]
420	60 000	Inconel

Dynamic Pressure Limit the following table 2 is for maximum loads up to 10 m/min shaft speed.

Table 2

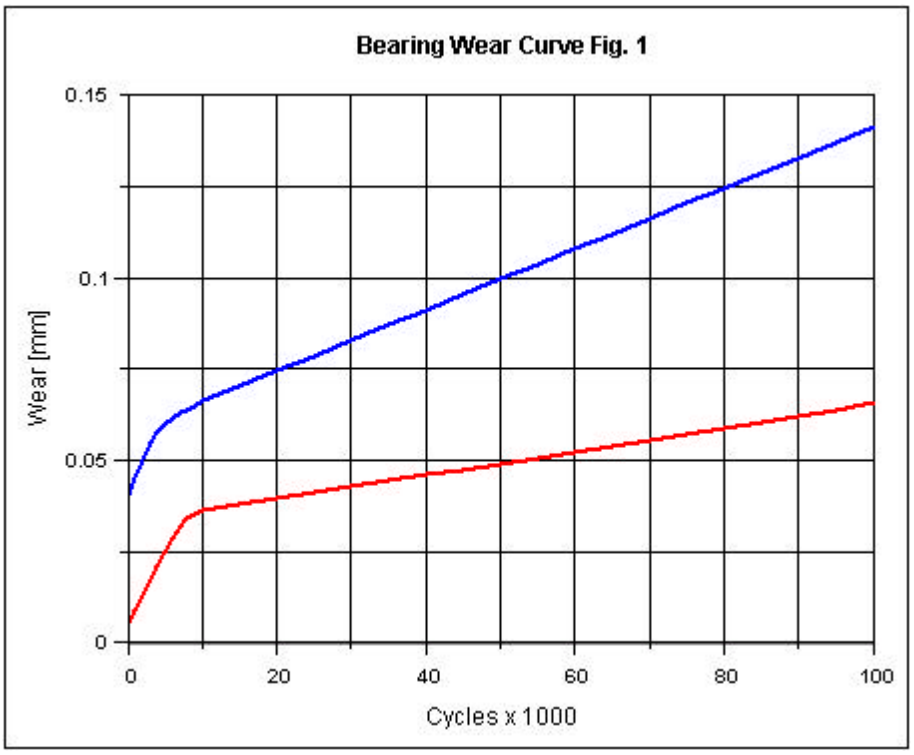
Maximum Dynamic Pressure N/mm^2	Dynamic Pressure PSI	Comments
14-28	2 000-4 000	Best Life & Friction
140	20 000	Suggested Maximum Load
176	25 000	High Strength backing metals

Values for hydroelectric applications see later table 8.

Bearing Wear

As indicated above, bearing wear is affected by many factors.

The graph Fig.1 shows the range of values obtained when journal bearings were subjected to loads of 140N/mm^2 (20 000 psi) with the bearing fixed and the shaft oscillating. The values shown in the graph are representative of the normal wear rate range that can be expected when amplitude is +/- 45°, frequency is 10 CPM, and shaft finish was 0.4 µm under ambient temperature conditions.



It will be noted that a wear-in period takes place during the first few thousand cycles. During this period some PTFE is transferred to the mating surface. In addition, the fibres are generally reoriented, the high spots of the weave are flattened and adjacent fibres tend to blend together. After the break-in period, the bearing surface will become smooth and shiny.

Because of the many variables which influence wear, it is extremely difficult to project bearing life for all types of applications.

Velocity Limit

Under dry running conditions, the maximum allowable surface velocity will depend on the applied load and other operating parameters. In general, the surface speed should be kept below 10m/min.

To calculate surface speed the following may be used:

Where	v = surface velocity	m/min
	d = inner bearing diameter	mm
	N = Revolutions [speed]	R.P.M.
	F = frequency	per min
	☐ = total angle moved	°Arc

Rotation velocity = $V = \frac{\pi \times d \times n}{1000}$

e.g. Rotational velocity of a 25 mm id bearing turning at 50 rpm

$V = \frac{\pi \times 25 \times 50}{1000} = 3.93$ m/min

Oscillation velocity = $V = \frac{\pi \times d \times n \times (\theta/360)}{1000}$

e.g. Oscillation velocity of a 25 mm id bearing at 10 cycles per min over +/- 5 °Arc

$V = \frac{\pi \times 25 \times 10 \times 10/360}{1000} = 0.022$ m/min

Pressure Velocity (PV) factor, load x surface speed

For plain dry running bearings, a PV factor is often referred to as a guide to bearing capacity, as it is a measure of the bearing frictional thermal capability i.e. pressure x velocity = generated heat.

The maximum PV established for FEROGLIDE with mild steel backing is 40 N/mm^2 x m/min (continuous) and 130 N/mm^2 x m/min maximum (intermittent).

Temperature Limit

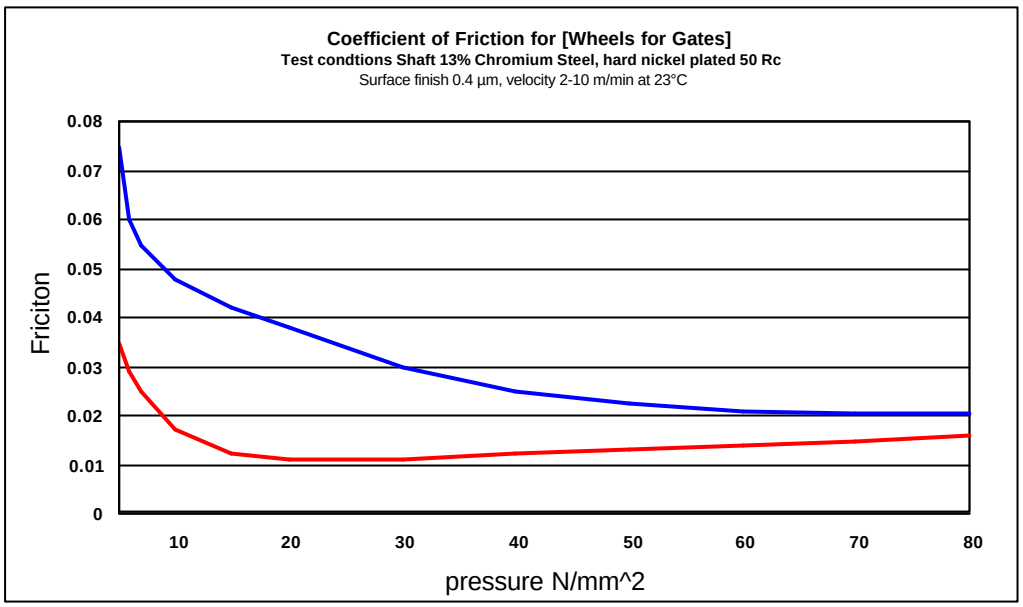
Normal operating temperatures should be kept below 150°C for standard FEROGLIDE bearings. An increase in wear rates may be experienced at temperatures above 120°C. Note that at elevated operating temperatures, the actual & calculated PV value will need to be decreased in order to prevent the surface temperature from exceeding 120°C (environmental temperature plus friction heat generated). When temperatures exceed 150°C or fall below -54°C consult TENMAT Ltd for specific recommendations.

Coefficient of Expansion

When bonded to a metal backing, FEROGLIDE bearings' coefficient of expansion can normally be regarded as identical to that of the backing. With moulded phenolic backing, the coefficient is approx. $11.3 \times 10^{-6}/^{0}C$.

Coefficient of Friction

The coefficient of friction depends upon the type of movement, finish of mating surface, ambient temperature, bearing pressure, velocity and other variables. Friction values of 0.02 to 0.10 have been obtained from flat specimens and may be used as a guide. Note that the coefficient decreases as bearing load increases, a feature which permits maximising design economies. This offers the advantage of using the smallest bearing sizes to obtain the least amount of friction. The coefficient of friction increases as surface velocity increases from 0-6m/min. The variation seen in bearings used in Gate Wheels is illustrated in the next graph.



Mating Surfaces

The working surface of FEROGLIDE bearings being non-metallic, will operate against most metals, but better performance is usually obtained with the hardest available mating surfaces. Hardened steel, hard anodised aluminium, hard chrome and nickel plate are recommended.

A surface hardness of 45-50 Rc is desirable, but satisfactory performance can also be obtained with softer materials. However, the harder the surface, the less likely that it will be damaged during assembly, and will reduce shaft wear in operation. Generally, a surface finish on the mating components of 0.4 to 0.8 µm should be provided. Shaft materials or surface treatments should be selected that will effectively resist corrosion. The influence of varying surface hardness and surface finish is demonstrated in table 3 below

Table 3

Surface Finish µm	Life Factor	Shaft Hardness RC	Life Factor
0.1-0.25	1.3	50.0	1.0
0.5	1.0	40.0	0.6
1.0	0.5	30.0	0.4

Dirty Environments

FEROGLIDE will tolerate solids that, with most other bearing materials, cause severe scoring to the mating surface. However it is desirable to exclude dirt particles from the bearing area to maximise bearing life.

Seals

Where there is likely to be ingress of foreign matter into the bearing, we recommend the use of protective seals such as O-rings, felt seals, grooved seals, radial seals, Nylosrings, V-rings etc.

Contaminating Fluids

FEROGLIDE bearings are unaffected by most fluids and contaminants found in bearing applications. The following are some of the environments in which these bearings have operated successfully:

Sea water	Gasoline	Mild acids	Detergent solutions
Hydraulic oils	Kerosene	Ammonium hydroxide	Liquid nitrogen
Toluene	Lubricating oils		

For more details see separate leaflet Resistance of FEROGLIDE Bearings to Chemicals.

NOTE :- Under normal operating conditions the use of most Hydro-Carbon Grease lubrication of FEROGLIDE bearings is not permitted. Consult TENMAT Ltd for recommendations.

Housing and Shaft Fits

FEROGLIDE Standard PA1 (coiled bearings)

Standard sizes of FEROGLIDE PA1 coiled bearings are governed by DIN1494 standards and are designed to fit into a housing with an ISO H7 tolerance. When correctly fitted the inner diameter tolerance will be ISO H10 when installed in the housing.

FEROGLIDE Standard PA7 & PA8 (solid bearings)

FEROGLIDE PA7 & PA8 bearings are generally installed using a press fit into the housing bore, and a running clearance (RC) on the shaft. It is recommended the tolerances shown in table 4 are used:

Table 4

Position	Fit	Reason	ISO tolerance
Housing Bore	Interference	All Cases	H7
Shaft Tolerance	Large RC	low load, turning motion, axial motion	e7
Shaft Tolerance	Medium RC	medium load, oscillating motion, stop start turning motion	f7
Shaft Tolerance	Close RC	high load, impact loads, close running fit	h7

For PA7 & PA8 bearings the actual clearance must always be calculated.

For oscillating motion only a maximum shaft oversize of 0,015 - 0.03 mm may be used (pre stressed bearing assembly).

Fits for diameters larger than 75 mm and bearing clearance calculation scheme see Table 5**.**

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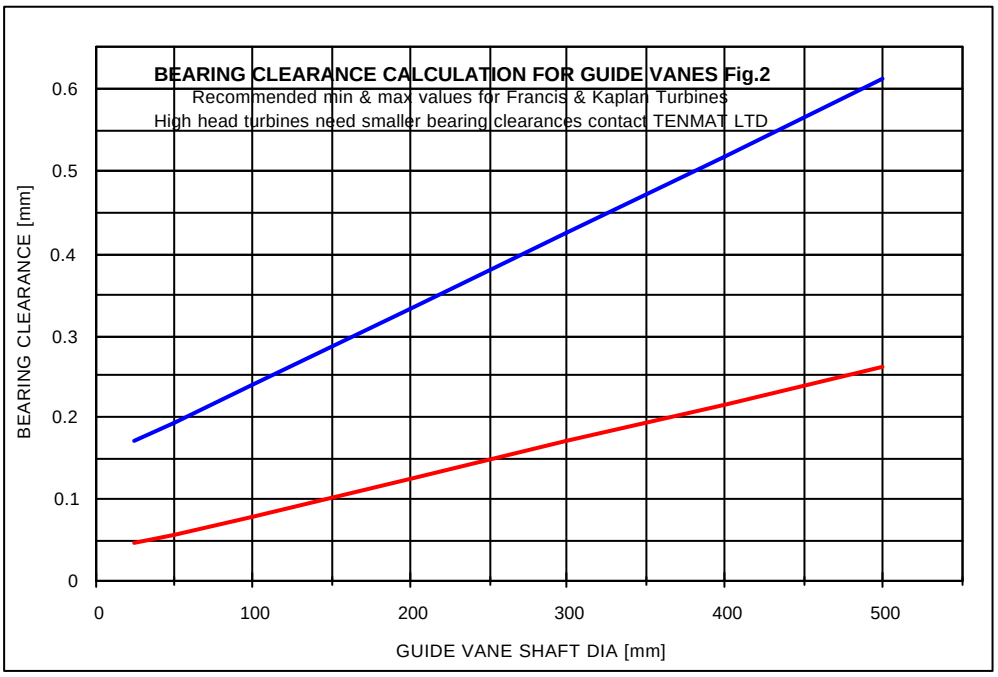
BEARINGS FOR HYDROELECTRIC POWER PLANT RECOMMENDED CLEARANCE & TOLERANCES

Table 5

Application	housing dia	Bearing Outer Dia	Bearing ID (Supplied State)	Shaft Dia.
Turbine guidevanes bearings* Up to 75 mm dia	H7	p6	G8	e6/d6
Turbine guidevanes bearings* over 75 mm dia	H7	p6	G8	d6/c6
Guidevane link bearings, bearing for valve & guidevane regulation servomotors. Bearings for water deflector (Pelton turbine) Guide bearings for nozzle needle (Pelton turbines	H7	p6	G8	f7/e6
Ball and Butterfly Valves Up to 400 mm dia	H7	s6	G8	c6
	H7	p6	G8	d6
Ball and Butterfly Valves over 400 mm dia	H7	h6	G9	e6
	H8	n6	F9	e6/f6
RADIAL GATES	H7	s6	G8	c6
	H7	r6	G8	d6
Wheels and guide rollers for turbine intake gates	H7	s6	G8	c6
	H7	r6	G8	d6

*Please Check All guidevane bearing clearances are according to the values shown in graph Fig.2

Fig 2



Calculation of bearing clearance: PA7&PA8

During installation of the FEROGLIDE bush the interference is transferred into the bore as a percentage of the maximum Interference, this is known as the bore closure factor (BCF).

To calculate the bore after installation use the following BCF table 6.

Table 6

Description	Size	BCF % of Interference
Normal wall thickness	+5 mm	100% of Interference
Thin wall thickness	2.5 mm wall	120% of Interference

To check there is suitable running clearances the calculation is shown in table 7 for the example of bearing P-A7-100.100 with 110 mm OD (deviations in microns)

Table 7

Position	Size	[maths]	Deviation in microns	Actual Size	Comments
Housing	110 H7		35	110.035	
			0	110.000	
Bearing OD	110 p6		59	110.059	
			37	110.037	
Interference	Max	110.059-110.000=		0.059	BCF = 100%=0.059
	Min	110.037-110.035=		0.002	BCF = 100% =0.002
Bearing ID	100 G8		66	100.066	
			12	100.012	
Bearing ID less BCF	max	100.066-0.002=		100.064	-47/+64 Bearing inner tolerance after installing
	min	100.012-0.059=		99.953	
Shaft dia	100 e6		-72	99.928	
			-94	99.906	
Running clearance	max	100.064-99.906=		0.158	+25/+158 Bearing clearance
	min	99.953-99.928=		0.025	

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BEARINGS FOR HYDROELECTRIC POWER PLANT RECOMMENDATION FOR TECHNICAL DATA

Table 8

Field of Application	P.dyn. N/mm^2	[PSI]	Carrying Bearing length[1] L:id ration	Maximum Shaft deflection [mm]	Seals
Wheels guide rollers for intake gates	15-30	2100-4300	1.3 to 1.6	<0.1	Park-O-Pak Solusele- G
Trunnion bearings for radial gates	30-40	4300-5700	0.8 to 1.2	<0.1	V-Ring
Ball & Butterfly Valves	30-40	4300-5700	0.4 to 0.8	<0.1-0.4 [3]	Manoy Seal O ring Quadring Nutring
Turbine guidevane bearings	15-35	2100-5000	0.4 to 0.8	<0.1-0.4 [3]	Park-O-Pak Solosele-G O-Ring
Gate crest flap bearings	20-30	2800-4300	[2]	< 0.1	[2]
Servo motor bearings	20-30	2800-4300	[2]	<0.1	[2]

1) Carrying bearing length = Length of the FEROGLIDE liner, the length of the O-ring or other seals are not included.
2) Primarily dependent upon conditions of installation.
3) Depending on shaft diameter and clearance.