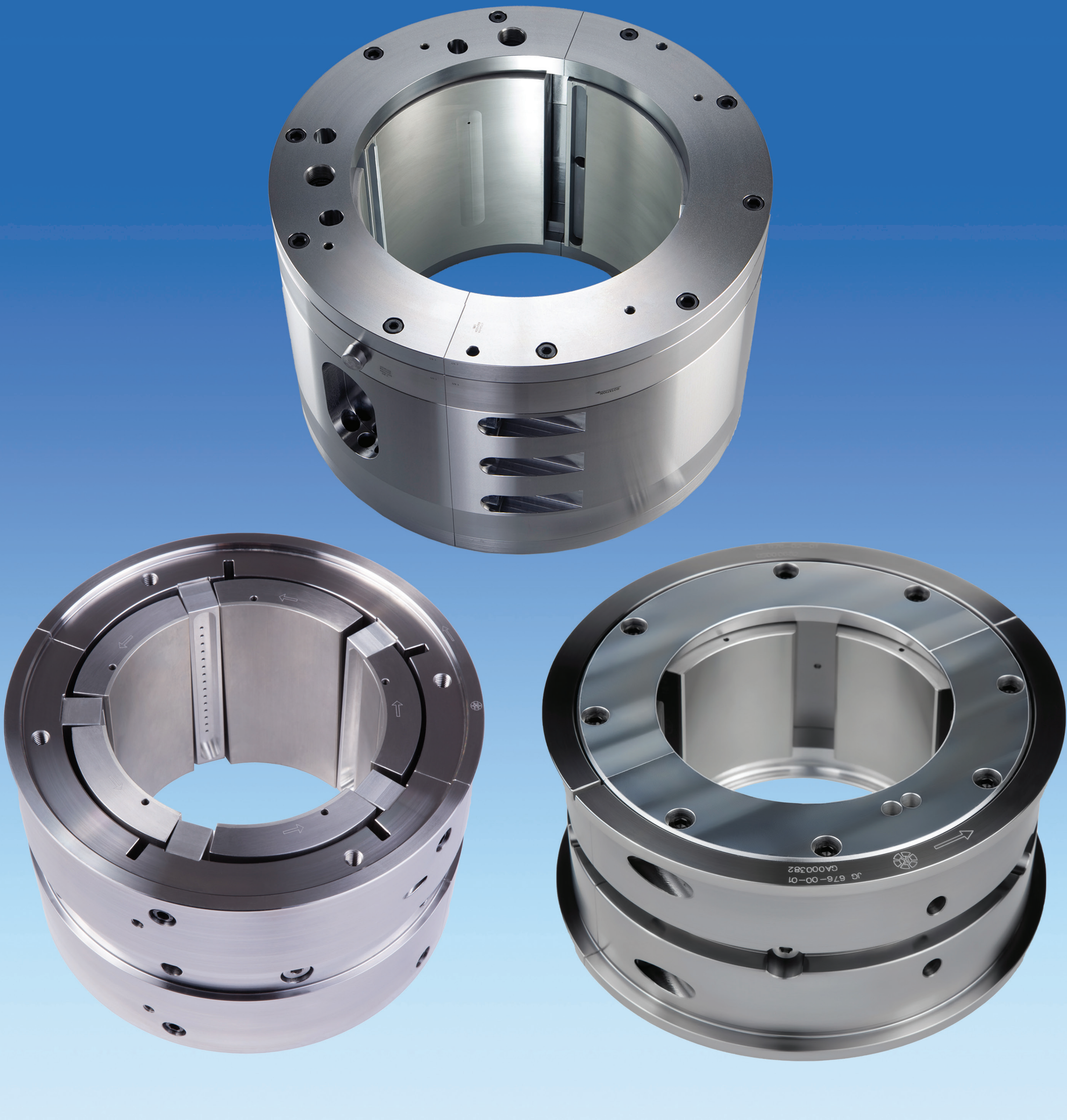
Kingsbury, Inc.®

Tilting Pad, Flooded and Directed Lube Types

Journal Bearings



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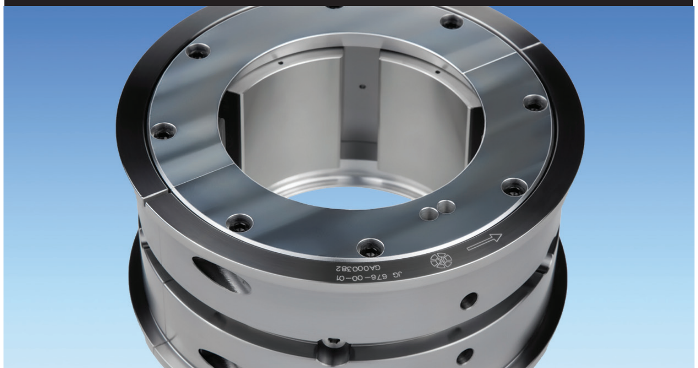
Kingsbury Journal Bearing Styles

PJ Tilting Pad Flooded Bearing



Features & Benefits:

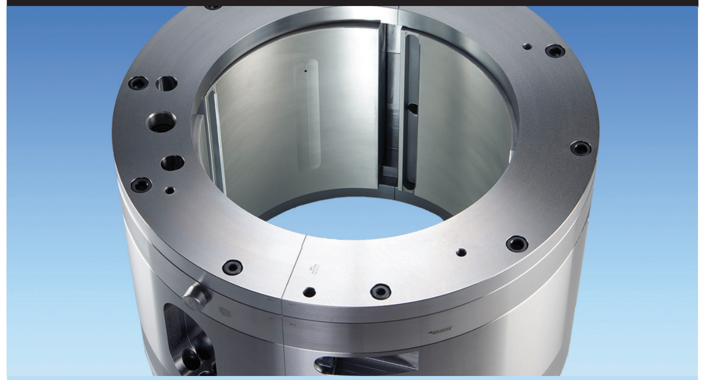
- End shields with or without floating rings ensure that the inside of the bearing is flooded with oil.
- The oil flow rate can be regulated by orifices in the annulus machined into the outside of the aligning ring or in the discharge through sealing gaps and outlet holes.
- The flooded type of lubrication has advantages in the event of an unexpected interruption in the oil supply or vibration problems that could arise due oil starvation seen with other lubrication types.

Maximum Load: 4 MPa (570 psi)

Maximum Speed: 70 m/sec (13,790 ft/min)

Applications: Medium-speed steam and gas turbines, gear-boxes, compressors, pumps and pulp refiners.

LEG® Tilting Pad Directed Lube Bearing



Features & Benefits:

- Kingsbury's patented LEG® journal bearings have directed lubrication using grooves incorporated at the leading edge of the pads.
- In LEG® bearings, the fresh oil goes straight into the lubrication gap. As a result, the oil requirement is reduced to almost the hydrodynamic oil flow.
- LEG® bearings are usually designed with a pad pivot offset 60% of its effective length, enhancing the load capacity at higher operating speeds. This bearing is meant for unidirectional shaft rotation.
- LEG® bearings can substantially reduce the oil flow rate, power losses, operating temperatures, all the while increasing the load capacity.

Maximum Load: 4 MPa (570 psi)

Maximum Speed: 110 m/sec (21,670 ft/min)

Applications: High-speed steam and gas turbines, gear-boxes, compressors, pumps and pulp refiners.

BPG® Tilting Pad Directed Lube Bearing

- BPG® journal bearings have directed lubrication, using feed bars placed between the pads to introduce cool oil from the groove directly into the load-carrying film.
- The proprietary shape of the oil feed bar allows reductions of the oil flow rate and enhances the cooling effect in the leading-edge area of the pad.
- The lower oil flow rate in the BPG® bearing results in significantly reduced power losses.
- The BPG® provides very good static as well as dynamic properties in turbomachinery applications.
- The BPG® design has a positive influence on the temperature profile in the laminar-turbulence transition regime.
- Unlike the LEG® bearing, the BPG® is designed for bi-directional shaft rotation.

Maximum Load: 4 MPa (570 psi)

Maximum Speed: 120 m/sec (23,640 ft/min)

Applications: High-speed steam and gas turbines, gearboxes, compressors, pumps and pulp refiners.

Hydrodynamic Bearings

Hydrodynamic bearings rely on the shaft speed and a lubricant to create a converging lubrication gap and thus the pressure required to transfer the externally applied load on a self-renewing lubricating film, which is usually oil, water, or air, and from there to the foundation or machine support. They are commonly used in diverse applications with a wide range of speeds and loads, where great emphasis is placed on load capacity, stability, service life and low noise.

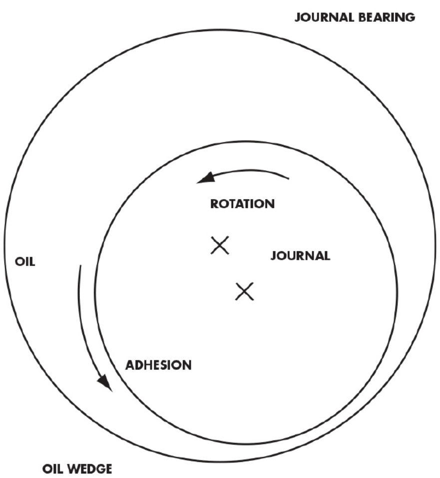


Fig. 4: Hydrodynamic Principle

Hydrodynamic Principle

Based on his theoretical investigation of cylindrical journal bearings, Professor Osborne Reynolds showed that oil, because of its adhesion to the journal (the part of the shaft that is in contact with the lubricant and enclosed by the bearing) and its resistance to flow (viscosity), is dragged by the rotation of the journal so as to form a wedge-shaped film between the journal and journal bearing (Fig. 4). This action sets up the pressure in the oil film which thereby supports the load (Fig. 5). This wedge-shaped film was shown by Reynolds to be the absolutely essential feature of effective journal lubrication. Reynolds also showed that "if an extensive flat surface is rubbed over a slightly inclined surface, oil being present, there would be a pressure distribution with a maximum somewhere beyond the center in the direction of motion."

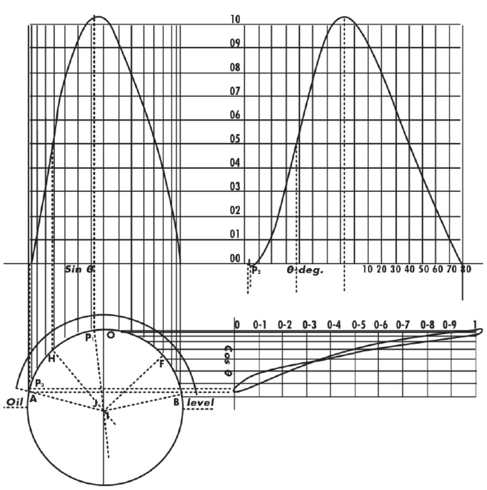


Fig. 5: A figure from Reynold's paper "On the Theory of Lubrication" showing oil film pressure distribution

Tilting Pad (Pivoted Shoe)

Applied to hydrodynamic tilting pad thrust bearings (Fig. 6) Albert Kingsbury stated: "If a block were supported from below on a pivot, at about the theoretical center of pressure, the oil pressures would automatically take the theoretical form, with a resulting small bearing friction and absence of wear of the metal parts. In this way a thrust bearing could be made with several such blocks set around in a circle and with proper arrangements for lubrication." The same concept applies to the tilting pad journal bearing. As with the plain cylindrical bearing, the tilting pad thrust and journal bearings rely on adhesion of the lubricant to provide the film with a self-renewing supply of oil.

Lubricant

The lubricant is an important "element" of the bearing. The loads are transmitted from the shaft to the bearing through the lubricant which separates the parts and prevents metal-to-metal contact. The lubricant also serves to carry heat caused by friction out of the bearing.

Lubrication

For hydrodynamic bearings to operate safely, a suitable lubricant must always be present at the collar and journal surfaces. The lubricant needs to be cooled to remove the heat generated from oil shear, before re-entering the bearing. It must also be warm enough to flow freely and filtered so that the average particle size is less than the minimum film thickness.

Various methods are applied to provide lubricant to bearing surfaces. The bearing cavities can be flooded with oil such as vertical bearings which sit in an oil bath. The bearings can also be provided with pressurized oil from an external lubricating system.

For high speed bearings, the frictional losses from oil shear and other parasitic losses begin to increase exponentially as the surface speed enters a turbulent regime. The amount of lubricant required increases proportionately. Industry trends for faster, larger machines necessitated the design of lower loss bearings. This has been incorporated by the introduction of other methods of lubrication.

Directed lubrication directs a spray of oil from a hole or nozzle directly onto the collar and respectively journal surface between the pads. Rather than flooding the bearings, sufficient oil is applied to the moving surface allowing the bearing to run evacuated. Such a method of lubrication reduces parasitic churning losses around the collar and between the pads.

In 1984, Kingsbury introduced its Leading Edge Groove (LEG®) Bearings, another technology developed for high tech machines. The LEG design introduces cool oil directly into the oil film, resulting in a significant reduction in oil flow, power loss and bearing temperature while improving the load capacity, safety and reliability of the equipment.

Cooling

A cooling system is required to remove the heat generated by friction in the oil. The housing may simply be air cooled if heat is low. Vertical bearings typically sit in an oil bath with cooling coils, but the oil can also be cooled by an external cooling system as typical in horizontal applications. The heat is removed by a suitable heat exchanger.

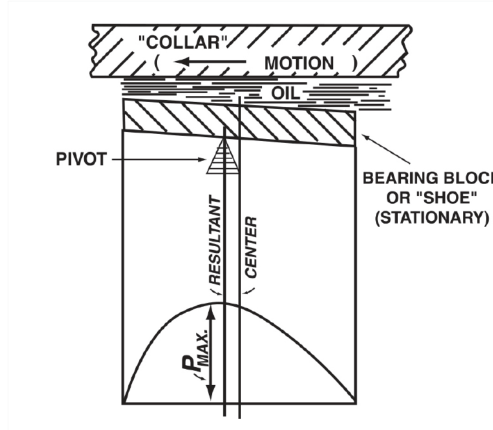


Fig. 6: Illustration from a page of Albert Kingsbury's paper "Development of the Kingsbury Thrust Bearing"

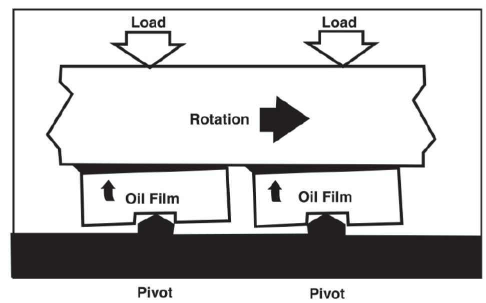
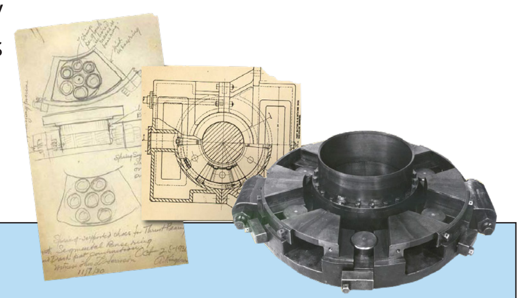


Fig. 8-1: Pivoting Shoe Hydrodynamic Film Formation



Albert Kingsbury's Invention

Albert Kingsbury became intrigued with lubrication science as a student at Cornell University. After graduation in 1889, he went on to teach mechanical engineering and soon joined Westinghouse as a young engineer.

Holtwood Station on the Susquehanna River was a sophisticated hydroelectric plant with ten 10,000-kilowatt turbine generators accepting about 45 tons of force from the water passing through. Conventional roller bearings were failing every two months under the heavy loads. The utility turned to Kingsbury for a solution just as he was finishing testing and patent application for a pivoted-shoe bearing that rested on a thin film of oil.

Kingsbury installed his new fluid film bearing in the No. 5 turbine unit as a test and although it had not yet been proven in a generator, it faltered just once. With a single modification, the bearing performed flawlessly. The rest, as they say, is history.

Kingsbury's Tilting Pad Journal Bearings

General Description

As rotating machinery has evolved, many types of bearings have come and gone. Today, rotational speeds and power density levels continue to increase, along with the complexity of the machinery. The rotordynamic characteristics of such machines depend heavily on the journal bearings. A fixed profile journal bearing, inherently unstable at light loads, can experience self-excited subsynchronous vibration during operation, a phenomenon known as oil whirl. While some bore profile modifications have been successful at raising the stability threshold, a fixed profile bearing is susceptible to damage from misalignment, imbalance, or wear. The inherent design characteristics of a tilting pad journal bearing, on the other hand, are best suited to eliminate oil film instabilities from wherever they are stimulated from, and depending on the type of pivot support, a shaft misalignment can be compensated to a certain extent.

All tilting pad journal bearings of from Kingsbury's standard platform share the same housing fit dimensions and have common design features such as the pad retaining system and the pad pivot style. They consist of four or five pads and are available for a large variety of width/bore ratios (L/D) such as 0.4, 0.5, 0.6, 0.7, 0.9 and 1.0. Depending on the requirements of the respective equipment job, LEG® and BPG® bearings can be supplied with or without end plates. If there are no concerns about oil discharge, we offer the solution without endplates, which minimizes the axial length of the assembly. If there is a need to protect sensitive items such as dry gas seals, we can readily bolt on one of two standardized endplate designs (with or without a floating seal ring) to the journal bearing. In any case, all three bearing types are designed for envelope dimensions that are used around the world for a wide range of applications such as steam and gas turbines, gearboxes, gas expanders and compressors, and pumps.

For optimized rotordynamic behavior, our direct lubricated LEG® and BPG® bearings aim for a standard preload factor between 0.3 and 0.35. The versatile designs also boast several options, among them alternative pad pivot designs configurations depending on the application demands, e.g. center vs. offset pivot, line vs. point contact (double radius) or ball and socket design, and enhancements such as anti-SSV (Sub Synchronous Vibration) grooves. Line contact supports offer the benefit of high stiffness, while point contact supports (also known as double radius supports) can compensate for shaft misalignment (bending or foundation deflections). Both options are available for center and offset pivot positions. Compared to point contact (double radius), ball and socket contact provides significantly higher stiffness, but can lead to instability at high speeds due to coupled dynamic coefficients.

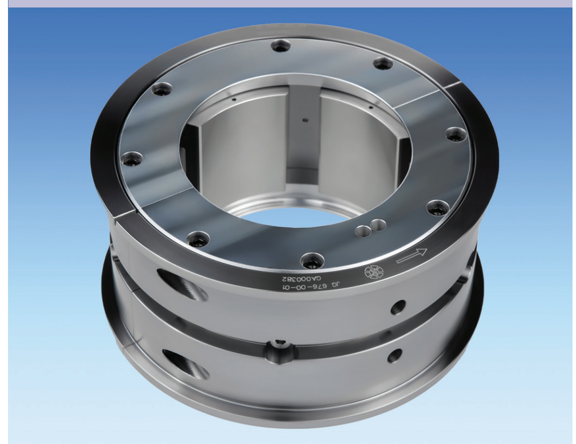
Our tilting pad journal bearings are lined with centrifugally cast high-tin babbitt such as ECKA© Tegostar™, or equivalent, and ASTM B23 Gr 2. Upon request, we can offer alternative linings like PEEK and bronze. The pads and aligning ring materials are typically made of mild steel. If pad operating temperatures are elevated, CrCu material can be used as the base material to improve heat transfer. The back of each journal pad is contoured circumferentially to mate with a radial contour in the aligning ring, creating a contact area that allows each pad to adjust to the hydrodynamic forces generated by the rotating shaft.

Our bearing designs are continually validated by in-house tests at Kingsbury's Research & Development Lab up to a sliding speed of 110 m/s and are used by customers in commercial operation even at higher speeds. The maximum permissible speed is heavily dependent on the load and the bore diameter of the journal bearing. The smaller the bearing size, the lower the "speed x specific load" value. For general orientation, Kingsbury recommends following maximum permissible sliding speeds and specific loads:

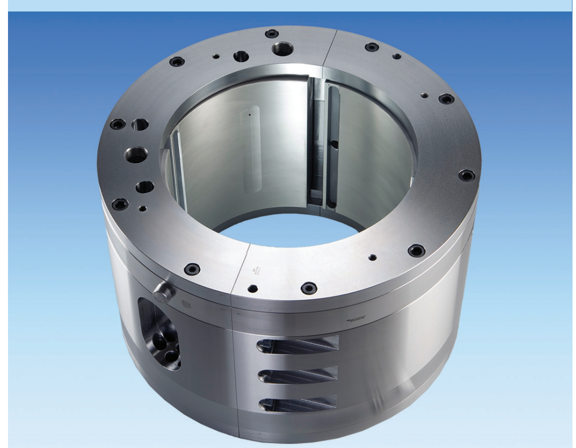
- 70 m/s for flooded bearings
- 110 m/s for LEG® bearings
- 120 m/s for BPG® bearings
- 4 MPa for all three types of bearings

In some cases, the maximum loads and speeds can differ from these limits, depending on other operating factors. Allow us to run our proprietary journal bearing performance program to confirm the final selection. Oil film thickness, surface temperature, power loss, and oil flow will be compared against our standards for acceptance.

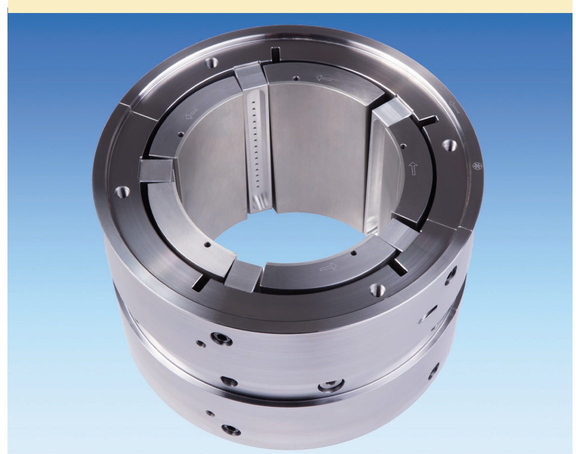
PJ FLOODED TILTING PAD JOURNAL BEARINGS



LEG® TILTING PAD DIRECTED LUBE JOURNAL BEARINGS

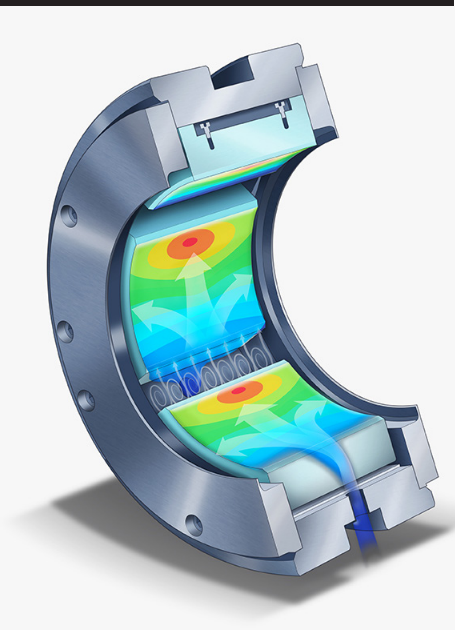


BPG® TILTING PAD DIRECTED LUBE JOURNAL BEARINGS



PJ Flooded Tilting Pad Journal Bearings

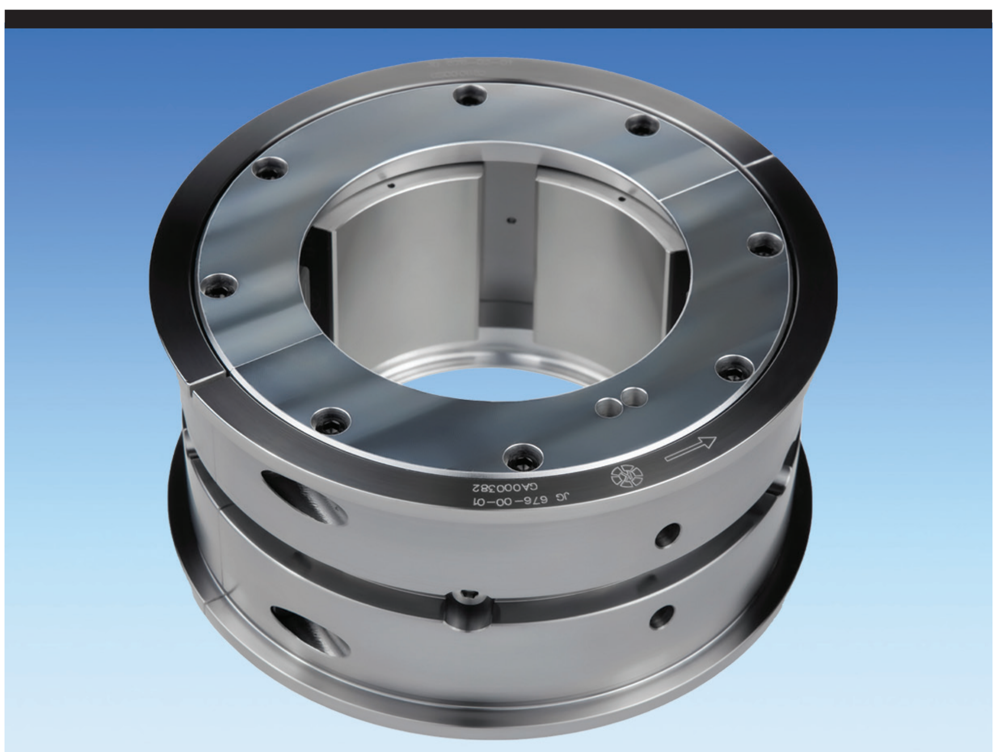
Product Description



Tilting pad journal bearings with flooded lubrication are ideally suited for a wide variety of applications with moderate speeds, usually up to 70 m/s.

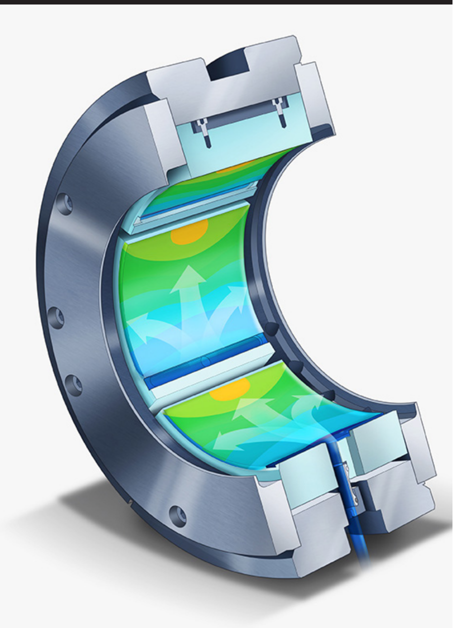
Laterally attached end shields or floating rings ensure that the inside of the bearing is flooded with oil due to the resulting minimum inside pressure. The required oil flow can be regulated in the supply through orifices in the annulus machined into the outside of the aligning ring or in the discharge through sealing gaps and outlet holes. The rotating shaft carries the oil surrounding the pads across the sliding surface of each pad, forming a wedge-shaped film that has tremendous load carrying capability.

The flooded type of lubrication has advantages in the event of an unexpected interruption in the oil supply or vibration problems that could arise due to oil starvation seen with other lubrication types. However, there can also be disadvantages, especially at higher speeds than recommended above, due to very high bearing temperatures and power losses caused by the poor mixing factor between freshly supplied oil and the circulating hot oil film. It is under these operating conditions where a direct-lubricated design such as LEG® or BPG® would provide more benefit.



LEG® Tilting Pad Directed Lube Journal Bearings

Product Description

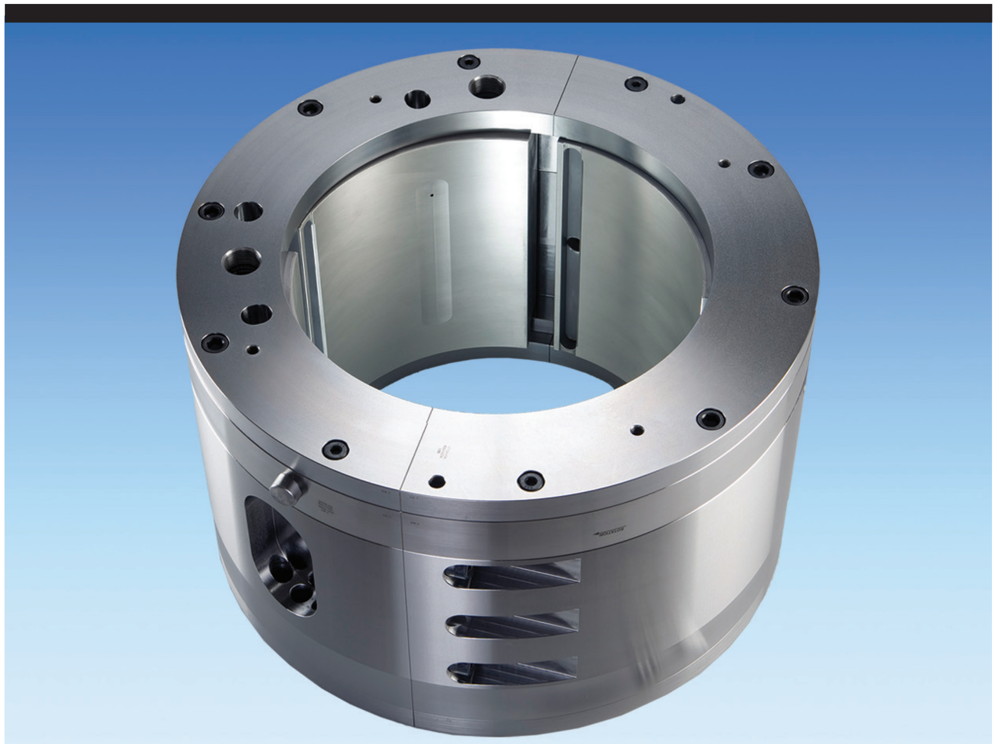


Kingsbury's patented LEG® journal bearings offer directed lubrication through Leading Edge Grooves incorporated at the beginning of the pads. These are connected by oil feed tubes to the annulus machined into the outside of the aligning ring where oil distribution occurs.

LEG® bearings are ideally suited for a wide range of applications with moderate to high speeds up to 110 m/s. They have the most effective direct lubrication method as the fresh oil goes straight into the lubrication gap, as shown in the following graphs. As a result, the oil requirement is reduced to almost the hydrodynamic oil flow, and the mixing factor between freshly supplied oil and the circulating hot oil film is close to 90%, the highest compared to all other types of lubrication.

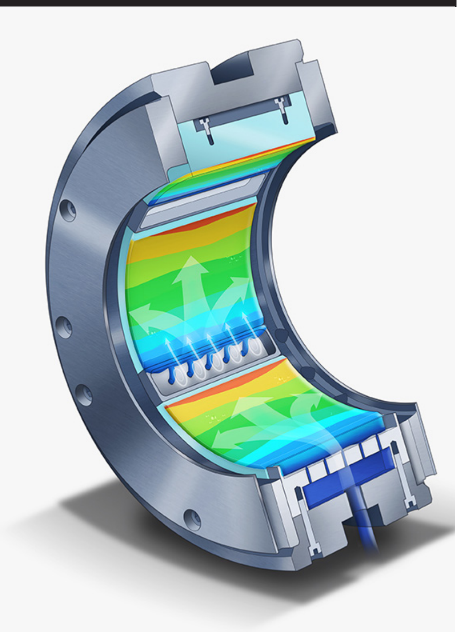
Applications have proven that advanced LEG® bearings can substantially reduce oil consumption, power loss and bearing temperatures and thus significantly increase load capacity.

LEG® bearings are usually designed with a pad pivot offset of 60% of its effective length and can only be operated in one direction of rotation when fully loaded. Up to a certain load value, they can also be operated in the opposite direction. However, these limits must be calculated and approved by Kingsbury. When using end plates, the bearing should have a bottom drain so that the cavity remains evacuated, which is essential to achieving the bearing's advantages.



BPG® Tilting Pad Directed Lube Journal Bearings

Product Description

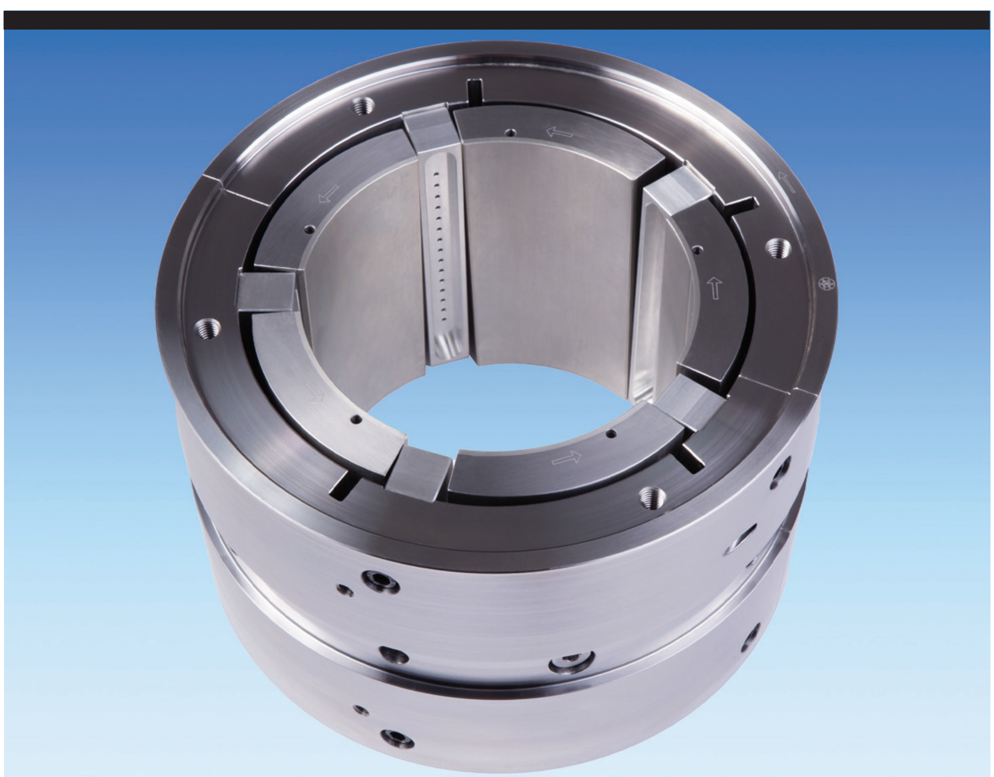


The patented BPG® stands for “Between Pad Groove” and is ideally suited for a wide range of applications with moderate to high speeds up to 120 m/s.

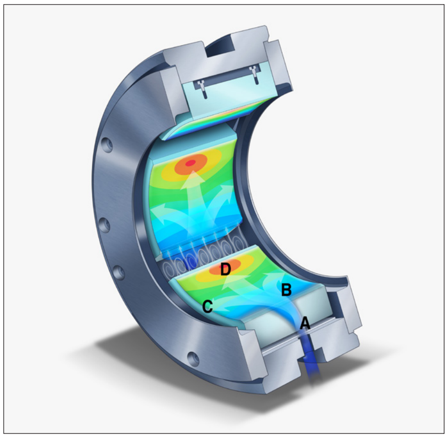
BPG® Tilting pad journal bearings have a directed lubrication type using Kingsbury’s distinctive oil feed bar placed between the pads.

Like our LEG® (Leading Edge Groove) bearings, the BPG® is designed to introduce cool oil from the groove directly into the load-carrying lubricating film. Due to the proprietary shape of the oil feed bar, an efficient oil supply in terms of oil consumption and cooling effect in the leading-edge area of the pad will be achieved. The BPG® provides very good static as well as dynamic properties in turbomachinery applications. According to our own test bench investigations, the BPG® also has a positive influence on the temperature profile in the laminar-turbulence transition regime.

Compared to a flooded bearing, the BPG® consumes significantly less oil resulting in a sharp drop in power losses also due to the elimination of parasitic losses. Furthermore, there is a corresponding reduction in operating temperatures, varying by 8° to 28° C, contingent on the load and shaft speed. When using end plates, these should have a bottom drain so that the cavity remains evacuated, which is essential to achieving the mentioned advantages.



Oil Path And Lubrication Activity



PJ Flooded Tilting Pad Journal Bearings

A. Oil Inlet

- Pressurized oil is delivered to the open area in between tilting pads
- Oil begins to fill the area in between tilting pads
- Churning of oil occurs in this area and oil temperature begins to rise before it enters the oil wedge

B. Beginning of Oil Film (Oil Wedge)

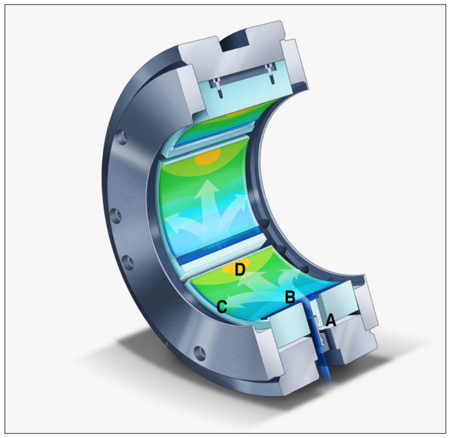
- Oil is pulled into the gap between the tilting pad and the shaft (oil wedge) due to the adhesion of oil to the rotating shaft
- Oil temperature is higher than the temperature when delivered to the area marked "A" due to the mixing that occurs in this region

C. Side Discharge

- Some discharge oil begins to exit the tilting pad in the axial direction, toward the oil seal of the journal bearing

D. Trailing Edge

- Oil film temperatures higher, as compared to BPG® and LEG®
- Hot discharge oil exits the trailing edge of pad and mixes with fresh oil supplied to area "A" of the next pad in the direction of rotation



LEG® Tilting Pad Directed Lube Journal Bearings

A. Oil Inlet

- Pressurized oil is delivered to oil feed tubes which provide a direct path to the leading edge of the tilting pad
- Fresh oil supply is transferred directly to the leading-edge groove through the oil feed tube

B. Beginning of Oil Film (Oil Wedge)

- Cool oil fills the groove area on the leading edge of tilting pad
- Oil is pulled into the gap between the tilting pad and the shaft (oil wedge) due to the adhesion of oil to the rotating shaft
- Oil has the lowest temperature (almost equal to the oil supply temperature) compared to other lubrication types

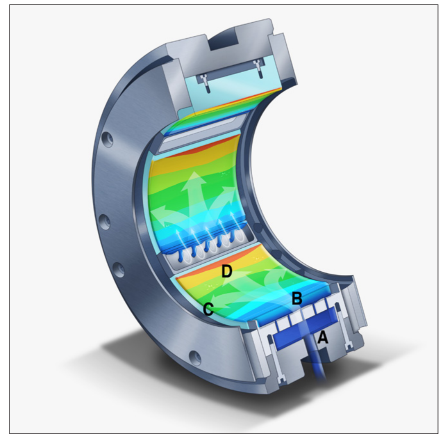
C. Side Discharge

- Some discharge oil begins to exit the tilting pad in the axial direction
- LEG® design can operate without oil seals on either end of the bearing, resulting in lower power loss and evacuation of hot discharge oil

D. Trailing Edge

- Oil film temperature is lower than Flooded and BPG® bearings
- Discharge oil at the trailing edge of pad partially escapes between pads and the residual oil adhering to the shaft mixes with the fresh cool oil delivered to area "B" of the next pad in the direction of rotation

LEG®, with its oil feed groove embedded in the pad, offers the potential for the lowest possible oil flow consumption.



BPG® Tilting Pad Directed Lube Journal Bearings

A. Oil Inlet

- Pressurized oil is delivered to the oil feed bar located in between each tilting pad
- Oil flow rate can be controlled by hole sizes internal to the oil feed bar chamber
- The groove area of the oil feed bar fills with cool oil

B. Beginning of Oil Film (Oil Wedge)

- Oil is pulled into the gap between the tilting pad and the shaft (oil wedge) due to the adhesion of oil to the rotating shaft
- Oil temperature is higher than with LEG® and is much lower as compared to Flooded lubrication

C. Side Discharge

- Some discharge oil begins to exit the tilting pad in the axial direction
- BPG® design can operate without oil seals on either end of the bearing, resulting in lower power loss and evacuation of hot discharge oil

D. Trailing Edge

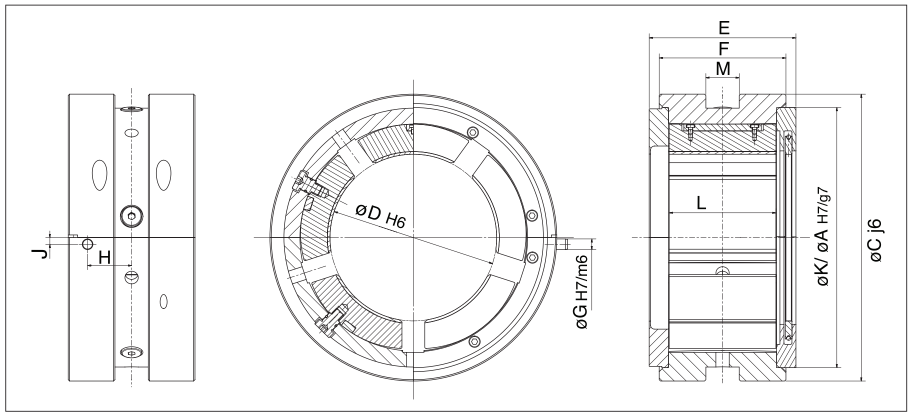
- Oil film temperature is lower, as compared to Flooded bearings
- Discharge oil exits the trailing edge of pad and mixes with the fresh cool oil delivered to area "B" of the next pad in the direction of rotation

BPG® design, with its axially sealed oil feed bar positioned closer to the pads, offers significantly less oil consumption and lower temperatures compared to the spray nozzle type.

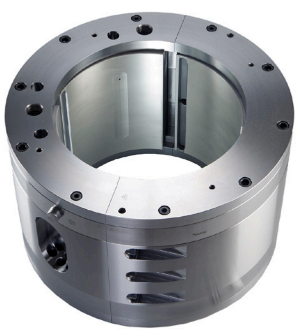
Tilting Pad Bearing Dimensions

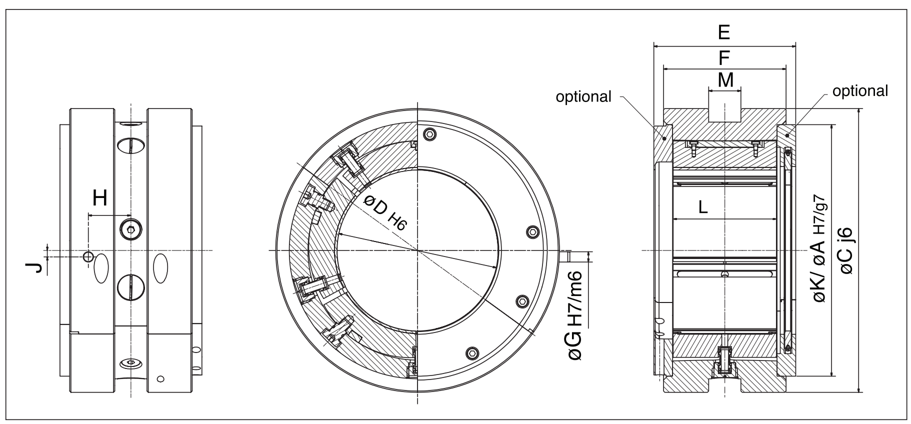
0.4, 0.5, 0.6 L/D Bearings – MM

PJ Flooded Bearing Dimensions

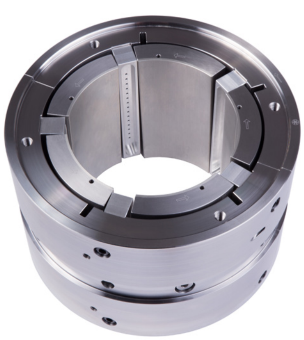


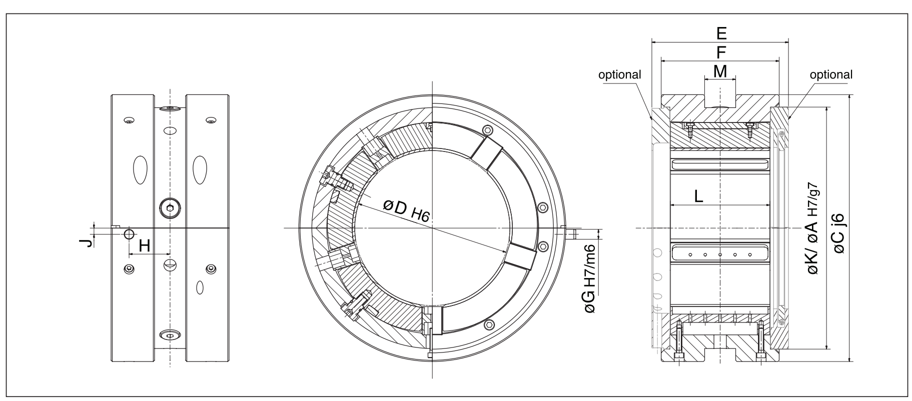
LEG® Directed Lube Bearing Dimensions





BPG® Directed Lube Bearing Dimensions





0.4, 0.5, 0.6 L/D Tables – Metric

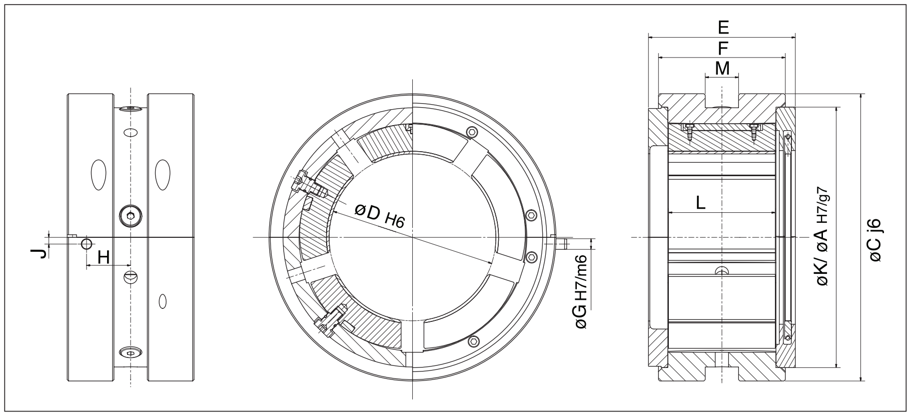
Metric Sizes (mm)			L/D=0.4			L/D=0.5			L/D=0.6		
Bearing Diameter	Aligning Ring OD	Annulus Width	Pad Width	Seat Width	Overall Width incl. endplates	Pad Width	Seat Width	Overall Width incl. endplates	Pad Width	Seat Width	Overall Width incl. endplates
D	C	M	L	F	E	L	F	E	L	F	E
45	130	10	18	33	39	23	34	44	27	38	48
50	130	10	20	33	41	25	36	46	30	41	51
55	130	20	22	33	43	28	39	49	33	44	54
60	130	20	24	35	45	30	41	51	36	47	57
65	160	25	26	37	47	33	44	54	39	50	60
70	160	30	28	39	49	35	46	56	42	53	63
75	160	30	30	41	51	38	49	59	45	56	66
80	160	30	32	43	53	40	51	61	48	59	69
85	160	30	34	45	55	43	54	64	51	62	72
90	160	30	36	47	157	45	56	66	54	65	75
95	200	30	38	49	63	48	59	73	57	68	82
100	200	32	40	51	65	50	61	75	60	71	85
110	200	34	44	55	69	55	66	80	66	77	91
115	230	34	46	57	72	58	69	84	69	80	95
120	230	34	48	59	74	60	71	86	72	83	98
125	230	34	50	62	76	63	75	89	75	87	101
140	280	35	56	68	82	70	82	96	84	96	110
150	280	35	60	72	86	75	87	101	90	102	116
160	280	35	64	76	90	80	92	106	96	108	122
180	315	42	72	84	98	90	102	116	108	120	134
200	350	42	80	92	118	100	112	138	120	132	158
225	425	45	90	102	128	113	125	151	135	147	173
250	475	50	100	112	138	125	137	163	150	162	188
280	500	60	112	124	150	140	52	178	168	180	206
300	515	65	120	133	159	150	163	189	180	193	219
315	540	65	126	139	165	158	171	197	189	202	228
335	580	70	134	147	173	168	181	207	201	214	240
355	620	70	142	155	183	178	191	219	213	226	254
The dimensions K, A, G, H and J are standardized and can be made available on request.											

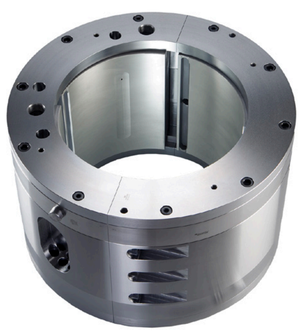
Our tables only provide dimensions for bearings up to a shaft diameter of 355 mm. We regularly manufacture bearings for shafts above 600 mm and can currently provide bearings for shafts up to 850 mm. Please consult our sales staff for any shaft sizes not found in our tables.

Tilting Pad Bearing Dimensions

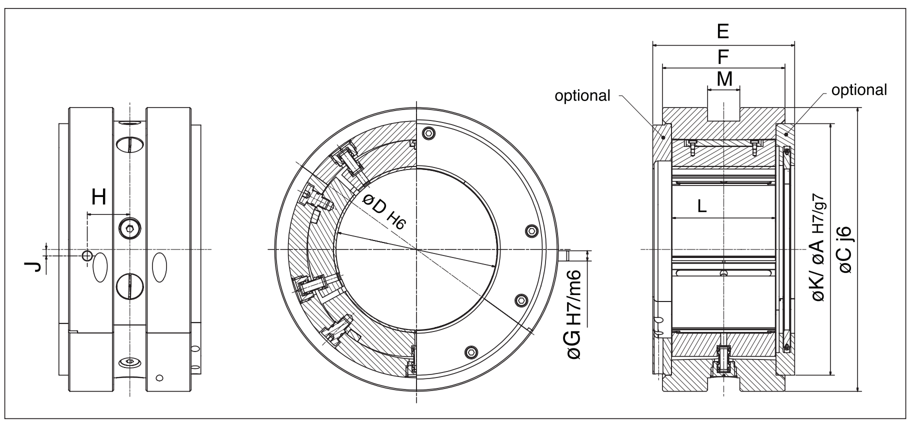
0.7, 0.9, 1.0 L/D Bearings – MM

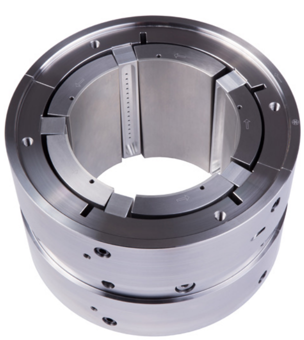
PJ Flooded Bearing Dimensions



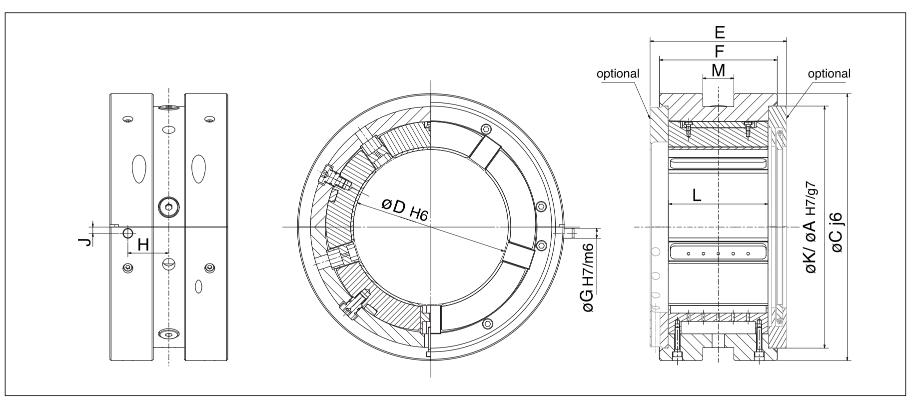


LEG® Directed Lube Bearing Dimensions





BPG® Directed Lube Bearing Dimensions



0.7, 0.9, 1.0 L/D Tables – Metric

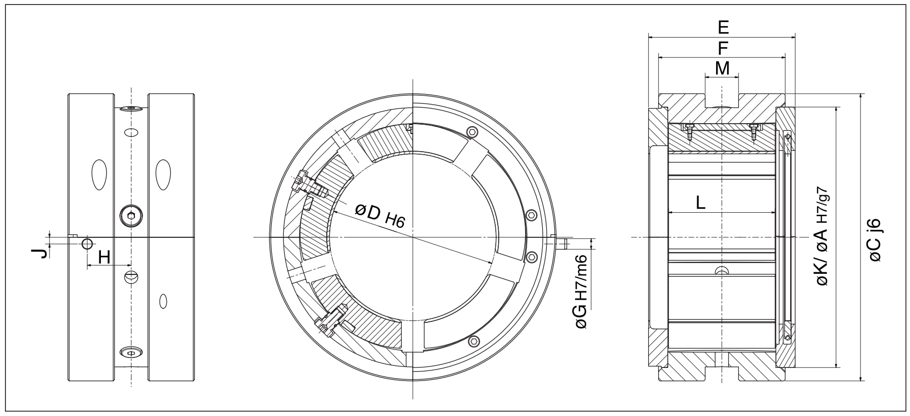
Metric Sizes (mm)			L/D=0.7			L/D=0.9			L/D=1.0		
Bearing Diameter	Aligning Ring OD	Annulus Width	Pad Width	Seat Width	Overall Width incl. endplates	Pad Width	Seat Width	Overall Width incl. endplates	Pad Width	Seat Width	Overall Width incl. endplates
D	**C**	**M**	**L**	**F**	**E**	**L**	**F**	**E**	**L**	**F**	**E**
45	130	10	32	43	53	41	52	62	45	56	66
50	130	10	35	46	56	45	56	66	50	61	71
55	130	20	39	50	60	50	61	71	55	66	76
60	130	20	42	53	63	54	65	75	60	71	81
65	160	25	46	57	67	59	70	80	65	76	86
70	160	30	49	60	70	63	74	84	70	81	91
75	160	30	53	64	74	68	79	89	75	86	96
80	160	30	56	67	77	72	83	93	80	91	101
85	160	30	60	71	81	77	88	98	85	96	106
90	160	30	63	74	84	81	92	102	90	101	111
95	200	30	67	78	92	86	97	111	95	106	120
100	200	32	70	81	95	90	101	115	100	111	125
110	200	34	77	88	102	99	110	124	110	121	135
115	230	34	81	92	107	104	115	130	115	126	141
120	230	34	84	95	110	108	119	134	120	131	146
125	230	34	88	100	114	113	125	139	125	137	151
140	280	35	98	110	124	126	138	152	140	152	166
150	280	35	105	117	131	135	147	161	150	162	176
160	280	35	112	124	138	144	156	170	160	172	186
180	315	42	126	138	152	162	174	188	180	192	206
200	350	42	140	152	178	180	192	218	200	212	238
225	425	45	158	170	196	203	215	241	225	237	263
250	475	50	175	187	213	225	237	263	250	262	288
280	500	60	196	108	234	252	164	290	280	192	318
300	515	65	210	223	249	270	283	309	300	313	339
315	540	65	221	234	260	284	297	323	315	328	354
335	580	70	235	248	274	302	315	341	335	348	374
355	620	70	249	262	290	320	333	361	355	368	396
The dimensions K, A, G, H and J are standardized and can be made available on request.											

Our tables only provide dimensions for bearings up to a shaft diameter of 355 mm. We regularly manufacture bearings for shafts above 600 mm and can currently provide bearings for shafts up to 850 mm. Please consult our sales staff for any shaft sizes not found in our tables.

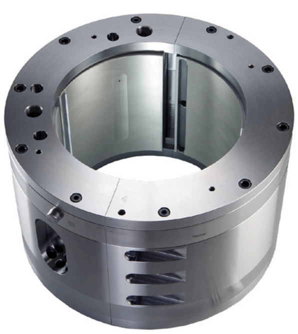
Tilting Pad Bearing Dimensions

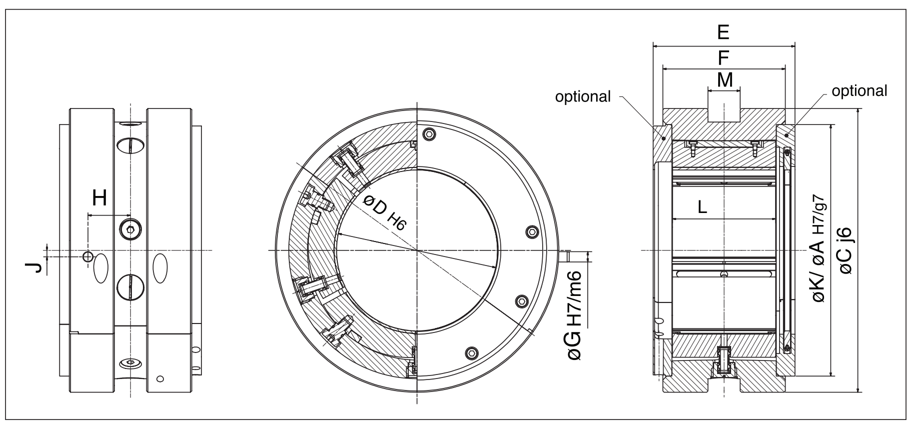
0.4, 0.5, 0.6 L/D Bearings – Inches

PJ Flooded Bearing Dimensions

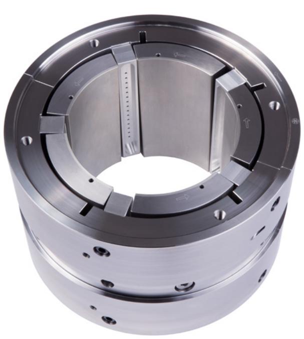


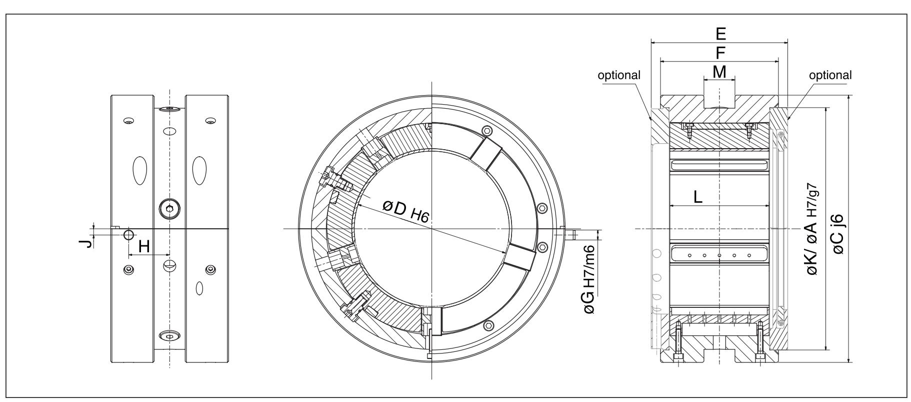
LEG® Directed Lube Bearing Dimensions





BPG® Directed Lube Bearing Dimensions





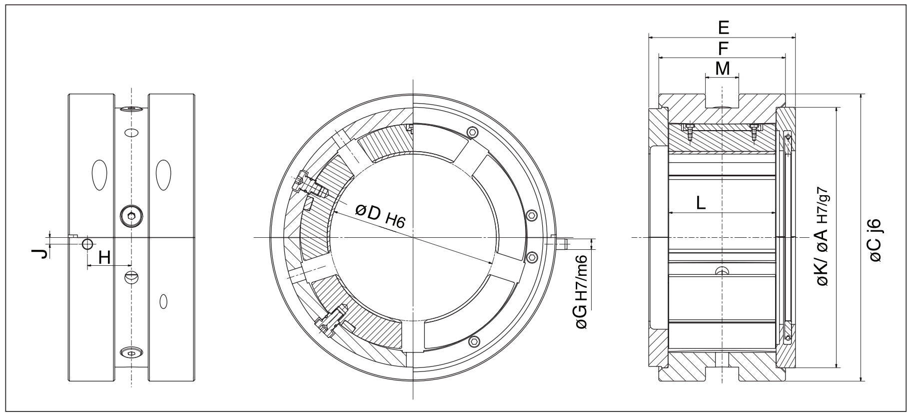
0.4, 0.5, 0.6 L/D Tables – Inches

Inch Standard Sizes (in)			**L/D=0.4**			**L/D=0.5**			**L/D=0.6**		
Bearing Diameter	**Aligning Ring OD**	**Annulus Width**	**Pad Width**	**Seat Width**	**Overall Width** incl. endplates	**Pad Width**	**Seat Width**	**Overall Width** incl. endplates	**Pad Width**	**Seat Width**	**Overall Width** incl. endplates
D	**C**	**M**	**L**	**F**	**E**	**L**	**F**	**E**	**L**	**F**	**E**
1.75	5.25	0.38	0.75	1.25	1.62	0.88	1.38	1.75	1.00	1.50	1.88
2.00	5.25	0.38	0.75	1.25	1.62	1.00	1.50	1.87	1.25	1.75	2.12
2.12	5.25	0.75	0.88	1.25	1.75	1.06	1.50	2.00	1.25	1.62	2.12
2.38	5.25	0.75	1.00	1.38	1.88	1.19	1.62	2.12	1.50	1.88	2.38
2.50	6.50	1.00	1.00	1.50	1.88	1.25	1.75	2.13	1.50	2.00	2.38
2.75	6.50	1.12	1.12	1.50	2.00	1.38	1.75	2.25	1.62	2.00	2.50
3.00	6.50	1.12	1.25	1.62	2.12	1.50	1.88	2.38	1.75	2.12	2.62
3.12	6.50	1.12	1.25	1.62	2.12	1.50	2.00	2.50	1.88	2.25	2.75
3.38	6.50	1.12	1.38	1.75	2.25	1.62	2.12	2.62	2.00	2.38	2.88
3.50	6.50	1.12	1.38	1.88	2.25	1.75	2.25	2.62	2.12	2.62	3.00
3.75	8.00	1.12	1.50	2.00	2.50	1.88	2.38	2.88	2.25	2.75	3.25
4.00	8.00	1.25	1.62	2.00	2.62	2.00	2.38	3.00	2.50	2.88	3.50
4.38	8.00	1.38	1.75	2.25	2.75	2.12	2.62	3.12	2.62	3.12	3.62
4.50	9.00	1.38	1.75	2.25	2.75	2.25	2.75	3.25	2.75	3.25	3.75
4.75	9.00	1.38	2.00	2.38	3.00	2.38	2.75	3.37	3.00	3.38	4.00
5.00	9.00	1.38	2.00	2.50	3.00	2.50	3.00	3.50	3.00	3.50	4.00
5.50	11.00	1.38	2.25	2.62	3.25	2.75	3.12	3.75	3.25	3.62	4.25
6.00	11.00	1.38	2.50	2.88	3.50	3.00	3.38	4.00	3.50	3.88	4.50
6.50	11.00	1.38	2.50	3.00	3.50	3.25	3.75	4.25	4.00	4.50	5.00
7.00	12.50	1.62	2.75	3.25	3.75	3.50	4.00	4.50	4.25	4.75	5.25
8.00	13.75	1.62	3.25	3.62	4.75	4.00	4.38	5.51	5.00	5.38	6.50
9.00	16.75	1.75	3.50	4.00	5.00	4.50	5.00	6.00	5.50	6.00	7.00
10.00	18.75	2.00	4.00	4.50	5.50	5.00	5.50	6.50	6.00	6.50	7.50
11.00	19.75	2.38	4.50	4.88	6.00	5.50	5.88	7.00	6.50	6.88	8.00
12.00	20.25	2.50	4.75	5.25	6.25	6.00	6.50	7.50	7.25	7.75	8.75
12.50	21.25	2.50	5.00	5.50	6.50	6.25	6.75	7.75	7.50	8.00	9.00
13.00	23.00	2.75	5.25	5.75	6.75	6.50	7.00	8.00	7.75	8.25	9.25
14.00	24.50	2.75	5.50	6.12	7.00	7.00	7.62	8.50	8.50	9.12	10.00
The dimensions K, A, G, H and J are standardized and can be made available on request.											

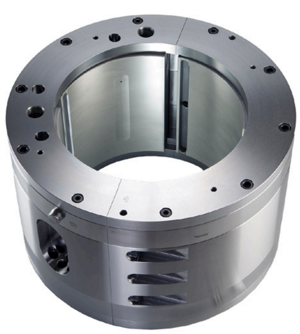
Our tables only provide dimensions for bearings up to a shaft diameter of 14". We regularly manufacture bearings for shafts above 23" and can currently provide bearings for shafts up to 34". Please consult our sales staff for any shaft sizes not found in our tables.

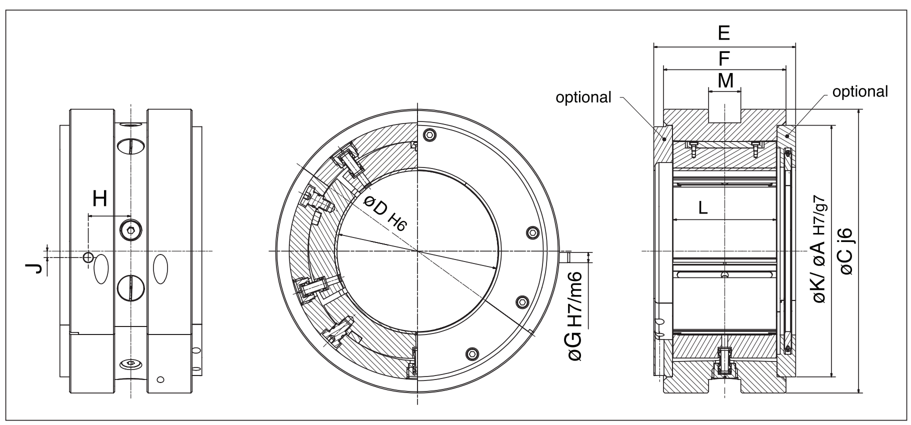
0.7, 0.9, 1.0 L/D Bearings – Inches

PJ Flooded Bearing Dimensions

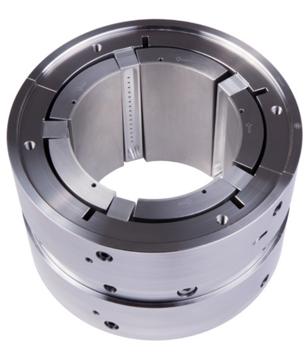


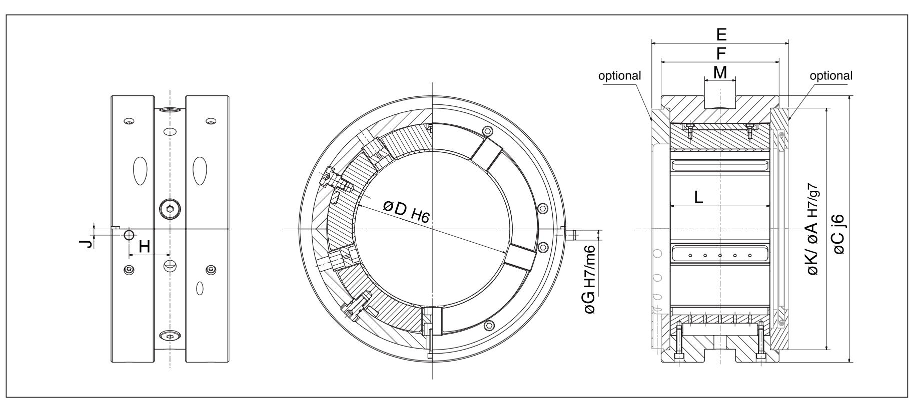
LEG® Directed Lube Bearing Dimensions





BPG® Directed Lube Bearing Dimensions



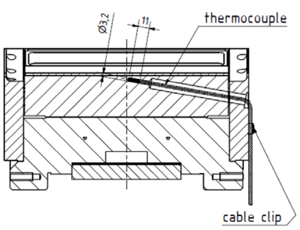


0.7, 0.9, 1.0 L/D Tables – Inches

Inch Standard Sizes (in)			L/D=0.7			L/D=0.9			L/D=1.0		
Bearing Diameter	Aligning Ring OD	Annulus Width	Pad Width	Seat Width	Overall Width incl. endplates	Pad Width	Seat Width	Overall Width incl. endplates	Pad Width	Seat Width	Overall Width incl. endplates
D	C	M	L	F	E	L	F	E	L	F	E
1.75	5.25	0.38	1.25	1.75	2.12	1.50	2.00	2.38	1.75	2.25	2.62
2.00	5.25	0.38	1.50	2.00	2.38	1.75	2.25	2.62	2.00	2.50	2.88
2.12	5.25	0.75	1.50	1.88	2.38	2.00	2.38	2.88	2.12	2.50	3.00
2.38	5.25	0.75	1.62	2.12	2.62	2.12	2.62	3.12	2.38	2.88	3.38
2.50	6.50	1.00	1.75	2.25	2.62	2.25	2.75	3.12	2.50	3.00	3.38
2.75	6.50	1.12	2.00	2.38	2.88	2.50	2.88	3.38	2.75	3.12	3.62
3.00	6.50	1.12	2.00	2.38	2.88	2.75	3.12	3.62	3.00	3.38	3.88
3.12	6.50	1.12	2.12	2.62	3.12	2.88	3.38	3.88	3.12	3.62	4.12
3.38	6.50	1.12	2.38	2.88	3.38	3.00	3.50	4.00	3.38	3.88	4.38
3.50	6.50	1.12	2.50	3.00	3.38	3.12	3.62	4.00	3.50	4.00	4.38
3.75	8.00	1.12	2.62	3.12	3.62	3.38	3.88	4.38	3.75	4.25	4.75
4.00	8.00	1.25	2.75	3.12	3.75	3.50	3.88	4.50	4.00	4.38	5.00
4.38	8.00	1.38	3.00	3.50	4.00	4.00	4.50	5.00	4.38	4.88	5.38
4.50	9.00	1.38	3.12	3.62	4.12	4.00	4.50	5.00	4.50	5.00	5.50
4.75	9.00	1.38	3.25	3.62	4.25	4.25	4.62	5.25	4.75	5.12	5.75
5.00	9.00	1.38	3.50	4.00	4.50	4.50	5.00	5.50	5.00	5.50	6.00
5.50	11.00	1.38	3.88	4.25	4.88	5.00	5.38	6.00	5.50	5.88	6.50
6.00	11.00	1.38	4.25	4.62	5.25	5.50	5.88	6.50	6.00	6.38	7.00
6.50	11.00	1.38	4.50	5.00	5.50	5.75	6.25	6.75	6.50	7.00	7.50
7.00	12.50	1.62	5.00	5.50	6.00	6.25	6.75	7.25	7.00	7.50	8.00
8.00	13.75	1.62	5.50	5.88	7.00	7.25	7.62	8.75	8.00	8.38	9.51
9.00	16.75	1.75	6.25	6.75	7.75	8.12	8.62	9.62	9.00	9.50	10.50
10.00	18.75	2.00	7.00	7.50	8.50	9.00	9.50	10.50	10.00	10.50	11.50
11.00	19.75	2.38	7.75	8.12	9.25	10.00	10.38	11.50	11.00	11.38	12.50
12.00	20.25	2.50	8.50	9.00	10.00	10.75	11.25	12.25	12.00	12.50	13.50
12.50	21.25	2.50	8.75	9.25	10.25	11.25	11.75	12.75	12.50	13.00	14.00
13.00	23.00	2.75	9.00	9.50	10.50	11.75	12.25	13.25	13.00	13.50	14.50
14.00	24.50	2.75	9.75	10.38	11.25	12.50	13.12	14.00	14.00	14.62	15.50
The dimensions K, A, G, H and J are standardized and can be made available on request.											

Our tables only provide dimensions for bearings up to a shaft diameter of 14”. We regularly manufacture bearings for shafts above 23” and can currently provide bearings for shafts up to 34”. Please consult our sales staff for any shaft sizes not found in our tables.

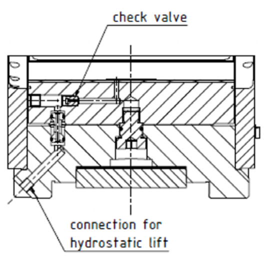
Additional Features



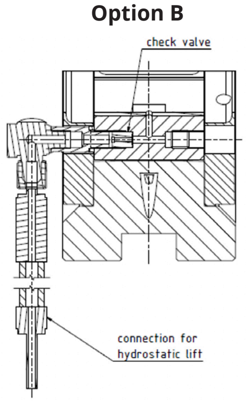
Bearings Temperature Probes

The tilting pads are usually equipped with thermocouples or resistance temperature detectors (RTDs) during operation to monitor the bearing temperature. For a more accurate measurement of the relevant bearing temperature, Kingsbury strongly recommends placing the detector at the 75/50 location, in close proximity to the white metal. Our standard temperature probe holes are 3.6 mm in diameter that can be changed according to customer requirements.

Option A

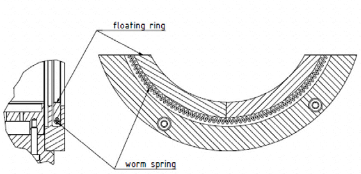


Option B



High Pressure Lift (Jacking Oil)

If needed, the bearing pads can be designed for a hydrostatic pressure lift by incorporating precisely calculated pockets that are also suitable for the hydrodynamic operation. These are mainly required at high initial loads and very low speeds to build up a minimum film thickness between shaft and bearing, preventing possible wear on the sliding surface and avoiding a negative impact on bearing performance. Kingsbury offers two basic design options for this, a direct connection to the aligning ring (option A) or using a separate adapter unit (option B). In both cases, a check valve is located inside the pad. Our engineers will supply full details on the required inlet pressure and oil flow rate to achieve the desired lift.

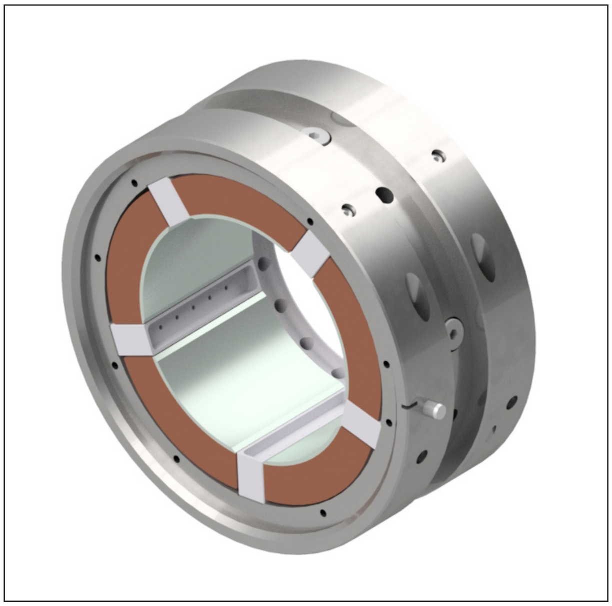


Floating Seals

Floating rings are usually used as sealing elements in tilting pad bearings with flooded lubrication to adjust the oil drain and thus the oil requirement of the bearing. In rare cases, they will only be used on one side of a tilting pad bearing with directed lubrication to divert the oil drain. At speeds above 70 m/s, this can lead to an increase in bearing temperature and power loss as well as to instabilities.

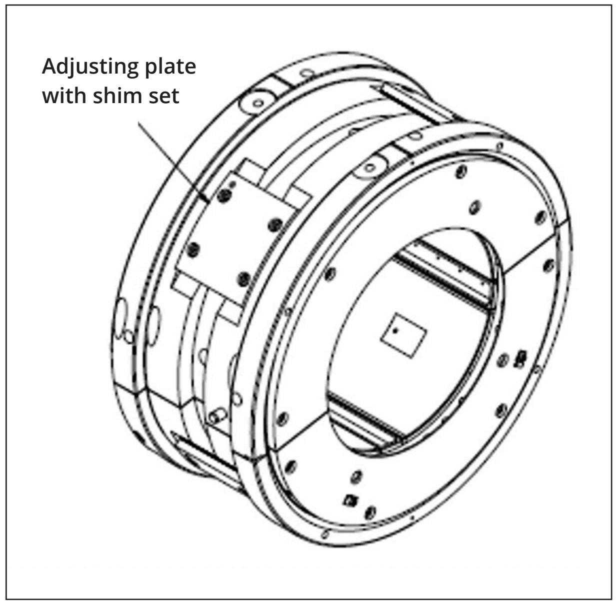
PJ, LEG® and BPG® Journal Bearings

Alternative Bearing Materials



Example of a BPG® bearing with CrCu as pad base material.

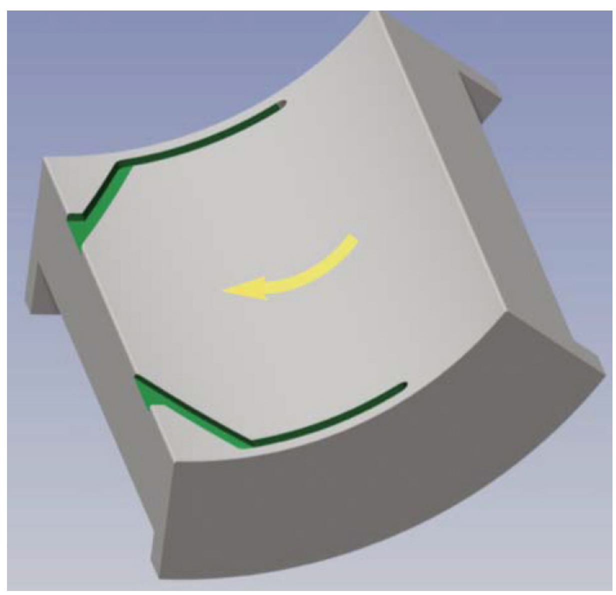
Alternative Bearing Support



Kingsbury also offers bearings with adjusting plates on the outside diameter that can help align the shaft in the machine.

SSV Grooves

Under certain operating conditions, sub-synchronous vibration can occur unexpectedly and give rise to rotor stability concerns. Kingsbury has a patented method of addressing this issue, consisting of lateral grooves machined into the babbitted surface that redirect side-leakage oil flow to the trailing edge of the pad to form a thicker film that diminishes or totally eliminates sub-synchronous vibration.



Detail of pad with SSV grooves.

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