THORDON

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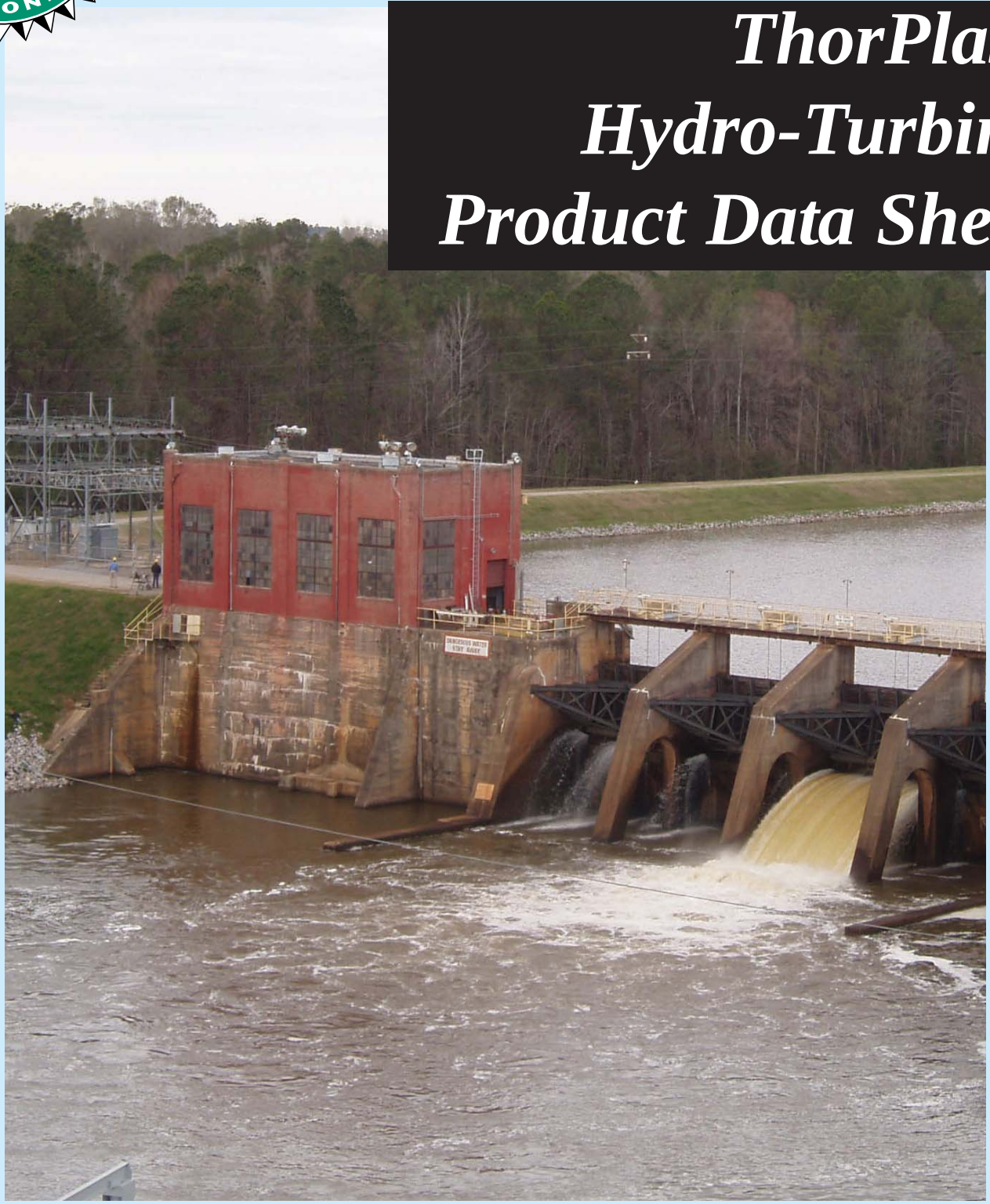
PROTECTING THE THORDON ENVIRONMENT

ThorPlas® Hydro-Turbine Product Data Sheet

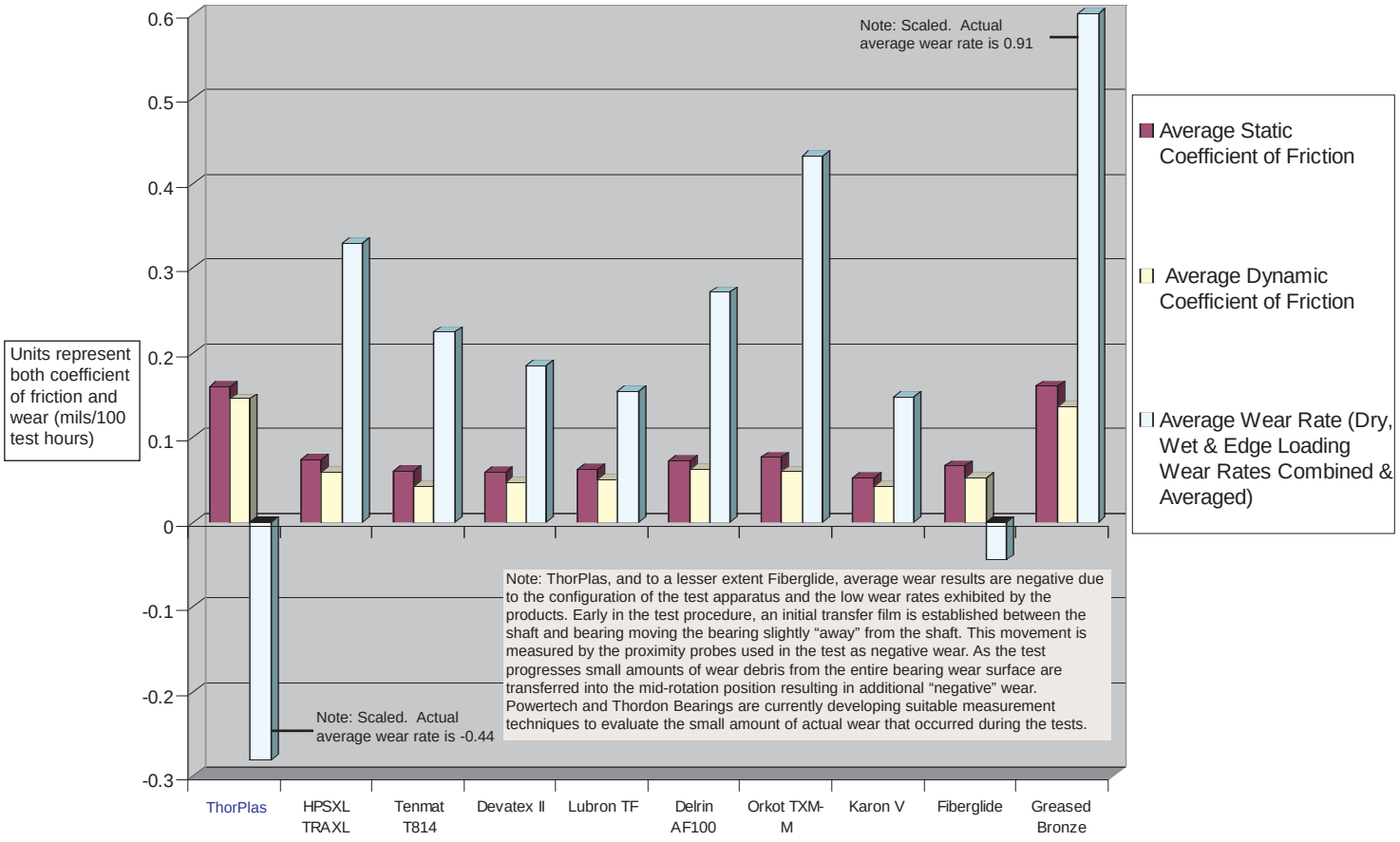


NEW THORPLAS® ENGINEERED THERMOPLASTIC DEVELOPED BY THORDON BEARINGS FOR THE HYDRO-TURBINE INDUSTRY

A proprietary engineered thermoplastic, ThorPlas® has been specifically formulated for use in hydro-turbine wicket gate and operating linkage applications. ThorPlas® is a homogeneous, self-lubricating polymer bearing capable of withstanding operating pressures up to 31 MPa (4500 psi) installed in a full-form, interference-fit configuration. In recent Powertech tests, ThorPlas® demonstrated exceptional wear performance particularly in the dry tests. According to Powertech there was little evidence of stress on the bearing material and no indication of damage to the journal surfaces. The coefficients of friction were at acceptable levels and the product performed well in the tests. Coincidentally, Thordon HPSXL TRAXL, a sister product, is also one of the top rated products. The detailed results of these tests are summarized below.

While Thordon HPSXL TRAXL features a thin layer of low friction, abrasive resistant elastomer material polymerized to a bronze shell, ThorPlas® is a much stiffer polymer capable of being interference-fit full form directly into the available bushing space. ThorPlas® offers hydro-turbine operators, who do not require the specific performance advantages offered by HPSXL TRAXL, an alternative Thordon high performance bearing solution without the cost premium inherent to TRAXL's bronze bearing shell configuration.

Powertech Simulated Wicket Gate Bearing Test Results



Formulated to complement the widely recognized range of existing Thordon elastomer bearing grades, ThorPlas® offers the following benefits:

- **excellent wear performance in reasonably clean application environments**
- **self-lubricating** - homogenous polymer with lubricants to lower friction and wear formulated into the molecular structure. Once the bearing enters service and a transfer film is established between the shaft and the bearing, friction stabilizes for the life of the bearing
- **low friction** - dynamic coefficients of friction of 0.10 to 0.15 (dry) and 0.12 to 0.17 (wet)
- **no stick-slip** - ratio of static to dynamic coefficient of friction is very low at +7.5% dry and +11.5% wet
- **dry start-up** - operation dry for 3 minutes at a PV of 15MPa - m/min (7070 psi - ft/min) using a 75mm (3.0”) shaft at 0.35 kg/cm^2 (5 psi) and 1800 rpm; or 1 minute at a PV of 22.4MPa - m/min (10,500 psi - ft/min) is possible
- **low coefficient of thermal expansion** - minimal change in installed bearing dimensions due to temperature variation (50% vs. Nylon and Delrin AF; <25% vs. UHMW/HDPE and 30% vs. Thordon SXL)
- **low water absorption rate** - minimal change in installed bearing dimensions (6% vs. Nylon; 50% vs. Delrin AF; 50% vs. Railko and 40% vs. Thordon SXL)
- **free machining** - no nuisance dust
- **reasonable abrasion resistance** - less than Thordon elastomer grades, but better than bronze, phenolics and many other common non-metallic bearing materials
- **increased strength and rigidity** - maximum pressures to 31 MPa (4500 psi) in an interference fit bearing
- **improved ability to operate at elevated temperatures** - maximum continuous service temperatures of 80°C (175°F) in water and 110°C (230°F) dry
- **improved chemical resistance in all major chemical product categories**

Typical ThorPlas® Hydro-Turbine Applications:

- Wicket gate bearings

- Operating mechanism bearings

- Linkage bearings

- Other higher pressure bearing applications such as servo-motor and servo-links, travelling screens, wear pads and butterfly valve trunion bearings

Note: In environments such as hydro-turbine wicket gates and operating linkages where abrasives are typically present, sealing of the ThorPlas® bearings is recommended.

Availability:

ThorPlas® tubes up to 250mm (10") outside diameter are in stock. Larger tubes up to 300mm (12”) outside diameter can be supplied quickly to meet specific customer requirements.

For product availability and additional application engineering information, contact your local Thordon distributor or Thordon Bearings Inc.

Typical ThorPlas® Properties and Competitive Comparison

Material	Unit of Measure	Thordon XL	Thordon SXL	Thordon HPSXL	ThorPlas®	Nylon 66SA	Orkot TXM-M	Orkot TLG-P/S	Delrin AF	Tenmat T814	Tenmat T14	Railko NF22	UHMW/ HDPE
Ultimate Tensile Strength D-638	MPa (psi)	35.0 (5200)	44.0 (6300)	42.0 (6090)	64.3 (9300)	93.3 (13500)	55.0 (8000)	55.0 (8000)	55.0 (8000)		80.0 (11600)	30.4 (4400)	22 - 35 (3200 - 5100)
Tensile Modulus	MPa (psi)	1,060 (150,000)	605 (86,000)	925 (132,000)	2,690 (390,000)	1,585 (230,000)			2,800 (405,000)			6,178 (900,000)	690 (100,000)
Elongation at Break	%	120	230	110	5 - 10	15			15-20				300-400
Hardness	Shore D	73	66	76	83	82	93	93	86	92	92	95	64 - 67
Compression Modulus	MPa (psi)		486 (70,000)	650 (94,250)	1530 (222,000)				1490 (216,000)			4020 (583,000)	
Compression Strength at Yield (D695)	MPa (psi)				92 (13,300)	86 (12,500)			115 (16,800)				
Compression Strain at Yield (D695)	%				8.6				18.0	5	5		
Maximum Working Pressure (Dynamic)	MPa (psi)	5.5 (800)	10 (1,450)	15.5* (2,250)	31** (4,500)	22 (3,150)				62 (9,000)	65 (9,425)	45 (6,400)	10 (1,430)
Notched Impact Strength IZOD	J/m (ft-lb/in)	160 (3.0)	320 (6.0)	106 (2.0)	26 (0.5)	47 (0.9)			47 (0.9)	35 (0.7)	50 (1.0)	75 (1.5)	640 (12.0)
Water Absorption 24-h immersion (D570)	%	0.50	0.5		0.035	1.2	0.01	0.01	0.2				0.1
Water Absorption (Max.)	%	1.30	1.3		0.5	9.0			1.0	0.35	0.50	1.0	0.3
Dynamic Coefficient of Friction on Steel (D3702)			0.07 - 0.15	0.05 - 0.11	0.07 - 0.11	0.28			0.16				
Typical Dynamic Coefficient of Friction in use (Dry)			0.1 - 0.15	0.07 - 0.12	0.1 - 0.15	0.15 - 0.30	0.06 - 0.10	0.13 - 0.16	0.06 - 0.12	0.04 - 0.10	0.13 - 0.18	0.1 - 0.15	0.10 - 0.20
Typical Dynamic Coefficient of Friction in use (Wet)			0.08 - 0.13	0.06 - 0.12	0.12 - 0.17		0.06 - 0.10		0.08 - 0.15	0.04 - 0.10			
Wear Rate Against Steel (Dry) (D3702)	M. hr^{-1} x 10^{-8} (in.$hr.^{-1}$ x 10^{-7})		22 86		1.9 7.7	510 2,000			51 200				
Rotary Drum Abrasive (Dry) Wear (D5963)	(mm^3)	100	195	200	272		365	365	304	321	321	401	198
Coefficient of Linear Thermal Expansion	cm/cm/ºC x 10^{-5} (in/in/ºF x 10^{-5})	14.8 (8.2)	15.1 (8.4)	12.0 (6.7)	4.6 (2.5)	8.1 (4.5)	5-10 (3 - 7)	6-13 (3 - 7)	8.6 (4.8)	5.0 (2.8)	5.0 (2.8)	4.0 - 6.0 (2.2 - 3.3)	20 - 35 (11 - 20)
Max. Operating Temp. (continuous) - Water	ºC (ºF)	60 (140)	60 (140)	60 (140)	80 (175)	70 (160)		100 (212)	70 (160)	100 (212)	100 (212)	80 (175)	80 (175)
Max. Operating Temp. (continuous) - Dry	ºC (ºF)	100 (212)	100 (212)	100 (212)	110 (230)	100 (212)		136 (266)	90 (195)	100 (212)	100 (212)	100 (212)	80 (175)
Density	$g.ml^{-1}$	1.21	1.16	1.28	1.40	1.16	1.25	1.25	1.50	1.25	1.32	1.64	0.95
Melting Point	ºC (ºF)	n/a	n/a	n/a	250 (480)	260 (500)			175 (345)				136 (277)

***** Note: 70MPa (10,000 psi) in high pressure TRAXL configuration.
** Note: Peak static pressure - 45 MPa (6500 psi)

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