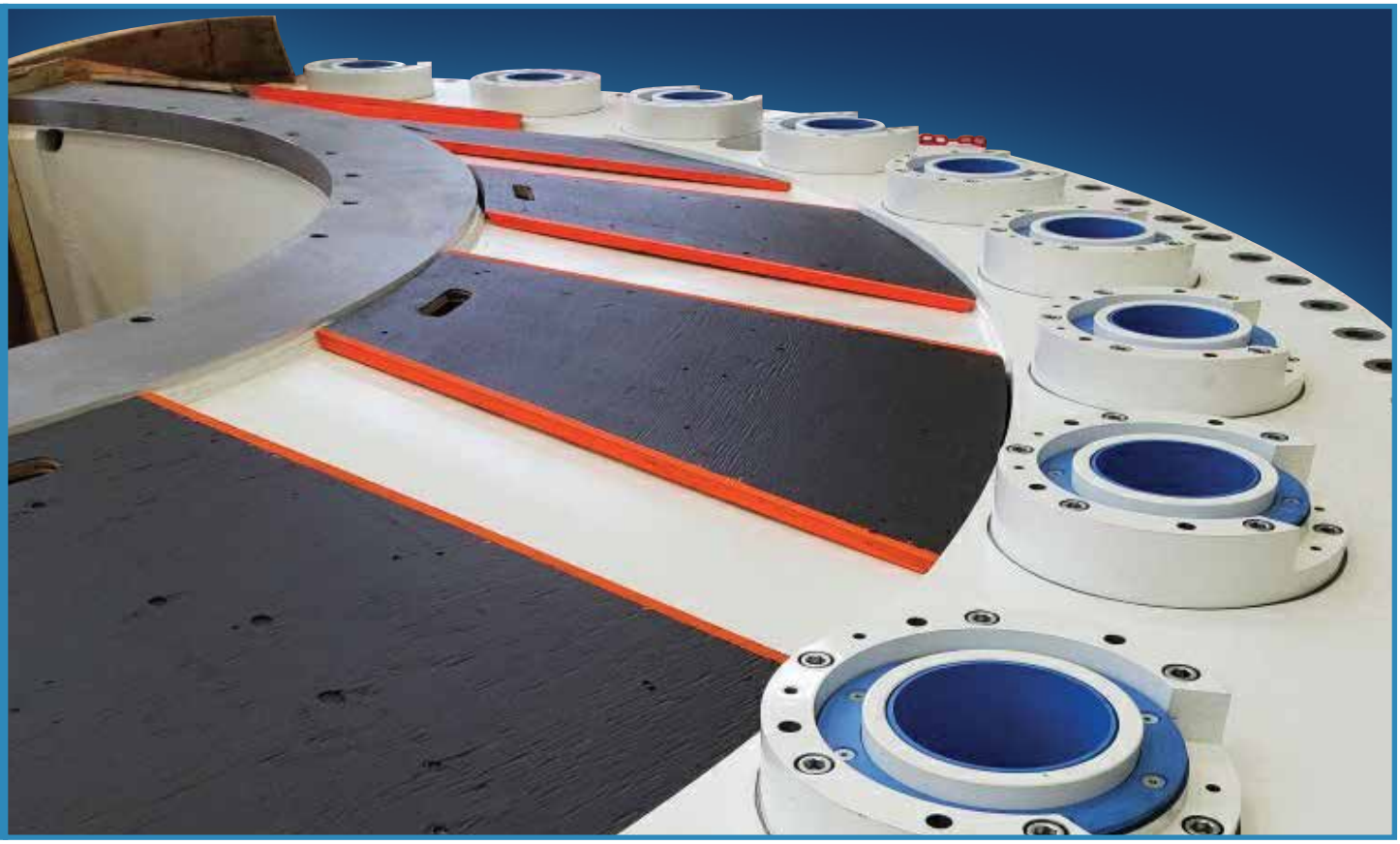
HYDRO
ISSUE 2024-1

THORDON NEWSWORKS



Wicket gate head covers at Otto Holden Generating Station

THORDON SUPPLIES ***FULL SUITE OF BEARINGS*** TO ONTARIO GENERATING STATION

Thordon Bearings is supplying multiple sets of grease-free bearings to completely replace old technology at the Otto Holden Generating Station on the Ottawa River in Ontario, Canada.

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THORDON SUPPLIES ***FULL SUITE OF BEARINGS*** TO ONTARIO GENERATING STATION *...continued*

Andritz Hydro was contracted to undertake the mid-life refurbishment of the station's turbines on behalf of Ontario Power Generation (OPG). Two of the 243MW station's eight units have now been fitted with Thordon's ThorPlas-Blue and Thorseal products, via its local distributors RMH Industries in Quebec and Millstream Engineering in Ontario.

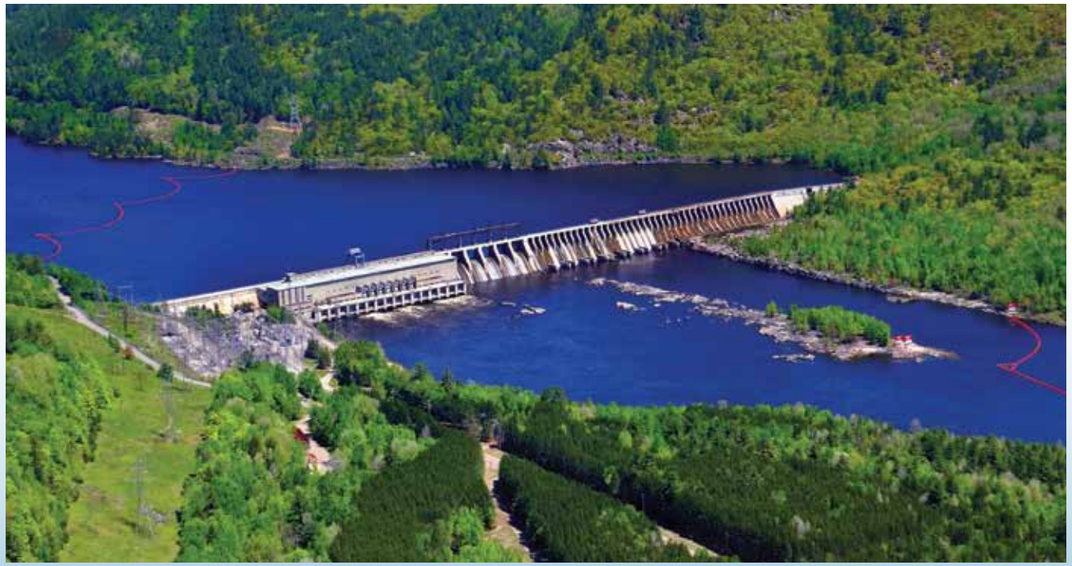
Unit 7 was refurbished in 2022, unit 5 in 2023, and unit 8 is next with installation expected in Q4 2024. By 2029, all eight of the station's units will have been refurbished.

Each retrofit involved 262 bearings per turbine including wicket gate bearings and seals, Thorseal linkage bearings, Thordon SXL operating ring wear pads, and servo motor bearings and seals. The bearings being installed have high-end edge loading performance and range from about 100 to 300mm (4-12in) outside diameter.

The servomotors are being made entirely by Thordon distributor RMH Industries, one of the company's specialties honed over the last 50 years. Gaétan Dionne, RMH Industries' General Manager, cites, for example, that the company can install Thordon's bearings on the servomotors using liquid nitrogen in less than a minute.

Thordon's bearing and sealing solutions were chosen for their reputation for being the highest-performance materials available on the market. A key on-going benefit is that they eliminate the need for regular greasing, thus reducing maintenance costs and avoiding contamination of rivers.

Thordon's wicket gate, operating mechanism and linkage bearings operate wet or dry and are self-lubricating to ensure performance in limited-motion applications. There is no galling from edge loading caused by minor misalignments or gate deflections.



Otto Holden Generating Station on the Ottawa River in Ontario, Canada.

The bearing material is ThorPlas-Blue which is a homogeneous, self-lubricating engineered thermoplastic capable of withstanding operating pressures up to 45 MPa (6,527 psi).

Thordon's Thorseals are made of a proprietary elastomer with no shelf life or degradation of properties over time. Thorseals are available in a wide range of standard sizes or can be quickly machined to custom size requirements up to 1.5 m (60 in) in diameter.

Greg Auger, Commercial Director at Millstream Engineering, explains that installing the wicket gate bearings requires careful attention to detail.

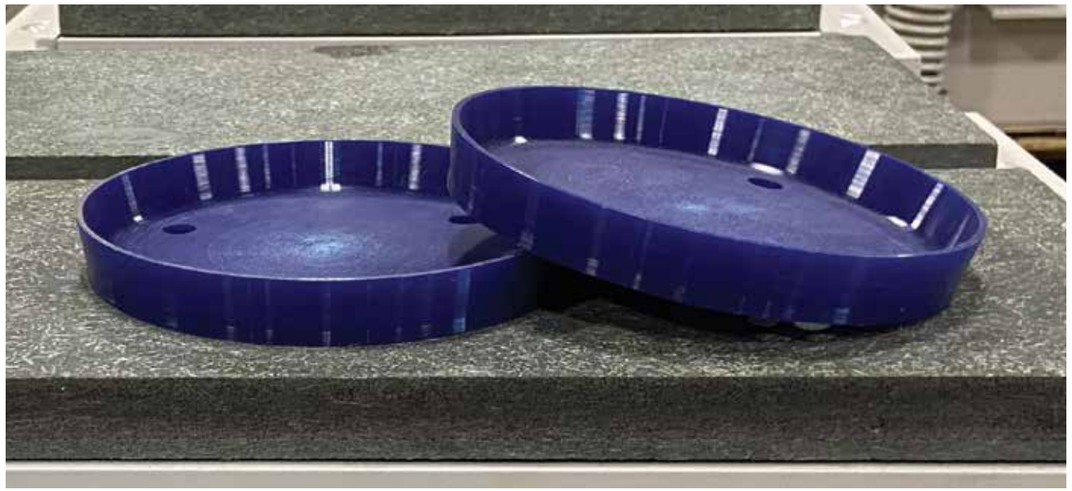
"It is critical to get accurate measurements of the shaft and housing dimensions before final machining of the ThorPlas-Blue bearings so that they can be sized correctly for proper fit and clearance. During installation, care must be taken to press-fit the bearings to prevent damage, and then they must be protected from risk of damage while other overhaul work continues. Careful measuring of the installed dimensions will help verify that all the large components will assemble correctly."

Millstream Engineering will continue to provide local support to OPG for all their facilities across Ontario. Auger says there is a big push underway for overhauling and modernizing hydropower facilities across Canada, and the Otto Holden station is one of many to be rehabilitated over the next decade.

Additionally, demand for electricity is constantly increasing, and OPG has identified significant untapped hydroelectric generation opportunities. In the northern rivers of Ontario alone, there are about 4,000 MW of potential power, or enough electricity to power about 3.5 million homes.

Business Development Manager for Hydro & Industrial at Thordon Bearings, Ryan Edmonds, said: "The hydropower market is growing globally due in part to the increasing demand for renewable energy. Hydropower is a clean, secure, domestic source of electricity, and Thordon's high-performance solutions are a perfect fit for these durable assets.

THORDON BEARINGS SUPPLIES ***BRAKE CUPS*** FOR HYDRO-QUÉBEC'S OVERHAUL PROGRAM



Thordon Thorseal brake cups machined by RMH Industries

Thordon Bearings' brake cups are being supplied to Hydro-Québec, the largest hydropower company in Canada, as part of a decade-long turbine brake system overhaul program.

The Burlington-based bearing and seal specialist is providing the brake cups to its Canadian distributor RMH Industries, an integrated company specializing in mechanical and hydraulic repair and machining of oversized parts. RMH Industries has been manufacturing and repairing brake blocks for Hydro-Québec since 2020.

Forty-eight Thorseal brake cups will be delivered for installation to the Manic-2 station (the Jean-Lesage generating station) in Québec, after previously supplying them to the Churchill Falls, Newfoundland station. While Manic-2 deliveries continue, Thordon is also supplying the first cups for the Bersimis-2 station.

One hydro-turbine typically has 8-12 brake blocks. Each brake block is generally made up of two to four pistons, depending on the size of the power plant. The cups are a critical component of the pneumatic/hydraulic braking system, because they ensure a seal is maintained for the pistons that are used to slow and stop the turbines.

The hydro-turbines typically weigh hundreds of tons and if the braking system were to fail, the thrust bearing could be subject to excessive load, leading to wiping and potentially catastrophic failure.

The brake blocks are also used to lift the turbine, and if low quality seals result in significant leakage, this operation cannot be performed. The brakes are located under the turbine, making them difficult to access.

The dimensions of the cups can vary considerably. For the Manic-2 power station, the Thorseal self-lubricating polymer lip seals are 152mm (6in) in diameter with 177-203mm (7-8in) lip.

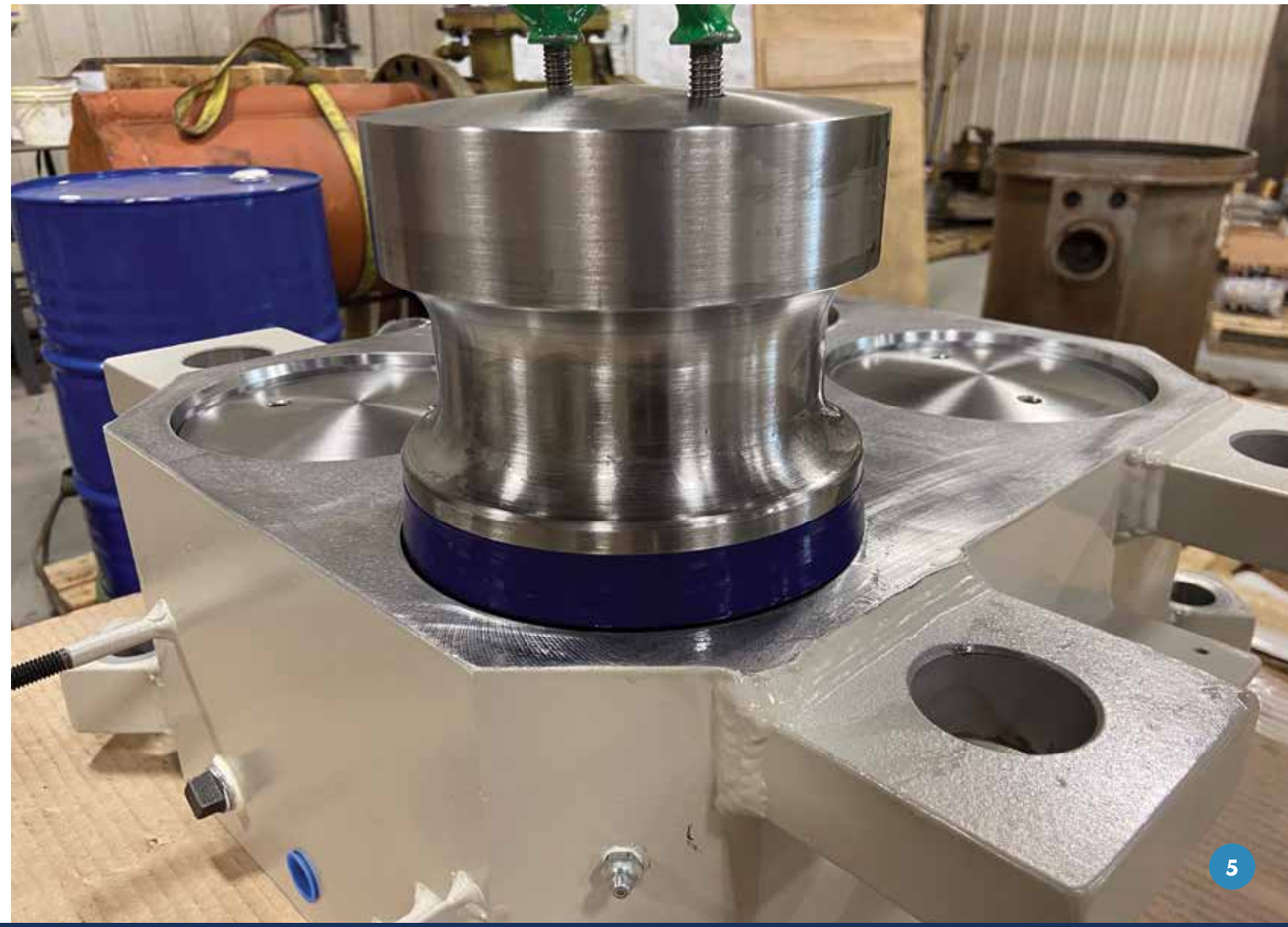
Ryan Edmonds, Business Development Manager for Hydro & Industrial at Thordon Bearings, notes that unlike slightly cheaper rubber cups, Thordon's Thorseal brake cups are made from a proprietary elastomer that has no shelf life or degradation of properties over time.

"The Thorseal material will not crack, so it eliminates the risk of slow wind down that can damage fragile babbitt sleeve bearings," he said.

Thorseal brake cups provide long wear life with no need for periodic replacement due to their internal lubricant that reduces drag more effectively than oil-lubricated alternatives.

Operators of many other hydro facilities around the world are considering brake system refurbishment programs, said Edmonds. "Saving a few thousand dollars on low-quality cups is not a wise investment when the catastrophic consequences of failure could result in extensive downtime and tens of millions of dollars in repairs."

Thordon Bearings designs and manufactures a complete range of high-performance, long-lasting hydro-turbine bearing system designs that require no oil or grease, including turbine guide bearings, wicket gate and operating mechanism bearings, and radial or axial shaft seals.



THORDON'S ***POLYMER TECHNOLOGY*** POWERS SUCCESS IN VIETNAM'S HYDROPOWER SECTOR

Sơn La Hydropower Plant, on the Đà River in It Ong, Muong La District, Sơn La Province, Vietnam

Thordon Bearings' pioneering polymer bearing technology is gaining traction in Vietnam's hydropower market, following the performance success of its self-lubricating bearings retrofitted to five turbines at the Sơn La Hydropower plant.

Thordon's wicket gate and linkage bearings have been in continuous use for four years and were installed when the company was asked to provide an alternative to a competing system, some parts of which had failed after just two years under the intensive conditions at the dam.

Having entered service in December 2012, the Sơn La Hydropower project is situated on the Đà River in It Ong, Muong La District, Sơn La Province and is the largest hydropower dam in Southeast Asia.

With a length of 961.6 m (3300 ft), the concrete gravity dam features a crest height of 228 m (748 ft), bottom width of 105 m (304 ft) and crest width of 10 m (33 ft). Total installed capacity of 2,400 MW and an average annual electricity output of over 10 billion kWh by way of six Francis-type turbines.

Delta Marine & Industries, Thordon's authorized distributor in Vietnam, worked with end user Vietnam Electricity (EVN) to choose suitable replacements for the original metal polymer lined bearing. The refit included ThorPlas-Blue wicket gate and linkage bearings with washers, Thordon SXL operating ring wear pads, Thordon Thor-Flex wicket gate seals, and SXL upper and lower gate seal.

> *"They offer high pressure performance and resilience, as well as extremely long wear life."*

Thordon's hydro turbine bearings and seals are designed to efficiently replace worn components such as those at Sơn La, said Johnny Dao, Managing Director, Delta Marine & Industries. "Thordon's grease-free bearing products for hydropower installation combine a very low coefficient of friction with low wear in abrasive water environment and high resistance to shock loading and vibration. They offer high pressure performance and resilience, as well as extremely long wear life."

Bearing installation at the Sơn La Hydropower plant

The original material was delaminated, with severe wear to the bushing surface. "Finding a sustainable solution was critical for the client due to the original parts having failed so soon after entering service," said Axel Swanson, Thordon Bearings' Business Development Manager – Hydro, Pump & Industrial.

"It was important to them that our products could perform well in the unique challenges of the application, as the high shock load of the existing wicket gates' operating ring that had destroyed the existing wear pads. The original seals had also hardened after a few years, leading to cracks and leaks."

Thordon's solution to these problems involved using Thor-Flex and Thordon SXL for the lower and upper gate seals, and SXL for the operating ring wear pads. Thorseals were used in place of the existing rubber seals and ThorPlas-Blue for the intermediate bearing.

The Sơn La Hydropower plant's new bearings and pads have been in safe and stable operation for four years, and Delta Marine & Industries is now looking forward to installing Thordon products across the dam's remaining turbines.

FRENCH UTILITY GIANT USES THORDON ***SXL SEGMENTED SHAFT SEALS*** IN EUROPE'S LARGEST TIDAL POWER PLANT

La Rance Power Plant in Brittany, France

A major French utility is planning to retrofit more of its facilities with Thordon's SXL polymer radial shaft seals, following successful trials and subsequent installation of the technology at one of its power plants.

Operated by Électricité de France (EDF), Brittany's La Rance Power Plant is one of the world's largest tidal power stations, with 24 turbines whose peak output is 240 MW and averaging 57 MW. Its annual power output is about 500 GWh.

The plant's original shaft seals – made of an ultra-high molecular weight polyethylene (UHMWPE) and carbon graphite material – required replacement due to their poor longevity and performance, explained Axel Swanson, Thordon Bearings' Business Development Manager – Hydro, Pump & Industrial.

"We knew from experience that SXL seals not only perform substantially better than UHMWPE and carbon seals, but they significantly reduce leakage rates and extend the wear life far beyond the original installations. Thordon SXL shaft seals have a typical wear life of more than 15 years.

"For the EDF plant we came up with an improved radial seal design that would fit into the existing housing. Thanks to our industry-leading expertise in hydro turbine seals and bearings, EDF was convinced the new SXL segmented seal was the right solution for this application.

Initial trials were a huge success," said Swanson.

During the retrofit project, the existing shaft seals were replaced with the SXL segmented shaft seals, supplied through the Thordon authorized distributor for France, Wenex Equipements SA. The SXL seal is unlike traditional shaft seals in that the elastomeric polymer material used is specifically designed to optimize performance and reduce operational costs.

"The SXL segmented shaft seal has several unique features that make it a perfect match for EDF's needs," said Laurent Le Trouher, Wenex Equipements' Area Sales Manager.

"Installation and replacement of all seal components can be carried out without removing the shaft. The main advantages of an SXL shaft seal over the carbon type, are reduced leakage, extended wear life, design flexibility, and a very robust material. Carbon-based seals can be brittle and break easily during installation. The SXL seal, however, lends itself to installation and operational simplicity. It is also easily maintained."

Operating parameters for Thordon SXL segmented shaft seals are generally similar to those for carbon graphite or phenolic seals in terms of maximum interface pressure and almost always reduces leakage. Thordon segmented seals have in the past been designed for shafts up to 3.9m (12.7ft) diameter and can be designed for use in either radial or axial sealing systems.

Le Trouher welcomed EDF's decision to invest further in Thordon's products. "After being in service for one year, the utility has expressed its satisfaction with the performance of the new Thordon SXL seals and ordered a second set."

When the La Rance facility, located on the estuary of the Rance River, in Brittany, France, opened in November 1966, it made headlines as the world's first-ever tidal power station. It remained the world's largest until 2011, when South Korea's Sihwa Lake Tidal Power Station started operations.

"The SXL segmented shaft seal has several unique features that make it a perfect match for EDF's needs."

— Laurent Le Trouher,
Area Sales Manager, **Wenex Equipement**

THORDON BEARINGS ***GROWS ITS PRESENCE*** IN THE EUROPEAN HYDROPOWER SECTOR

Two European hydropower plant operators have replaced the bearings on their Francis-type turbines with water-lubricated bearings from Canada's Thordon Bearings after oil was leaking from their original metal bearings.

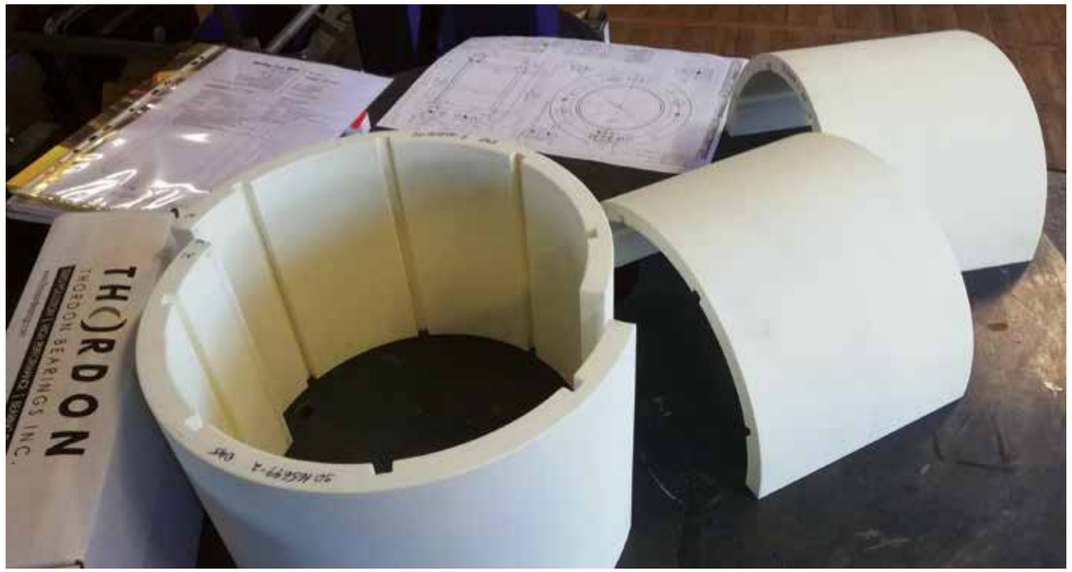
In two separate contracts, Croatia-based Skoring d.o.o., Thordon's authorized distributor for the region, supplied wicket gate bearings to the 36.8 MW Hrvatska Elektroprivreda-operated plant in Rijeka, Croatia, in July. In August, they retrofitted new turbine guide bearings to turbines at the 1500 kW Elektro Ljubljana-operated HPP Sava Brod plant, in Slovenia.

For Hrvatska Elektroprivreda (HEP Group), the decision to replace the original greased bronze wicket gate bearings on the Rijeka plant's 18.4 MW Turbine B was an easy one to make: Skoring has been supplying Thordon bearings to this operator for more than twenty years.

Skoring's Technical Manager, Goran Orlic, provides more insight: "We have a great relationship with Hrvatska Elektroprivreda, an important customer for us. We have provided the utility supplier with numerous bearings over the years, with our first installation taking place at the Ozalj hydropower plant in 2002. Since then, we have retrofitted turbines at HEP plants in Fuzine, Zagreb, Lepenica, and more."

In July 2021, ThorPlas-Blue wicket gate bearings were retrofitted to Turbine A of the Rijeka plant, and in May 2023 Turbine B was fitted out with the same.

For each turbine, the Thordon scope of supply comprised of twenty self-lubricating ThorPlas-Blue bearings, machined to fit outside shaft diameters of 105 mm (4.13 in), and twenty 135 mm (5.31 in) Thorseal polymer lip seals.



SXL turbine guide bearing ready for installation at the Elektro Ljubljana plant

ThorPlas-Blue wicket gate bearing being press-fit into place

The smaller 100-year-old Elektro Ljubljana plant near Ljubljana, Slovenia, was retrofitted with Thordon SXL water-lubricated turbine guide bearings to both 499 kW Francis turbines in August. Skoring supplied the SXL bearing material to local turbine refurbishment company Hydro-hit for final machining to fit shaft diameters of 305 mm (12 in).

"Skoring has a long history supplying Thordon seals and bearings to these operators," said Axel Swanson, Thordon Bearings' Business Development Manager – Hydro, Pump & Industrial. Both HEP Group and Elektro Ljubljana have been very satisfied with the performance and environmental efficiency of our products and they often upgrade their turbines with Thordon's bearing and seal solutions at each refurbishment to achieve the ultimate wear life and eliminate the risk of pollution.

"Thordon solutions do not pollute, are simple to maintain, and offer excellent wear performance and abrasion resistance compared to other oil- or water-lubricated bearing solutions in the marketplace. Of course, shorter lead times and competitive pricing also play a part!"

"Globally, more than half of all active hydropower plants were originally commissioned over half a century ago but upgrades, refurbishments, and the use of more reliable turbine components, such as Thordon's pioneering elastomer technology, can be hugely beneficial in reducing downtime and keeping the lights on," said Thordon Bearings' Regional Manager – Southern Europe & Gulf Med, Malcolm Barratt.

Commissioned in 1968, HPP Rijeka is a high-pressure derivation plant that takes water from the Rječina watercourse at an elevation of 229.50 m (753 ft) above sea level. About 84.45 GWh of electricity is produced annually.

The historic HPP Sava Brod is a Mini Hydropower Plant that started generating electricity in 1928 from a small facility in Brod, a village north of Ljubljana, Slovenia. The plant takes water from the Sava River.

GENESIS ENERGY'S ***TEKAPO A PLANT*** COMPLETES THORDON BEARING UPGRADE

New Zealand's Genesis Energy completed a first phase refurbishment of the 190MW hydropower plant at Lake Tekapo, in the South Island.

In 2020, Thordon Bearings' products were installed in a vertical Kaplan turbine at the Tekapo A generating station, replacing a competitor's upper, intermediate, and lower wicket gate bearings, as well as the lip seals, operating ring wear pads, and wicket gate blade sealing strips.

Through its Auckland-based distributor Henley Group, Thordon supplied ThorPlas-Blue wicket gate bushes, Thorseal lip seals (which replaced nitrile rubber sealing rings in the lower and intermediate wicket gate bearings), and SXL operating ring wear pads. A new SXL turbine guide bearing, upgraded with better tolerances, was designed, supplied and installed. The shaft seal carbon segments were also replaced with SXL segments.

Genesis Energy, operates eight hydropower stations across New Zealand's North and South Islands. Its Tekapo A Power Station has been using a Thordon water-lubricated SXL turbine guide bearing since 2003.

Jacob Power, General Manager, Henley Group said: "We are delighted to have been involved with another Genesis project. The ThorPlas-Blue bearings selected for the Tekapo A unit are a great option for upgrading regulating mechanism in the Kaplan turbine."

Traditional rubber dovetail guide vane sealing strips were separating from their seats due to forces encountered during the motion of the guide vane over the final portion of closure. Henley Group was approached to evaluate if Thordon products could be a potential solution.

Axel Swanson, Thordon Bearings' Business Development Manager – Hydro, Pump & Industrial said: "We have been investigating the use of our softer Thor-Flex material grades to prevent this particular problem from occurring for several other customers as well. The wearing out and mechanical damage of rubber sealing strips is a recurring issue for plant operators as the rubber ages and becomes brittle. We had a solution more or less ready to go."

The solution for Tekapo A was to fit 22 mm (0.86 in) (W) x 10 mm (0.39 in) (H) x 1700 mm (66.9 in) (L) Thor-Flex strips, manufactured from Thordon's proprietary polymer material, Thor-Flex, between the vane's metal rings.

"The Thor-Flex product is significantly more durable than rubber in most sealing applications, with excellent toughness resisting damage during installation and operation. For this application we selected a relatively low durometer (hardness) of 83 Shore A and produced a custom mold to allow us to produce the strips to the most precise finished dimensions. Thor-Flex can provide a more flexible sealing element if there are large gaps and variations to be sealed between metal components. Traditional rubber grades will harden over time and have limited load bearing capacity compared to Thor-Flex," said Swanson.

While Thor-Flex itself has been used in many industrial applications, this was a new application to solve a tough problem for the customer. Thordon officially offers the Thor-Flex blade sealing strips after their performance was evaluated during plant outage inspections in November 2020.

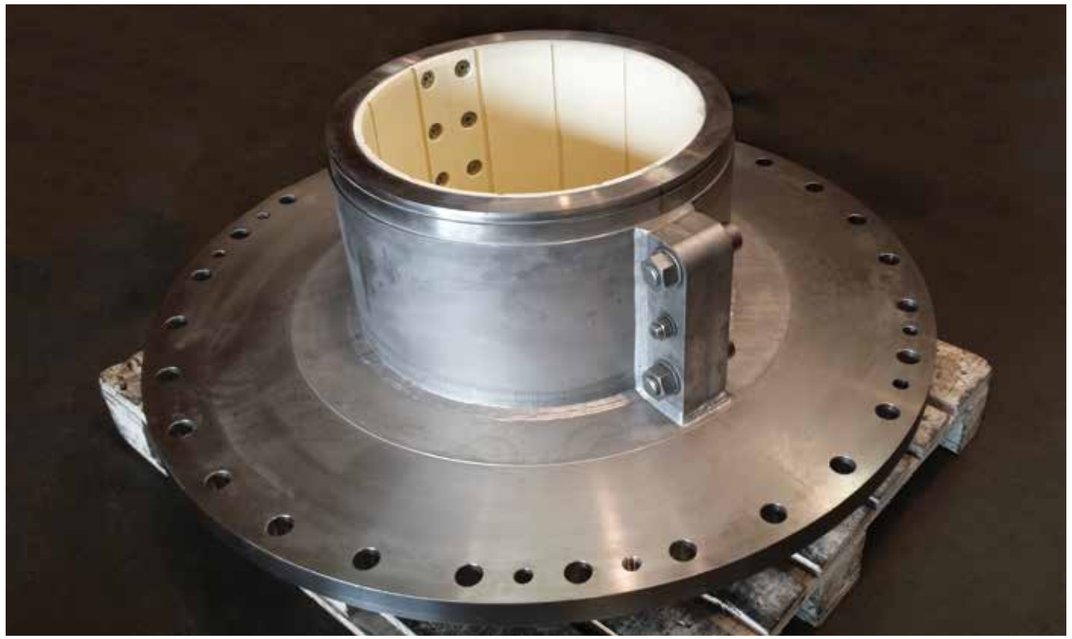
Construction of Tekapo A began in 1938 but was halted between 1942 and 1944 as labour and materials were diverted to World War II. The station was finally commissioned in 1951. Tekapo A Power Station generates electricity from water diverted from Lake Tekapo via a 1.4 km (0.9 mi) intake tunnel.

In 1970, a 25.5 km (15.8 mi) canal was constructed to take outflows from Tekapo A to Tekapo B. The Tekapo Canal has a maximum capacity of 130 m^3 (4591 cu ft.) per second.

Water in Lake Tekapo can bypass Tekapo A Power Station via water releases through the Lake Tekapo Control Structure (State Highway 8 bridge at Tekapo). When the control gates are open water passes to the canal, down the upper Tekapo River via Lake George Scott.

Thordon is pleased to be able to play a small part in helping Genesis Energy continue to supply clean and reliable hydroelectric power to the New Zealand electricity grid.

THORDON REDUCES HYDRO MAINTENANCE IN SPAIN WITH NUMEROUS WATER-LUBRICATED BEARING CONVERSIONS



One of eight SXL turbine guide bearings installed at Endesa hydropower

As Spain looks to enhance and upgrade its renewable energy sources, the country's utilities are looking once again to reliable and cost-effective hydro-electric power. Thordon Bearings is helping to lower operational costs and improve the environmental credentials of several older Spanish hydropower stations.

Thordon distributor, Echetalde, based in San Sebastian, Spain, has replaced the oil-lubricated turbine guide bearings of a number of installations by utilizing Thordon's water-lubricated bearings.

"This not only extends maintenance intervals for the turbine's bearings and seals; it simplifies replacement and prevents any risk of oil being discharged into the environment," said Echetalde owner and CEO, Iñigo Arrancudiaga.

Spain's largest utility company, Endesa, generates around 35% of its electricity from hydro-electric sources. Since 2010, Echetalde has converted eight Endesa hydropower installations to environmentally friendly, low-maintenance Thordon water-lubricated bearing and seal installations.

Endesa's first Thordon conversion, in 2010, involved a Kaplan vertical turbine at the CH Lleida power station. This was followed by a similar project at Endesa's CH Termens power station in 2012.

These two successful installations led to two more similar conversions at Endesa's CH Prada power station. The first vertical turbine at CH Prada, of Francis type, with a 500 mm (19.6 in) shaft running at 600 rpm at 300 m (984 ft) head, was converted in 2015 followed by the second unit in 2016.

In all projects, the work involved replacing the existing oil bearing and seal with a Thordon SXL elastomeric bearing in a new split stainless-steel housing. A new water supply system was added to provide lubrication and cooling to the bearing. The old lower seal underneath the original oil bearing was replaced by a new shaft seal installed above the turbine bearing for easier access.

A number of similar oil-to-water conversions were carried out with Endesa to continue the upgrade program of older vertical Francis turbines – CH Esterri in 2017; two units at CH Ondinas, in 2017 and 2018 respectively; CH Bossot in 2018; CH Aguamoix and CH Tavascan in 2018. With a 720 mm (28.3 in) shaft diameter, the conversions at CH Ondinas are the largest diameter conversions to date.

Conversions in 2019 include CH Torrefarrera, a privately-owned vertical Kaplan turbine, CH Tavascan Inferior for Endesa, and CH Olloniego, for Hidroastur. All of these bearing conversions were focused on upgrading the turbine guide shaft bearings and seals, but Thordon can also supply self-lubricated wicket gate bearings to replace greased bronze bushings.

"Oil-to-water conversions are not always feasible, but in these cases, conventional carbon radial segmented seals can be easily replaced with Thordon SXL seals, which offer a greatly extended lifetime and significantly better reliability, particularly in dirty water conditions," said Arrancudiaga.

"The segmented seal design allows particularly simple installation and replacement. Examples of shaft seal upgrades can be found at Iberdrola's CH San Martin hydro plant, and Acciona's CH Argone installation. CH Argone had its axial carbon seal replaced with a Thordon SXL seal in 2016, and is still working, with no problems experienced.

"At CH San Martin, a radial seal was installed in 2015 in order to achieve three times the life of the carbon seals which is also still running successfully. We have upgraded two more similar plants for Iberdrola to Thordon SXL segmented shaft seals in the past year, and the operator is considering further carbon to SXL shaft seal upgrades."

Arrancudiaga furthered: "Extended lifetimes of bearings and seals and thus lower maintenance costs are the prime reason Spanish hydropower companies have been adopting Thordon technology, but there are other benefits – using water as lubricant saves the cost of special lubricating oils, and the water-lubricated bearings are completely pollution-free."

Commenting on the Spanish hydropower market, Axel Swanson, Thordon Bearings' Business Development Manager – Hydro, Pump & Industrial said: "Although use of other renewables, in particular wind, has increased, Spain's hydropower capacity has remained much the same for many years. However, as existing operating concessions expire, operators are required to improve and upgrade the plants. Thordon can help with this, by extending the life of turbine bearings and cutting both operating and maintenance costs."

SXL segmented shaft seals reduce maintenance costs

EXPERIENCE UNMATCHED PERFORMANCE & LONGER LIFE WITH THORDON'S PROVEN HYDRO SOLUTIONS

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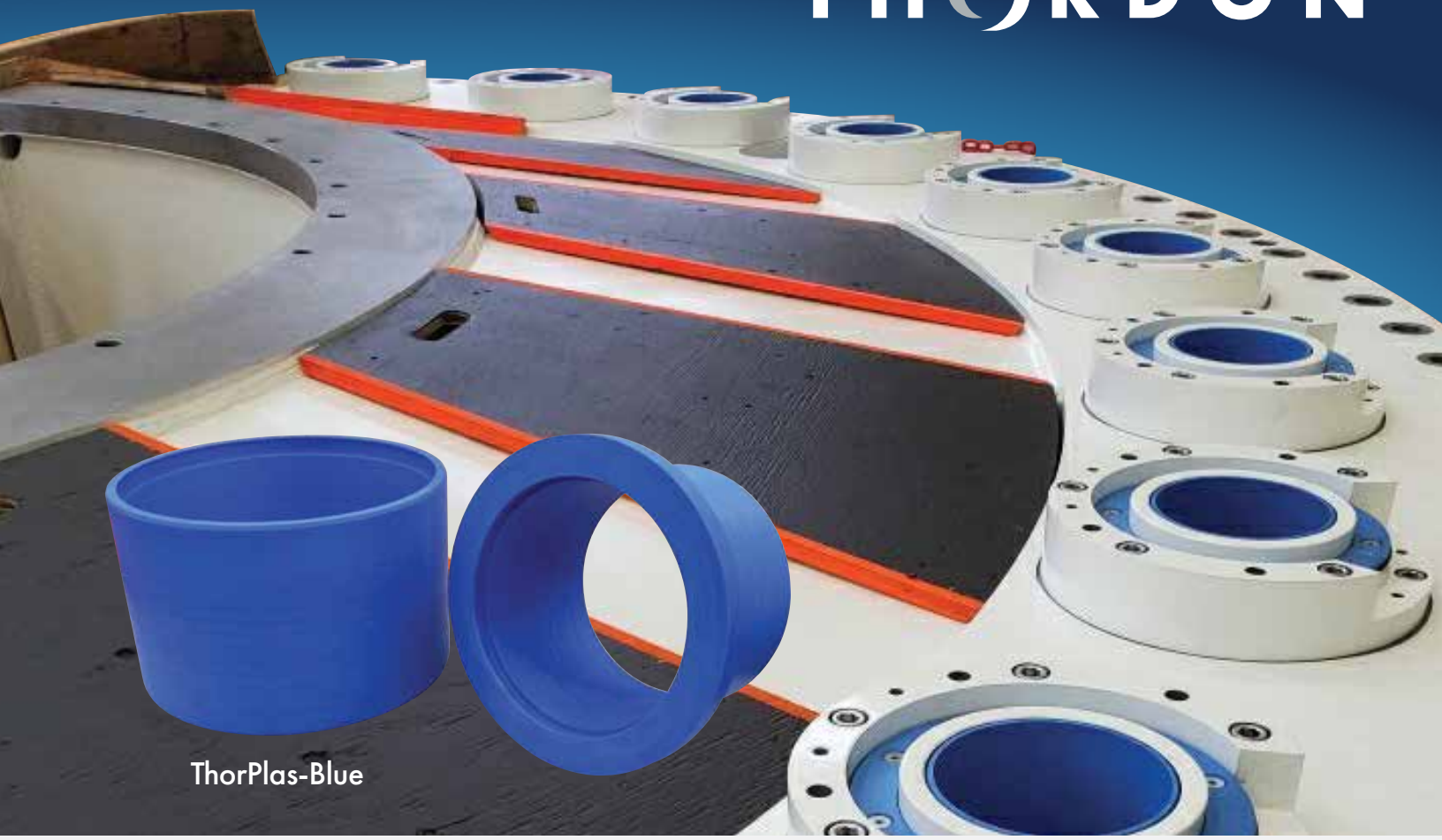

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