THORDON

THORDON BEARINGS INC.

Hydro-Turbine Applications Product Manual

HT2009.2

THORDON

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Note: *The information contained in this document is offered as part of our service to customers. Thordon Bearings reserves the right to revise any information or specifications included in this document without prior notice.*

COMPANY PROFILE

Thordon Bearings Inc., a member of the Thomson-Gordon Group of Burlington, Ontario, Canada, designs and manufactures a complete range of high performance, environmentally-friendly bearings and bearing systems. Recognized internationally for superior performance, Thordon solutions and products are specified extensively in marine, offshore, pump, hydro-turbine and other many other industrial applications in over 70 countries throughout the world.

Utilizing proprietary polymers developed and manufactured by Thordon as the bearing surface, Thordon bearing solutions deliver high reliability and long wear life, particularly in tough, abrasive operating conditions. This high level of product performance results in decreased life cycle costs and increased mean time between failures for Thordon's customers. A team of experienced, in-house application design engineers provides innovative bearing system designs to meet or exceed each customer's technical requirements. Thordon products and services are available worldwide through local distributors whose factory-trained specialists consult with customers from the establishment of bearing system specifications to ensuring the product is correctly installed and commissioned in the field.

Since the turn of the century, Thordon Bearings' parent company, the Thomson-Gordon Group, a fourth generation family-owned business, has recognized the importance of providing industry with superior products, precision manufacturing and solid application engineering support. Thordon Bearings' own engineering and quality focus has earned worldwide recognition from its many customers. Quality procedures are certified to ISO 9001:2000 Quality System requirements.

Thordon bearings, and bearing systems, are the proven, cost-effective, environmentally-friendly, solution for rigorous and demanding journal bearing applications.

SECTION B

PRODUCT AND CONFIGURATIONS

Thordon has developed two types of polymer bearings and several grades that allow selection of the optimal bearing for your unique application.

Elastomeric Bearings

Thordon Bearings introduced a proprietary, elastomeric, synthetic polymer alloy more than 30 years ago originally for use as a sleeve bearing for vertical pump applications. The unique polymer structure yields basic properties more in line with those you could expect from a very high performance rubber if one existed. However, Thordon is harder - yet elastomeric, tough and resilient in nature, self-lubricating with a much lower coefficient of friction and able to accommodate much higher specific pressures than rubber.

Thordon elastomeric bearing grades are not reinforced with layers of woven fabric, rather, it is a fully homogenous product with all properties consistent throughout the entire wall thickness of the bearing. Compared to other non-metallics such as phenolic laminates, Thordon is somewhat softer and more compliant. As a result, under slight misalignment conditions where edge loading is created, Thordon is able to deform slightly, allowing the load to be distributed over a larger area. The localized pressure on the bearing edge is significantly reduced. Due to its elastomeric nature, Thordon is also able to withstand higher degrees of vibration and shock loading without incurring permanent deformation or damage. Thordon offers three elastomeric grades and two configurations

Continuous research over the years has resulted in development of four different bearing-grade elastomer products - XL, SXL, HPSXL and GM2401. This allows selection of an optimum solution based on matching product characteristics to the specific application requirements.

ThorPlas® Thermoplastic Bearings

ThorPlas® is a new, proprietary, engineered thermoplastic bearing product recently introduced by Thordon Bearings. While the Thordon range of high performance elastomeric bearing products clearly offers superior performance in the applications in which they can be specified, there are technical limits, such as maximum temperatures and pressures beyond which they cannot be used.

To address this issue, Thordon Bearings has introduced ThorPlas®, which significantly expands the range of applications where Thordon bearings can be specified, while still maintaining many of the recognized Thordon performance advantages.

PRODUCT AND CONFIGURATIONS (cont'd.)

When compared to the Thordon elastomer-based products, ThorPlas® offers:

- increased strength and rigidity allowing maximum dynamic working pressures up to 31 MPa (4500 psi) in a full-form tubular configuration
- improved ability to operate at elevated temperatures up to 80°C (176°F) in water
- improved chemical resistance in all major chemical categories
- enhanced wear life in non-abrasive environments

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.

THORDON GRADES

ThorPlas® (Blue)

- thermoplastic material developed by Thordon specifically as a homogeneous high pressure bearing
- maximum dynamic working pressure to 31.0 MPa (4500 psi)
- very low wear in non-abrasive environments
- reasonable abrasion resistance - less than Thordon elastomeric grades, but better than bronze, epoxy phenolics and many other non-metallic bearing materials

Thordon SXL (Off White)

- maximum dynamic working pressure to 10.0 MPa (1450 psi) in limited motion
- lower coefficient of friction (typically 0.10-0.20) than XL
- higher dry PV (Pressure Velocity) rating than XL
- higher resistance to abrasion than XL in wet applications; good abrasion resistance operating dry
- dry start-up capability as a vertical pump bearing
- high resistance to shock loading and vibration

THORDON GRADES (cont'd.)

Thordon HPSXL (Grey)

- designed for higher pressure applications, as the bearing component in HPSXL TRAXL bearings (HPSXL bonded in a metallic shell)
- maximum dynamic working pressure to 15.0 MPa (2175 psi) in limited motion
- HPSXL TRAXL has maximum dynamic working pressure to 55.0 MPa (8000 psi) in limited motion
- lowest coefficient of friction (typically 0.06 - 0.12)
- moderately abrasion resistant (lower abrasion resistance than XL or SXL)
- high resistance to shock loading and vibration

Thordon XL (Black)

- maximum dynamic working pressure to 5.5 MPa (800 psi) in limited motion
- low coefficient of friction (typically 0.20-0.25)
- high resistance to abrasion in dry applications
- high resistance to shock loading and vibration

Thordon GM2401/Composite (Yellow Shell, Black Wear Surface is GM2401)

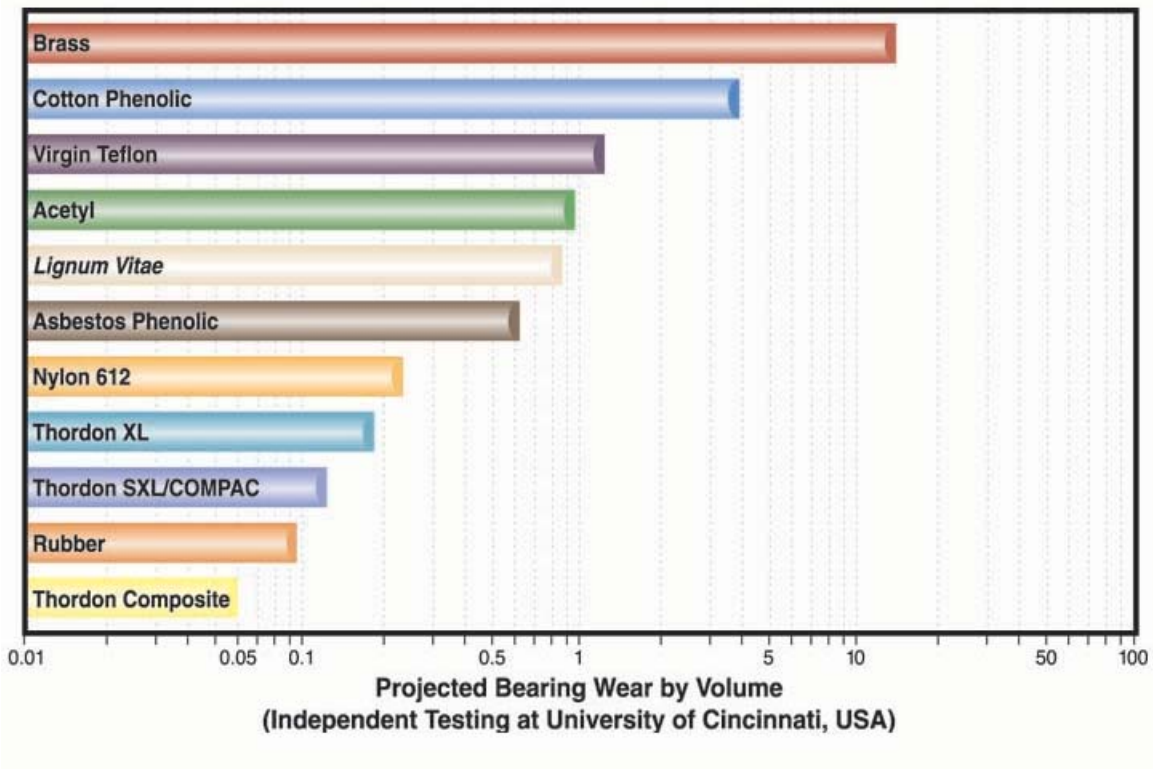
- bearing formulated specifically for use in very abrasive environments
- used in rotating applications in abrasive water conditions such as pump and dredge bearings
- outstanding abrasion resistance - two or more times that of rubber
- significantly lower coefficient of friction than rubber
- higher resilience and stiffness than rubber

THORDON GRADES (cont'd.)

Thorseal

- high performance elastomer hydraulic lip (cup) seal
- highly abrasion resistant - use as a seal to exclude abrasives from limited motion bearings
- suitable for pressures from 0 to 100.0 MPa (0 - 15,000 psi)
- recommended for reciprocating linear or limited motion rotary applications
- very tough - cut and tear resistant
- low friction - self-lubricating
- available in single lip or stacked ThorPak ("chevron" style)

TYPICAL BEARING ABRASIVE WEAR RATES



THORDON

GENERAL MATERIAL SELECTION GUIDE FOR VARIOUS APPLICATION PARAMETERS

Lubrication / Operating Pressure	Recommended Thordon Grades		
	★★★★★	★★★★	★★★
Dry (sealed or minimal abrasives)			
0-10 MPa (0-1450 psi)	SXL	ThorPlas	
10-15 MPa (1450-2175 psi)	HPSXL	ThorPlas	
15-31 MPa (2175-4500 psi)	HPSXL TRAXL	ThorPlas	
31-55 MPa (4500-8000 psi)	HPSXL TRAXL		
Dry (abrasives present)			
0-5.5 MPa (0-800 psi)	XL	SXL	ThorPlas
5.5-10 MPa (800-1450 psi)	SXL	ThorPlas	
10-15 MPa (1450-2175 psi)	HPSXL	ThorPlas	
15-31 MPa (2175-4500 psi)	ThorPlas		
Wet (sealed or minimal abrasives)			
0-10 MPa (0-1450 psi)	SXL	ThorPlas	
10-15 MPa (1450-2175 psi)	HPSXL	ThorPlas	
15-31 MPa (2175-4500 psi)	HPSXL TRAXL	ThorPlas	
31-55 MPa (4500-8000 psi)	HPSXL TRAXL		
Wet (abrasives present)			
0-3 MPa (0-500 psi)	GM2401	SXL	ThorPlas
3-10 MPa (500-1450 psi)	SXL	ThorPlas	
10-15 MPa (1450-2175 psi)	HPSXL	ThorPlas	
15-31 MPa (2175-4500 psi)	ThorPlas		

Note: The maximum pressures given for the various products are based on maximum dynamic working pressures for intermittent, limited motion. For applications involving continuous rotary motion, PV limits of the materials will significantly reduce the maximum allowable pressures stated above.

This is a general guide for technical reference only. Critical applications that are close to pressure or temperature limits, or subjected to non-standard environments should be reviewed and approved by Thordon Engineering.

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MATERIAL SELECTION GUIDE FOR PUMP BEARING APPLICATIONS

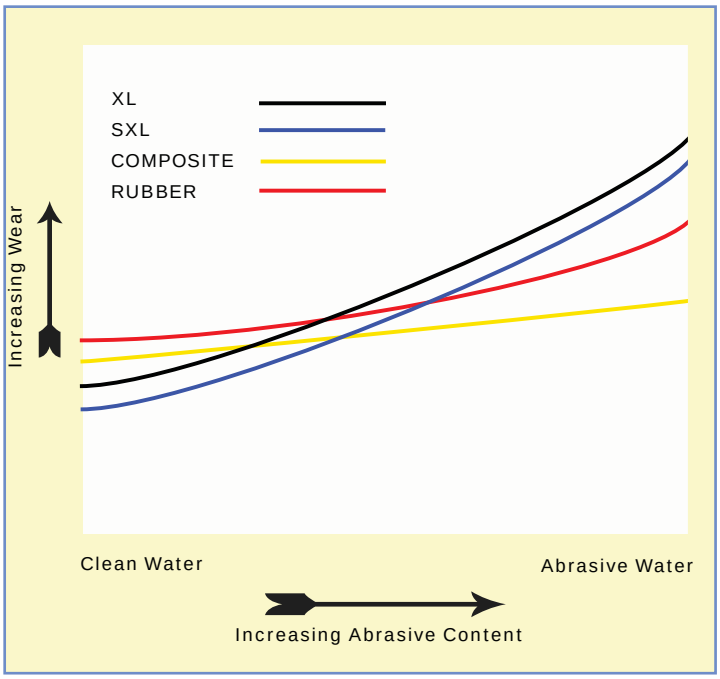
Parameter	Thordon Grades			
	Thordon XL	Thordon SXL	Thordon Composite (GM2401)	ThorPlas
Description	Elastomeric Polymer Alloy	Elastomeric Polymer Alloy	Elastomeric Polymer Alloy	Engineered Thermoplastic
Temperature Limit	60°C (140°F)	60°C (140°F)	60°C (140°F)	80°C (176°F)
Suitable for Dry Start Up	NO	YES**	NO	YES**
Resistance to Acids	Limited	Limited	Limited	Fair to Good
Resistance to Alkalies	Limited	Limited	Limited	Fair to Good
Suitable for Hydrocarbons	YES	YES	YES	YES
Abrasion Resistance	Good	Better	Best	Acceptable
Shaft Sleeve Material	Bronze, Stainless Steel	Bronze, Stainless Steel	Ni-Cr-B Recommended	Bronze, Stainless Steel
Lubrication	Water, Seawater, Most Fluids (pH 5-10)	Water, Seawater, Most Fluids (pH 5-10)	Water, Seawater, Most Fluids (pH 5-10)	Water, Most Fluids (pH 3-11) except Chlorinated Solvents and Strong Acids and Bases
Remarks	Good balance between abrasion resistance and low friction	Lowest friction; Suitable for dry start-up; Good abrasion resistance	For use in highly abrasive operating environments	Good choice for low abrasion applications and for use at temperatures and in chemical solutions unsuitable for Thordon elastomers

** For dry start up times longer than 30 seconds, please contact Thordon Engineering for grade selection

Note: For Nuclear use, Quality Control certificates including certified test reports can be supplied. Thordon Bearings Inc. operates under the provision of 10 CFR21.

This is a general guide for technical reference only. Critical applications that are close to pressure or temperature limits, or subjected to non-standard environments should be reviewed and approved by Thordon Engineering.

TYPICAL BEARING WEAR RATE VS. WATER ABRASIVE CONTENT



DESIGN AND INSTALLATION CONSIDERATIONS

Before choosing a Thordon grade for an application, the following criteria must be considered:

- speeds (rpm)
- type of lubrication
- pressures
- amount of abrasives
- degree of impact loading
- ambient temperatures (maximum/minimum)
- special ambient conditions (e.g. intermittent exposure to high temperature steam cleaning)
- media temperature (pumps)
- process temperature (pumps)
- pH levels (pumps)
- Thordon has produced a Bearing Sizing
- Calculation computer program to assist designers in the calculations required to correctly size Thordon bearings (see sample output above)
- Thordon engineers can help in designing bearing solutions and drawings can be provided

TECHNICAL SUPPORT

Thordon Bearings recognizes the importance of superior products, precision manufacturing and application engineering support. Thordon Bearings in-house engineers work closely with customers to provide innovative bearing system designs that meet or exceed the technical requirements of the application. Full engineering drawings are generated as necessary. Thordon has many years of experience with numerous industrial applications in virtually all industries and offers technical support during machining and installation.

Geared to provide quick response to customer needs, Thordon Bearings understands the importance of quick delivery and reduced downtime. Standard size bearings are stocked at the factory and by Thordon distributors around the world. Special sizes or designs can be machined to the exact requirements of the customer and delivered quickly throughout the world.

THORDON BEARING SIZING PROGRAM

The Thordon Bearing Sizing Calculation Program is provided to assist designers in the calculations required to correctly size Thordon bearings. The program input parameters include shaft RPM, interference or bond fit, type of lubrication, type of service, load on bearing, etc. Output parameters include machined bearing sizes and tolerances, amount of interference, bore closure amount, min. installed clearance, running clearance, etc. An example of the Thordon Bearing Sizing Calculation Program output is attached.

Designed to operate on a PC (personal computer), the software operates in the Windows operating system. The program is in a color, menu-based format so that entries can be made with a minimum of effort. Outputs can be printed and inputs can be saved to a file. Contact Thordon or your distributor to obtain a copy of the program or visit our website at http://www.thordonbearings.com.

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SAMPLE OUTPUT

Thordon Bearings Sizing Calculation Program

No: 901263BM33 V 2006.2
Printed Date: 2/28/2007

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General Information

Thordon Distributor:	Thordon Head Office
Customer:	
Project Reference:	Hydro-turbine bearings
Calculated By:	
Checked By:	
Comments:	
Drawing Number:	
MRP Number:	

Results

-= ATTENTION =-
Method of axial retention must be considered.

	Designed at 21 °C	**Machined at 21 °C**	
Machined Bearing Inside Diameter:	80.70	80.70 mm	(For reference only)
Machined Bearing Outside Diameter:	88.48	88.48 mm	+0.05, -0.05
Calculated Machined Bearing Length:	113.78	113.78 mm	+0.00, -0.25
Bearing Wall Thickness:	3.89	3.89 mm	+0.00, -0.05
Amount Of Interference:	0.53 mm		
Bore Closure Factor:	1.100		
Bore Closure Amount:	0.58 mm		
Minimum Installed Diametrical Clearance:	0.12 mm		
Diametric Running Clearance:	0.08 mm		
Diametric Thermal Expansion:	0.03 mm		
Diametric Absorption Allowance:	0.01 mm		
Axial Thermal Expansion:	0.05 mm		
Axial Absorption Allowance:	0.17 mm		
Outside Diameter After Dry Ice Cooling:	88.17 mm		

Note: Forced press required after Dry Ice cooling, Never immerse a ThorPlas® bearing in Liquid Nitrogen!

Input Data

Dimension Scale:	Metric
Temperature Scale:	Celsius
Maximum Operating Temperature:	30 °C
Minimum Operating Temperature:	-2 °C
Machine Shop Ambient Temperature:	21 °C
Maximum Shaft Diameter:	80.00 mm
Maximum Housing Diameter:	87.95 mm
Minimum Housing Diameter:	87.95 mm
Housing Length:	114.00 mm
Type of Lubrication:	Water
Grade of Thordon Used:	ThorPlas®
Type of Service:	Ind. Oscillating Rotation
Type of Installation:	Interference Freeze Fit
Load on Bearing:	0 kg
Shaft RPM:	0

APPLICATIONS

Application: Main Guide Bearings
Recommended Grades: SXL and GM2401

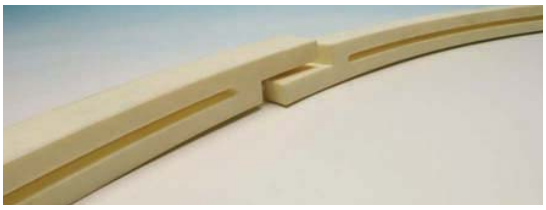
Thordon Bearings recommends two bearing grades for use in water-lubricated turbine main guide bearings. Thordon SXL offers the lowest coefficient of friction, superior adhesive wear performance and good resistance to wear resulting from third particle abrasion. GM2401 is specially formulated to provide optimal wear resistance in abrasive-laden water conditions, routinely outwearing rubber bearings by a factor of two or more, yet still exhibiting a significantly lower coefficient of friction compared to rubber.

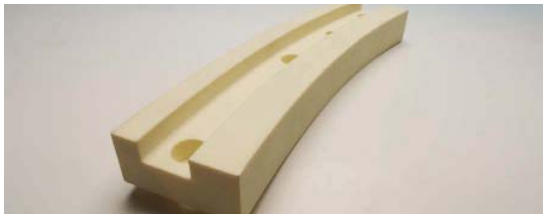
Thordon can be specified as an upgrade for rubber or other non-metallic bearings in existing water-lubricated bearing systems or as a complete conversion from sealed oil or grease lubricated systems to pollution-free water lubrication. Although elastomeric in nature, Thordon bearings, particularly SXL are stiffer than rubber and capable of supporting higher loading. A high degree of resilience, however, is still maintained and running clearances similar to rubber are possible.

Thordon main guide bearings are usually supplied factory-bonded into split bearing housings, or on larger diameter shafts, onto multiple segment blocks. Thordon bearings can also be supplied in stave configuration if required.

Application: Segmented Shaft Seals
Recommended Grade: SXL

Thordon SXL radial and axial segmented shaft seals provide extended wear life compared to carbon graphite-based seals, particularly when abrasives are present. There is absolutely no risk of damaging a tough SXL seal during installation and overall life cycle costs are significantly reduced. Thordon segmented shaft seals are supplied molded to size to suit the shaft diameter.





Application: Wicket Gate and Operating Mechanism Bearings
Recommended Grades: HPSXL, HPSXL TRAXL and ThorPlas®

Thordon HPSXL TRAXL, or on some smaller machines HPSXL full form bearings are suitable for the lower pressures encountered, are recommended for use in wicket gate and linkage bearing systems. HPSXL, an enhanced elastomer product introduced by Thordon more than five years ago, offers even better friction and wear performance operating either wet or dry than SXL TRAXL. HPSXL TRAXL achieved a top level overall rating in the Powertech simulation tests for wicket gate and operating linkage bearings.

Thordon ThorPlas® is also well suited for wicket gate and linkage bearing applications. An engineered thermoplastic, ThorPlas® can be installed as a full-form product and does not require a bronze shell that HPSXL requires to meet the specific pressure requirements of this application. Also successfully tested by Powertech, ThorPlas® demonstrated very low wear and acceptable friction levels. Where there is a preference for a full form bearing, ThorPlas® is the clear choice for performance and value.

Both HPSXL and ThorPlas® are easily machined and can be supplied either finished to final sizes provided by the customer, or with overbuild to facilitate line boring after installation to correct the misalignment and dimensional consistencies often encountered during turbine rehabilitation.

Application: Wicket Gate Thrust Bearings
Recommended Grade: HPSXL

Thordon HPSXL gate thrust collar bearings eliminate the need for grease required by conventional designs. Elastomeric HPSXL's inherent resilience and low coefficient of friction ensures smooth gate operation with no stick slip. Thordon's designs typically incorporate the thrust bearing into the upper head cover bearing by polymerizing HPSXL onto a flange on the upper bearing, however separate thrust bearings can also be supplied.

Application: Servo-Motor and Servo-Link Bearings
Recommended Grades: HPSXL TRAXL and ThorPlas®

HPSXL TRAXL bearings are recommended for the servo-motor and servo-link bearing positions. Elastomeric HPSXL is able to accommodate the minor misalignment that often occurs at these bearing locations and grease lubrication can be eliminated.

ThorPlas® is also a good bearing choice for these bearing positions. Self-lubricating and capable of being installed as a full form tube, ThorPlas® also performs well under the edge loading that can occur due to minor misalignment.

Application: Operating Ring Wear Pads
Recommended Grades: SXL and HPSXL

Thordon SXL and HPSXL vertical and horizontal operating ring wear pads offer smooth, grease-free operation and high abrasion resistance. Usually supplied molded to size complete with stainless steel inserts for mechanical fastening, Thordon wear pads can also be bonded in position using a Thordon-approved adhesive.

Application: Pump Bearings
Recommended Grades: SXL, XL, GM2401 and ThorPlas®

Non-polluting Thordon water-lubricated pump bearings offer dry-start capabilities, long wear life, low friction and superior resistance to abrasive wear. Available in four grades, Thordon pump bearings can be selected to optimize specific performance requirements. From Thordon Composite for highly abrasion resistant bottom bowl bearings to Thordon SXL for dry-start upper bearings to ThorPlas® for higher temperature applications, Thordon pump bearings outperform rubber bearings by a factor of two or more in abrasive conditions. Not limited by shelf life or a range of standard production sizes, Thordon pump bearings facilitate quick turn-around and reduced maintenance inventories. Costly sleeve or shaft replacement can often be avoided by machining a pre-grooved Thordon tube to the exact non-standard dimensions required. A separate Pump Bearing Product Manual is available.

Application: Control Gate Bearings
Recommended Grade: HPSXL

Supplied in ball and socket, or bushing and pad configurations to suit all types of control gate applications, Thordon HPSXL bearings with their low coefficient of friction operate smoothly and easily without grease lubrication. Abrasion resistant and resilient, Thordon bearings provide long wear life and are not damaged by the impact loading resulting from frequent operation.

Application: Butterfly Valve Trunnion Bearings
Recommended Grades: HPSXL TRAXL and ThorPlas®

Thordon HPSXL TRAXL valve trunnion bearings operate smoothly and easily without grease lubrication. ThorPlas® bearings also operate well when specified in this application.

Application: Screen Bearings and Wear Pads
Recommended Grades: SXL, HPSXL and ThorPlas®

Resilient, and highly resistant to abrasion, Thordon SXL is the obvious choice for the shaft bearings and wear pads used in travelling and stationary screens. Non-corroding Thordon bearings offer extended wear life while eliminating the maintenance and pollution concerns associated with grease lubrication. In some designs and locations where pressures may exceed the limit for SXL, HPSXL or, if necessary, ThorPlas® are the recommended options due to their higher pressure capabilities.

Application: Butterfly Valve Seals
Recommended Grade: Thorseal

Highly abrasive resistant, tough, and compliant, Thorseal butterfly valve seals offer extended wear life and are resistant to damage resulting from debris becoming lodged in the valve during operation.

Application: Servo-Motor and Other Hydraulic/Pneumatic Sealing Applications
Recommended Grade: Thorseal

In servo-motor and other hydraulic/pneumatic sealing applications, high performance, tough, Thorseal lip self-lubricating polymer lip seals offer positive sealing up to 100 MPa (15,000 psi). Thorseals provide long wear life with no need for periodic adjustments; resist tearing and extrusion; and as a result of their internal lubricants, operate with less drag and reduced cylinder wear. Thorseals are not only available in a wide range of standard sizes but can also be quickly machined to custom size requirements up to 1.5m (60") in diameter.

Application: Seals for Wicket Gate, Operating Mechanism and other Limited Motion Bearings
Recommended Grade: Thorseal

To prevent contamination of wicket gate, or other hard-to-reach, bearings by abrasive laden waters; or operating mechanism bearings by corrosion residue or other contaminants, seals are recommended. High quality Thorseal lip seals are formulated from a tough, high-strength polymer impregnated with internal lubricants and are supplied as an integral part of the bearing design.

Application: Kaplan Runner Hub Seals
Recommended Grade: Thorseal

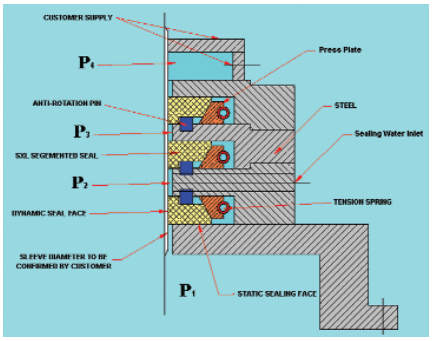
Taking advantage of tough, long-wearing Thorseal polymer lip seals, an enhanced sealing design has been developed for Kaplan runner blade hubs. Essentially, two specially designed Thorseal single ring U-cup seals are locked together to function as a monolithic double-acting seal and fitted back to back in the blade shaft stuffing box. The outer seal lip prevents ingress of water into the hub contaminating the lubricating oil and the inner seal prevents oil from leaking out of the hub into the environment. This design is easy to install, resists distortion during blade re-positioning and the modified lip design insures positive sealing under conditions of significantly more blade droop than conventional packing. Shaft wear is reduced due to the friction and wear reducing additives in the polymer and the seals can be supplied split for easy in-situ replacement.

THORDON

MORE POLYMER SHAFT SEALS ORDERED BY CHINESE TURBINE INDUSTRY

Dongfang Electrical Machinery Co., Ltd (part of Dongfang Electric Corp.) and Harbin Electric Machinery Co., Ltd. have recently placed additional orders for Thordon SXL elastomeric polymer segmented turbine shaft seals bringing the total on order or already installed in 2005, to six sets. The shaft seals sold by Proco International Co. Ltd., Thordon's exclusive Distributor in China, are/will be installed at the Kangyang, Sanbanxi, Xiafu, Baishan and Nalan power plants in China and the Tekeze Hydropower Plant in Ethiopia.

Sealing large hydro turbine shafts from 400mm up to 2000+mm (16 up to 80 in.) diameter can be a maintenance challenge for power plant operators. Typically, turbine seals consist of two or three sets of stacked segmented carbon rings that can be difficult to install without breakage and can be subject to relatively short life if misaligned or subjected to abrasives.



SXL Segmented Shaft Seal

Since its first shaft seal installation in 1982 at the Manapouri Power Station in New Zealand, Thordon Bearings has compiled a history of segmented shaft seal installations. In 2003, Thordon embarked on a program to further optimize it's segmented shaft seal design utilizing its proprietary SXL material. SXL is formulated using a tough elastomeric synthetic polymer alloy offering ease of installation, high natural abrasion resistance and good sealing performance.

SXL Segmented Shaft Seal References

Customer	Power Plant/Dam	Country	Seal Type	Turbine/ Pump	RPM	Shaft Diameter (mm)	Shaft Diameter (inches)	Install Date
Itaipu Binacional	Itaipu	Brazil	Axial			3770 mm	148.43	Oct. 2005
Dongfang Electric Machinery Co., Ltd	Nalan	China	Axial	Francis		892mm	35.12	Oct. 2005
Harbin Electric Machinery Co., Ltd.	Baishan	China	Radial	Pump Turbine	200	1015 mm	39.96	Aug. 2005
Harbin Electric Machinery Co., Ltd.	Xiafu	China	Radial	Francis	107	1170 mm	46.06	Apr. 2005
Harbin Electric Machinery Co., Ltd.	Sanbanxi	China	Axial	Francis	166	1532 mm	60.31	Mar. 2005
Dongfang Electrical Machinery Co. Ltd.	Tekeze Hydropower Plant	Ethopia	Radial			1160 mm	45.67	Mar. 2005
Dongfang Electrical Machinery Co. Ltd.	Tekeze Hydropower Plant	Ethopia	Radial	Francis	300	1160 mm	45.67	Mar. 2005
Harbin Electric Machinery Co., Ltd.	Kangyang	China	Axial	Horizontal	125	970 mm	38.19	Mar. 2005
Meridian Energy	Manapouri Power Station	New Zealand	Radial			910 mm	35.83	Jan. 2005
Infraserv Hochst		Germany				2060 mm	81.10	Oct. 2004
Harbin Electric Machinery Co., Ltd.	Nirji	China	Radial	Francis	107	1170mm	46.06	Jun. 2004
Harbin Electric Machinery Co., Ltd.	Etan	China	Radial	Kaplan	22.5	2380 mm	93.70	Nov. 2003
Dongfang Electrical Machinery Co. Ltd.	Fenshuijiang	China	Radial	Horizontal	166	720 mm	28.35	Jul. 2003
Harbin Electric Machinery Co., Ltd.	Gongboxia Power Station	China	Axial	Francis		1820 mm	71.65	Mar. 2003
California Department of Water Resources	San Luis Dam	U.S.A.	Radial			940 mm	37.01	Mar. 2003
China Power Complete Equipment Co., Ltd	Gongboxia Power Station	China	Axial	Francis		1820 mm	71.65	Feb. 2003
Harbin Electric Machinery Co., Ltd.	Huilong Power Plant	China	Radial	Pump Turbine	750	620 mm	24.41	Feb. 2003
US Bureau of Reclamation		U.S.A.	Radial	Toshiba Turbine		792 mm	31.18	Jan. 2003
Harbin Electric Machinery Co., Ltd.	Banglang	China	Axial	Francis		892mm	35.12	May. 2002
Harbin Electric Machinery Co., Ltd.	Kalun II	China	Axial	Francis		1526mm	60.08	Jan. 2001
Mighty River Power	Maraetai Power Station	New Zealand	Radial			635 mm	25.00	Jul. 1999
Snohomish Co. P.U.D., Washington	Henry M. Jackson Project	U.S.A.	Axial	Francis Turbine				Nov. 1998
Northern Wasco Co. P.U.D., Oregon	McNary Dam	U.S.A.	Radial			650 mm	25.59	Aug. 1998
LA Dept. of Water Power (LADWP)		U.S.A.	Radial			499 mm	19.65	Sep. 1997
Genesis Power	Rangipo Power Station	New Zealand	Radial			644 mm	25.35	Dec. 1996
Seattle City Light, Washington	Centralia City Light Power Plant	U.S.A.	Radial		400	337 mm	13.27	May. 1996
Central Arizona Water Conservation Distr	Havasu, Colorado River	U.S.A.	Radial	Hitachi pump	514	1067 mm	42.01	Jul. 1995
Mighty River Power	Aratiatia Power Station	New Zealand	Radial			755 mm	29.72	Jan. 1992
Hydro Quebec	Beauharnois Generating Station	Canada	Radial			1022 mm	40.24	Aug. 1988
US Bureau of Reclamation	Grand Coulee Dam	U.S.A.	Radial	Toshiba Turbine		792 mm	31.18	Mar. 1988
Meridian Energy	Manapouri Power Station	New Zealand	Radial			910 mm	35.83	Jan. 1982

THORDON

GREASE FREE THORPLAS® FOR KAPLAN RUNNER BLADE BUSHINGS

In April 2005, operators at Alabama Electric Cooperative's 3-MW Gantt hydroelectric plant on the Conecuh River in Alabama, U.S.A., decided to replace the four runner blade trunnion bushings in the vertical Kaplan turbine of Unit 4. The bushings reduce friction when the runner blade pitch varies according to head and flow.

The powerhouse originally contained three vertical Francis turbines. In 1984, Alabama Electric replaced Units 1 and 2 with a single 2-MW vertical Kaplan unit (Unit 4). Unit 3 remains in service.

For Unit 4, Alabama Electric selected a bushing manufactured by Thordon Bearings. The bushing is the company's new ThorPlas®, a grease and oil-free engineered (i.e., non-elastomer) thermoplastic bearing.

"We chose the Thordon bushing because we have been using a Thordon turbine main guide bearing without any problems since 1984," says Wes Thomasson, a mechanical engineer in the central generation section of Alabama Electric.

ThorPlas® is a crystalline, premium grade, homogeneous, engineered thermoplastic bushing that is self-lubricating and can accept operation pressures up to 31 MPa (4,500 psi) without the need for metal backing, says Ingrid A. Muschta, P.Eng., Product Manager for Thordon.

"ThorPlas® has demonstrated exceptional wear and abrasion resistance and has one of the lowest wear rates among nearly all rigid polymers, "says Muschta. "Due to its ratio of static to dynamic co-efficient of friction, it does not exhibit any stick slip effect. Instead,

it provides a smooth, quiet, stable operation in demanding applications such as wicket gate trunnion bearings."

The material has good thermal stability (minimal to no changes due to temperature) and low water absorption (minimal to no changes due to exposure to water), which allow for tighter installed clearances, Muschta says. Furthermore, she says it is easy and safe to machine because it produces no hazardous dust and releases no dangerous byproducts.

Alabama Electric's Thomasson says the fact that the bearing is self-lubricating was the most important characteristic in its selection. "The runner location is not easily accessed," he says. "You have to stop the unit, put down headgates or stoplogs, dewater the pit, and climb in there. And even then it's still not easy to get to the bearings. It was not designed to be lubricated.

He also appreciates the environmentally friendly nature of ThorPlas®. "If you used one with grease and the seal failed, you could contaminate the stream," he says.

Thomasson cited ease of installation as another key factor in choosing the Thordon product. According to Muschta, the product is installed using a "freeze fit" or "shrink fit" method. "Due to its coefficient of thermal expansion, ThorPlas® will contract or shrink somewhat when cooled," she says. "You can then place the bearing into the housing by slipping it or lightly pressing it in."

Thomasson reports no problems so far. "The bushings are easy to work with," he says. "And in the year they have been in use at the plant, they have been trouble free."

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Alabama Electric installed ThorPlas® runner blade trunnion bushings for their Kaplan turbine

THORDON

MAINTENANCE AT INCO GENERATING PLANT NO LONGER FRAZZLED BY DOWNTIME CONCERNS

Frazzle ice is created when long periods of extremely cold weather, typically in the -35°C range, turn river water into a giant Slushie®. This isn't uncommon on The Spanish River in Northern Ontario, Canada, home of three Inco Hydropower Generating Stations. Frazzle ice is a regular occurrence almost every spring, pounding into the intakes and causing pumps that provide water to the turbines to ice up and shut down.

"When this occurs," says Claude Mailloux, Planner/Supervisor for Inco, "there is a risk that the turbine may run dry." As a result, the main guide bearings may overheat and need to be removed, inspected and reinstalled again.

Easier said than done. Until, that is, Inco began to use Thordon SXL.

Powering A Century Of Growth

The Spanish Riverways has an important dual role in Northern Ontario. It is one of the most breathtaking recreational waterways in the Province, attracting tourists worldwide. It is also the source of hydroelectric power that fuels the region's vast pulp and paper and nickel mining industries. Inco taps this tributary with generating plants located in Big Eddy, High Falls and Nairn Falls.

For most of the operational history of these plants, wood called *lignum vitae* was used as the main guide bearing. But as the rare source of this hard and oily timber - the guayacum tree - became even rarer, Inco was forced to look for alternatives.

"They originally switched over to phenolic bearings," said Lorne Thornton, President of Pioneer Power Industries, a long-time Thordon Bearings distributor, "But these came with maintenance headaches and other concerns."

The problem was, the river water contains a high level of particulates, making it abrasive. As a result, the phenolic bearings would wear rapidly and need to be changed approximately every two to three years. This was not a quick process. In fact, because of the hands-on lead chinking that was involved, the turnaround time to remove and install the bearings was up to four months.

"To make matters worse," says Thornton, "the phenolic bearings would constantly need adjusting to maintain performance, which only added to the workload and expense."
Clearly, Inco needed a better solution. And they found it, in Thordon SXL.

A Track Record That Speaks For Itself

Proven in demanding hydroelectric applications around the globe, Thordon SXL has become the industry standard. An elastomeric polymer, the bearing features grease-free operation, remarkably low wear and exceptional performance in dirty water conditions. It's the bearing of choice for water lubricated main shafts and pumps in both rehabilitation and new turbine projects.

"Inco not only wanted to lower maintenance costs, but they also wanted to eliminate lead chinking. Thordon SXL was the answer to both of these issues," says Thornton.

To reduce downtime in the future, Thornton and the engineers at Thordon Bearings recommended a stave configuration. This helped reduce the time it would take to remove, service and reinstall the bearings from the current standard of three to four months to just a few days!

The new bearings were installed in Unit #3 (one of three turbines in total) at the Nairn Falls plant in 1999. After excellent performance over the next 24 months, SXL was installed in the other two units.

"So far, Thordon has lasted twice as long as the previous phenolic bearing," says Mailloux. "And the longer lifespan has kept labour and materials costs down while expanding uptime." Bearing performance is monitored continuously and has being running within acceptable parameters for more than five years. "This is remarkable considering the rough operating conditions and the fact that the turbines are nearly one hundred years old!"

Getting Frazzled Once Again

Then mother nature struck. In January 2004, frazzle ice once again formed on The Spanish River. During this inclimate period, Unit #2 started and stopped five times, each time running dry. The fear was that the bearing would be burnt and require immediate changeout, something that would be expected from a phenolic material. It wasn't. In fact, after inspection, Thordon SXL was only mildly scuffed.

"And the good news is," says Thornton, "Inco's maintenance staff was able to clean the exfoliated material from the water grooves and reinstall the bearing in the same day."

This allowed Inco to keep this unit on line for the upcoming spring run-off period and have a planned outage in the summer for the changeout of the bearing during the low water flow period.

THORDON

THORDON SXL GUIDE BEARING ELIMINATES RISK AT THE STAR LAKE GENERATING STATION

Reliability was an important factor in the Star Lake Hydro Partnership's decision to replace the Star Lake Generating Station's turbine guide bearing. The 18-MW facility — owned by a partnership of Abitibi-Consolidated Inc. (51 percent) and Enel North America, Inc. (49 percent) — runs about 98 percent of the time, shutting down for scheduled maintenance for only six to seven days a year.

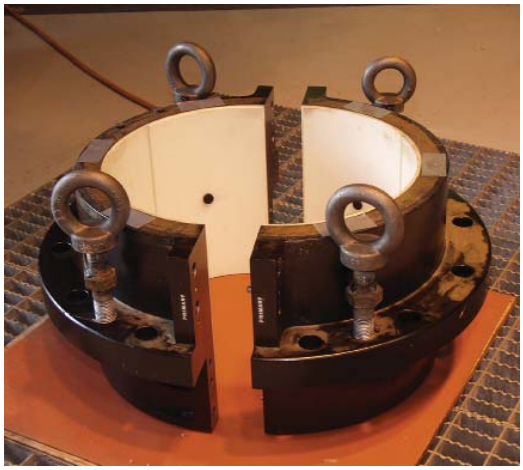
As manager of the Star Lake Generating Station in southwestern Newfoundland, Canada, Robert Conlon wanted to replace a water-lubricated, hydrostatic turbine guide bearing in a vertical Francis unit that required a complex high pressure filtered water supply. This filtration system was very costly to maintain and a previous hydrostatic bearing failure during initial startup had required the replacement of both the turbine shaft and the bearing, which meant a month-long and costly outage.

"The second water-lubricated, metal turbine guide bearing has performed fine for four years," says Conlon. "However, we were concerned of the consequences if this bearing failed at full load. The result could be an unexpected failure destroying the bearing, damaging the shaft and possibly damaging the generator."

Those fears were eliminated, however, when the hydrostatic metal bearing was replaced with a water-lubricated, Thordon SXL turbine guide bearing operating in hydrodynamic conditions.

For water lubricated metal bearings such as the one at Star Lake, the fluid film must be consistent between the shaft and the bearing. If abrasives are present in the lubricating water, the fluid film may be disrupted and the bearing will fail. The water supplied to water lubricated metal bearings has to be extremely clean (contaminants removed to 25-30 microns).

Thordon SXL bearings allow a larger diametrical clearance between the shaft and the bearing surface and require more water than the metal bearing. The water flow requirements to the SXL bearing surface for cooling purposes are 0.15 litres/minute per mm (1 U.S. gallon/minute per inch) of shaft diameter at standard clearances. However, the water filtering requirements are not as stringent for SXL bearings, because wear life is not seriously effected with water contaminants up to 150 to 200 microns.



Thordon SXL Main Guide Bearing ready for installation at Star Lake

Thordon SXL is an elastomeric polymer bearing material with a 25-year history of long-life performance in water lubricated main shaft guide bearings. "It was certainly the right choice for us," says Conlon. "Even if the Thordon SXL bearing were to fail, it would not fail suddenly and unexpectedly. The most that would happen is that the Thordon material would wear a little bit."

Before making the commitment to purchase the Thordon SXL bearing, the Star Lake Hydro Partnership researched the product extensively. This included checking references in North America and Europe. "Satisfied with the experience of others," says Conlon, "the order was eventually placed for two bearings (one plus a spare) in July 2003".

Rapid installation reduces downtime

Normally, the turbine shaft has to be dismantled to install a solid journal bearing. Disassembly and re-assembly is an arduous process. In addition, the whole unit has to be realigned as a part of the process.

Working with Thordon's engineers, however, the decision was made to design and fabricate the bearing in two halves. "We simply took the two halves and bolted them together around the shaft," says Conlon. "Once the Thordon bearing was in place, it was positioned with a constant annulus around the shaft." Before removing the old bearing, the turbine runner had been wedged in position so that the turbine shaft was centered on the old bearing. As a result, no time-consuming realignment was necessary.

The Thordon bearing was so simple to install, in fact, that the outage lasted just six days, which Conlon observed, "was a large saving in time and money."

Confident that the Thordon SXL bearing will not fail unexpectedly, the Star Lake Hydro Partnership is comfortable that they have made a major improvement in Station reliability. The Thordon SXL bearing is performing as anticipated.

THORDON

THORSEALS AND HPSXL SOLVE WICKET GATE LEAKAGE PROBLEM

As any beaver will tell you, stemming the unrelenting force of river water is a complex engineering feat. So it's not surprising that the first dam to span the massive Columbia River in Washington State, U.S.A. - the *Rock Island Dam Hydroelectric Project* - would run into its share of leakage problems.

Operated by the Chelan County Public Utility District (PUD), the project has a history that dates back seventy-five years. Today, the dam consists of two powerhouses. The second, constructed during the late 1970s, features eight horizontal bulb turbines, each with 24 wicket gates. Collectively, these turbines produce 1.8 million megawatt hours of power annually.

Leakage began to occur in the wicket gates soon after the second powerhouse was put into commercial operation due to the original poor seal design. "This resulted in costly maintenance problems over the years," says PUD Project Engineer Ken Anderson. "Water ingression occurred directly into areas where electronic devices, sensors, and electrical equipment were located." A makeshift system of tarps was used to divert the water. Raincoats became a necessity.

When Anderson joined the project in 1999, solving this excessive leakage problem became his primary concern. He began the process by consulting Tom Breiwick of *Pacific Marine Equipment* of Seattle, a longtime Thordon distributor.

"Ultimately," says Breiwick, "we were awarded two consecutive contracts to build 24 new wicket gate housing assemblies with upgraded bearings and seals." These new units would serve as interchangeable spares, facilitating the upgrading of all the existing units over time.

Back in 1988, Thordon SXL Thor-Tape had been installed to address some original bearing problems. "This time around," says Breiwick, "we collaborated with Ken, and the application engineering specialists at Thordon, and it was decided that we needed a bearing that could be interference fit into the housing." This would tighten the dimension on the bearing bores, resulting in less play and damage to the seals.

The answer was HPSXL. This is the hardest and stiffest grade of Thordon, featuring the lowest coefficient of friction for less wear and elastomeric qualities for strong performance under edge loading conditions.

The seals selected for the job were Thorseals. These are Thordon's high performance line of tough, abrasive resistant hydraulic cylinder seals providing positive sealing over a wide range of operating pressures. "Due to all the previous sealing problems, I came up with a new double seal design to replace the single seal system," says Anderson. In the new design, the space between the first and second seal was plumbed so that, if leakage did occur, the water could be drained and the volume tracked and evaluated. "Thordon designed and manufactured the second seal for us within a very short timeframe," says Anderson, "which I thought was extraordinary."

After the successful installation of the initial 24 wicket gate housings, *Pacific Marine Equipment* was eventually awarded the contract to overhaul all 192 existing units. They are managing the project, including production and assembly, while Thordon is providing the bearing and sealing elements, design and technical support. Five turbine units have been overhauled to date. The remaining three are due to be completed by May 2004.

The ultimate question is, of course, has the leakage stopped? "We were dealing with an infiltration rate of 20 gallons per minute on some units," says Anderson. "Today there's virtually no leakage at all from the new units we have installed. So, yes, finally the problem has been solved."

Rock Island Dam Hydroelectric Facility located on the Columbia River, Washington, USA

Thordon HPSXL wicket gate bearings with Thorseals

THORDON IMPROVES HYDROELECTRIC EFFECIENCIES...

Thordon non-metallic bearings are the recognized choice of hydroelectric power producers for long life, low friction bearing systems. These pollution-free bearings function well whether sealed and dry or immersed in water.

A testament to the durability and flexibility of Thordon bearings in hydroelectric applications is Mercer Construction Company, Inc. (MCC), an operations and maintenance company that does extensive municipal and third-party work. Since 1991, MCC has installed five Thordon bearings at hydroelectric plants throughout upstate New York.

"We have a consistent operating history with Thordon," says MCC's president, Dave Crandell. "We just hadn't gotten the service life we wanted out of the rubber turbine marine bearings that we were using. The Thordon bearings have reduced our downtime and operating costs."

MCC has teamed up with Thordon Distributor Johnson Packings, to install Thordon bearings with shaft diameters ranging from 355mm to 900mm (14" to 36") and lengths up to 1820mm (72"), in both horizontal and vertical applications. A Thordon main guide bearing that was installed at Fourth Branch on the Mohawk River in 1991 performs as well today as it did nearly 10 years ago. In this horizontal application, it is important to maintain a water film in uniform surface contact, and rubber bearings that were formerly used wore out in three to four years. Crandell reports that the more durable Thordon bearing has already proven to last three times as long as any rubber bearing. In another application, a Thordon bearing has held up for more than seven years, while the grease-lubricated Babbitt bearings that were formerly used only lasted about a year and a half each.

"With Thordon, we got a much longer service life and extended our dewatering schedule from one to three years," Crandell said. "These bearings are just more reliable."

Thordon SXL Main Guide Bearing

THORDON

UPDATE CELEBRATING 25 YEARS EXPERIENCE WITH ONTARIO POWER GENERATION

By 1974, Thordon had earned the respect of the marine industry, but had yet to prove itself in the power generation industry. A successful test run at the Ontario Power Station at the base of Niagara Falls opened the way for Thordon to provide many more bushings to Ontario Power Generation (formerly known as Ontario Hydro). Now, 25 years later, the head offices at Ontario Power Generation specify Thordon as their material of choice.

After a quarter of a century, Thordon's performance and momentum in the power generation industry has only strengthened due to customer satisfaction with superior product wear resistance and longer life while eliminating a source of pollution.

Thordon SXL wicket gate and linkage bearings installed at Cameron Falls, Ontario

The Cameron Falls Power Plant near Nipigon, Ontario is a typical example for showcasing Thordon performance.

In May of 1989, Thordon SXL wicket gate and linkage bushings were installed in Unit 1 at the 77 MW plant at Cameron Falls, located in Northwestern Ontario, Canada on the Nipigon River that drains into Lake Superior. Bruce Caldwell, Plant Engineer for the Northwest Plant Group of Ontario Power Generation says," Since then, Thordon SXL wicket gate and linkage bushings have been installed at Unit 7 in 1995, Unit 2-Pine Portage in 1996 and Unit 1-Manitou Falls in 1998."

In June 1997, Unit 1- Pine Portage was overhauled to have a new runner installed and for work to be done on the penstock. "During this overhaul, we decided to replace the Thordon SXL wicket gate bushings that were originally installed in 1989 and ordered a set of bushings from Thordon. When the wicket gates were removed, the bushings showed minimal signs of wear and the machining marks could still be seen on the pins. With everything in perfect working order, we put the new Thordon bearings back on the shelf," says Bruce. "So far, in my experience with Thordon since 1995, the SXL bushings have performed beautifully in all our installations," says Bruce.

Thordon SXL wicket gate and linkage bushings were also installed at another recent rehabilitation project at the 16 unit R.H. Saunders Generating Station on the St. Lawrence River in Cornwall, Ontario, Canada.

ONTARIO POWER GENERATION

"Our experience with Thordon has been very positive and this has led to using Thordon in 14 of 16 units at R.H. Saunders (the final two units will install Thordon within the next two years) and in many other plants in Ontario," says Keith Eastman, Senior Plant Engineer, Ottawa/St. Lawrence Plant Group. "By replacing the use of grease with self-lubricating Thordon, we have prevented a source of river pollution and eliminated maintenance associated with the greasing systems," says Keith.

It is only when people are willing to take a chance and try something different that greater success can be achieved," says D'Arcy Wilson, President of Thordon Bearings. "As we begin our next quarter century of service to the power generating industry, Thordon will strive to remain innovative and continue to exceed our customer's expectations."

THORDON BEARINGS INC. A member of the Thomson-Gordon Group

Thordon Hydro Turbine Bearing - Main Guide Bearings

Thordon Grade	Company	Power/Dam Station	Country of Installation	Max. Head (M)	Shaft Diameter (mm)	Type of Turbine	Direction	RPM	Initial Installation Date
SXL	LMZ	Krasnojarsk	Russia		2390		Vertical		Jun -2001
SXL	LMZ	Krasnoyarsk	Russia		2390		Vertical		Jan -2002
SXL	LMZ	Krasnoyarsk	Russia		2390		Vertical		May -2003
SXL	LMZ	Sayano-Shushenskaya	Russia		1970		Vertical		Jan -2001
SXL	LMZ	Volga	Russia		1520		Vertical		Mar -2004
GM2401	LMZ	Narva Hydro Power Station	Russia	18	955		Vertical	701	Jul -2000
GM2401	LMZ	Narva Hydro Power Station	Russia	18	955		Vertical	701	Jun -2001
GM2401	LMZ	Narva Hydro Power Station	Russia	18	955		Vertical	701	Feb -2002
GM2401	LMZ	Narva Hydro Power Station	Russia		955		Vertical		Jan -2004
SXL	LMZ	Bukhtorma Hydro	Russia		920		Vertical	1251	Sep -1999
SXL	Laquadara Inc.	Stillwater 1	U.S.A.		874		Horizontal		Jul -1992
SXL	Northbrook Energy, Inc.	Glen Park, NY	U.S.A.		864		Vertical		Jul -1996
SXL	Northbrook Energy	Glen Park Hydro	U.S.A.		864		Horizontal		Feb -2004

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GM2401	Mercer Management		U.S.A.		864		Vertical		Mar -1996
GM2401	Cottrell Paper Mill		U.S.A.		851		Vertical		Apr -2001
SXL	Alabama Power	H. Neely Henry Hydroelectric Generating Plant	U.S.A.		838	Francis	Vertical		May -2004
SXL	American Hydro	Neely Henry	U.S.A.		838		Vertical		Jul -1996
SXL	American Hydro	Neely Henry	U.S.A.		838		Vertical		Jul -1996
SXL	American Hydro	Neely Henry	U.S.A.		838		Vertical		Jul -1997
SXL	American Hydro	Neely Henry	U.S.A.		838		Vertical		Jul -1997
SXL	LMZ	NIVA-3	Russia		800		Vertical		Jan -2004
SXL	Electricity Corp. of New Zealand	Karapiro Station	New Zealand	67	761		Vertical		Jul -1995
SXL	Consolidated Hydro, Inc.	North Canal, MA	U.S.A.		752		Horizontal		
SXL	LMZ	Buchtarminskaya	Russia		720		Vertical		Jan -1998
SXL	LMZ	Buchtarminskaya	Russia		720		Vertical		Jan -1999
SXL	LMZ	Buchtarminskaya	Russia		720		Vertical		Jun -2000

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Thordon Grade	Company	Power/Dam Station	Country of Installation	Max. Head (M)	Shaft Diameter (mm)	Type of Turbine	Direction	RPM	Initial Installation Date
SXL	LMZ	Buchtarminskaya	Russia		720		Vertical		Feb -2001
SXL	LMZ	Buchtarminskaya	Russia		720		Vertical		Jan -2002
SXL	American Hydro	Boise Cascade, USA	U.S.A.		635		Horizontal		Jul -1990
SXL	American Hydro	Washington Water Power	U.S.A.		628		Horizontal		Jul -1993
SXL	Rochester Gas & Electric	Station 5 Unit #3	U.S.A.		622		Vertical		Jul -1994
SXL	Rochester Gas & Electric	Station 5 Unit #4	U.S.A.		622		Vertical		Jul -1997
SXL	LMZ	Mamakanskaya	Russia		615		Vertical		Jan -2000
SXL	LMZ	Mamakanskaya	Russia		615		Vertical		Jan -1999
SXL	Wisconsin Power Station	Merrill #3	U.S.A.		610		Horizontal		Jul -1987
SXL	American Hydro	Yadkin Narrows	U.S.A.	65	584		Vertical		Jul -1992
SXL	Waplans Mek. Verkstad AB	Rotnen	Sweden		570		Vertical		Jul -1998
SXL	Waplans Mek. Verkstad AB	Rotnen (Reservlager)	Sweden		570		Vertical		Jul -1998
SXL	Enel North America	Star Lake, Newfoundland	Canada	135	550	Francis	Vertical	514	Oct -2003

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Thordon Hydro Turbine Bearing - Main Guide Bearings

Thordon Grade	Company	Power/Dam Station	Country of Installation	Max. Head (M)	Shaft Diameter (mm)	Type of Turbine	Direction	RPM	Initial Installation Date
SXL	Algonquin Power	Glenn Falls, Unit G2	U.S.A.		494		Vertical		Jan -2003
SXL	Central Maine Power	West Buxton	U.S.A.		476		Vertical		Jul -1990
SXL	Graningeverken	Bjorna 2 (1+4 lager)	Sweden		460		Vertical		Jul -1998
SXL	Graningeverken	Gidbole 2 (1+4 lager)	Sweden		460		Vertical		Jul -1998
SXL	Graningeverken	Gidea 2 (1+6 lager)	Sweden		460		Vertical		Jul -1997
SXL	Duke Energy	Cedar Creek	U.S.A.		457		Vertical		May -2002
SXL	CHI Energy	Weeks Falls	U.S.A.		457		Vertical		Sep -2002
SXL	L.A. Dept. of Water & Power	San Franciscito Powerplant	U.S.A.		445		Vertical		Jul -1991
SXL	Orion Power-Glens Falls	Sherman Station	U.S.A.		445		Vertical		Jul -1996
SXL	Duke Power, ME	Millinocket Unit #1	U.S.A.		438		Horizontal		Jul -1995
SXL	Moller Undenas Turbin AB	Karasen, G2	Sweden		430		Vertical		Jan -2001
SXL	American Hydro	Washington Water Power	U.S.A.		425		Horizontal		Jul -1993
SXL	Northeast Generating	Bear Swamp, MA	U.S.A.		409		Vertical		Jul -1996

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Thordon Hydro Turbine Bearing - Main Guide Bearings

Thordon Grade	Company	Power/Dam Station	Country of Installation	Max. Head (M)	Shaft Diameter (mm)	Type of Turbine	Direction	RPM	Initial Installation Date
SXL	Bowater Paper	Millinocket Lake Dam	U.S.A.		406		Vertical		Jul -1996
SXL	Alabama Electric	Gantt Hydro Unit #3	U.S.A.		403	Kaplan	Vertical		Jul -1995
SXL	Alabama Electric	Gantt Hydro Unit #4	U.S.A.		403		Vertical		Jul -1995
COMPAC	Grand Coulee Power Authority	GCPA Russell Smith Power Station	U.S.A.	16	400	Kaplan	Horizontal		Feb -2007
Water Qua	Grand Coulee Power Authority	GCPA Russell Smith Power Station	U.S.A.	16	400	Kaplan	Horizontal		Feb -2007
SXL	Southern California Edison	Big Creek	U.S.A.		393		Vertical		Jul -1994
SXL	Forsvik Bygg & Turbine Service	Bratforsen	Sweden		390		Horizontal		Oct -2005
SXL	Niagara Mohawk Power	Race St.	U.S.A.		381		Vertical		Jul -1991
SXL	Orion Power-Glens Falls	Sherman Station	U.S.A.		369		Vertical		Jul -1995
SXL	Allegheny Power	Falling Water	U.S.A.		369		Vertical		Jul -1997
SXL	Burrows Paper Corp.		U.S.A.		368		Vertical		Jan -2001
SXL	Orion Power		U.S.A.		368		Vertical		Nov -2001
SXL	Northbrook Energy, Inc.	Lyons Falls Paper, NY	U.S.A.		367		Vertical		Jul -1996

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Thordon Grade	Company	Power/Dam Station	Country of Installation	Max. Head (M)	Shaft Diameter (mm)	Type of Turbine	Direction	RPM	Initial Installation Date
SXL	Graningeverken	Gidea 1 (1+6 lager)	Sweden		360		Vertical		Jul -1998
SXL	Graningeverken	Gidbole 1 (1+4 lager)	Sweden		360		Vertical		Jul -1997
SXL	Central Maine Power	Cataract	U.S.A.		359		Vertical		Jul -1992
SXL	Great Northern	E. Millinocket	U.S.A.		356		Horizontal		Jul -1990
SXL	Niagara Mohawk Power	School Street	U.S.A.		356		Vertical		Jul -1991
SXL	Waplans Mek. Verkstad/Graningeverke	Brynge	Sweden		355		Vertical		Jul -1994
SXL	Iberdrola	Foxo Power Station	Spain		350		Horizontal		
SXL	Alstom Power	AIT Messaoud	Morocco	34	350		Vertical		Feb -2002
SXL	Iberdrola	Plasticos Ferro Power Station	Spain		349		Vertical		
SXL	City of Ann Arbour, MI	Superior	U.S.A.		343		Vertical		Jul -1992
SXL	Wisconsin Power Station	Wausau #2	U.S.A.		343		Horizontal		Jul -1985
SXL	American Hydro	PSEG Power-Kearney	U.S.A.		343		Vertical		Mar -2001
SXL	Central Maine Power	Hiram	U.S.A.		333		Vertical		Jul -1989

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Thordon Hydro Turbine Bearing - Main Guide Bearings

Thordon Grade	Company	Power/Dam Station	Country of Installation	Max. Head (M)	Shaft Diameter (mm)	Type of Turbine	Direction	RPM	Initial Installation Date
SXL		Salt River Project	U.S.A.		331		Horizontal		Dec -1996
SXL	McLaren Power	Buckingham, QC	Canada		330		Vertical		Jul -1986
GM2401	Central Maine Power		U.S.A.		325		Horizontal		Jul -2002
SXL	Iberdrola	La Pardina Power Station	Spain		320		Horizontal		
SXL	Iberdrola	Sarria Power Station	Spain		320		Horizontal		
SXL	Wisconsin Power Station	Alexander	U.S.A.		318		Horizontal		Jul -1986
SXL	Waplans Mek Verkstad/Birka	Glava	Sweden		310		Vertical		Jan -2001
SXL	Iberdrola	La Calza de Saya Power Station	Spain		310		Horizontal		
SXL	TURAB	Tannefors Reserv	Sweden		305		Horizontal		Jun -2005
SXL	New Brunswick Power	Musquash	Canada		305		Vertical		Jul -1985
SXL	New Brunswick Power	Musquash	U.S.A.		305		Vertical		Jul -1987
SXL		Philadelphia Falls	U.S.A.		300		Horizontal		Jul -1986
SXL	Iberdrola	Sartaguda Power Station	Spain		300		Horizontal		

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Thordon Hydro Turbine Bearing - Main Guide Bearings

Thordon Grade	Company	Power/Dam Station	Country of Installation	Max. Head (M)	Shaft Diameter (mm)	Type of Turbine	Direction	RPM	Initial Installation Date
SXL	Iberdrola	Santacana Power Station	Spain		300		Horizontal		
SXL	International	Huttenmuhle			300		Vertical		Jul -1984
SXL	International	Kl. Munchen			300		Horizontal		Jul -1985
SXL	International	Stratos			300		Horizontal		Jul -1986
SXL	Consolidated Hydro, Inc.	North Canal, MA	U.S.A.		300		Horizontal		Jul -1987
SXL	American Hydro	Edwards Mfg. Co.	U.S.A.		300		Vertical		Jul -1995
SXL	American Hydro	Pacific Power Ashton Unit #31	U.S.A.		298		Vertical		Jul -1993
SXL	American Hydro	Pacific Power Utah Power	U.S.A.		298		Vertical		Jul -1991
SXL	Mercer Management	Stillwater	U.S.A.		297		Vertical		Jul -1996
SXL	American Hydro	Finch Pruyn & Co., Glen Falls	U.S.A.		292		Horizontal		Jul -1995
SXL	Iberdrola	El Cabildo Power Station	Spain		290		Horizontal		
SXL	Iberdrola	Montequiero Power Station	Spain		290		Horizontal		
SXL	Iberdrola	Berbegal Power Station	Spain		290		Horizontal		

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Thordon Hydro Turbine Bearing - Main Guide Bearings

Thordon Grade	Company	Power/Dam Station	Country of Installation	Max. Head (M)	Shaft Diameter (mm)	Type of Turbine	Direction	RPM	Initial Installation Date
SXL	Iberdrola	Bubunawan Power Station	Spain		290		Horizontal		
SXL	Waplans Mek. Verkstad/Skelleftea Kraft	Hednas	Sweden		290		Vertical		Jul -1995
SXL	Niagara Mohawk Power	Schaghticoke Hydro	U.S.A.		280	Francis	Vertical		Jul -1995
SXL	Iberdrola	San Miguel Del Pino Power Station	Spain		280		Horizontal		
SXL	American Hydro	Duke Power Gaston Shoals	U.S.A.		279	Francis	Horizontal		Jul -1995
SXL	American Hydro	Duke Power Gaston Shoals	U.S.A.		279	Francis	Horizontal		Jul -1992
SXL	Waplans Mek. Verkstad		Sweden		275		Vertical		May -2002
SXL	Comemasa	Graus Power Plant	Spain	13	270		Vertical	300	Jan -2005
Water Qua	Comemasa	Graus Power Plant	Spain	13	270		Vertical	300	Jan -2005
SXL	Endesa	Caldas Power Station	Spain		270		Vertical		
SXL	Iberdrola	Mores Power Station	Spain		270		Horizontal		
SXL	Iberdrola	Huermeda Power Station	Spain		270		Vertical		
SXL	American Hydro	Appalachian Power Co.	U.S.A.		267		Vertical		Jul -1991

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Thordon Hydro Turbine Bearings - Wicket Gate and Operating Mechanism References

Thordon Grade	Company	Power/Dam Station	Max. Head (M)	Shaft Diameter (mm)	Type of Turbine	Direction	RPM	Initial Installation Date
SXL	Iberdrola	Cedillo Power Station		330				
HPSXL	Talleres Aramburu			320				Jul -2001
HPSXL TRAXL	City of Seattle	Boundary Dam		298				Jun -2000
ThorPlas	Alabama Electric	Gantt Hydro, No. 4		282	Kaplan			Sep -2004
HPSXL TRAXL	American Hydro			272				Jan -2003
HPSXL TRAXL	U.S. Bureau of Reclamation	Folsom Dam #1, #2, #3	104	266				Nov -2001
HPSXL TRAXL	American Hydro	Unit # 5 & 6		264				Jan -2003
HPSXL TRAXL	American Hydro	Unit # 7 & 8		264				Feb -2004
ThorPlas	Harbin Electric Machinery Co. Ltd.	Baishan		260	Francis		200	Jul -2005
ThorPlas	Exel Energy			229				Mar -2006
ThorPlas	Harbin Electric Machinery Co. Ltd.	MalutangII	380	160	Francis			Mar -2008
HPSXL TRAXL	Harbin Power Equipment			150				Nov -2002
ThorPlas	Dongfang Electrical Machinery	Pubugou	150	145	Francis			Oct -2007

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Thordon
Radial and Axial Segmented Shaft Seals

Customer	Power Plant / Dam	Country	Type of Seal	Turbine / Pump	No. of Turbines with Seals	Shaft Diameter (mm)	No. of Rings / Turbine	Initial Installation Date
Itaipu Binacional	Itaipu Hydroelectric Power Plant	Brazil	Axial			3770		Oct -2005
Harbin Electric Machinery	Etan Power Station	China	Radial	Kaplan	3	2380	2	Nov -2004
Infraserv Hoechst		Germany	Axial	Filter		2060		Oct -2004
IMPSA Hydro		Argentina	Axial			2044		Mar -2001
IMPSA Hydro		Argentina	Axial			1925		Mar -2001
Harbin Electric Machinery	Gongboxia Power Station	China	Axial	Francis	3	1820	3	Feb -2003
Harbin Electric Machinery	Sanbanxi Power Plant	China	Axial		4	1530	1	Aug -2005
Harbin Electric Machinery	Zhelin Power Plant	China	Axial		2	1526		Jan -2001
Harbin Electric Machinery	Kalun III	China	Axial		4	1520		May -2002
Harbin Electric Machinery	Gelatan Power Plant	China	Axial		3	1395	1	Apr -2006
Harbin Electric Machinery	Fujinba Power Station	China	Axial		3	1240	1	May -2006
Harbin Electric Machinery	Xiafu Power Plant	China	Axial		2	1240	1	Jun -2006
Harbin Electric Machinery	Jupudu Power Plant	China	Axial		3	1210	1	Apr -2006
Harbin Electric Machinery	Nirji Power Plant	China	Radial	Francis	4	1170	2	Jun -2004
Dongfang Electrical Machinery	Tekeze Hydropower Plant	Ethopia	Radial	Francis	2	1160	3	Jan -2006
Harbin Electric Machinery	Zhouba Power Plant	China	Axial		2	1130	1	Apr -2006
Harbin Electric Machinery	Xishan Power Plant	China	Radial		2	1070	3	Sep -2006
Central Arizona Water Conservation District	Havasu, Colorado River	U.S.A.	Radial	Hitachi Pump		1067		Jul -1995

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Thordon
Radial and Axial Segmented Shaft Seals

Customer	Power Plant / Dam	Country	Type of Seal	Turbine / Pump	No. of Turbines with Seals	Shaft Diameter (mm)	No. of Rings / Turbine	Initial Installation Date
Hydro Quebec	Beauharnois Generating Station	Canada	Radial			1022		Aug -1988
Harbin Electric Machinery	Baishan Power Plant	China	Radial	Pump Turbine	2	1015	3	Aug -2005
Harbin Electric Machinery	Kangyang Power Station	China	Axial		4	970	1	Aug -2005
Harbin Electric Machinery	Fengman Power Station	China	Radial		1	970	2	Aug -2003
IMPSA Hydro		Argentina	Axial			970		Sep -2001
California Department of Water Resources	San Luis Dam	U.S.A.	Radial			940		Mar -2003
Meridan Energy	Manapouri Power Station	New Zealand	Radial			910		Jan -1982
Harbin Electric Machinery	Banglang Power Plant	China	Axial	Francis	6	892	6	May -2002
Dongfang Electric Machinery	Nalan Power Plant	China	Axial	Francis	4	892	1	Oct -2005
Harbin Electric Machinery	Sanxia Power Plant	China	Radial		1	892	1	Nov -2001
Dongfang Electric Machinery	Aoluke Power Plant	China	Axial		3	835	1	Nov -2006
U.S. Bureau of Reclamation	Grand Coulee Dam	U.S.A.	Radial	Toshiba		792		Mar -1988
U.S. Bureau of Reclamation	Grand Coulee Dam	U.S.A.	Radial	Toshiba		792		Jan -2003
Mighty River Power	Aratiatia Power Station	New Zealand	Radial			755		Jan -1992
Dongfang Electrical Machinery	Fenshuijiang Power Plant	China	Radial		3	720	3	Jun -2005
Northern Wasco Co. P.U.D. Oregon	McNary Dam	U.S.A.	Radial			650		Aug -1998
Genesis Power	Rangipo Power Station	New Zealand	Radial		3	644		Dec -1996
Mighty River Power Plant	Maraetai Power Station	New Zealand	Radial			635		Jun -1999

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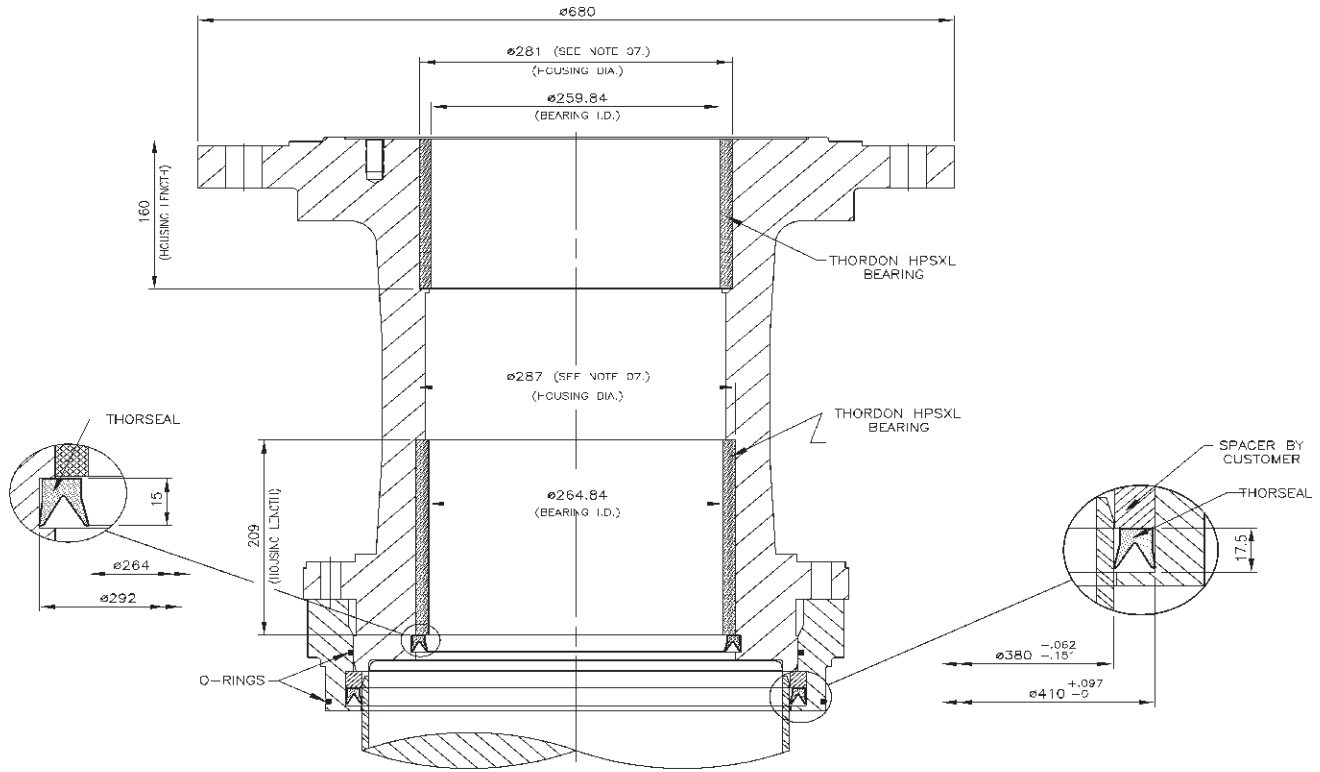
Thordon
Radial and Axial Segmented Shaft Seals

Customer	Power Plant / Dam	Country	Type of Seal	Turbine / Pump	No. of Turbines with Seals	Shaft Diameter (mm)	No. of Rings / Turbine	Initial Installation Date
Harbin Electric Machinery	Huilong Power Plant	China	Radial	Pump Turbine	2	620	3	Nov -2004
LA Dept. of Water Power (LADWP)		U.S.A.	Radial			499		Sep -1997
Seattle City Light, Washington	Centralia City Light Power Plant	U.S.A.	Radial			337		May -1996
Cedillo Power Station	Cedillo Power Station	Spain	Axial			330		
ENECO	Centrale Di Cassano D'Adda	Italy	Axial	Francis	7	240	2	Aug -2005
Snohomish Co. P.U.D. Washington	Henry M. Jackson Project	U.S.A.	Axial	Francis				Nov -1998



UPPER BEARING SHAFT ø = 259.52
LOWER BEARING SHAFT ø = 264.52
TEMPERATURE = -2°C to 30°C

GENERAL NOTES:

01. MAT'L – BEARING: THORDON HPSXL
02. ALL DIMENSIONS ARE EXPRESSED IN MM UNLESS NOTED OTHERWISE.
03. DO NOT SCALE THIS DRAWING. WORK TO DIMENSIONS SPECIFIED.
04. TOLERANCES FOR ALL DIMENSIONS SHALL BE NONCUMULATIVE.
05. BREAK ALL CORNERS AND DEBURR ALL SHARP EDGES.
06. ALL FILLET AND RADII DIMENSIONS ARE NOMINAL UNLESS NOTED OTHERWISE.
07. MACHINED BY CUSTOMER.

DO NOT SCALE THIS DRAWING. WORK TO DIMENSIONS SPECIFIED

UNLESS SHOWN OTHERWISE, MACHINING TOLERANCES ARE:

LINEAR UP TO 1m(40") ±0.5mm(±0.020")
OVER 1m(40") ±1.0mm(±0.040")

ANGULAR ±0.25°
SURFACE FINISH 3.2mmRa (125minch)

THORDON MATERIAL SURFACE FINISH TO BE DETERMINED ONLY BY USE OF COMPARITOR

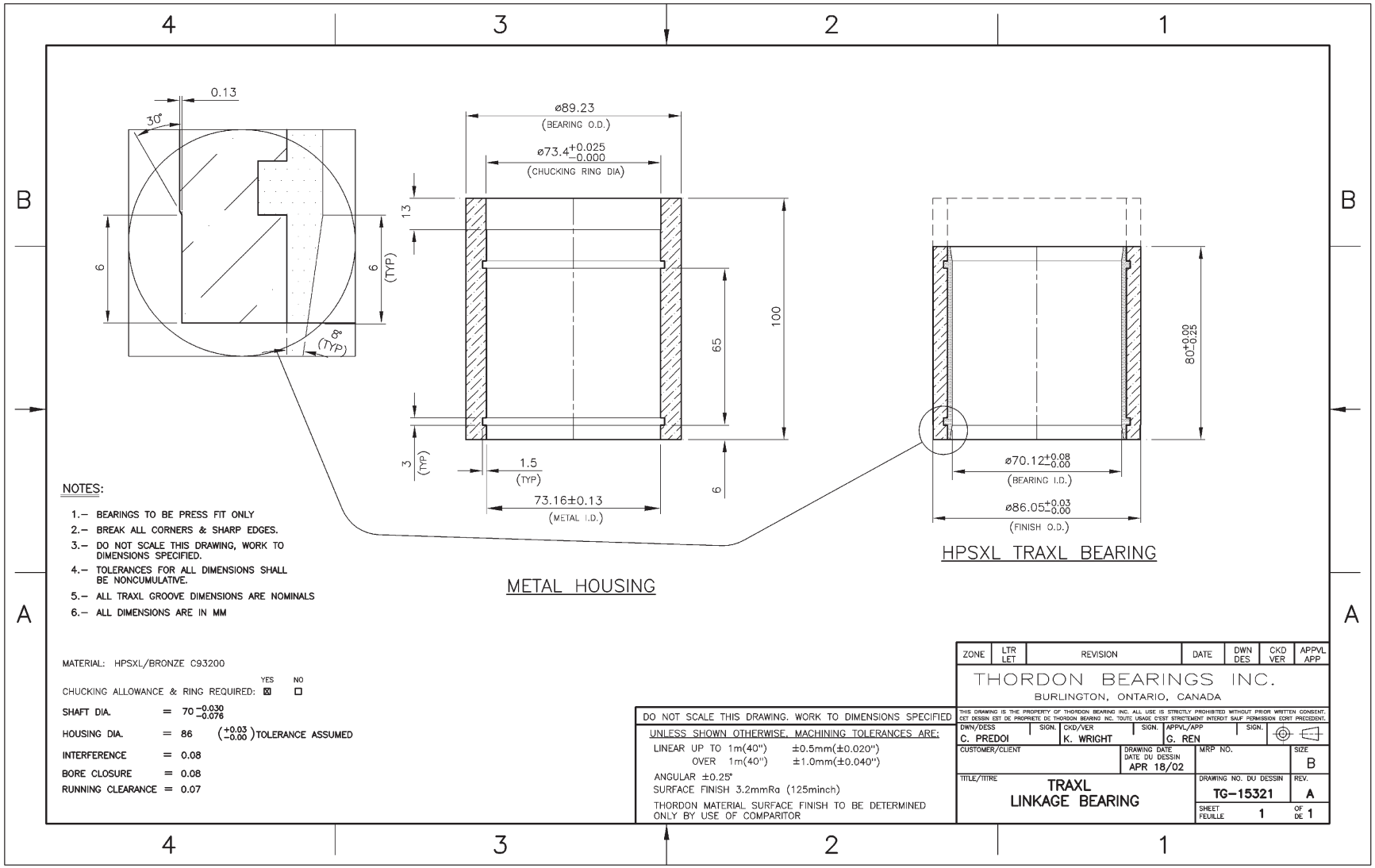
ZONE	LTR LET	REVISION	DATE	DWN DES	CKD VER	APPVL APP

THORDON BEARINGS INC.
BURLINGTON, ONTARIO, CANADA

DWN/DES	SIGN.	CKD/VER	SIGN.	APPVL/APP	SIGN.
K. WRIGHT		G. LETOURNEAU		L. ESTRADA	

CUSTOMER/CLIENT
DRAWING DATE / DATE DU DESSIN: NOV 19/01
MRP NO.
SIZE: C

TITLE/TITRE: WICKET GATE BEARING
DRAWING NO/ DU DESSIN: TG-15128
REV.: B
SHEET / FEUILLE: 1 OF / DE 1



METAL HOUSING

HPSXL TRAXL BEARING

NOTES:

1.– BEARINGS TO BE PRESS FIT ONLY
2.– BREAK ALL CORNERS & SHARP EDGES.
3.– DO NOT SCALE THIS DRAWING, WORK TO DIMENSIONS SPECIFIED.
4.– TOLERANCES FOR ALL DIMENSIONS SHALL BE NONCUMULATIVE.
5.– ALL TRAXL GROOVE DIMENSIONS ARE NOMINALS
6.– ALL DIMENSIONS ARE IN MM

MATERIAL: HPSXL/BRONZE C93200

	YES	NO
CHUCKING ALLOWANCE & RING REQUIRED:	☒	☐

SHAFT DIA. = $70^{-0.030}_{-0.076}$

HOUSING DIA. = 86 $\left(^{+0.03}_{-0.00}\right)$ TOLERANCE ASSUMED

INTERFERENCE = 0.08

BORE CLOSURE = 0.08

RUNNING CLEARANCE = 0.07

DO NOT SCALE THIS DRAWING. WORK TO DIMENSIONS SPECIFIED

UNLESS SHOWN OTHERWISE, MACHINING TOLERANCES ARE:

LINEAR UP TO 1m(40") ±0.5mm(±0.020")
OVER 1m(40") ±1.0mm(±0.040")

ANGULAR ±0.25°

SURFACE FINISH 3.2mmRa (125minch)

THORDON MATERIAL SURFACE FINISH TO BE DETERMINED ONLY BY USE OF COMPARITOR

ZONE	LTR LET	REVISION	DATE	DWN DES	CKD VER	APPVL APP

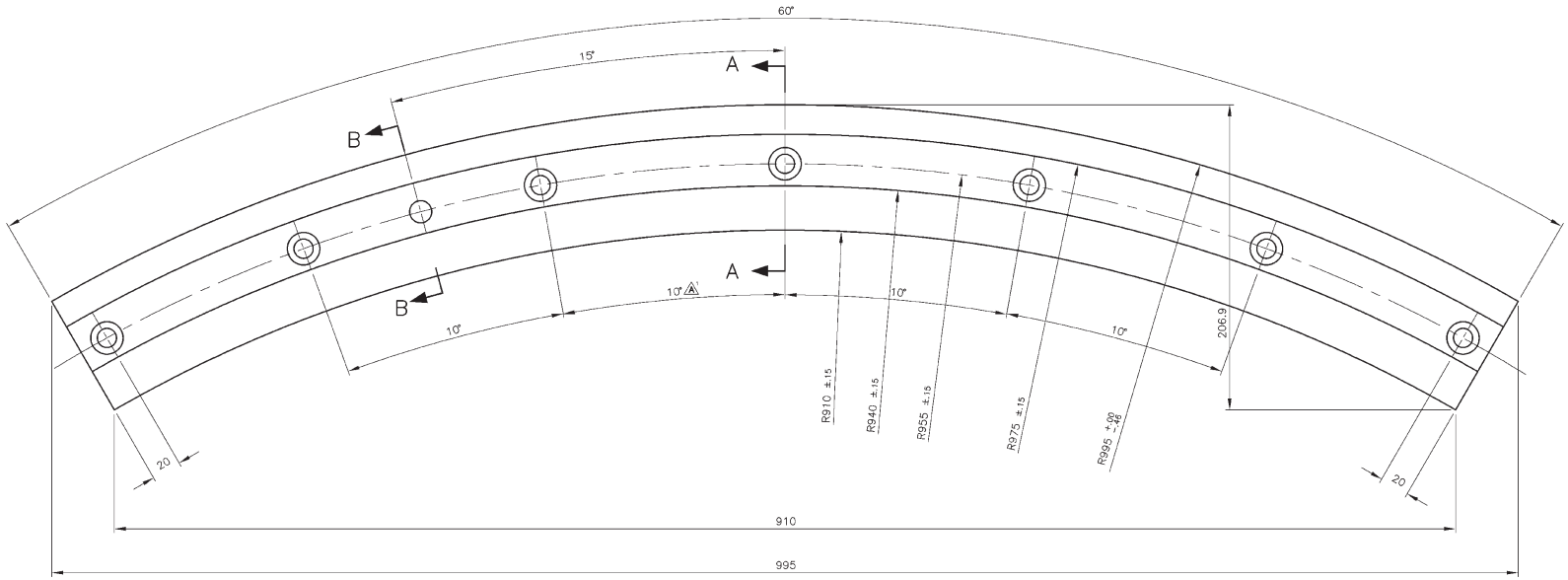
THORDON BEARINGS INC.
BURLINGTON, ONTARIO, CANADA

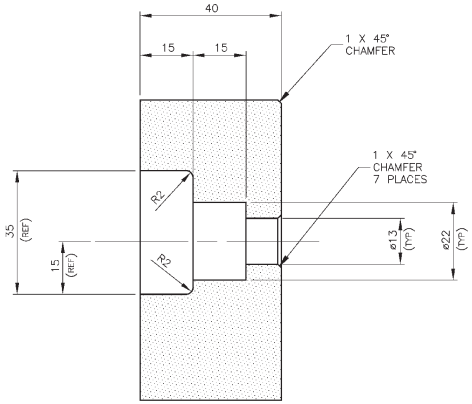
DWN/DESS	SIGN.	CKD/VER	SIGN.	APPVL/APP	SIGN.
C. PREDOI		K. WRIGHT		G. REN	

CUSTOMER/CLIENT	DRAWING DATE DATE DU DESSIN	MRP NO.	SIZE
	APR 18/02		B

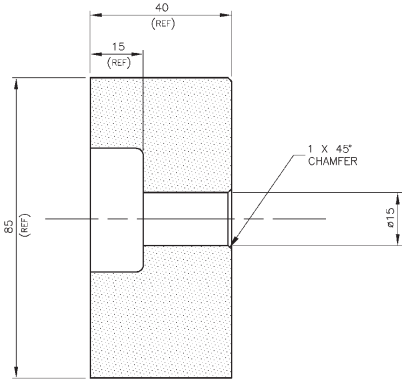
TITLE/TITRE	DRAWING NO. DU DESSIN	REV.
TRAXL LINKAGE BEARING	TG-15321	A

SHEET FEUILLE 1 OF DE 1





SECTION A–A



SECTION B–B

GENERAL NOTES:

01. MAT'L – THORDON SXL
02. ALL DIMENSIONS ARE EXPRESSED IN MM UNLESS NOTED OTHERWISE.
03. DO NOT SCALE THIS DRAWING. WORK TO DIMENSIONS SPECIFIED.
04. TOLERANCES FOR ALL DIMENSIONS SHALL BE NONCUMULATIVE.
05. BREAK ALL CORNERS AND DEBURR ALL SHARP EDGES.
06. ALL FILLET AND RADII DIMENSIONS ARE NOMINAL UNLESS NOTED OTHERWISE.

DO NOT SCALE THIS DRAWING. WORK TO DIMENSIONS SPECIFIED

UNLESS SHOWN OTHERWISE, MACHINING TOLERANCES ARE:

LINEAR UP TO 1m(40") ±0.5mm(±0.020")
OVER 1m(40") ±1.0mm(±0.040")

ANGULAR ±0.25°

SURFACE FINISH 3.2mmRa (125minch)

THORDON MATERIAL SURFACE FINISH TO BE DETERMINED ONLY BY USE OF COMPARITOR

C3	A1	WAS 6X 10°	MAR 06/03	GLL	CP	GR
ZONE	LTR LET	REVISION	DATE	DWN DES	CKD VER	APPVL APP

THORDON BEARINGS INC.
BURLINGTON, ONTARIO, CANADA

DWN/DESS	SIGN.	CKD/VER	SIGN.	APPVL/APP	SIGN.
GLetourneau		K.WRIGHT		G.REN	

CUSTOMER/CLIENT	DRAWING DATE DATE DU DESSIN	MRP NO.	SIZE
	APR 19/02	F100114410	C
TITLE/TITRE		DRAWING NO. DU DESSIN	REV.
THORDON SXL RING SEGMENT		TG–15316	A
		SHEET FEUILLE 1	OF DE 2

Customer Focused to Support your Immediate and Future Needs

Supply and Service: Geared to provide quick response to customer needs, Thordon Bearings understands the importance of quick delivery and reduced down time. Thordon products can be designed, produced to the exact requirements of the customer and shipped quickly.

Distribution: With Thordon bearings specified all around the world, an extensive distribution network has been established in over 70 countries. Inventories of common bearing sizes are stocked by local Thordon Distributors and are backed up by large regional and head office Thordon stocks.

Application Engineering: Thordon Bearing's engineers work closely with customers to provide innovative bearing system designs that meet or exceed the technical requirements of the application.

Manufacturing: Thordon's modern polymer processing facility is staffed with experienced and dedicated employees. Bearings up to 2.2 m (86") in diameter have been supplied and bearings up to 1.5 m (60") O.D. have been machined in-house.

Quality: Thordon Bearings Inc. is a Canadian company manufacturing to ISO 9001:2000 Quality System requirements. With over 30 years experience in elastomeric bearing design, application engineering and manufacturing, Thordon bearings are recognized worldwide for both quality and performance.

Research and Development: Thordon bearings are being continuously tested by our Bearing Test Facility. The Facility evaluates new designs and applications before they are put into service. Ongoing testing not only allows for design refinements, but ensures quality and performance after installation. Our polymer laboratory evaluates new and modified polymers in a continuing quest to improve Thordon bearing performance and search for new ploymer bearing solutions.

THORDON

THORDON BEARINGS INC.

ZERO POLLUTION | HIGH PERFORMANCE | BEARING SYSTEMS

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Tel: +1.905.335.1440 Fax: +1.905.335.4033
www.ThordonBearings.com