THORDON

THORDON BEARINGS INC.

Pump Bearings Product Manual

PB2016.1

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CORPORATE 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 through more than 85 distributors in over 100 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 9001:2008 Quality System requirements.

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

THORDON

HIGH PERFORMANCE OIL & GREASE-FREE PUMP BEARINGS

Thordon Bearings is the world's leading manufacturer of high performance, long lasting bearings that require no oil or grease. Thousands of pump repair shops, OEM's and end users around the world recognize Thordon bearings as the proven choice for performance and value. Thordon bearings are built to last, with no impact to the environment.

We design and manufacture the most complete line of oil and grease-free vertical pump bearings in the industry. Our elastomer grades offer the best combination of strength and stiffness with flexibility and elasticity, along with high abrasion resistance. Our thermoplastic grades operate at higher temperatures and pressures than Thordon elastomers with improved chemical resistance.

Regardless of grade or configuration, Thordon bearings do not require grease or oil lubrication in dry or wet conditions, and can be used in a wide range of water and product lubricated vertical pumps.

Benefits for Pump Operators:

- Long wear life and lower maintenance costs mean predictable, lower life-cycle costs
- Self-lubrication eliminates pollution
- Global availability provides superior customer service and quick turnaround
- Full-cycle technical support includes system design, machining, installation and after-sales service
- ThorPlas-White has been listed by the NSF International Certification and WRAS for NSF/ANSI 51 (food equipment) and 61 (Drinking Water System Components)
- Certification to ISO 9001:2008 ensures consistent quality of custom and stock solutions

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.

Continuous research over the years has resulted in development of four different pump bearing-grade elastomer products - XL, SXL, Composite (GM2401), and PT80. This allows selection of an optimum solution based on matching product characteristics to the specific application requirements.

ThorPlas-Blue Thermoplastic Bearings

ThorPlas-Blue is a 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-Blue, which significantly expands the range of applications where Thordon bearings can be specified, while still maintaining many of the recognized Thordon performance advantages.

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PRODUCT AND CONFIGURATIONS (cont'd.)

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

- Improved ability to operate at elevated temperatures up to 80°C (176°F) in water or other fluids
- Improved chemical resistance in all major chemical categories
- Enhanced wear life in non-abrasive environments
- Increased strength and rigidity allowing maximum dynamic working pressures up to 45 MPa (6527 psi) in a full-form tubular configuration

Thor-Plas White

ThorPlas-White is an engineered thermoplastic alloy specifically developed to operate as a drinking water system component used in the treatment and distribution of potable water, and as a material used in the construction of food equipment. ThorPlas-White has several certifications including:

- NSF/ANSI 51 for Food Equipment Applications
- NSF/ANSI 61 for Drinking and Potable Water Applications
- WRAS (Water Regulations Advisory Scheme) approval

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

- Low friction operation
- Long bearing wear life
- Good dry run capability due to built-in lubricants
- Easy to machine – no nuisance dust
- Easy to install
- High resistance to heat, corrosion and abrasion

COMPLETE LINE OF HIGH PERFORMANCE VERTICAL PUMP BEARINGS

Thordon SXL
- Preferred choice for dry start-up capability
- Lower dry coefficient of friction typically 0.10 - 0.20
- Working pressure to 10 MPa (1450 psi)
- Wet or dry operation
- High resistance to abrasion, shock loading and vibration

Thordon Composite (GM2401)
- Made specifically for use in very abrasive water environments
- Stiffer and at least twice the abrasion resistance of rubber
- Lower coefficient of friction than rubber
- Reduced maintenance downtime
- Water lubricated – no grease
- Easy installation

PT80
- Excellent mechanical property retention (in water), at higher temperatures
- Internal lubricants provide dry run capabilities similar to Thordon SXL
- Wear characteristics similar to existing Thordon elastomer grades
- High abrasion resistance
- Low coefficient of friction

Thordon XL
- Long life with low dry coefficient of friction
- Good abrasion resistance
- Optimum performance in clean water applications

ThorPlas-Blue
- Dry start up capability
- Operates in water and chemicals up to 80°C (176°F) and 110°C (230°F) dry
- Engineered thermoplastic capable of design pressures up to 45 MPa (6527 psi)
- Very low wear in non-abrasive environments

ThorPlas-White for Drinking Water Applications
- NSF/ANSI 61 and WRAS approval
- Low friction operation
- Very low wear
- Good dry run capability due to built-in lubricants
- Easy to machine – no nuisance dust
- Easy to install

Trilor: Thordon Non-Metallic Carrier

If a carrier or housing is required for Thordon elastomer bearings, Thordon Trilor non-metallic carriers can be used as a cost effective alternative to metallic carriers
- Lower weight (approximately 1/5 the weight of bronze) making it easier to move and install
- Cost effective – pricing not influenced by external factors (e.g. Copper commodity index)
- Fit for long term life in water and marine conditions
- Good dimensional stability – low water absorption and low thermal expansion
- Corrosion free
- Compatible with chocking and bonding

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CHEMICAL RESISTANCE CHART

The compatibility of Thordon and ThorPlas-Blue to the following chemical fluids is a general rating based on the effect of the chemical at room temperature. For more information, please contact Thordon Bearings Inc.

Chemical/Fluid	Thordon Elastomers	ThorPlas-Blue
Salt solutions	A	A
Sodium chloride	A	A
Weak acids	B-D	A-B
Acetic acid	D	B
Lactic acid	B	A
Strong acids	B-D	A-C
Sulphuric, 5%	B-C	A
Sulphuric, concentrated	D	C
Hydrochloric, 10%	B	C
Weak bases	A-B	A-B
Ammonia 10%Aq.	A	A
Sodium carbonate	B	A
Triethanolamine	B-D	B
Strong bases	B	C-D
Sodium hydroxide, 10%	B	C
Oxidizing agents	B-C	A
Hydrogen peroxide, 1-3%	B	A
Chromic acid	C	A

Chemical/Fluid	Thordon Elastomers	ThorPlas-Blue
Hydrocarbon/fuels	A-B	A
Aromatic – benzene, toluene	B	A
Aliphatic – gasoline, grease	A-B	A
Lubricating oils (petroleum)	B	A
Chlorinated solvents	D	C-D
Alcohols	D	A
Ethanol	D	A
Methanol	D	A
Ketones	D	A-B
Methyl ether ketone	D	A
Acetone	D	B
Ethers	D	A
Diethyl ether	D	A
Esters	D	A
Ethyl acetate	D	A
Methyl acetate	D	A
Freon 12	A-C	A
Vegetable Oils	A-B	A

A: Excellent-No Affect; B: Good-Little Affect; C: Fair-Moderate Affect; D: Unacceptable

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 / PT80	ThorPlas-Blue	
10-15 MPa (1450-2175 psi)	HPSXL	ThorPlas-Blue	
15-45 MPa (2175-6525 psi)	ThorPlas-Blue	HPSXL TRAXL	
45-55 MPa (6525-8000 psi)	HPSXL TRAXL		
Dry (abrasives present)			
0-5.5 MPa (0-800 psi)	XL	SXL/PT80	ThorPlas-Blue
5.5-10 MPa (800-1450 psi)	SXL / PT80	ThorPlas-Blue	
10-15 MPa (1450-2175 psi)	HPSXL	ThorPlas-Blue	
15-45 MPa (2175-6525 psi)	ThorPlas-Blue		
Wet (sealed or minimal abrasives)			
0-10 MPa (0-1450 psi)	SXL / PT80	ThorPlas-Blue	
10-15 MPa (1450-2175 psi)	HPSXL	ThorPlas-Blue	
15-45 MPa (2175-6525 psi)	ThorPlas-Blue	HPSXL TRAXL	
45-55 MPa (6525-8000 psi)	HPSXL TRAXL		
Wet (abrasives present)			
0-3 MPa (0-500 psi)	GM2401	SXL / PT80	ThorPlas-Blue
3-10 MPa (500-1450 psi)	SXL / PT80	ThorPlas-Blue	
10-15 MPa (1450-2175 psi)	HPSXL	ThorPlas-Blue	
15-45 MPa (2175-6525 psi)	ThorPlas-Blue		
Potable Water (wet or near dry)			
0-3 MPa (0-500 psi)	ThorPlas-White		
3-10 MPa (500-1450 psi)	ThorPlas-White		
10-15 MPa (1450-2175 psi)	ThorPlas-White		
15-45 MPa (2175-6525 psi)	ThorPlas-White		

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.

THORDON MATERIAL SELECTION GUIDE FOR PUMP BEARING APPLICATIONS

Parameter	Thordon Grades					
	XL	**SXL**	**Composite (GM2401)**	**PT80**	**ThorPlas-Blue**	**ThorPlas-White**
Description	Elastomeric Polymer Alloy	Elastomeric Polymer Alloy	Elastomeric Polymer Alloy	Elastomeric Polymer Alloy	Engineered Thermoplastic	Engineered Thermoplastic
Temperature Limit	60°C (140°F)	60°C (140°F)	60°C (140°F)	80°C (176°F)	80°C (176°F)	80°C (176°F)
Suitable for Dry Start Up	NO	YES**	NO	YES**	YES**	YES**
Resistance to Acids	Limited	Limited	Limited	Fair	Good	Good
Resistance to Alkalies	Limited	Limited	Limited	Fair to Good	Fair	Fair
Suitable for Hydrocarbons	YES	YES	YES	YES	YES	YES
Abrasion Resistance	Good	Better	Best	Better	Acceptable	Acceptable
Installation Clearance	Medium	Medium to Low	Higher	Medium to Low	Lowest	Lowest
Shaft Sleeve Material	Bronze, Stainless Steel	Bronze, Stainless Steel	Ni-Cr-B Recommended	Bronze, Stainless Steel	Bronze, Stainless Steel	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, Seawater, Most Fluids (pH 3-11)	Water, Seawater, Most Fluids (pH 3-11)	Potable Water
Remarks	Good balance between abrasion resistance and medium level of friction	Low friction; Suitable for dry start-up; Good abrasion resistance	For use in highly abrasive operating environments	Suitable for higher temperatures up to 80°C (176°F); Low friction; Suitable for dry start-up; Good abrasion resistance	Lowest friction. Good for low abrasion applications and for use at temperatures and in chemical solutions unsuitable for Thordon elastomers	NSF International Certification for NSF/ ANSI 51 (food equipment) and 61 (Drinking Water System)

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

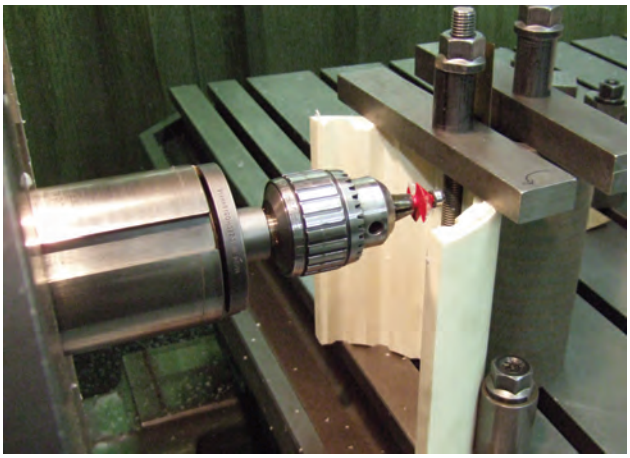
Note: For Nuclear use, Quality Control certificates including certified test reports can be supplied. Thordon Bearings Inc. operates under the provision of 10 CFR21.

THORDON

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.

SAMPLE OUTPUT

Thordon Bearings Sizing Calculation Program
No: 393836KJS6 V 2006.2
Printed Date: 11/13/2015

THORDON BEARINGS INC.
3225 Mainway Drive, Burlington, Ontario, Canada L7M 1A6
Tel: 905-335-1440 Fax: 905-335-0209, www.thordonbearings.com

General Information

Thordon Distributor:	Thordon Distributor
Customer:	ABC Water Management
Project Reference:	Vert pumps for plant
Calculated By:	George Brown
Checked By:	
Comments:	
Drawing Number:	TG-12345
MRP Number:	****

Results

-- ATTENTION --
Means of axial retention required.
Positive flow of lubricant is required.

	Designed at 21 °C	Machined at 21 °C	
Machined Bearing Inside Diameter:	257.50	257.50 mm	+0.13, -0.00
Machined Bearing Outside Diameter:	314.47	314.47 mm	+0.13, -0.00
Calculated Machined Bearing Length:	320.15	320.15 mm	+0.00, -0.5
Bearing Wall Thickness:	28.49	28.49 mm	(For reference only)
Amount Of Interference:	1.92 mm		
Bore Closure Factor:	1.179		
Bore Closure Amount:	2.37 mm		
Minimum Installed Diametrical Clearance:	1.08 mm		
Diametric Running Clearance:	0.38 mm		
Diametric Thermal Expansion:	0.26 mm		
Diametric Absorption Allowance:	0.43 mm		
Axial Thermal Expansion:	1.64 mm		
Axial Absorption Allowance:	1.62 mm		
Number of Grooves:	12		
Width of Grooves:	8.00 mm		
Depth of Grooves:	6.00 mm		
Pressure on Bearing:	0.038 MPa		
Peripheral Velocity:	23.96 m/sec		
Outside Diameter After Dry Ice Cooling:	311.60 mm		
Outside Diameter After Nitrogen Cooling:	308.10 mm		

Input Data

Dimension Scale:	Metric
Temperature Scale:	Celsius
Maximum Operating Temperature:	45 °C
Minimum Operating Temperature:	-2 °C
Machine Shop Ambient Temperature:	21 °C
Maximum Shaft Diameter:	254.05 mm
Maximum Housing Diameter:	312.55 mm
Minimum Housing Diameter:	312.50 mm
Housing Length:	323.40 mm
Type of Lubrication:	Water
Grade of Thordon Used:	SXL
Type of Service:	Ind. Vertical Pump
Type of Installation:	Interference Freeze Fit
Grooved Bearing Style:	Grooved
Load on Bearing:	320 kg
Shaft RPM:	1800

DESIGN AND INSTALLATION CONSIDERATIONS

Before choosing Thordon or ThorPlas-Blue 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

THORDON

PROVEN BENEFITS OF USING THORDON PUMP BEARING PRODUCTS

Pollution-Free High Performance Bearings

Thordon's pollution-free bearings help preserve the environment. They require no oil or grease lubrication and offer an outstanding wear life, reduced downtime and lower life cycle costs.

Long Wear Life, Low Friction & High Abrasion Resistance

Thordon bearings absorb impact or shock loads with a dampening capacity that is nearly 500% greater than rubber!

Our bearings are self-lubricating which reduces abrasion and prevents wear. They also have a lower dry coefficient of friction which improves efficiency in frequent stop-starts. Low friction bearings also operate longer, wear less and have reduced start-up torque and "stick-slip".

High Temperature & Improved Chemical Resistance

Thordon bearings are corrosion resistant and can withstand high temperatures. ThorPlas-Blue and ThorPlas-White can be used in water and chemicals up to 80°C (176°F) while our elastomeric polymer grades operate up to 60°C (140°F).

Easily Machined & Installed On-site

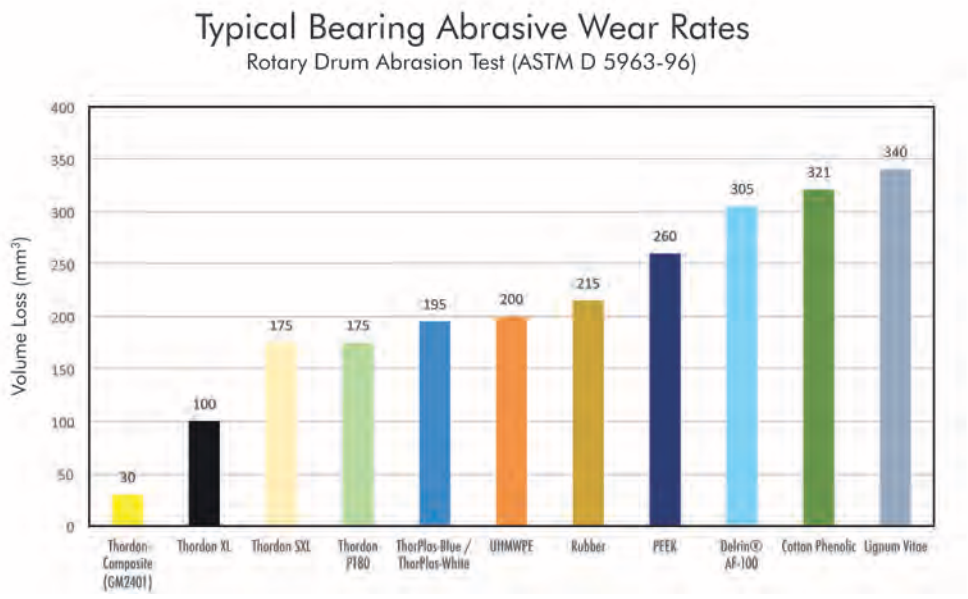
Thordon bearings are easily machined to exact dimensions and can either be press-fit or freeze-fit using dry ice or liquid nitrogen, or bonded using a Thordon approved adhesive.

Over 40 Years Experience in a Variety of Pump Applications

Thordon pump bearings have been used in open and closed tube vertical pumps in a variety of applications including power plants, pulp and paper mills, sewage and waste water treatment plants, nuclear power plants, steel mills, oil and chemical refineries, and shipyards.

Continuous innovation along with a variety of bearing grades and configurations position Thordon bearings as the ideal solution for cooling water, potable water, circulating, drain, stock, fire, dry dock, deep well, drain water lifting, condensation, submersible and screw lift pumps.

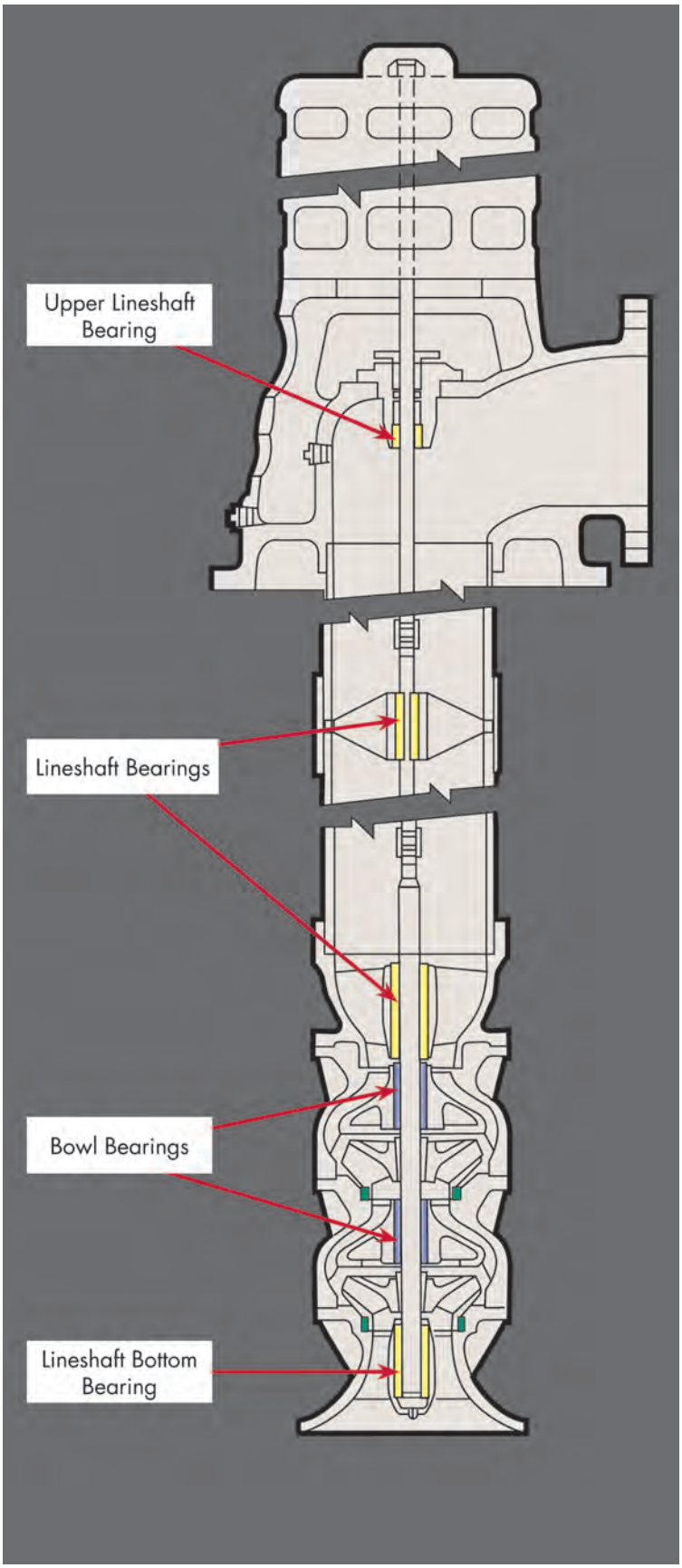
For pump-turbine applications refer to Thordon's Hydro-Turbine Bearings brochure.



THORDON PUMP BEARING SOLUTIONS

Thordon Bearings designs and manufactures the industry's most complete line of oil and grease-free water lubricated vertical pump bearings.

Elastomeric grades (XL, SXL, Composite, GM2401 and PT80) offer exceptional wear life, low friction and reduced starting torque. Thordon also manufactures ThorPlas-Blue and ThorPlas-White engineered thermoplastic bearings that offer better chemical resistance and operate at temperatures up to 80°C (176°F). ThorPlas-White is the newest Thordon grade, specifically developed to operate as a drinking water system component used in the treatment and distribution of potable water.



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THORDON SXL SEGMENTED SHAFT SEALS

Reliable shaft sealing is an important concern for large pump or hydro turbine operators for shaft dia. 400 to 2000+ mm (16 to 80 in). Typical turbine axial seals are constructed of a non-rotating segmented carbon face ring operating against a rotating steel collar. Carbon seal rings comprise of very brittle segments which present significant handling and installation difficulties and may have a somewhat foreshortened life span if misaligned or subjected to abrasives.

Thordon Bearings Inc. has embarked on a program to optimize designs of such seals utilizing its proprietary SXL elastomeric material. SXL has high natural abrasion resistance and is well suited for such sealing applications.

Typical axial seal segments comprise two annular lands formed via a central groove. The individual segments are bonded into place to form the ring and secured with bolting. The ends of the segments are typically sealed with adhesive. Each of the circumferential lands will perform a pressure breakdown function between a centrally fed injection pressure and the turbine pressure on the one side and atmospheric pressure on the other. The arrangement will depend on whether the seal is outside or inside pressurized. The higher pressure injection flow (10 to 15% above turbine pressure) functions as a seal lubricant, coolant and a barrier to abrasives entering the seal faces.

Typical radial segmented seals comprise three stages of interlocking segments. Each ring has both dynamic (against the shaft) and static (against the housing) sealing sections. First stage seals are normally reversed compared with the two upper rings, to allow introduction of a higher-pressure injection flow between the first and second rings. This higher pressure flow (1.10 to 1.15 turbine pressure) functions as a seal lubricant, coolant and a barrier preventing abrasives from entering the seal faces. A garter spring functions to hold the segments with a nominal light force against the shaft during periods of shutdown and low pressure and also to maintain the integrity of the seal ring within the housing cavity.

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THORDON BEARINGS INC.

Pump OEM and OEM Repair Centres Using Thordon Bearings

OEM	Country	Pump Types	Thordon Grades
Flowserve Corp.	Australia	Vertical	GM2401, SXL, ThorPlas-Blue, XL
ITT Pumps	Australia	Vertical	SXL, XL
Sulzer Pumps	Australia	Vertical	SXL, ThorPlas-Blue
Xylem	Australia	Vertical	SXL, XL
KSB Pumps	Brazil	Water Treatment	ThorPlas-Blue
Weir Pumps (Clear Liquid Div.)	Brazil	Vertical	SXL
Flowserve Pump Division	Canada	Vertical	SXL
ITT A-C Pumps	Canada	Vertical Cooling Water	SXL
Sulzer Pumps (Canada) Inc.	Canada	Vertical	SXL, XL
Weir Pumps Canada	Canada	Vertical	GM2401, SXL, XL
Changi	China	Vertical	SXL, XL
Changsha Pump	China	Vertical	SXL, XL
Hai Duong	China	Vertical	SXL, XL
Huanggong Pump	China	Vertical	ThorPlas-Blue
KSB Pumps	China	Vertical	SXL
Kumdian	China	Vertical	SXL, XL
Lanzhi	China	Vertical	SXL, XL
Liou	China	Vertical	SXL, XL
QHP	China	Vertical	SXL, XL
Shanhai Hong Zhou	China	Vertical	SXL, XL
Shenyang Pumps	China	Vertical	SXL, XL
Weiyana	China	Vertical	SXL, XL
Sigma Lutin	Czech Republic	Vertical	GM2401, SXL
Flowserve Corp.	France	Vertical	SXL, ThorPlas-Blue
Sulzer Pumps	France	Vertical	SXL, ThorPlas-Blue
KSB Pumps	Germany	Vertical	GM2401, SXL
Sulzer Pumps	Germany	Vertical	SXL
Ganz Pumps	Hungary	Vertical	GM2401, SXL
Flowserve Corp.	India	Vertical	GM2401, SXL, ThorPlas-Blue, XL
ITT Pumps	India	Vertical	SXL, XL
Jyoti ltd.	India	Vertical	SXL
Kirloskar Brothers Ltd.	India	Vertical Turbine, Horizontal Split Case	SXL
WPIL	India	Vertical	SXL
Xylem	India	Vertical	SXL, XL
DMW Corp.	Japan	Vertical	SXL
Ebara Corp.	Japan	Vertical Cooling Water	GM2401, SXL
Hitachi	Japan	Vertical	SXL
Ishigaki	Japan	Vertical	SXL
Kubota Hirakata	Japan	Vertical	SXL
Mitsubishi	Japan	Vertical	SXL
Torishima Pump	Japan	Vertical	SXL
Flowserve Corp.	Mexico	Vertical	SXL
ITT Pumps	Mexico	Vertical	SXL, XL
Ruhrpumpen Pumps	Mexico	Vertical	SXL
Sulzer Pumps	Mexico	Vertical	SXL, ThorPlas-Blue
Xylem	Mexico	Vertical	SXL, XL
Flowserve Corp.	Netherlands	Vertical	GM2401, SXL
KSB Pumps	Pakistan	Vertical	SXL
Sulzer Pumps	South Africa	Vertical	SXL
Daehlan	South Korea	Vertical	SXL, XL
Hyosung Ebara Corp.	South Korea	Vertical Cooling Water, Drain Pump	SXL, XL
Shilla	South Korea	Vertical	SXL, XL
Flowserve Corp.	Spain	Vertical	GM2401, SXL, ThorPlas-Blue

THORDON BEARINGS INC.

Pump OEM and OEM Repair Centres Using Thordon Bearings

OEM	Country	Pump Types	Thordon Grades
Sulzer Pumps	Switzerland	Vertical	SXL, ThorPlas-Blue
Carry Pumps	U.S.A.	Vertical	SXL
Floway	U.S.A.	Vertical	SXL
Flowserve Corp.	U.S.A.	Vertical	GM2401, SXL, XL, ThroPas-Blue
Hayward Tyler	U.S.A.	Vertical Cooling Water	GM2401, SXL
ITT A-C Pumps	U.S.A.	Vertical	GM2401,SXL, XL
ITT Goulds Pumps	U.S.A.	Vertical Cooling Water	GM2401, SXL
Johnston Pump Company	U.S.A.	Vertical Cooling Water	GM2401, SXL
Lawrence Pumps	U.S.A.	Waste Water	GM2401, SXL, XL
Peerless Pump Company, Inc.	U.S.A.	Vertical	SXL
Ruhrpumpen Pumps	U.S.A.	Vertical	SXL
Sulzer Pumps	U.S.A.	Vertical	SXL, ThorPlas-Blue
Xylem	U.S.A.	Vertical	SXL, XL
Flowserve Corp.	United Kingdom	Vertical	GM2401, SXL
Sulzer Pumps	United Kingdom	Vertical	SXL, XL
Ebara Corp.	Vietnam	Vertical	SXL

THORDON APPLICATIONS

Public Utility - Salt River Project

Company:	Michael and Associates, U.S.A.
Pump Type:	Vertical pump
Application:	Bearings installed in the stuffing box, spider, bowl and suction bell locations
Solution:	Replaced bronze with Thordon SXL in May 2002
Installation:	Fully machined and pressed in
Results:	Pump pulled in January 2007, with 31,000 operating hours. Original target was 22,000. Many lineshaft bearings showed limited wear

Pump Supplier

Company:	KSB Pumps, Brazil
Pump Type:	Vertical pump
Application:	Liquid composition details: Kerosene 70-85%, Copper extractant 15-30%, Chlorine - 1000 mg/l, H2SO4 - 50 g/l, Solids < 20 mg/l, Temperature 15 to 50°C (59°F to 122°F)
Solution:	Installed ThorPlas-Blue bearings in May 2005
Results:	Excellent wear life

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THORDON APPLICATIONS

Pump Manufacturer

Manufacturer:	Johnston Pump
Pump Type:	Vertical; full line
Application:	Standard pumps, all bearings except top stuffing box
Sizes:	11/4" - 4 1/2" (31.7mm - 114.3mm) shafts 8" - 10" (200mm - 250mm) long
Problem:	Abrasive water wear
Solution:	Thordon Composite [GM 2401] with hard shaft liners
Installation:	Fully machined and pressed in
Results:	Longer life than rubber
Reason for selection:	Initial use based on customer request

Nuclear Generating Station

Company:	Northeast Utilities, Connecticut, USA
Pump Type:	Hayward Tyler vertical pump
Application:	Supply cooling seawater to Millstone Nuclear Generating Station
Problem:	Silt in seawater causing bearing wear resulting in short periods between overhaul
Solution:	Thordon Composite (GM2401) polymerized in a metallic shell
Installation:	Replaced bronze with an open line shaft design using Thordon Composite making it self lubricating along with a hard-coated shaft sleeve to protect from abrasive wear and corrosion
Results:	Doubled the bearing wear life and lengthened the period between overhauls from three years to six years; eliminated the need for a separate lubricating system
Reason for selection:	Discussed application with other utilities using Thordon Composite which had excellent improvements in increasing bearing wear life

THORDON APPLICATIONS

Pump Manufacturer

Manufacturer:	Wellmaster, Canada
Pump Type:	Submersible pump
Application:	Farms and rural residents of Canada; pressure on-demand water systems
Typical Pump:	7/16" (11.1mm) to 2" (50.8mm) shaft size; 2 to 3 bearings per pump
Problem:	Sand in well water, very fine to coarse [unpredictable]
Solution:	Thordon Composite [GM 2401] on 304 Stainless steel sleeve; bearings always submerged
Installation:	Fully machined and bonded, approx. 2" (50.8mm) length. Hundreds of bearings per month
Reason for selection:	Thordon's history of performance working in the Mississippi River

Processing Plant

Company:	Shell Chemical, Geismer, LA, USA
Pump Type:	Peerless deep well 2-stage
Application:	Supply plant service water from Mississippi River
Typical Pump:	1.687" (42.8mm) and 2.187" (55.5mm) shaft sizes
Problem:	Very abrasive Mississippi River water
Solution:	Thordon Composite [GM 2401] in bronze shell on chrome sleeve
Installation:	Dec. 1993. Fully machined and pressed in, 6" (152.4mm) length.
Results:	No vibrations or other signs of wear after 24+ months and 18+ months operation. Previously experienced a 6 - 8 month life.
Reason for selection:	Thordon's history of performance working in the Mississippi River

THORDON

THORDON APPLICATIONS

Feed/Fertilizer Manufacturing Plant

Company:	Westway Trading, Omaha, NE, USA
Pump Type:	Positive Displacement Pump (Roper Model No. 3658)
Application:	Pumping raw soap stock consisting of soybean fat/oil, soybean meal, propyonic acid and sulfuric acid
Problem:	After six months operation, the abrasive conditions caused the four bronze bushings to wear so much that the shaft would wear into the cast iron housings. This meant a complete rebuild every six months and a new pump after 18 months.
Solution:	Thordon SXL bearings
Installation:	Replace bronze bearings when pump was disassembled
Results:	After 16 months of operation the pump was disassembled. After inspection the pump was reassembled with the same components. After 24 months operation the pump was still running with the same parts.
Reason for selection:	Thordon evaluation and recommendation

Coal Fired Power Plant

Company:	Tennessee Valley Authority (TVA), Paradise Plant, Kentucky, USA
Pump Types:	Layne-Bowler vertical, multi-stage, 600 HP, 3 1/2" (90mm) shaft U.S. Pump, 7 stage vertical, 1 7/16" (36.5mm) shaft Foster Wheeler circulating, 5" (127mm) shaft
Application:	Supply plant service water and cooling water from Green River [tributary of Ohio River]
Problem:	River water very abrasive
Solution:	Thordon SXL tubes with NI-Cr-B sleeves
Installation:	Replaced Cutless rubber on larger shafts, bronze on smaller diameters; each bearing machined at plant
Results:	Some bearings now exceed 10 years service

THORDON APPLICATIONS

Coal Fired Power Plant

Company:	Virginia Power, Chesapeake Energy Center, USA
Pump Type:	Ingersoll-Rand single stage vertical, 4-1/2" (114.3mm) shaft
Application:	Supply plant service water and cooling water from Elizabeth River
Problem:	Bronze components sufffered from chemicals in water [chlorides, sulfides, etc.]; Cutless bearings suffered from silt. Bronze/rubber serviced every 6 mos.
Solution:	Thordon Composite, fully finished
Installation:	Epoxy bonded with nitronic 60 shaft sleeves, 6" - 9" (152mm - 228mm) bearing length
Results:	4 years+ life with minimal wear observed
Reason for selection:	Thordon evaluation and recommendation

Nuclear Power Plant

Company:	Southern California Edison, El Segundo, CA, USA
Pump Type:	Goulds vertical pump, 4-stage
Application:	Plant cooling water intake screen wash pump
Problem:	Excessive abrasive wear
Solution:	Thordon SXL bowl and shaft bearings, Nine bearings with 11/4" (31.8mm) shaft
Installation:	Sept. 94, replaced bronze having relatively short life
Results:	Have not been inspected to date
Reason for selection:	Evaluation of Thordon and success in plant with Thordon on condensate pump application dating from mid 1980's.

효성그룹
효성EBARA주식회사

본사 : 121-020 서울시 마포구 공덕동 450
TEL : (02)707-6114 FAX : (02)711-5501
창원공장 : 641-290 경남 창원시 웅남동 43-1
TEL : (0551)61-0141 FAX : (0551)61-0142

HYOSUNG EBARA CO., LTD.
43-1 Unam-Dong, Changwon
641-290

SHINSHIN ENGINEERING CO., LTD.
5-6 3KA, Ulchi-Ro, Joong-Ku
Seoul 100-193, Korea

Date : 1997. 3. 5

Gentlemen,

APPLICATION : THORDON SXL BEARING FOR VERTICAL PUMP

The first application of Thordon SXL Bearing was made to vertical pumps of Young kwang Nuclear Power Plant Project in May of 1991.

At that time, we fitted total 104ea of Thordon SXL Bearings into two types of vertical pump-60ea of bearings were fitted for 90mm shaft diameter and 44ea for 70mm shaft diameter. Those were designed to operate by dry start-up for a limited period of time, pre-lubrication with cooling water was eliminated.

The Thordon SXL Bearings have been in good condition with no visible wear shown.

We have the record that more than 250 units of vertical pumps are good service with Thordon SXL Bearing as of this date.

Yours truly,
HYOSUNG EBARA CO., LTD.

W. S. LIM
Plant Manager

Kang, John J. - Dir, Maintenance

To: Bill Coppedge, Coppedge Marine
Subject: Use Of Thordon Bearings At JEA

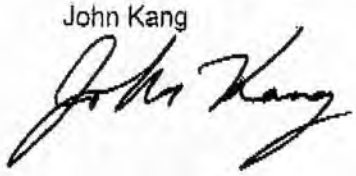
Bill, I just want to drop a line and thank you for your excellent service you have provided JEA over the years. Your follow up and professional service during the past 4 years of Thordon material evaluation and testing at JEA is greatly appreciated. This fall JEA made the final decision to utilize Thordon bearings as the exclusive material for all of our river front Circulating Water Pumps.

During 4 years of testing, Thordon GM2401 has held up well under brackish, high silt, river water application on 500 HP vertical shaft Circulating Water pumps at Northside Station. In one incident one of the pumps ran with minimal seal water for 24 to 48 hours due to a clogged seal water strainer. I am not suggesting that GM2401 can run dry for long periods but past experience with a different bearing material would have been catastrophic. This pump continues to operate 2 years after the incident, for a total of 4 years of operation with no deviations in vibration which is the primary indicator of pump bearing wear. We believe that Thordon 2401's superior material characteristics over cutlass rubber enable it to be more resilient, and resistant to silt and sand impregnation which result in longer wear and stable pump operation.

Cudos to your product and best of continuing business with JEA. We have initiated complete inventory switch out of our cutlass bearings for all circulating pumps with Thordon GM 2401.

Sincerely yours.

John Kang



Director of Maintenance
Jacksonville Electric Authority
Jacksonville, Florida, U.S.A.

NADELLA

Nadella GmbH

T E L E F A X: 001 / 905 / 335 0209

Cornelia Ludewig
Lilly-Reich-Str. 5
D-31137 Hildesheim
Telefon 05121 / 26 53 65
Telefax 05121 / 70 47 63

Bereiche:
- **NADELLA** Nadellager Führungssysteme und Linearachsen
- **THK** LM System
- **THORDON** Gleitlagerwerkstoff
- **PACIFIC BEARING** Gleitlager

THORDON BEARINGS INC.
Burlington, Ontario, Canada

Attn. Frank Trivieri

Copy:

No. of Pages: 1

cc: RW

From: Gerhard

KSB / Thordon Composite Tests

Frank,

KSB have sent us the following assessment of the Composite material (translation):

> „We have tested the Thordon Composite material in our test stand for radial bearings. A steel housing coated with chrome-carbide was used as counterpart. The bearing was run 100 h with a sand concentration of 300 mg/l. After finishing the test the surface of the Thordon bearings was unchanged. The housing showed a slight wear (5-10 µm) in the loaded area. The housing surface is evenly, no grooves could be found.
>
> Compared to all other materials we have tested so far with regard to sand wear, Thordon Composite ranks as one of the best materials."

Best regards,

i.A. Cornelia Ludewig

for Ronald Wolff

KIRLOSKAR BROTHERS LIMITED

Enriching Lives

TO WHOMSOEVER IT MAY CONCERN.

We do hereby declare that we are regularly procuring Thorden Bearings from M/s. Om Engineering Corporation for water lubricated vertical Turbine Pumps Designed, Manufactured and supplied by us for different pumping system for domestic and export projects. Performances of these bearings are satisfactory.

We wish M/s Om Engineering Corporation success and prosperity in their business endeavor.

For KIRLOSKAR BROTHERS LTD.

AUTHORISED SIGNATORY.

Vitthal M. KULKARNI
Associate Purchase Manager
SDL-IV

A Randall Publication

PUMPS & SYSTEMS

ROTATING EQUIPMENT

The Magazine for Pump Users Worldwide

June 2001

Pumping and Protecting the Everglades

Step-by-step procedures for ANSI pump installation

Easy, cheap and reliable: oil sump lubrication

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Non-metallic Bearings: Mature Marine Technology Meets a Difficult Fluid-handling Challenge

Moving lots of water through the Everglades

Brad Wilson
with Bill Coppedge,
Principal,
Coppedge Marine
and Industrial

For years now, non-metallic elements have been making inroads into the fluid-handling industries.

Elastomers, ceramics and composites all have found their way into a variety of wetted-part applications traditionally handled by metals. Chemical compatibility, corrosion resistance, low weight and ease of machining have led to these materials being used in the construction of seals, impellers, and even whole pumps. In the Everglades, a non-metallic material now has been introduced successfully into a different pump element, the shaft bearings. Traditional concerns, such as strength of material, and resistance to abrasion, played a role in the process. The primary impetus for the change, however, was waste minimization. In this application, the low-friction properties of the new material allow for the use of process-fluid lubrication, thus removing the need for greasing, and eliminating a grease discharge to a sensitive ecosystem.

The Setting

The Florida Everglades, at one time, was a vast floodplain in south Florida. Known as the "River of Grass," the water originated in and freely flowed from lakes south of Orlando, through the Kissimmee River and Lake Okeechobee, and then through the Everglades to Florida Bay and the Gulf of Mexico

In 1947, Congress authorized the Central and Southern Florida Project, to drain the land for agricultural purposes, and to protect people from hurricanes, flooding, droughts and fires. The Project encompassed diverting floodwaters away from low-lying agricultural and populated areas via a system of pumping stations and a network of flood-control canals. When the Project was designed in the 1950s, only about 500,000 people lived in the region. Today's population is about 6 million people, and is growing by as many as 15,000 new residents per month. The south Florida landscape has changed.

Drainage of the wetlands and changes to the natural variability of water flows have altered the Everglades ecosystem on a regional scale. As significantly less water has flowed through, there has been a reduction in resident wading-bird populations as well as in migratory-bird breeding within the area, and a decline in important fish populations in neighboring estuaries. With the increase in agricultural development and the loss of the "natural filtration" provided by the wetlands, water quality has declined.

The drainage also has contributed to the water-supply problems of the burgeoning population. Water consumption, mostly supplied by groundwater wells, has soared. Water shortages are frequent, and saltwater intrusion into local aquifers is evident, at the same time that up to 1.7 billion gallons of Everglades drainage is discharged to the ocean each day.

Efforts at ecological restoration and at water management for south Florida have culminated in the Comprehensive Everglades Restoration Plan, authorized under the Water Resources Development Act of 2000. Under this ambitious and

Photo 1. S-9, a retrofitted pumpstation and its environs

high profile plan, fresh water that is currently diverted to the ocean will be retained and treated for use. Specifically, the water will be stored in more than 217,000 acres of new reservoirs and wetlands-based treatment areas, and in 300 underground aquifers. Of this "newly" captured water, 80% will go to the environment and 20% will be used for urban and agricultural supplies.

The South Florida Water Management District (SFWMD) is responsible for operating and maintaining existing pumping stations built prior to the Everglades Restoration Project, as well as new stations specifically built for the work. Most of the existing stations were built for wetland drainage under the 1947 Central and Southern Florida Project, and have been in operation up to 50 years. Pumps in these facilities, both vertical and horizontal, use greased bronze for shaft bearings.

The Problem

As the District's mission has evolved, the bearings have come under increased scrutiny. Materials acceptable for ocean discharge can be viewed as contaminants when redirected to land applications or human use. According to Fred Remen, Director of Field Operations for the SFWMD Central Region, the use of petroleate lubricants had been discontinued out of environmental concerns. The District has been using biodegradable, food-grade lubricants "for years now," with good results. These materials degrade quickly with little impact—especially in Florida sunshine. But, Remen says, biodegradable grease was "still a waste stream," and not a very cheap one, at that.

The District manages a 16-county area, and deals with a variety of waters. Some are quite clear. Others contain significant solids, many abrasive. All of it, though, is water. "We pump fresh water," says Remen, and "we might as well take advantage of it."

Typical of the existing pumping stations is the S-9, with three pumps (Photo 1). Remen, who has a Merchant Marine background, noted that the 1710-HP diesels, each driving an 11-ft stainless steel impeller, were essentially "marine engines." (In fact, two newly built pumping stations are even fitted with actual marine engines. Drive engines recovered from an Alaska Ferry, and overhauled to the manufacturers specifications by District personnel, drive two of the six pumps. Generator engines from decommissioned naval vessels power the other four.)

Another engineer on the project carried the analogy even further. According to Butch Dias, who is also a former Merchant Marine, the pumping stations were essentially moored ships, revving their props. The ship doesn't move, but the water does. Water-lubrication of shaft bearings is a mature technology in the marine industry. That's why Remen turned to a marine-supply distributor several years ago.

Technology Transfer

The marine distributor worked with Remen to select a candidate bearing material. A proprietary elastomeric polymer was chosen because of its abrasion resistance, dry start-up capability, and extremely low coefficient of friction. Because this application would be a retrofit, ease of machining and installation were also considerations.

The choice seemed natural. There were probably boats, using the candidate material, plying the same waters that the stations were pumping. The material has been in use, in marine applications, since the 1970's. It is commonly used on ocean-going vessels, from yachts to cruise ships, as water-lubricated bearings for the prop shafts. Because of its durability and low-friction, this material also finds use in the hinge bushings for ship rudders. While most people in the shipyards are familiar with the material—marine use still represents over 70% of all sales—it is only now "coming of age" in industrial applications.

Photo 2. Bronze and elastomer, side by side

Photo 3. Fitting to the shaft

The long-time marine-industry experience with these nonmetallic bearings seemed to practically guarantee its success in the pump stations. These bearings already had demonstrated a capacity for long life submerged in dirty-water environments. Their abrasion resistance was superior to that of bronze. Also, as an elastomer, they showed considerable "shape memory," returning to original shape after temporary deformations. Finally, and most importantly, they were able to perform grease-free in aquatic environments (Photo 2).

In the first test case, the manufacturer relined the old bronze bearing housing with the new material, and shipped it back to the District. Based on 1 1/2 years of satisfactory service, a second pump was refitted the same way, with the custom-fit bearings bonded into the existing housing. Over time, as District personnel gained confidence in and familiarity with the material, and as a cost and time saving measure, this procedure was changed. The split bearing material, with OD machined, was shipped to the District, where the element was bonded into the housing and the ID was machined in-house (Photo 3).

The Results

That original, retrofitted pump now has been in service for seven years. Additional conversions across the system are being done as time and finances allow, and a number of other individual pumps have been operating for several years with the new bearings. The first entire pumping station, S-9, was refitted three years ago and has been deemed a success. Over time, the District intends to refit all existing vertical pumps with water-lubricated bearings. Moreover, in 1996, the local Jacksonville District of US Army Corps of Engineers modified its purchase specifications to incorporate this innovation in new pumps, as well.

Further extensions of marine technology to freshwater management are also in the works. Reminiscent of its use in ship rudders, the bearing material is now under consideration as a non-metallic, greaseless bushing for floodgate hinges.

Butch Dias inherited the conversion project after a promotion for Fred Remen some time ago. Dias hopes to have all small turbines in the District retrofitted for water-lubricated bearings in a year or so. Rework of all the 42 pumping stations will proceed as budgets allow. Working with 45-50-year-old pumps, in the face of budget and staffing constraints, he recognizes that operational and maintenance costs can be more significant than purchase price. Each conversion reduces the consumption of both time and materials by this far-flung system. Dias expects these long-lived bearings, and their elimination of the need for active lubrication, to contribute to the bottom line. Though the environmental benefits of his actions are more difficult to quantify, he believes use of these bearings is clearly the "right thing to do. ■

Bill Coppedge is a principle with Coppedge Marine and Industrial, a parts distributor and technical-services provider in Jacksonville, FL. The Coppedge family, with long marine experience, operated a shipyard prior to opening their distributorship in 1982. For more information on the applications and products referenced in this article, contact Mr. Coppedge at 904-398-9586, or Craig Carter at Thordon Bearings, 905-335-1440.

Editor's Note: Process-fluid lubrication figures prominently in recent efforts to simplify processes. Waste-minimization, in a considerably different environment, contributed to the novel bearing design in another project, presented elsewhere in this issue (see "Innovative Pump Solves Nuclear Waste Dilemma – Part II"). Process-fluid lubrication also allowed for the simplification of a new energy project covered in a Pump-Zone.com online bonus article for April. If you missed it, you can still access www.pump-zone.com and go to "Archives" to read about "Development of a High-Temperature, Long-Shafted, Molten-Salt Pump For Power Tower Applications."

THORDON SELECTED FOR WORLD'S LARGEST PUMPS

Kirloskar Brothers Limited (KBL) of India, has recently ordered Thordon SXL pump bearings for installation in large vertical turbine and horizontal split case pumps for the Sardar Sarovar project in the west Indian state of Gujarat. KBL won the order to provide the pumps for the world's largest pumping system, comprising five pumping stations and a total of 48 pumps. The system will lift 410,000 L (108,000 US Gal.) of water per second from the Narmada river providing irrigation and drinking water to 132 drought-affected towns of the Saurashtra region of Gujarat.

Incorporated in 1920 and certified to ISO 9001 and 14001 standards, Kirloskar Brothers Limited, is acknowledged as India's leader in fluid handling and the largest manufacturer and exporter of pumps. KBL's product range includes a wide range of centrifugal pumps for agriculture, domestic, industrial, process and general applications as well as large vertical pumps and concrete volute pumps for power projects, water supply and irrigation schemes. Pumps sizes range from 0.375 KW to concrete volute pumps of 4500 KW.

Thordon SXL pump bearings

Shaw Engineering Corporation, Thordon's Industrial Distributor in India has been supplying Thordon bearings to KBL for over 18 years. Thordon SXL continues to be KBL's preferred pump bearing as a result of its dry start-up capability, long wear life and superior service, quality and delivery. ■

Vertical Lift Pumps Now Fitted With Grease-Free SXL Bearings

During a routine statutory shutdown of PetroSA's offshore FA Platform in Mossel Bay, South Africa, existing rubber bearings in the vertical main seawater lift pumps were replaced with Thordon grease-free SXL pump bearings. The statutory shutdown is part of PetroSA's operating permit which allows opportunity for inspection and repair of critical equipment in order to ensure its integrity.

In total, 20 Thordon bearings were supplied for their 39m (128') vertical Ingersoll-Dresser pump which included 17 shaftline bearings and three bowl bearings. The initial need to overhaul the pump came from the poor performance experienced with the rubber bearings. The hope was to use the existing spiders even though they were worn from the previous rubber bearings turning in the housing. The local Thordon distributor - Alignment With Laser (AWL), pump manufacturer - Flowserve, along with Thordon engineering were able to create a solution that did not require new spiders to be purchased. Using the existing spiders, even though they had experienced wear, dramatically reduced the cost on the project. If the decision had been to go back to rubber bearings, new spiders would have been mandatory since they had worn to over the standard size.

Thordon SXL pump bearings are easy to machine and install. The bearings were machined at a local machine shop to sizes that were generated by the Thordon Bearings Sizing Calculation Program and dry ice was used for quick and easy installation of the bearings into the housing. PetroSA was on hand to witness the first bearing being installed and to verify the fit of the bearing into the housing. With the success of this project, PetroSA are looking at other applications to incorporate Thordon grease-free SXL bearings. NW

PetroSA's Offshore FA Platform in Mossel Bay, S. Africa

Easy to install Thordon SXL pump bearings

Thordon SXL pump bearings installed into existing bronze

MAKING A CASE FOR NON-METALLIC PUMP BEARINGS

This article will discuss some of the issues associated with vertical pump bearings in general, and non-metallic bearings specifically. Non-metallic bearings may not be the best answer in every case but have been an excellent choice for a great many applications worldwide. In general, these will be product lubricated bearings thus precluding additional contaminants (oils, greases) infiltrating the pumped fluid.

Non-metallic materials include rubbers, synthetic rubbers (elastomers), plastics, graphite based materials, ceramics and lignum vitae.

Design

When selecting bearings for a given application, there are many design issues to be considered involving aspects from both bearing and pump design. Bearings in a vertical pump are a necessary machine component forming the basic support structure for the power transmission system from the driver to the impeller(s). This system must be designed and selected with all the pertinent mechanical aspects considered to ensure that the overall performance will be satisfactory for the pump operating life. If the pump design and operating conditions are not carefully explored, the bearings being the weak link in the chain will indicate distress well before other components in the pump are affected. This is true whether the issue belongs specifically to the bearings or the pump.

Bearing Considerations

The typical length of non-metallic bearings conforms to L/D ratios ranging from 1 to 1.5. Bearing stiffness values for the general range of pump shaft sizes will be equivalent to metallic bearings from a shaft and column dynamics standpoint.
Loading of vertical pump bearings is difficult to analyze in general. It will normally be fairly light establishing bearing stability as a significant issue. While typical pump speeds are not high enough to develop serious observable instability effects, such activity may have detrimental outcomes on the life of a bearing.

Grooves in the bearing will tend to develop centering forces and small side loads may result from the stack up of tolerances during the assembly stage. For this situation, minor assembly offsets may be a good thing, resulting in improved operating stability.

Bearing clearances must be adequate to allow free running of the bearings but not so large as to compromise the important shaft support mechanism provided by the bearing. Typical running clearances will be 0.0015 mm/mm (0.00006 in./in.) of shaft diameter with a minimum of 0.08 mm (0.0031 in.). In the case of non-metallic materials, consideration must be made for fluid absorption and thermal expansion. These allowances, although less for Thordon than for most other materials, must be considered and may be minimized by reducing wall thickness to minimum values. In any case, the operational dynamics of the pump will be dependant on establishing correct running clearances between the shaft and bearing.

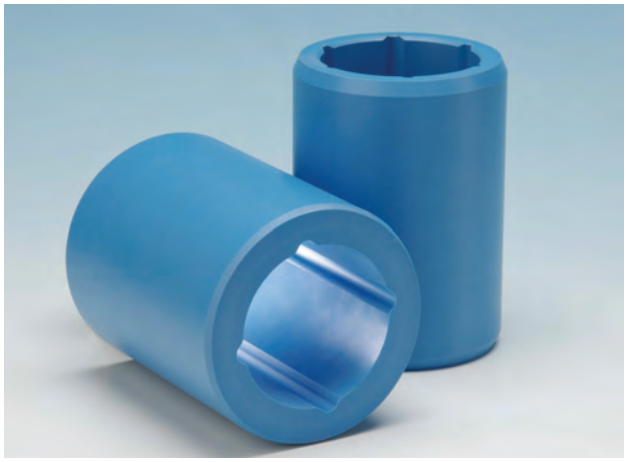
Standard pump sleeve materials such as 400 or 300 series stainless steels will function well with Thordon. For salt or brackish water applications, better corrosion resistance will be experienced with the 300 series or duplex type stainless steels. If significant abrasives are present in the pump fluid, enhanced life of the bearing system will be achieved with hardened sleeves. In such case, superior performance has been achieved with Thordon GM2401 material mated with nickel chrome boron (NiCrB) coated shaft sleeves.

In general, grooves should be provided to allow adequate flow through the bearing and to allow easy passage of any abrasive particulate debris. Some smaller bearings (under 50 mm or 2 in. shaft dia.) operating in clean fluids may work well without grooves. In either case, the recommended supply of clean water must flow through the bearing to ensure adequate lubrication and cooling.

Pump Issues

Bearing spacing is the province of the pump designer, but is often an issue for pump re-builders if bearings of different materials are contemplated. The preferred design approach is to provide a shaft/bearing system stiffness having the first bending critical of the shafting above the operating speed by a margin of 10 to 20% (stiff shaft design). However, for small shafting

...continued on back



ThorPlas® pump bearings offer a broader chemical compatibility and higher operating temperatures than other Thordon grades

...continued from page 5

Elastomeric Thordon SXL pump bearings offer excellent load distribution, low coefficient of friction and dry start-up capability

20% (stiff shaft design). However, for small shafting using more flexible bearings such as rubber, it has been well accepted to design based on the operating speed falling between the first and second bending critical speed (flexible shaft design).

The above shafting criticals must be determined using the stiffness values for the actual bearings and support system in use. The stiffness of a Thordon bearing will be large enough in comparison with typical shaft bending stiffness to be considered equivalent to a metal bearing for establishing spacing requirements. Use of a less stiff rubber material may require closer spacing of the bearings or a change in philosophy to the flexible shaft design.

Most of the installed vertical pumps worldwide do not have any lateral structural support below the pump mounting floor. This means that the casing holding the bearings, which are supporting the shafting, is itself quite flexible and subject to the possibility of resonance in the operating speed range. If this issue is not carefully investigated in the design of the machine, the bearings may suffer odd wear patterns which may not be easily interpreted.

Many vertical pumps are located in sumps without proper attention to approach velocities, or clearance guidelines provided in the literature for bottom, back wall, sidewall, or neighboring pumps. This may result in cavitation and/or separation producing excessive turbulence in operation. In addition, if minimum submergence recommendations by pump manufacturers are contravened, vortexing may be generated allowing air to be entrained in the suction flow with associated undesired machine vibrations.

Many pumps are operated across the performance curve without appropriate consideration for the best efficiency point. If a pump is highly throttled, or allowed to run out well beyond best efficiency point, excessive vibration can again result with possible overheating and damage of product lubricated bearings.

It is common practice to dynamically balance impellers of vertical pumps to ensure smooth operation without vibration. However, if an impeller core shifts in the casting process, it will not only result in mechanical unbalance, but hydraulic unbalance as well. No amount of dynamic balancing can correct for the latter condition which may lead to excessive vibration and shorter bearing life.

Advantages of Non-Metallic Bearings

There are several advantages offered by non-metallic bearings such as impact capability, low friction, self-lubricating qualities, edge loading capability. Most non-metallics, Thordon included, offer significant electrical resistance. As a consequence stray currents will not be a factor in bearing erosion, and a connection point is not provided for galvanic activity.

The significant advantages of using non-metallic pump bearings will ensure many years of excellent service life provided the various design issues imposed upon the pump and system are carefully investigated and considered in the pump design or re-build stage prior to putting the machine into service.

Written by:
Dr. Keith Laskey, PhD.,
Chief Design Engineer,
Thordon Bearings Inc.

THORDON SXL APPROVED FOR DEEP WELL PUMPS IN ARIZONA

Ensuring the water supply for residents of the driest desert in North America - the Sonora - isn't a task that Salt River Project (SRP) takes lightly. Through a system of reservoirs, canals, irrigation laterals and more than 250 deep wells, the organization delivers nearly 1.2 billion m^3 (1 million acre-feet) of water to central Arizona; a vast area that includes Phoenix and other surrounding cities, plus a myriad of towns and rural villages.

SRP is actually a combination of two cooperative entities: The Salt River Project Agricultural Improvement and Power District, a political subdivision of the State; and the Salt River Valley Water Users' Association, a private corporation.

"The organization is very careful when it comes to selecting components for its systems," says Mike Helfrich, President of Michael & Associates Inc., Thordon's distributor in Arizona. "Water is a huge issue in this State, and residents take quality, supply and conservation very seriously."

Oil And Water Don't Mix

Traditionally, SRP uses oil-lubricated metal bearings in their deep well pumping applications. This material works fine, but has some distinct disadvantages. Unlike oil-lubricated metal bearings, Thordon SXL would not fail catastrophically. This is significant", says Helfrich, "because the cost of pulling a pump out of the ground for repairs averages US $30,000 to $80,000! Costly maintenance and repairs, particularly unscheduled maintenance, are a big concern".

In addition, there are environmental and esthetic issues. Minute amounts of oil from the pump bearings can potentially make its way into the water supply. The oil used is mineral oil and, therefore, harmless. However, it could create an unsightly sheen if it were to find its way into the drinking glasses of Arizonians.

Fortunately, there is a solution. "We introduced the folks at SRP on the advantages of water- and product-lubricated Thordon SXL pump bearings in 2001," says Helfrich. "Three years ago they finally decided to put the product to the test."

Putting Thordon To The Test

The initial project involved replacing the metal bearings in one of the deep well pumps with Thordon SXL in March 2002. SRP worked in tandem with Michael Helfrich's team and the engineers at Thordon on the new design.

Rather than completely re-configuring the well for open spider bearings, the project team converted the enclosed tube, oil drip system, so that the existing column and coupler bearings could be used.

The results in terms of performance? After three years and almost 20,000 hours of operation, the Thordon SXL bearings are still operating within specifications. There have been no problems. And no sign that the bearings need to be replaced.

In terms of water quality and environmental concerns, Thordon SXL uses water exclusively as a lubricant. Oil has been completely taken out of the equation. It's no longer an issue.

Tom Frost, Pump Specialist at SRP, added, "…we are impressed on how well the Thordon bearings have performed. The bearings in the well installed in 2002 have over 20,000 hours of run time and are still operating with no problems."

Water Lubricated SXL Bearings Installed In SRP Deep Well Pump, Arizona, U.S.A.

Other Water Management Authorities

The performance of Thordon SXL in water supply applications has made other jurisdictions take notice.

The City of Scottsdale, for example, has specified Thordon SXL bearings for their re-charge wells and recently ordered 320 bearings. The City of El Paso has also installed Thordon SXL bearings for two water supply pumps for their new reverse osmosis system.

"Many water treatment facilities are switching from flocculating as a means to take contaminants out of the water to reverse osmosis," Helfrich points out. "But the membranes used in this process are very sensitive and cannot tolerate oil. That's what makes Thordon's oil-free bearings so attractive."

Oil and water don't mix. But oil-free Thordon SXL bearings and deep well pumping applications are fast becoming a perfect match.

GM2401 SHOWS NO VISIBLE SIGNS OF WEAR IN DIRTY WATER PUMP APPLICATION

When the engineers at Peach Bottom Atomic Station (Pennsylvania, USA) needed to improve the facility's river water circulation system, they were faced with two options: a costly upgrade of the water filtration system by installing new corrosion-free piping to protect the current bearings; or, a much less expensive upgrade of the Bingham pumps by replacing the bearings with Thordon GM2401. They choose the latter. Two years after installation, an inspection has revealed no visible signs of bearing wear, despite the dirty water conditions.

"Obviously, the Peach Bottom engineers are very pleased," says Larry Bohn, Sales Engineer for Fleetwood Industrial Products, the Thordon Bearings distributor in Pennsylvania. "They now expect to get several years out of the bearings before replacement is required."

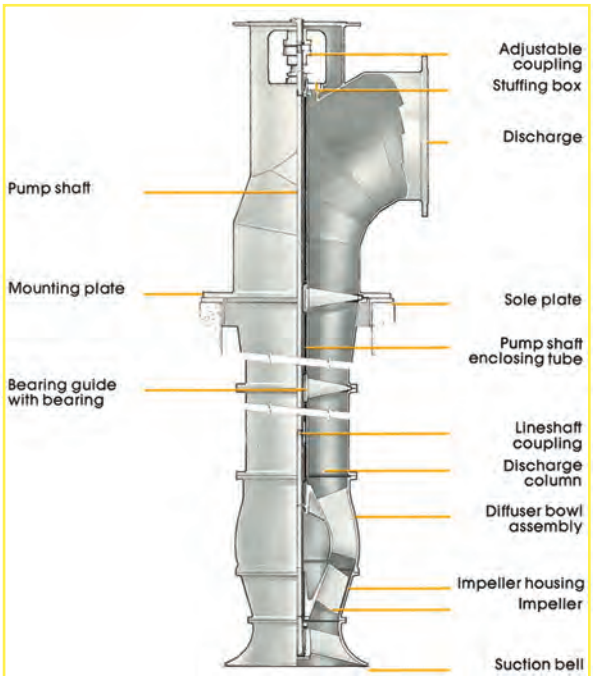
Long life in abrasive conditions

Thordon GM2401 is a tough elastomeric polymer bearing material that was introduced by Thordon in 1974. In applications around the globe, the product has demonstrated incredible wear resistance in extremely abrasive environments when used in combination with a hard shaft surface. The bearing material has significantly outperformed rubber - often by a factor of two or more - in pump and propeller shaft bearing applications.

"We needed reliable, water-lubricated pump bearings that could stand the test of time in abrasive-laden water conditions," says Phillip Hennessy, Equipment Reliability Engineer for Exelon Nuclear, the operator of the station. "Thordon was the obvious choice."

Peach Bottom Atomic Power Station is situated on the Susquehanna River in York County, Pennsylvania, U.S.A. Peach Bottom has two boiling water reactors, which jointly produces over 2,300 megawatts. The station is co-owned by Public Service Electric & Gas of New Jersey and Exelon Corporation.

River water is circulated throughout the facility and is used for cooling a variety of systems and components. Although Susquehanna waters are relatively clear on most days, rain and other weather conditions can stir up silt from the river bed. These particles remain suspended in the water and are highly abrasive.



Bingham SAFV Vertical Pump with Thordon GM2401 Bearings (Photo Courtesy of Sulzer-Bingham)

A world of references

During plans to upgrade the river water circulation system, Peach Bottom engineers were enthusiastic - yet cautious - about a bearing material that claimed to perform well in dirty water. Replacing the pump bearings would be significantly less costly than replacing the piping. Yet, convincing evidence was required before Thordon GM2401 could be specified.

"That's where that staff at Thordon was very helpful," says Bohn. "The Peach Bottom people were definitely impressed by what we were telling them [about the bearing material], but they wanted to contact references before making a final decision."

Fortunately, references were not a problem.

Thordon GM2401 is installed in dozens of hydroelectric and pump systems worldwide. Numerous references were available involving applications that were just what the Peach Bottom engineers were looking for: large, vertical pump bearings operating in dirty river water and seawater. "Those references really helped us close the deal."

Peach Bottom is now another application of a long history of successes featuring Thordon GM2401. The bearings have been operating for approximately two years; running on 215 mm (8.5 in.) nickel-chrome-boron coated sleeves in the six Bingham pumps with a capacity of 250,000 GPM. Divers were recently sent into the river to inspect for bearing wear. They didn't find any. "In fact," says Hennessy, "they described the bearings using just one word: pristine."

PUMP REPAIR BUSINESS GROWS WITH THORDON

"If Thordon bearings worked well in propeller shaft and rudder bearing applications, wouldn't they would work equally as well in pump applications." This was the thought of Odd Brevik, former Marine Engineer with Texaco, and current President of New England Pump & Valve, in Connecticut, USA.

After spending over 20 years travelling the world keeping Texaco ships running smoothly, Brevik decided that it was time to stay at home for a while and started up his own pump repair business in 1986.

One of Brevik's first customers was Pfizer Global Research & Development located in New London, Connecticut. Pfizer was having bearing problems in their large vertical turbine pumps. The bronze bearings were only lasting approximately 18 months due to the abrasive brackish water. Brevik contacted Thordon and was referred to Eric Nitsch at Johnson Packings and Industrial Products, Thordon's Distributor for Connecticut. After reviewing the application with Johnson Packings, Thordon SXL pump bearings were recommended.

Typical vertical turbine pumps

As Brevik has a large machine shop, Johnson Packings showed him how to use the Thordon Bearing Sizing Calculation Program to size the bearings, how to easily machine the elastomeric polymer bearings and how to freeze fit the bearings using liquid nitrogen. Pfizer currently have over 6 year's life from the Thordon SXL bearings installed in 1996. And the four bearing replacements avoided to date by converting to Thordon means Pfizer has saved a lot of downtime money.

Brevik also used Thordon to eliminate oil pollution from large Johnson flood control pumps operated by the City of Stanford, CT. "The bearings in these pumps were oil lubricated and originally had to be hand cranked to achieve the required oil pressure. I recommended using water lubrication by replacing the bearings with Thordon and upgrading to a stainless steel 316 shaft. After installing a solenoid valve and PLC that fills the housing with water should the pump ever run dry, City of Stanford eliminated any source of oil seeping into the river," says Brevik.

"I believe in using high quality products that give the best return to my customers," says Brevik. "Thordon bearings make my customers happy and when customers are happy, they tell other people and my business grows. Thordon bearings last longer, they eliminate grease or oil and they are so damn easy to work with," says Brevik. "My biggest problem is trying to get pump equipment engineers to change from the existing metal bearings they have been using for years to try these new materials."

Odd Brevik of New England Pump & Valve

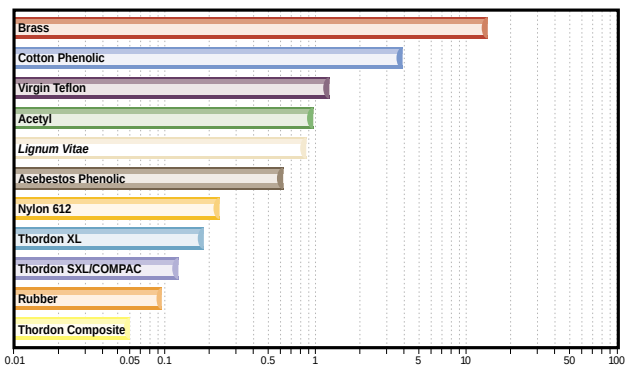
THORDON SOLUTION TO ABRASIVE-MEDIUM PUMP PROBLEMS

Sleeve bearings in vertical, medium lubricated pumps are a frequent source of problems. Poor shaft support, dry starts, high friction and rapid wear in abrasive services are some of the more common problems encountered. One of the common solutions to some of these problems is the addition of a sealed tube around the shaft with either a fresh water flush or oil/grease lubrication. This approach has a high initial cost and a continuing expense in the supply of fresh water or oil/grease and also has the potential for contamination of the medium being pumped. Jacksonville Electric Authority (JEA) of Florida has solved their abrasive wear problem by installing Thordon bearings.

Jacksonville Electric Authority has been using Thordon bearings in their riverfront circulating water pumps since 1996. "Over the past 3½ years, Thordon steel-backed GM2401 (Composite) bearings have held up well under brackish, high silt, river water application on 500HP vertical shaft circulating water pumps at Northside Station," stated John Kang, Director of Maintenance at JEA. John said, "In one incident, one of the pumps ran with minimal seal water for 24 to 48 hours due to a clogged seal water strainer. Past experience with a different bearing material would have been catastrophic." John added, "This pump continues to operate with no deviations in vibration which is the primary indicator of pump bearing wear. We have also had excellent follow-up and professional service during the past three years of material evaluation from Thordon's Florida Distributor, Coppedge Marine."

JEA has initiated a complete inventory switch to Thordon Composite from cutless bearings for all circulating pumps. John added, "We believe that Thordon GM2401's superior material characteristics over cutless rubber enables it to be more resilient and resistant to silt and sand impregnation resulting in longer wear and stable pump operation."

Typical Bearing Abrasive Wear Rates



Projected Bearing Wear by Volume
(Independent Testing at University of Cincinnati, USA)

UPDATE

ASIA GETS "PUMPED" ON THORDON

After 3 years of rigorous testing by Ebara Japan, Asia's largest pump manufacturer, Thordon SXL has proven to be Ebara's best choice for "friction free" (defined by Ebara as a bearing allowing dry running during pump start up and not requiring pre-lubrication) vertical pump bearings.

Thordon's first major Asian pump bearing success story began over 10 years ago in Korea where annual precipitation is high with occasional summertime rains of 500mm (20") in a 24 hour period. To manage these rainfalls, Korea's cities have built extensive networks of drainage pumping stations alongside the rivers to pump out the water.

The pumps used were commonly fitted with grease lubricated sealed bronze bearings and were leaking grease into the water. The bronze bearings were also failing due to insufficient lubrication when the grease hardened in the supply lines to the bearings. Shinshin Engineering Co. Ltd., Thordon's Korean Distributor, was consulted, and recommended that the seals be eliminated, the greased bronze bearings converted to water lubricated Thordon SXL and the grease lines be removed. "The engineers had serious concerns when we told them that with SXL, the pumps could be started dry and would not require pre-lube of the bearings that were not submerged," explained Mr. H.S. Park, Sales Manager of Shinshin Engineering. "They told us that dry running at start up was impossible! We were able, however, to show them tests that Thordon Bearings had conducted on behalf of Kirloskar Pumps of India showing Thordon SXL would survive dry running start up in their pumps. Even with these test results, it took a number of visits before we convinced them to convert a pump and try it. Finally they said okay, and agreed to go ahead if Shinshin Engineering took full responsibility for any problems. We agreed and supplied SXL bearings for a vertical pump with a 220mm (9") diameter shaft. We worked with them on the conversion and the pump has performed flawlessly."

"Since then, we have fully converted more than 10 pumping stations," said Mr. Park. "The engineers tell us that they never worry about grease polluting the water anymore; they save money because the bearings last longer, they don't have to purchase grease and maintain the grease lines; and when a pump has to be brought on line quickly they just push the start button with no worries about lubrication status."

A number of Korean pump manufacturers are now specifying Thordon SXL as their standard pump bearing.

"One of the Korean pump manufacturers who converted to Thordon was Hyosung Ebara and word of their satisfaction reached Ebara Japan," said Larry Leung, Thordon's Asian Sales Manager. Ebara Japan was using a teflon coated rubber bearing for dry running start up. Due to the teflon lining this bearing had low friction characteristics and performed well during dry running start up, but was quite expensive to manufacture. When operating in even small amounts of abrasives both the shaft and bearing experienced significant wear. Ebara was looking for an alternative product and contacted Japan Marine Technologies Co. Ltd. (JMT), the Japanese agent for Thordon industrial bearings. JMT supplied technical information and a set of SXL test bearings and in time were advised by Ebara that the bearings had failed. "After visiting the Ebara factory and reviewing the test procedure, we determined that the test pressure was almost 10 times the normal operating pressure and the dry running test time was greater than what was required," said Larry. "The combination of these two factors had resulted in failure of the bearings. We then asked Jeffrey Butt, Manager of Engineering Services for Thordon Bearings to work closely with the Ebara engineers to develop more realistic test procedures. The test was rerun with satisfactory results this time and Ebara went on to set up a very comprehensive series of tests including dry running at varying pressures and time intervals where they measured friction, wear and shaft vibration. Wear tests in dirty water were run as well."

"Ebara has told me that Thordon SXL performed better than expected and passed their entire series of tests," said Larry. "Bearing and shaft wear were significantly less compared to their existing locally produced bearing. In the future, Ebara plans to specify Thordon, having proven that SXL bearings will make their pumps simpler and even more reliable than in the past."

Thordon SXL Pump Bearings

THAT'S A LOT OF WATER!!

Moving water across the state of Arizona is by no means an easy task and, when that water has to be pumped up the side of an 870' (265m) high mountain at volumes as great as 3,000 cubic feet per second (85,000 litres/second), the need for pump reliability is critical.

Relying on six large 60,000 hp Hitachi pumps, the Central Arizona Water Conservation District pumps water from the Colorado River to an open cement lined canal. From there it passes through a mountain that is 7 mi (11km) long and comes out into an open aqueduct. The water then travels 356 mi (573km) across the state of Arizona from the Colorado River to Tucson, Arizona. During the trip, the water passes through 13 re-lift plants that pump the water up to the next elevation. Some water is then pumped into a 765,000 acre (3,096 km^2) storage reservoir for power generation and later use.

"The unique thing about our pump is that it is a single stage centrifugal pump that pumps water on a 45 degree angle up a mountain that is about 870' (265m) high," says Glenn Weddle, Supervisor of Mechanical Maintenance. "By the time the water reaches the top of the mountain you have about 400 psi (2.75 MPa) head pressure. In similar projects requiring that type of lift, two or three stage pumps or two different pumping stations staged progressively up the mountain are usually used." Glenn added, "We don't pump year round, but during the heavy pumping season (typically about 5 months of the year), these units run 24 hours a day each pumping 500 cubic feet/second (14,166 litres/second)...that's a lot of water!"

"We were having sealing problems resulting from two different conditions," says Dick Gibson, Mechanical Engineer. "Due to the grit in the water, the carbon seals were wearing quickly causing downtime during our busiest time of the year. Secondly, we were also experiencing pitting of the shaft sleeve because of electrolysis resulting from the number of dissimilar materials in the stuffing box. We had stainless steel, cast steel, bronze, two rows of carbon seals and a row of phenolic impregnated material. Our first approach was to change the carbon seals to something which was more inert and the best product we could find was Thordon SXL."

Six 60,000 HP Hitachi pumps at the Havasu Pumping Plant, Arizona.

"The first trial with Thordon seals was about 5 years ago," says Dick, who did the initial research of the Thordon material to see if it would stand up to the challenge of their applications. "We had heard of the great results from the Bureau of Reclamation regarding the use of Thordon SXL at the Grand Coulee Dam. They had used SXL successfully in their seals, which are somewhat similar to ours, so we thought we'd try Thordon. Fortunately, it has worked out very well."

"During the initial installation, we had problems determining the proper reference points for machining the seals," says Glenn. "We were working with a very large diameter shaft - close to 42" (1067mm) - rotating at 514 rpm, which means the surface of the shaft is traveling at over 5500' (1700m) per minute. Initially, the Thordon seal did not expand as much as was originally factored into the machined dimensions, so we re-calculated and machined to tighter tolerances."

"We have had the pumps apart for overhaul several times and we are reasonably pleased with the results," says Glenn. "Sometimes the seals get hot and scorch the running faces so we take them into the shop, put them in a big lathe and bore them out; removing the burnt surface and bringing a new surface to the top, making it like a brand new seal." Glenn added, "Although the carbon seals could also be remachined, they did not seal as well as Thordon SXL. Unless we have something catastrophic happen, by remachining the faces of the Thordon seals occasionally, we expect them to last over 10 years."

As of June 1996, Thordon SXL is installed in all six pump turbines at the Central Arizona Water Conservation District.

"We are investigating converting the oil-lubed main guide bearings in some of our vertical turbine pumps to Thordon water-lubricated bearings for

environmental reasons, as well as exploring a few ideas on other auxiliary equipment," says Dick. "We have been really pleased with the success we've had with the Thordon seals in the pumping units. Thordon SXL is a good product that has multiple uses."

"We have been really pleased with the success we've had with the Thordon seals in the pumping units. Thordon SXL is a good product that has multiple uses."

Thordon SXL segmented shaft seals used in Central Arizona Water Conservation District pumps.

THORDON BEARINGS INC.

Vertical Pump Bearing References

Customer Name	Thordon Grade	Pump User	Country	Application	Manufacturer	Initial Installation Date	Shaft Diameter (mm)
Changsha	SXL	Zhejiang zhoushan	China		Changsha	Dec -2007	380
Changsha	SXL	Huaneng jinling shipyar	China		Changsha	Dec -2007	380
Changsha	SXL	Huaneng jinling power plant	China		Changsha	Dec -2008	380
KSB	SXL	Xianhe pump station	China		KSB Pumps	Dec -2008	380
Wuxi	SXL	Huaneng dezhou power plant	China		Wuxi	Dec -2008	380
Flowserve	Composite		Netherlands	Vertical pump bearings	Flowserve	Dec -2013	345
Taean Thermal Power Plant		Taean Thermal Power Plant	South Korea	Cooling Water Pump		Nov -2001	333
Danjin Thermal Power Plant		Danjin Thermal Power Plant	South Korea	Cooling Water Pump		Jul -1999	330
Danjin Thermal Power Plant		Danjin Thermal Power Plant	South Korea	Cooling Water Pump		Aug -1999	330
Danjin Thermal Power Plant		Danjin Thermal Power Plant	South Korea	Cooling Water Pump		Jan -2000	330
Taean Thermal Power Plant		Taean Thermal Power Plant	South Korea	Cooling Water Pump		Apr -2000	330
Taean Thermal Power Plant		Taean Thermal Power Plant	South Korea	Cooling Water Pump		May -2000	330
Taean Thermal Power Plant		Taean Thermal Power Plant	South Korea	Cooling Water Pump		Aug -2000	330
Taean Thermal Power Plant		Taean Thermal Power Plant	South Korea	Cooling Water Pump		Jan -2002	330

THORDON

THORDON BEARINGS INC.

Vertical Pump Bearing References

Customer Name	Thordon Grade	Pump User	Country	Application	Manufacturer	Initial Installation Date	Shaft Diameter (mm)
Danjin Thermal Power Plant		Danjin Thermal Power Plant	South Korea	Cooling Water Pump		Apr -1998	328
Danjin Thermal Power Plant		Danjin Thermal Power Plant	South Korea	Cooling Water Pump		May -1998	328
Danjin Thermal Power Plant		Danjin Thermal Power Plant	South Korea	Cooling Water Pump		Apr -1998	328
Danjin Thermal Power Plant		Danjin Thermal Power Plant	South Korea	Cooling Water Pump		May -1998	328
Changsha	SXL	Qingdao ocean oil base	China		Changsha	Dec -2008	320
Changsha	SXL	Zhejiang dongbang	China		Changsha	Dec -2007	320
Changsha	SXL	Tongyu river	China		Changsha	Dec -2008	310
Pyungtaek Thermal Power Plant		Pyungtaek Thermal Power Plant	South Korea	Cooling Water Pump		Mar -1998	300
Wuxi	SXL	Puyang jinti river	China		Wuxi	Dec -2008	300
Ingersoll Dresser Pump Compan	SXL	South Florida Water Brooksville, FL	U.S.A.		Ingersoll Dresser	Sep -2003	292
Youngkwang Nuclear Power Plan		Youngkwang Nuclear Power Plant	South Korea	Cooling Water Pump		Apr -1999	292
Youngkwang Nuclear Power Plan		Youngkwang Nuclear Power Plant	South Korea	Cooling Water Pump		Mar -1999	292
Youngkwang Nuclear Power Plan		Youngkwang Nuclear Power Plant	South Korea	Cooling Water Pump		Nov -1998	292
Youngkwang Nuclear Power Plan		Youngkwang Nuclear Power Plant	South Korea	Cooling Water Pump		Dec -1998	292

THORDON

THORDON BEARINGS INC.

Vertical Pump Bearing References

Customer Name	Thordon Grade	Pump User	Country	Application	Manufacturer	Initial Installation Date	Shaft Diameter (mm)
Youngkwang Nuclear Power Plan		Youngkwang Nuclear Power Plant	South Korea	Cooling Water Pump		Dec -1998	292
Youngkwang Nuclear Power Plan		Youngkwang Nuclear Power Plant	South Korea	Cooling Water Pump		Feb -1999	292
Youngkwang Nuclear Power Plan		Youngkwang Nuclear Power Plant	South Korea	Cooling Water Pump		Apr -1999	292
Youngkwang Nuclear Power Plan		Youngkwang Nuclear Power Plant	South Korea	Cooling Water Pump		Jun -2002	292
Wuxi	SXL	Ppuyang jindi river zhanglaozhuang	China		Wuxi	Dec -2007	290
Changsha	SXL	Wuxi maisheng	China		Changsha	Dec -2008	290
Samcheonpo Thermal Power Plan		Samcheonpo Thermal Power Plant	South Korea	Cooling Water Pump		Jan -2002	284
Florida Power Corp.	SXL	Florida Power Corp.	U.S.A.	Water Treatment Pump	ITT A-C Pumps (USA)	Feb -1996	283
Wuxi	SXL	Zhenjiang yihangdao water conservancy project	China		Wuxi	Dec -2007	280
Wuxi	SXL	Puyang jindi river	China		Wuxi	Dec -2007	280
Wuxi	SXL	Puyang jindihe	China		Wuxi	Dec -2007	280
Wuxi	SXL	Dalian dayang	China		Wuxi	Dec -2008	280
KSB Pumps	SXL	Huangdao power plant	China		KSB Pumps	Dec -2008	280
KSB Pumps	SXL	Yiyang power plant	China		KSB Pumps	Dec -2008	280

THORDON BEARINGS INC.

Vertical Pump Bearing References

Customer Name	Thordon Grade	Pump User	Country	Application	Manufacturer	Initial Installation Date	Shaft Diameter (mm)
Changsha	SXL	Changxin island	China		Changsha	Dec -2007	280
Changsha	SXL	Zou county power plant	China		Changsha	Dec -2007	280
Changsha	SXL	Yiyang power plant	China		Changsha	Dec -2007	280
Changsha	SXL	Beihai shipyard	China		Changsha	Dec -2007	280
Changsha	SXL	Changxing island shipyard	China		Changsha	Dec -2007	280
Changsha	SXL	Qiandong power plant	China		Changsha	Dec -2007	280
Samcheonpo Thermal Power Plan		Samcheonpo Thermal Power Plant	South Korea	Cooling Water Pump		Jan -2001	277
Samcheonpo Thermal Power Plan		Samcheonpo Thermal Power Plant	South Korea	Cooling Water Pump		Sep -2002	275
Samcheonpo Thermal Power Plan		Samcheonpo Thermal Power Plant	South Korea	Cooling Water Pump		Sep -2000	275
Wuxi	SXL	Nanhai jiujiang(heqing)	China		Wuxi	Dec -2008	270
Wuxi	SXL	Nanhai jiujiang(renyu)	China		Wuxi	Dec -2008	270
Changsha	SXL	Pingwei power plant	China		Changsha	Dec -2007	270
Changsha	SXL	Minquan power plant	China		Changsha	Dec -2007	270
Changsha	SXL	Wuhu power plant	China		Changsha	Dec -2007	270

THORDON BEARINGS INC.

Vertical Pump Bearing References

Customer Name	Thordon Grade	Pump User	Country	Application	Manufacturer	Initial Installation Date	Shaft Diameter (mm)
Changsha	SXL	Xuancheng power plant	China		Changsha	Dec -2007	270
Changsha	SXL	Luohuang power plant	China		Changsha	Dec -2007	270
Changsha	SXL	Hefei power plant	China		Changsha	Dec -2007	270
Changsha	SXL	Wenzhou power plant	China		Changsha	Dec -2008	270
Changsha	SXL	Minquan power plant	China		Changsha	Dec -2008	270
Changsha	SXL	Taicang harbor power plant	China		Changsha	Dec -2008	270
Changsha	SXL	Shanhaiguan shipyard	China		Changsha	Dec -2008	270
KSB Pumps	SXL	Wenzhou power plant	China		KSB Pumps	Dec -2007	270
ChangSha Pump Co., LTD	SXL			Vertical Pumps		Jun -2013	270
Kunsan Thermal Power Plant		Kunsan Thermal Power Plant	South Korea	Cooling Water Pump		Mar -1994	267
Uljin Nuclear Power Plant		Uljin Nuclear Power Plant	South Korea	Cooling Water Pump		Nov -2001	267
Uljin Nuclear Power Plant		Uljin Nuclear Power Plant	South Korea	Cooling Water Pump		Feb -2001	267
DaeHam	SXL	Woom Yang Pumping Station		Cooling Water Pump		Feb -2012	260
Wuxi	SXL	Qingdao ocean oil base	China		Wuxi	Dec -2007	260

THORDON

THORDON BEARINGS INC.

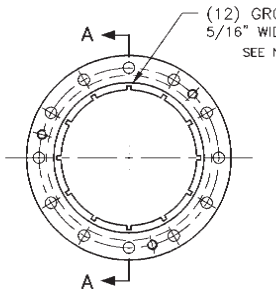
Vertical Pump Bearing References

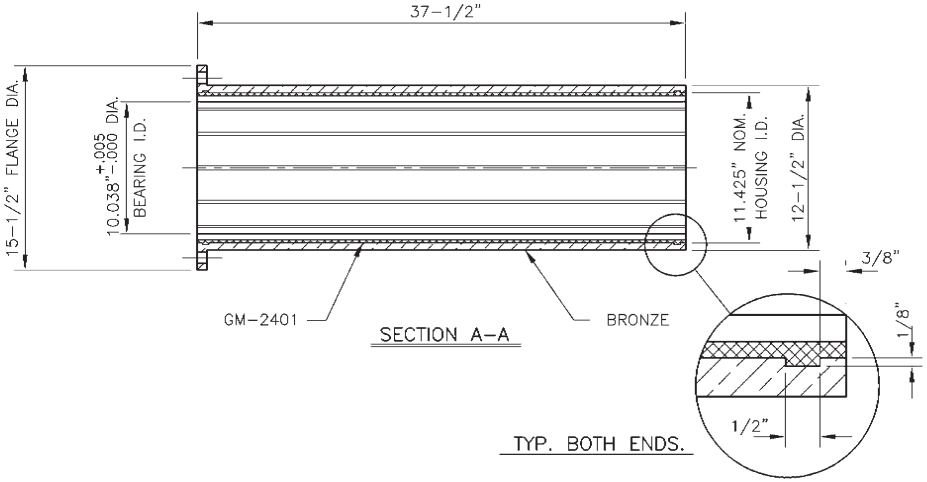
Customer Name	Thordon Grade	Pump User	Country	Application	Manufacturer	Initial Installation Date	Shaft Diameter (mm)
KSB Pumps	SXL	Hebei huangtan power plant	China		KSB Pumps	Dec -2008	260
Changsha	SXL	Wuxi maisheng	China		Changsha	Dec -2008	260
Changsha	SXL	Wuxi maisheng	China		Changsha	Dec -2007	260
Changsha	SXL	Tuyu river	China		Changsha	Dec -2007	260
Changsha	SXL	Vertical	China		Changsha	Dec -2006	260
Fairbanks Morse	SXL	Fairbanks Morse	U.S.A.	Waste Water Pump	ITT A-C Pumps (USA)	Feb -1996	257
ITT A-C Pumps (Canada)	Composite		U.S.A.	Flushing Pump		Nov -1993	256
	SXL	Tam Am Thermal Power Plant				Dec -2012	254
Danjin Thermal Power Plant		Danjin Thermal Power Plant	South Korea	Cooling Water Pump		Apr -1997	252
Kunsan Thermal Power Plant		Kunsan Thermal Power Plant	South Korea	Cooling Water Pump		Dec -1994	250
Yeosoo Thermal Power Plant		Yeosoo Thermal Power Plant	South Korea	Cooling Water Pump		May -1998	250
Wuxi	SXL	Chanjiagang power plant	China		Wuxi	Dec -2007	250
Changsha	SXL	Mashashan power plant	China		Changsha	Dec -2007	250
Changsha	SXL	Liyujiang power plant	China		Changsha	Dec -2007	250

THORDON BEARINGS INC.

Vertical Pump Bearing References

Customer Name	Thordon Grade	Pump User	Country	Application	Manufacturer	Initial Installation Date	Shaft Diameter (mm)
Changsha	SXL	Fangchenggang power plant	China		Changsha	Dec -2007	250
Changsha	SXL	Qinbei power plant	China		Changsha	Dec -2007	250
Changsha	SXL	Kaifen jingyuan power plant	China		Changsha	Dec -2007	250
Changsha	SXL	Huanjinbu power plant	China		Changsha	Dec -2007	250
Changsha	SXL	Fei county power plant	China		Changsha	Dec -2007	250
Changsha	SXL	Qingdao tuoliu	China		Changsha	Dec -2007	250
Changsha	SXL	Xianfan power plant	China		Changsha	Dec -2007	250
Changsha	SXL	Dabieshan power plant	China		Changsha	Dec -2007	250
Changsha	SXL	Huilai power plant	China		Changsha	Dec -2007	250
Changsha	SXL	Caohu power plant	China		Changsha	Dec -2007	250
Changsha	SXL	Yingkou power plant	China		Changsha	Dec -2007	250
Changsha	SXL	Yuanbaoshan power plant	China		Changsha	Dec -2007	250
Changsha	SXL	Chenjia harbor power plant	China		Changsha	Dec -2008	250
KSB Pumps	SXL	Huangshi power plant	China		KSB Pumps	Dec -2007	250





SHAFT DIA. = 10.000"

GENERAL NOTES (UNLESS SPECIFIED OTHERWISE):

01. MAT'L – BRONZE/GM-2401
02. ALL DIMENSIONS ARE EXPRESSED IN INCHES 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. LUBRICATION GROOVES TO BE MACHINED AFTER BEARING I.D. IS MACHINED TO SIZE.
07. ALL DIMENSIONS PER BRONZE CARRIER SUPPLY BY CUSTOMER WITH THE EXCEPTION OF THE BEARING I.D.

CONDITIONS – UNLESS OTHERWISE SPECIFIED:/CONDITIONS – SAUF INDICATION CONTRAIRE:

DIMENSIONS ARE IN/DIMENSIONS SONT EN ORIGINAL SCALE/ECHELLE ORIGINALE — IN 1/8

TOLERANCES	IMP. (in)	MET. (mm)
SURFACE FINISH/FINIS DE SUEFACES	125	3.2
DECIMAL/DECIMALE – 1 PLACE (X.X)	± 0.1	
DECIMAL/DECIMALE – 2 PLACE (X.XX)	± 0.01	TABLE A
DECIMAL/DECIMALE – 3 PLACE (X.XXX)	± 0.005	
FRACTIONAL	± 1/64	
ANGULAR DECIMAL/ANGULAR DECIMALE		
HOLE SIZES/DIM DE TROUS	± 1/64	± 0.4
FLAME CUTTING, SHEARING, NIBBLING, FORMING AND WELDING	± 1/16	± 1.6
FLAMME DECOUPAGE, CISAILLER, POINTE, FORGEAGE ET SOUDURE AUTOGÈNE		

TABLE A

DIMENSIONS ABOVE / AU-DELA DE	DIMENSIONS THROUGH / JUSQU'A	TOLERANCE (mm)
	6	± 0.1
6	30	± 0.2
30	100	± 0.3
100	300	± 0.5
300	1000	± 0.8
1000	2000	± 1.2
2000	4000	± 2
4000	8000	± 3
8000	12000	± 4
12000	16000	± 5

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CET DESSIN DE N'EST PAS CONSIDÉRÉ APPROUVÉ À MOINS QUE SOIT ESTAMPÉ PAR THORDON BEARINGS INC. EN ENCRE ROUGE ET SIGNÉ.

ZONE	LTR LET	REVISION	DATE	DWN DES	CKD VER	APPVL APP

THORDON BEARINGS INC.
BURLINGTON, ONTARIO, CANADA

DWN/DESS CKD/VER	SIGNATURE	APPVL/APP	SIGNATURE
R. GARCIA.		J. BUTT	

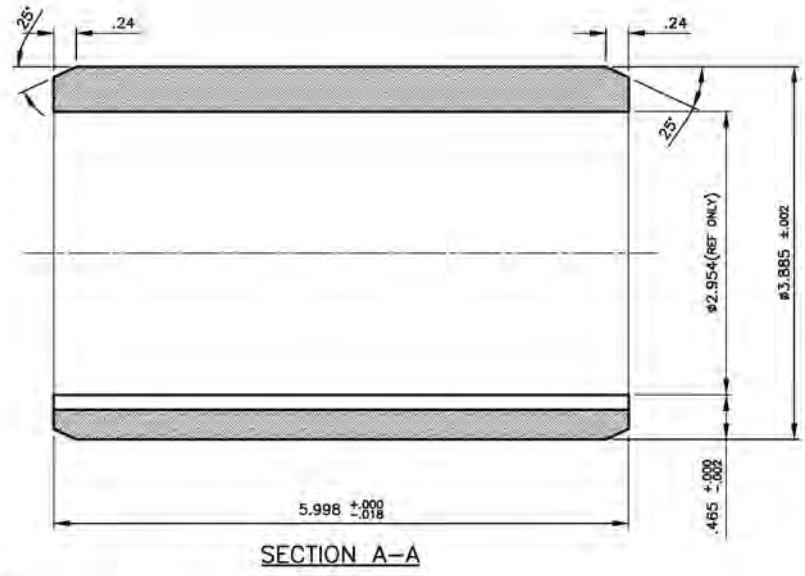
CUSTOMER/CLIENT	DRAWING DATE DATE DU DESSIN	MRP NO.	SIZE
	MAR 04/94	F129550005	B

TITLE/TITRE	DRAWING NO. DU DESSIN	REV.
FLANGE PUMP BEARING FOR NUCLEAR PLANT	TG-12208	D
	SHEET FEUILLE 1	OF DE 1

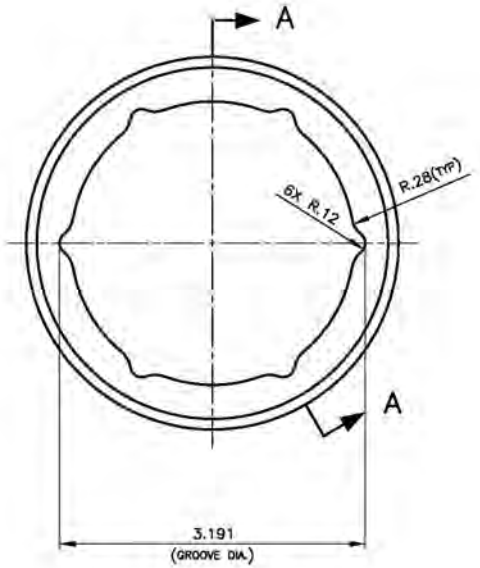
Millimeters/Millimetres
Centimeters/Centimetres

46

IF IN DOUBT, DO NOT ASSUME – ASK!



SECTION A–A



SHAFT DIA. = 2.938
HOUSING DIA. = 3.875
HOUSING LG. = 6.00
INSTALLED DIAMETRICAL CLEARANCE(21°C) = .006
DIAMETRICAL CLEARANCE AT MAX TEMP(30°C) = .004

GENERAL NOTES:

01. MAT'L – THORDON ThorPlas
02. ALL DIMENSIONS ARE EXPRESSED IN INCHES 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.

PROPOSAL
DATE: JUN 12/03

DO NOT SCALE THIS DRAWING. WORK TO DIMENSIONS SPECIFIED

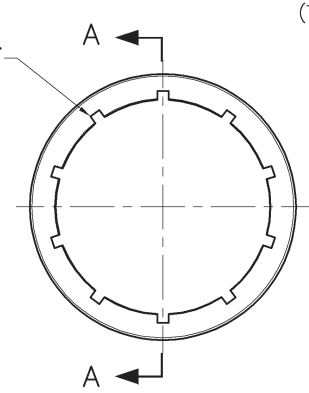
UNLESS SHOWN OTHERWISE, MACHINING TOLERANCES ARE:
LINEAR UP TO 1m(40") ±0.5mm(±0.020")
OVER 1m(40") ±1.0mm(±0.040")
ANGULAR ±0.25°
SURFACE FINISH 3.2μmRa (125μinch)
THORDON MATERIAL SURFACE FINISH TO BE DETERMINED ONLY BY USE OF COMPARATOR

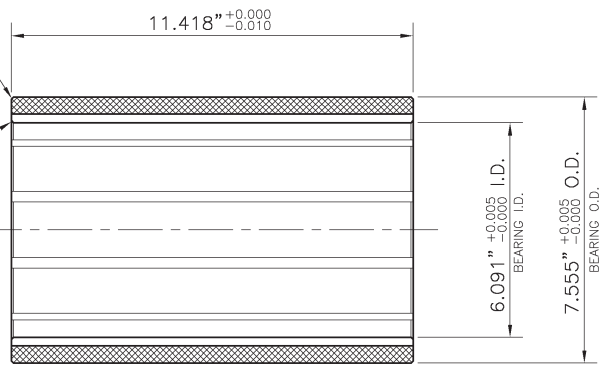
ZONE	LTR LET	REVISION	DATE	DWN DES	CKD VER	APPVL APP

THORDON BEARINGS INC.
BURLINGTON, ONTARIO, CANADA

DWN/DESS | SIGN. | CKD/VER | SIGN. | APPVL/APP | SIGN.

CUSTOMER/CLIENT: JOHNSON PACKINGS & INDUSTRIAL PRODUCTS, INC.
PROJECT: HIGH FALLS PUMP
DRAWING DATE / DATE DU DESSIN
MRP NO.
SIZE: B
TITLE/TITRE: THORDON ThorPlas PUMP BEARING
DRAWING NO. DU DESSIN: TG–15969
REV.
SHEET / FEUILLE: 1 OF / DE 1





SECTION A–A

MAXIMUM SHAFT DIA.	=	5.999"
HOUSING DIA.	=	7.500" +.002 −.000
HOUSING LENGTH	=	11.500"
TEMPERATURE RANGE	=	−2°C to 30°C
INTERFERENCE	=	0.053"
BORE CLOSURE	=	0.071"
WATER ABSORPTION	=	0.009"
RUNNING CLEARANCE	=	0.009"
THERMAL EXPANSION	=	0.003"

GENERAL NOTES :

1) MAT'L – THORDON SXL
2) ALL DIMENSIONS ARE EXPRESSED IN INCHES UNLESS OTHERWISE SPECIFIED.
3) DO NOT SCALE THIS DRAWING. WORK TO DIMENSIONS SPECIFIED.
4) TOLERANCES FOR ALL DIMENSIONS SHALL BE NONCUMULATIVE.
5) BREAK ALL CORNERS AND DEBURR ALL SHARP EDGES.
6) ALL FILLET, RADII AND CHAMFER DIMENSIONS ARE NOMINAL UNLESS OTHERWISE SPECIFIED.

CONDITIONS – UNLESS OTHERWISE SPECIFIED:/CONDITIONS – SAUF INDICATION CONTRAIRE:

DIMENSIONS ARE IN/DIMENSIONS SONT EN
ORIGINAL SCALE/ECHELLE ORIGINALE

IN
N.T.S.

TOLERANCES	IMP. (in)	MET. (mm)
SURFACE FINISH/FINIS DE SUEFACES	125	3.2
DECIMAL/DECIMALE – 1 PLACE (X.X)	± 0.1	
DECIMAL/DECIMALE – 2 PLACE (X.XX)	± 0.01	TABLE A
DECIMAL/DECIMALE – 3 PLACE (X.XXX)	± 0.005	
FRACTIONAL	± 1/64	
ANGULAR DECIMAL/ANGULAR DECIMALE	± 0.5°	± 0.5°
HOLE SIZES/DIM DE TROUS	± 1/64	± 0.4
FLAME CUTTING, SHEARING, NIBBLING, FORMING AND WELDING FLAMME DECOUPAGE, CISAILLER, POINTE, FORGEAGE ET SOUDURE AUTOGÈNE	± 1/16	± 1.6

TABLE A

DIMENSIONS ABOVE AU–DELA DE	DIMENSIONS THROUGH JUSQU'A	TOLERANCE (mm)
	6	± 0.1
6	30	± 0.2
30	100	± 0.3
100	300	± 0.5
300	1000	± 0.8
1000	2000	± 1.2
2000	4000	± 2
4000	8000	± 3
8000	12000	± 4
12000	16000	± 5

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ZONE	LTR LET	REVISION	DATE	DWN DES	CKD VER	APPVL APP

THORDON BEARINGS INC.
BURLINGTON, ONTARIO, CANADA

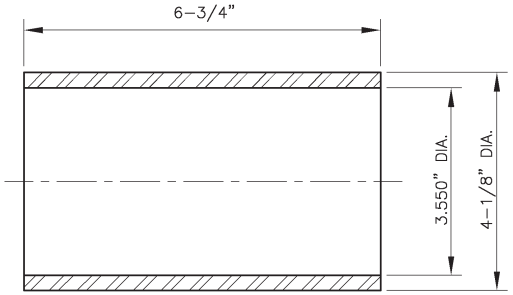
DWN/DESS	SIGNATURE	APPVL/APP	SIGNATURE
CKD/VER S. CLOUGH		J. BUTT	

CUSTOMER/CLIENT	DRAWING DATE DATE DU DESSIN	MRP NO.	SIZE
	FEB 01/96		B

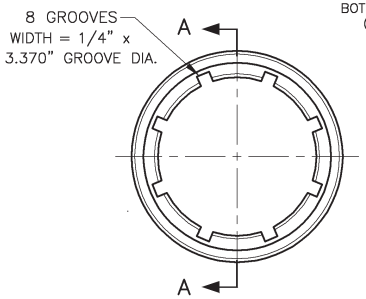
TITLE/TITRE	DRAWING NO. DU DESSIN	REV.
SXL PUMP BEARING	TG–12935	
	SHEET FEUILLE 1 OF DE 1	

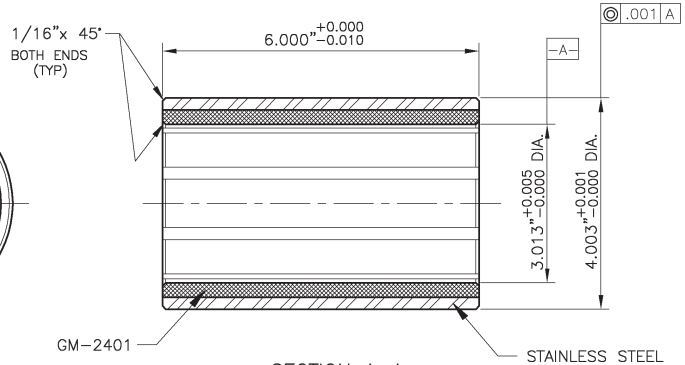
Millimeters/Millimetres
Centimeters/Centimetres

48



METAL CARRIER





SECTION A–A

SHAFT = $3.000"^{+0.000}_{-0.001}$ (ASSUMED)

HOUSING = $4.000"^{+0.001}_{-0.000}$ (ASSUMED)

O.D. = $4.003"^{+0.001}_{-0.000}$ (INCLUDES .004" INTERFERENCE)

BORE CLOSURE = 0.004"
RUNNING CLEARANCE = 0.005"
ABSORPTION ALLOWANCE = 0.003"
THERMAL EXPANSION = 0.001"

GENERAL NOTES (UNLESS SPECIFIED OTHERWISE):

01. MAT'L – GM–2401/316 STAINLESS STEEL
02. ALL DIMENSIONS ARE EXPRESSED IN INCHES.
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. MINIMUM THORDON WALL THICKNESS BEHIND GROOVE IS 0.030"

EMAN #41 CAST IN METAL

CONDITIONS – UNLESS OTHERWISE SPECIFIED:/CONDITIONS – SAUF INDICATION CONTRAIRE:

DIMENSIONS ARE IN/DIMENSIONS SONT EN — ORIGINAL SCALE/ECHELLE ORIGINALE — IN 1:2

TOLERANCES	IMP. (in)	MET. (mm)
SURFACE FINISH/FINIS DE SUEFACES	125	3.2
DECIMAL/DECIMALE – 1 PLACE (X.X)	± 0.1	TABLE A
DECIMAL/DECIMALE – 2 PLACE (X.XX)	± 0.01	
DECIMAL/DECIMALE – 3 PLACE (X.XXX)	± 0.005	
FRACTIONAL	± 1/64	
ANGULAR DECIMAL/ANGULAR DECIMALE		
HOLE SIZES/DIM DE TROUS	± 1/64	± 0.4
FLAME CUTTING, SHEARING, NIBBLING, FORMING AND WELDING	± 1/16	± 1.6
FLAMME DECOUPAGE, CISAILLER, POINTE, FORGEAGE ET SOUDURE AUTOGENE		

TABLE A

DIMENSIONS ABOVE AU–DELA DE	DIMENSIONS THROUGH JUSQU'A	TOLERANCE (mm)
	6	± 0.1
6	30	± 0.2
30	100	± 0.3
100	300	± 0.5
300	1000	± 0.8
1000	2000	± 1.2
2000	4000	± 2
4000	8000	± 3
8000	12000	± 4
12000	16000	± 5

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ZONE	LTR LET	REVISION	DATE	DWN DES	CKD VER	APPVL APP

THORDON BEARINGS INC.
BURLINGTON, ONTARIO, CANADA

DWN/DESS CKD/VER	SIGNATURE	APPVL/APP	SIGNATURE
R. GARCIA		J. BUTT	

CUSTOMER/CLIENT	DRAWING DATE DATE DU DESSIN	MRP NO.	SIZE
	MAR 21/96		B

TITLE/TITRE	DRAWING NO. DU DESSIN	REV.
GM–2401/S.S PUMP BEARING	TG–12994	
	SHEET FEUILLE 1	OF DE 1

Millimeters/Millimetres
Centimeters/Centimetres

THORDON

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