



# Orkot® Hydro Bearings Engineering Manual



## ■ Orkot® Hydro Bearings

Trelleborg Sealing Solutions has been supplying the hydro industry for more than 20 years and is a world leading manufacturer of self-lubricating hydro bearings. Reliability, long life and a history of proven performance have made Orkot® bearings the preferred choice for critical hydropower applications.

Trelleborg's Orkot® Hydro Bearings are manufactured from proprietary Orkot® TLMM and Orkot® TXMM materials that incorporate woven fabric reinforcement and solid lubricants within a thermosetting resin matrix. They are capable of operating in non-lubricated conditions and have excellent wear characteristics, reduce friction and are non-toxic. Both Orkot® materials can also be utilized in water, water-based fluids, oil or grease-lubricated applications.

Through extensive material and solution testing, Orkot® Hydro Bearings are proven to offer superior friction and wear performance, even in dry-running conditions.

### ADVANTAGES

- **Low coefficient of friction.** Orkot® Hydro Bearings exhibit a very low coefficient of friction whether operating in a wet or dry application.
- **High load capabilities.** Orkot® TXMM bearing materials have high ultimate compressive strength and yield strength. Generally, the material fits within the same design envelope as traditional bronze bearings.
- **Proven service life.** The excellent wear resistance of Orkot® TXMM has been proven over many years of service in hydro, marine and civil engineering applications.
- **Environmentally friendly.** Orkot® Hydro Bearings require no lubrication, eliminating any pollution concerns associated with petroleum-based greases or lubricants. No asbestos is used in the manufacturing of Orkot® and the material is completely non-toxic.
- **Outstanding edge loading capabilities.** The mechanical properties of Orkot® TXMM allows the bearing to operate effectively under severe edge loading conditions while protecting expensive hardware.

### APPLICATION EXAMPLES

- Wicket gate/guide vane bearings
- Wicket gate linkage and thrust bearings
- Vertical and horizontal main guide bearings
- Kaplan runner blade bearings and thrust washers
- Operating rings, vertical & horizontal wear pads
- Butterfly valve shaft bearings
- Control gate bearings
- Servo motor bearings
- Eccentric pin bearings
- Fish pump steady bearings
- Bulkhead wear pads
- Spillway gate trunnion bearings and thrust washers
- Trash rake bearings and wear pads

### INSTALLATION METHODS

There are three different ways to install Orkot® Hydro Bearings:

#### Interference Fitting (Radial Bearings Only)

Orkot® Bearings with a calculated interference can be freeze or press fitted into the housing. As all bearings are customized to the application, Trelleborg Sealing Solutions engineering teams will provide guidance on the required press force or suitability for freeze fitting with liquid nitrogen.

#### Bonding

Adhesives can be used to fix thin-walled bearings, pads or segments to a housing or substrate. Use structural adhesives, such as epoxy or toughened acrylic, which can withstand applied compressive loads, and follow the manufacturers guidelines for best performance and application advice. Orkot® surfaces do not require special preparation before bonding. Contact your local Trelleborg Sealing Solutions marketing company for advice on bonding and suitable products.

#### Mechanical Fasteners

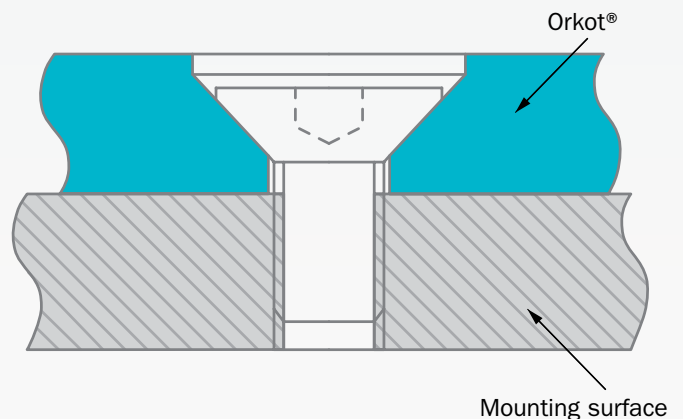


Figure 1: Mechanical fastening of Orkot® bearings

Orkot® bearing pads and segments can be fitted using threaded fasteners, based on resisting shear around the fasteners. The fasteners cannot be retained using a prevailing torque due to the lower elastic modulus of the Orkot® and should be hand tightened.

It is advised to lock the fastener using a chemical locking compound or tighten the fastener against the housing. Always ensure that the fasteners are sunk deep enough in the bearing material to avoid metal-to-metal contact between the counter face and fastener, keeping in mind any deformation of the Orkot® and potential wear.

## SHAFT MATERIAL

Most recognized shaft materials can be used, such as stainless steel (e.g. 316L), Inconel, Monel and phosphor bronze. The surface finish of the shaft should be 0.4 - 0.8 Ra.

Trelleborg Sealing Solutions recommends a shaft hardness of at least 200 HV.

## MACHINING

### General

Orkot® materials are readily machinable by conventional machine shop techniques. As a general guide, methods used for brass, aluminium or lignum vitae will apply for Orkot® materials. It is preferable to use tungsten carbide turning tools with cutting speeds of 5.5 meters per second. Orkot® materials must be machined dry without the use of coolant.

### Turning

Tungsten carbide tooling of the butt-welded type using K20 grade carbide is suitable for most applications. If carbide inserts are used, then aluminium grades with high positive rakes give best results e.g. Plansee grade H10T.

## TESTING FACILITIES

Trelleborg Sealing Solutions has invested in a range of dedicated test equipment to monitor internal production quality. This equipment allows replication of customer-specific applications and provides accurate data to aid design and support the product through its installed service life.

### Compressive Test

- 100 kN Maximum load. Technical reports tailored to customer requirements
- Compression/Tensile/Shear/Lap Shear

### Rotary Friction and Wear

- 50 kN maximum load, Ø100 shaft
- Continual rotation at 0.5 m/min to 300m/min
- Reciprocating between ±2° and ±30°
- Technical reports to give specific friction and wear data against range of counterfaces either dry or in a range of lubricating media

### Linear Friction and Wear

- 50 kN maximum load
- 500 mm stroke length, up to 20 m/min
- Technical reports to give specific friction and wear data against range of counterfaces either dry or in a range of lubricating media

## MATERIALS

Orkot® TXMM is recommended for turbine guide bearings. At slower speeds the bearing may not run fully hydrodynamic, running instead in 'boundary conditions'. In these conditions, Orkot® TXMM has shown lower friction and wear, giving improved service life in applications that see frequent interruptions in operation. The properties of both Orkot® TLMM and TXMM are given in Table 1.

Table 1: Orkot® material properties

Physical Properties	TLMM	TXMM
Color	gray	gray
Density, g/cm <sup>3</sup>	1.25	1.25
Swell in water (% of wall thickness)	0.1	0.1
Mechanical Properties		
Compressive Strength, N/mm <sup>2</sup> Normal to laminate	300	280
Parallel to laminate	90	90
Compressive Modulus, N/mm <sup>2</sup>	2800	2800
Yield Strength, N/mm <sup>2</sup>	90	90
Flexural Strength, N/mm <sup>2</sup> Flexural Modulus, N/mm <sup>2</sup>	65 1900	65 1800
Coefficient of Friction (Dry at 15 N/mm <sup>2</sup> )	0.15 - 0.18	0.05 - 0.10
Impact Strength (Charpy, unnotched), KJ/m <sup>2</sup>	120	120
Hardness, Rockwell M	90	90
Thermal Properties		
Linear Expansion Coefficients (20-100 °C), x10 <sup>-5</sup> /°C Parallel to laminate	5 - 6	5 - 6
Normal to Laminate	9 - 10	9 - 10
Maximum Operating Temperature, °C	130	130

## ■ Guide Vane and Link Bearings

Orkot® can be used in guide vane and link bearings. By utilizing the properties of Orkot®, these bearing can be run with low running clearances, demonstrating excellent friction and wear properties in dry and wet conditions.

### STANDARD INSTALLATION RECOMMENDATIONS

These guideline figures are recommended for pressures of up to 20 MPa continuously or 40 MPa for intermittent service. All sizes

are at 20 °C. The calculations are based on a bearing contact angle of 170° and shaft alignment of 0.05°. For conditions outside of the specified loads and alignment, please contact your local Trelleborg Sealing Solutions marketing company for guidance.

These recommendations apply to bushes retained by elastic compression, assembled by freeze fitting or by press fit. Thinner walled bearings than shown may require bond fitting instead.

Table 2 – Installation Dimensions – Standard Recommendations

Shaft Diameter h7	Housing Diameter H7	Bearing Length*	Machining Tolerance				Fitted Diameter	
			OD		Wall		Max.	Min.
mm	mm	mm	mm	mm	mm	mm	mm	mm
20	26	16	26.16	26.08	2.98	2.93	20.15	20.03
30	36	24	36.19	36.11	2.98	2.93	30.16	30.03
40	46	32	46.22	46.14	2.98	2.93	40.16	40.03
50	56	40	56.26	56.18	2.97	2.92	50.16	50.03
60	66	48	66.29	66.21	2.97	2.92	60.16	60.03
70	76	56	76.33	76.25	2.97	2.92	70.16	70.03
80	86	64	86.37	86.29	2.97	2.92	80.17	80.03
90	96	72	96.40	96.32	2.97	2.92	90.17	90.03
100	106	80	106.44	106.36	2.97	2.92	100.17	100.03
110	116	88	116.48	116.40	2.97	2.92	110.17	110.03
120	126	96	126.53	126.45	2.96	2.91	120.17	120.03
130	140	104	140.53	140.45	4.96	4.91	130.18	130.04
140	150	112	150.57	150.49	4.96	4.91	140.18	140.04
150	160	120	160.60	160.52	4.96	4.91	150.18	150.04
160	170	128	170.64	170.56	4.96	4.91	160.18	160.04
170	180	136	180.68	180.60	4.95	4.90	170.18	170.04
180	190	144	190.73	190.65	4.95	4.90	180.19	180.04
190	200	152	200.77	200.69	4.95	4.90	190.19	190.04
200	210	160	210.81	210.73	4.95	4.90	200.19	200.04
210	225	168	225.81	225.71	7.44	7.39	210.20	210.05
220	235	176	235.85	235.75	7.44	7.39	220.20	220.05
230	245	184	245.89	245.79	7.44	7.39	230.20	230.05
240	255	192	255.93	255.83	7.44	7.39	240.20	240.05
250	265	200	265.97	265.87	7.44	7.39	250.20	250.05
260	275	208	276.01	275.91	7.44	7.39	260.20	260.05
270	285	216	286.01	285.91	7.44	7.39	270.20	270.05
280	295	224	296.10	296.00	7.44	7.39	280.20	280.05
290	310	232	311.08	310.98	9.94	9.89	290.20	290.05
300	320	240	321.12	321.02	9.93	9.88	300.21	300.05
310	330	248	331.16	331.06	9.93	9.88	310.21	310.05
320	340	256	341.20	341.10	9.93	9.88	320.21	320.05
330	350	264	351.24	351.14	9.93	9.88	330.21	330.05
340	360	272	361.28	361.18	9.93	9.88	340.21	340.05
350	370	280	371.28	371.18	9.93	9.88	350.21	350.05

\* Calculated from 0.8 x shaft diameter

## Water-Lubricated Hydrodynamic Bearings

### HYDRODYNAMIC OPERATION

Orkot® Hydro Bearings for turbine guides must be water lubricated and operate hydrodynamically (on a water film). To ensure hydrodynamic operation, we recommend:

$$V / P > 320$$

Where V is the shaft velocity at the bearing surface, in m/min and P is the projected bearing pressure in N/mm<sup>2</sup>.

### WATER FLOW RATE

The bearing must receive a positive supply of clean water through the bearing to prevent overheating. The recommended water flow rate is 0.18 l/min per mm of shaft diameter to ensure a full hydrodynamic water film is generated, however internal tests have shown a minimum of 0.12 l/min per mm of shaft diameter will still operate hydrodynamically.

Supply of clean and filtered water can extend bearing service life. Trelleborg Sealing Solutions recommends using a two-stage filtration system. Tests have demonstrated that a 20-mesh strainer followed by a 100-mesh filter provides the best balance between filtration and maintenance requirements.

A water-lubricated turbine guide bearing will usually be of the multi-groove design, the details of which are shown in Table 3.

To ensure the bearing running area is always filled with water, a restriction device can be used below the bearing. Alternatively the axial grooves can be stopped short of the bottom of the bearing for a similar effect.

### INSTALLATION RECOMMENDATIONS FOR WATER-LUBRICATED HYDRODYNAMIC BEARINGS

#### Fitting

Turbine guide bearings are often split-design type fitted to the housing with countersunk screws, adhesive or a patented taper key design. These allow installation without removing the shaft.

Complete, non-split bearings can be fitted with an interference fit.

#### Design Recommendations for Multi-groove Bearings

The design of the bearings is modified based on how they are intended to be installed.

For vertically-positioned bearings, the grooves are equally spaced over the circumference. For horizontally-positioned bearings, omit the bottom groove.

Multi-groove bearings typically have 3 mm x 30 degree chamfers on the outer and inner diameters. See Table 3 for hardware and bearing sizes for vertically fitted bearings.

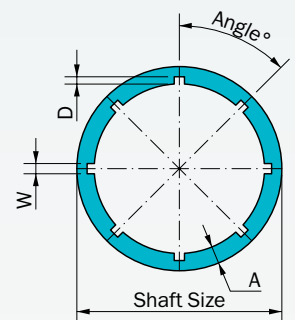


Figure 2 – Cross-section of a multi-groove bearing.

Table 3 – Vertically fitted, multi-groove bearing hardware and bearing sizes for water-lubricated hydrodynamic bearings

Shaft Size	Minimum Wall Thickness A	Minimum Interference (if applicable)	Minimum Shaft Clearance	Number of Grooves	Angle between grooves	Groove Width W	Groove Depth D
mm	mm	mm	mm		Degrees	mm	mm
30 - 60	8	0.15	0.10	5	72.0	8	4
60 - 100	9	0.22	0.10	6	60.0	8	4
100 - 150	10	0.34	0.15	7	51.4	10	6
150 - 200	12	0.43	0.20	8	45.0	10	6
200 - 250	14	0.56	0.25	9	40.0	12	7
250 - 300	14	0.70	0.30	10	36.0	12	7
300 - 350	16	0.84	0.35	11	32.7	14	8
350 - 400	16	0.97	0.40	12	30.0	14	8
400 - 450	20	1.11	0.45	13	27.7	16	10
450 - 500	20	1.25	0.50	14	25.7	16	10
500 - 550	22	1.40	0.55	15	24.0	18	11
550 - 600	22	1.50	0.60	16	22.5	18	11

## ■ Sealing and Bearing Solutions for Hydropower Turbines

A key component in any hydropower application is the bearing. Trelleborg Sealing Solutions is the world's leading developer and manufacturer of self-lubricating bearings for the hydropower market.



### Distributor Ring

Orkot® wear pads on the distributor ring guarantee low friction.



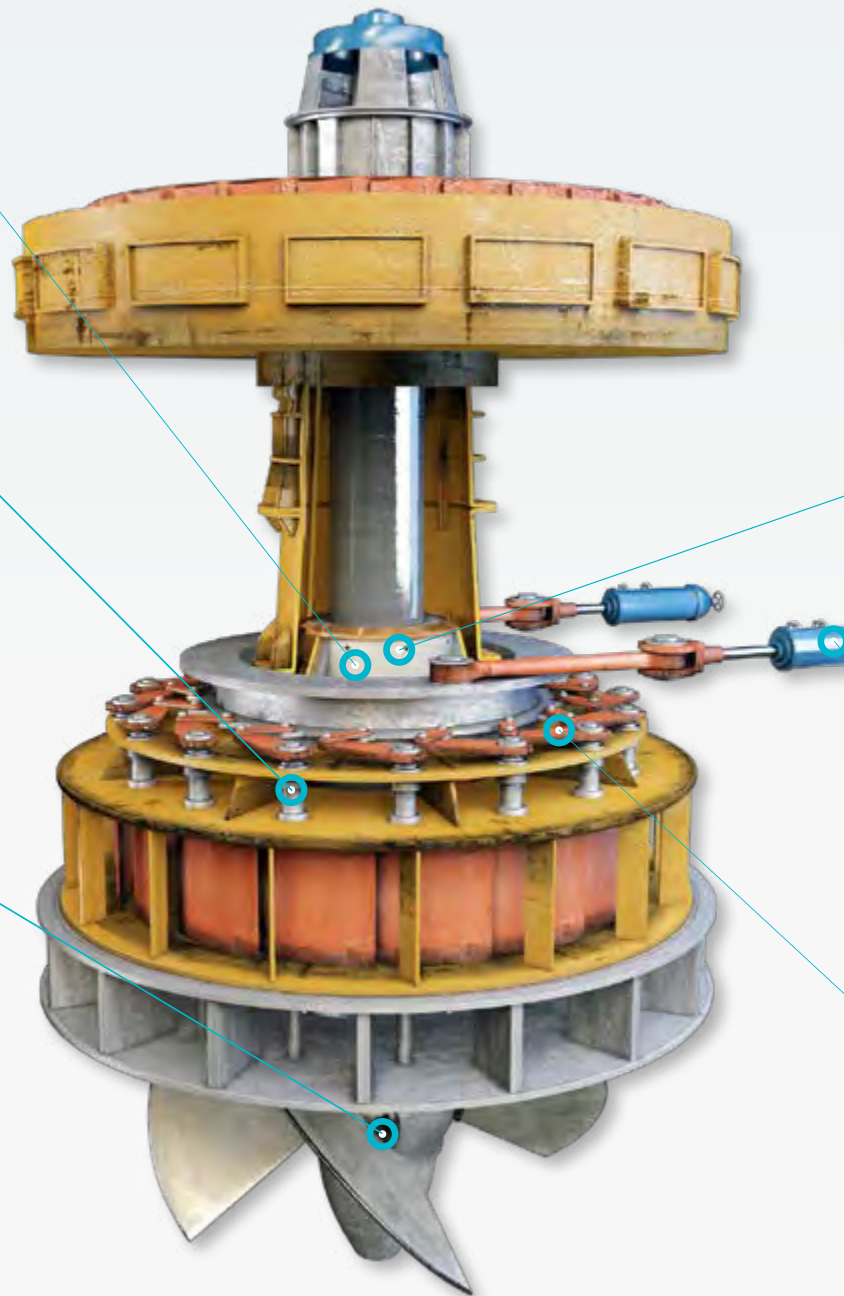
### Wicket Gate

Orkot® TXMM bearing and spring-energized Turcon® Variseal® on the intermediate and lower assembly of the wicket gate guide prevent suspended solids in the water from damaging the wicket gate stems and bearings.



### Runner Blade Bearing

Orkot® TXMM bearings allow for high load capabilities and custom-designed hub seals prevent ingress of water into the hub at the same time as preventing oil from leaking out of the hub into the environment.



## Penstock/Butterfly Valve

Orkot® TXMM bearings allow for high load capabilities with low friction for intermittent use.



## Spillway Gates

Orkot® TXMM trunnion bearings on spillway gates guarantee long life even under the harshest conditions.



## Main Guide

A self-lubricating Orkot® TXMM bearing on the main guide prevents metal-to-metal contact and allows the turbine to run smoothly.



## Servo Cylinder

Orkot® TXMM bearings, rod and piston seals, scrapers and Slydring® wear rings combine to make a sealing and bearing system that means long life for cylinder applications.



## Control Linkages

Orkot® TXMM bearings guarantee long life while ensuring performance in limited-motion applications.



## Orkot® Hydro Bearings

Trelleborg's proprietary Orkot® Hydro Bearings are manufactured from Orkot® TLMM and Orkot® TXMM, materials that incorporate woven fabric reinforcement and solid lubricants within a thermosetting resin matrix. Orkot® TXMM bearings run completely dry and have excellent wear characteristics, reduce friction and are non-toxic. Both Orkot® materials can also be utilized in water, water based fluids, oil or grease lubricated applications.



## FURTHER INFORMATION

**Read the book.**  
**See the movie.**

Check out the Trelleborg Sealing Solutions hydropower film, available in English, Spanish and Portuguese! Go to:

[www.tss.trelleborg.com/films](http://www.tss.trelleborg.com/films)

Trelleborg is a world leader in engineered polymer solutions that seal, damp and protect critical applications in demanding environments. Its innovative solutions accelerate performance for customers in a sustainable way.

Trelleborg Sealing Solutions is a leading developer, manufacturer and supplier of precision seals, bearings and custom-molded polymer components. It focuses on meeting the most demanding needs of aerospace, automotive and general industrial customers with innovative solutions.

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