How Hydro Plant Owners are Solving Bearing Problems

When the turbine guide bearings installed at several hydroelectric plants in the U.S. suffered short lives and significant wear, the owners turned to lignum vitae material. Their experience has shown that this material, although more costly, can provide longer service life than composite and plastic bearing materials.

TEMPORARY PLACEMENT DING

By Elizabeth Ingram

The plant manager for a small hydroelectric facility in the southeast found out via a magazine advertisement that lignum vitae materials are once again available for use in bearing applications. This plant had run using lignum vitae bearings since it went online in 1914, but in the mid-1980s this plant manager switched to composite bearing materials when he thought the supply of lignum vitae was scarce.

Although the composite bearings performed satisfactorily, they had a life only about half that of lignum vitae for this application. And taking the units off line for bearing repair or replacement wastes valuable water flow that could be used to generate electricity, not to mention the time and effort needed to mobilize personnel to the site to perform the work, he says.

Based on this, one of the main guide bearings in one of the eight units has been converted back to lignum vitae, using materials supplied by Lignum-Vitae North America in Powhatan, Va. And as the bearings on the other units need to be replaced, the plant manager plans to use lignum vitae. This is just one example of a company that is using lignum vitae materials in its bearing applications and finding success.

Understanding lignum vitae

Lignum vitae, latin for "tree of life," is a wood obtained chiefly from the *Guiacum officinale* and *Guiacum sanctum* trees. Both are small, slow-growing trees that are listed as potentially endangered species in the Convention on International Trade in Endangered Species of Wild Fauna and Flora. In fact, it takes 350 years to grow a lignum vitae tree that can be harvested.

The wood is self-lubricating from a natural substance called guaiac gum that is bound in the homogeneous fiber of the wood and is impervious to water. It releases and coats the surface of the bearing as the shaft warms the bearing. These bearings can be adjusted to zero clearance and can be used on older plants with worn or grooved shafts because the material wears into the shape of the groove.

Thomas Edison first specified lignum vitae bearings in the 2-MW Appleton hydroelectric plant that began operating in Wisconsin in 1882. Lignum vitae was the main industrial bearing before World War I, and World War II placed a heavy demand on the supply of lignum vitae for stern tubes for nearly every ship in the U.S., German and Japanese fleets. This pressure brought the supply of lignum vitae wood to a low point, but this material remained in hydropower applications for another 40 to 50 years because of its longevity. Eventually, however, hydro plant owners moved to other materials.

Lignum-Vitae North America, one of the companies that supply these types of bearings, is involved in a harvest plan for lignum vitae and says it has a perpetual supply of 2 million pounds per year. The company says this quantity is sufficient to supply about 3,250 bearing sets per year. Other companies that supply lignum vitae bearings include Pacific Marine & Industrial in Richmond, Calif., and Retsel Corporation in McCammon, Idaho.

Nearly unlimited service life

The 4.5-MW Mechanicville hydroelectric plant on the Hudson River in New York began operating in 1897 using lignum vitae bearings. In fact, the six quadriplex Francis units at the plant operated for about 70 years, each with four bearings made of this material. The owner at that time, a utility, decided to try substitute types of materials for the bearings, including plastics and composites, presumably based on the notion that there must be something better than wood. The owner used these alternative materials for two or three decades.

Elizabeth Ingram is senior editor of Hydro Review.

The main turbine shaft bearing at the 4.5-MW Mechanicville plant in New York is made of lignum vitae. The plant has run reliably, 24/7, using this material since it was installed on all six units in the early 1990s. (photo courtesy Albany Engineering Corporation)

In 1986, Albany Engineering Corporation began operating the plant on behalf of the utility owner. The utility believed the plant was on its last legs, and there was a lot of competition from outside parties to redevelop the site. Albany Engineering provides consulting engineering services but also operates its own hydro projects and develops new ones. On behalf of the utility, Albany Engineering developed a scheme to preserve and relicense the plant.

The facility was experiencing chronic bearing issues that led to numerous shaft failures, so the company continued to experiment with new types of materials and new bearing technologies for the plant. This included non-water-lubricated bearings and submerged roller bearings.

However, by the time a new Federal Energy Regulatory Commission operating license was issued for the project in 1993, the utility decided it did not want to continue the rehabilitation project at Mechanicville. Albany Engineering then took over the plant and continued the complete restoration. In fact, to this day the plant retains its original turbines and 40-hertz generators and operates at its original installed capacity.

In about 1990, Jim Besha, president of Albany Engineering, decided to return to the use of lignum vitae at Mechanicville. They still had some of the original lignum vitae bearings available at the plant, so as restoration work progressed they replaced the composite bearings with lignum vitae.

The plant has run reliably, 24/7, using this material ever since. "It's a miracle material for situations such as this," he says. "All of the other materials have real issues and real problems. Lignum vitae is not cheap, but it has an extremely long life." The company adjusts the bearings occasionally and optically aligns them, and they have experienced no problems whatsoever with the lignum vitae bearings.

Albany Engineering recently took over operation of the 6-MW Stuyvesant Falls plant on Kinderhook Creek in New York that began operating in 1899. The company has installed two vertical Francis units that were originally installed at a hydro plant in Osage, Mo. These units were equipped with phenolic laminate-type bearings. Albany Engineering has replaced them with lignum vitae as well.

Besha says the material is not cheap compared with composite and plastic bearings. In fact, lignum vitae can be several times more expensive. But, "It is the kind of material you do not need a lot of, and it lasts a long time," he says.

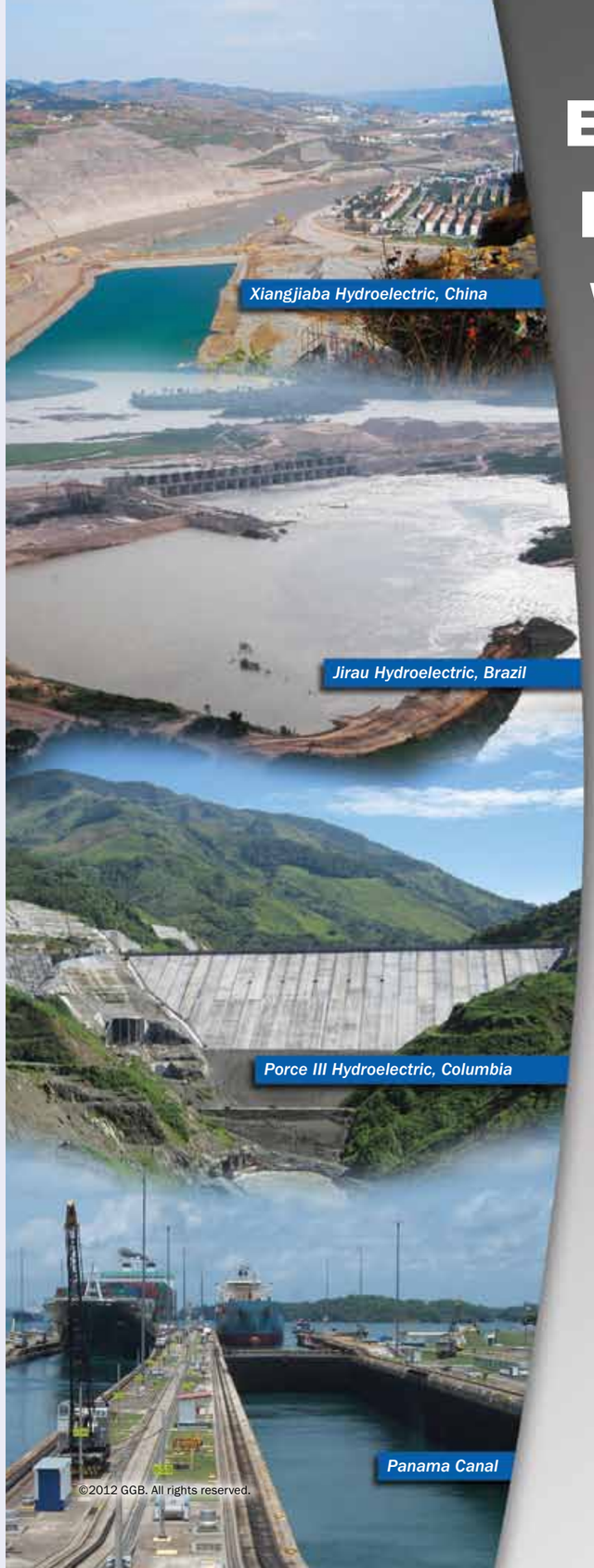
A material that works

Bobby Brown with FirstEnergy *knows* lignum vitae works. He's seen that first-hand. In the 1960s, when Brown was in high school, he was working at the 1.6-MW Luray plant on the Shenandoah River in Virginia when they replaced a set of lower guide bearings on one of the three units. The bearing they pulled out of the unit, which was made of lignum vitae, was likely original to the plant when it began operating in 1927, and "we probably could have still used that bearing," Brown says.

Brown, [please provide job title], says the lignum vitae bearings were replaced over the years because the company was looking for less-expensive options. He estimates newer composite bearings cost about a fourth of the expense for lignum vitae. And with four plants containing a total of 15 turbine-generating units, cost is certainly a consideration for equipment supply and maintenance.

The four plants Brown is responsible for are Luray, 1.4-MW Newport, 862-kW Shenandoah and 750-kW Warren, all on the Shenandoah River in Virginia. Having run the units using new bearing technologies for several decades, Brown determined lignum vitae was still the best option. In fact, using it would save a significant amount of money in the long run in not having to replace bearings regularly. Brown cites a case where he installed polyurethane bearings in a unit and when it was taken out of service for maintenance six months later, the bearings needed to be replaced.

He believes personnel moved to the new materials both because lignum vitae was getting hard to find and because they believed they could save money. However, "I know for a fact we're not saving money using the new bearing material," Brown says. So, he presented his case to his supervisor and got permission to purchase enough lignum vitae to



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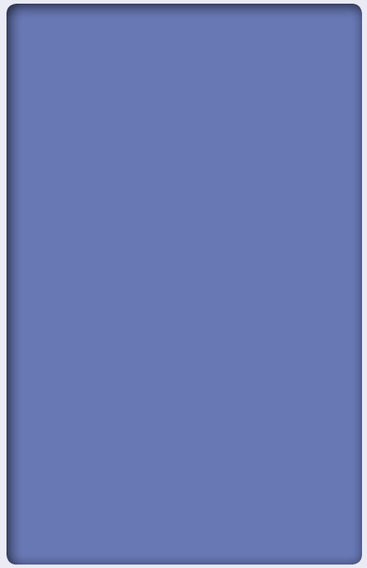

Lignum vitae trees are slow-growing, requiring 350 years of growth before they can be harvested. The wood is self-lubricating from a natural substance, eliminating concerns about leakage of oil or grease into the water.

replace the bearings in all the units. But before he could move forward with this, the budget changed. Brown's new tack is to purchase one set of bearings at a time and gradually convert all the units. With all four plants being run-of-river, personnel take them offline a minimum of once a year and more often if water conditions allow for routine maintenance. In 2012, Brown installed lignum vitae bearings on Unit 1 at Luray. He has another set of bearings waiting to be installed [in which plant?]. And he has an order in for yet another set, with plans to order a fourth set in the next quarter.

Have operational experiences justified Brown's decision? He took Unit 1 at Luray off line after about a year of operation and saw absolutely no wear to the bearing. And he's confident he will not be around to replace the lignum vitae bearings in the future, because of their longevity.

"I know it works," he says. "This is not an experiment."

Application at a southwestern plant

In 1914, an eight-unit plant in the southwest began operating using lignum vitae bearings. Over the years, operating experience at the plant showed lignum vitae in the bottom guide bearing of a unit lasted about 20 years.

However, the plant manager got to the point, in about 1985, where he could not find the material anywhere, and he was told it would not be available in the future. Even if he could find a source for the wood, it would have to be cut and transported, which would be costly and take time. So the plant manager began looking for other options. He heard about composite bearing materials and thought they might be the solution he was looking for. "We had to change," he says. "We might have done it this way [using lignum vitae] for 50 years and been doing it wrong."

Because materials were available from multiple manufacturers, the plant manager decided to install two different materials on two units that run side by side in the powerhouse. This would allow a true comparison of the materials. One outlasted the other by a couple of years, but even so, average lifespan of the composites in this application was only eight to 10 years, compared with 20 years for lignum vitae.

Then, about three and a half years ago, the plant manager saw the lignum vitae advertisement. The timing was opportune, as the plant was running low on the composite materials, which it had stockpiled in the 1980s to allow for replacement of several bearings. With the significantly shorter lifespan of composites being the primary concern, "When we found out we could get lignum vitae, we ran back to it," he says.

He cautions that lignum vitae is more expensive than composite bearings and that when the bearings are not in service they have to be stored in water to keep from drying out. However, these minor negatives are outweighed by the longer lifespan and fewer unit outages needed for bearing replacement, the plant manager says. "This allows us to use all the water flowing into the plant, rather than spilling it while a unit is down for a bearing replacement," he explains.

The unit in which lignum vitae was installed two years ago suffered a broken shaft and has been out of service for the past year. However, while it was operating the bearing performed well, he says. The unit was scheduled to be reassembled in mid-April and returned to service. And as other bearings need to be replaced in the plant, the company will move back to lignum vitae. "Lignum vitae wood is the best bearing material of anything we've got on the market today," the plant manager says. ■

Meeting with seal suppliers

Seals are a vital component in every hydroelectric facility, with their function being to either eliminate or minimize water leakage. Many companies supply this equipment for the hydro market. As of mid-April, 10 of these companies were signed up to exhibit at HydroVision International 2013 in Denver the week of July 23. They are:

— A.W. Chesterton Co. of the USA;
— Fematics Canada;
— Fugesco Inc. of Canada;
— Hunger Hydraulics C.C. Ltd. of the USA;
— Johnson Centrifugal Technology of the USA;
— PXL Americas/All True Designs of the USA;
— Seals Unlimited Inc. of the USA;
— SKF Sealing Solutions Austria GmbH;
— Synaflex Rubber Products Company of the USA; and
— Thordon Bearings of Canada.

For information on the products these companies will be showcasing at HydroVision International, or to schedule an appointment to meet with them, visit our DirectEventConnect website at community.hydroevent.com.

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