Using a Sensor to Continuously Monitor Water Contamination in Oil in Hydro Units

By installing an in-line sensor at its 115-MW Moccasin project that monitors water in oil at levels as low as 0.1 percent by volume, Hetch Hetchy Water and Power detected a leak and saved thousands of dollars in oil replacement and disposal fees.

By Matthew E. Gass and Joe D. Hedges

Water contamination of the oils used to lubricate large flooded guide and thrust bearings at hydroelectric projects can result in expensive downtime for the turbine-generator unit. As little as 1 percent contamination in water-cooled oil pots can force a utility to shut down a unit for repairs. And this can be a costly situation. For example, shutting down one of the two turbine-generators at the 115-MW Moccasin hydro project on the Tuolumne River in California would cost project owner Hetchy Hetchy Water and Power as much as $60,000 per day in lost power during the peak generation period. In addition, repairing a water leak into the oil pots sometimes requires several days.

The methods typically used to detect a leak into the bearing oil are:

— An alarm that sounds when the oil rises above a certain level; or

— Visually inspecting the oil pot weekly for evidence of emulsified oil.

Matthew Gass, P.E., is engineering manager for Hetch Hetchy Water & Power, which owns the 115-MW Moccasin project. Joe Hedges is president of Voelker Sensors Inc., developer of the sensor installed at Moccasin.

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Although these can be effective approaches, there are drawbacks. For example, a level sensor requires water contamination of up to 5 percent by volume before sounding an alarm, while a routine preventive maintenance approach does not take into account leaks that may indicate catastrophic coolant system failure.

Another option is an in-line water sensor. This sensor fits directly in any turbine-generator oil reservoir and continuously measures for the presence of water or coolant in the oil in the thrust or guide bearings. The sensor enables water contamination to be determined at levels as low as 0.1 percent by volume.

Installing an in-line sensor

To test for performance and long-term stability of the sensor, Hetch Hetchy hired Voelker Sensors Inc. in Palo Alto, Calif., in 2003 to install its in-line Oil Advantage – Hydro System water sensor in a water-cooled oil bearing pot of a 50-MW turbine at Moccasin. This was the first use of this sensor at a hydro project. The pot at the Moccasin project contains food-grade International Organization for Standardization (ISO) 68 viscosity turbine oil supplied by Chevron. The turbine was run continuously under normal operating conditions.

For the first six months of operation, results indicated a negligible amount of water present, corresponding to fewer than ten parts per million water content measured by Karl Fischer titration methods at an independent laboratory. But in the seventh month, a leak from a coolant line tripped the level sensor when the level of the oil/water mixture rose more than 1.5 inches. The Hydro System display indicated water contamination was about 1 percent, by volume. (See Figure 1.)

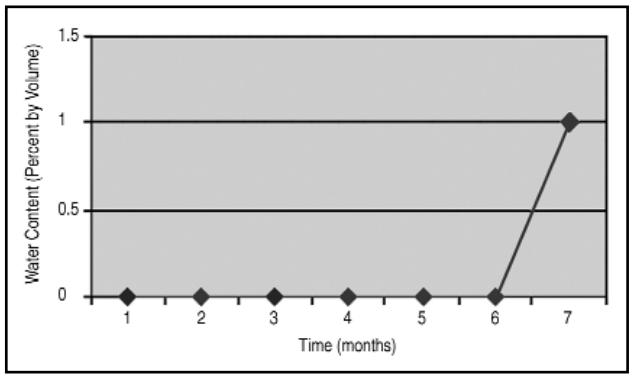

Figure 1: In the seventh month of monitoring, the Oil Advantage – Hydro System installed at the 115-MW Moccasin project detected water contamination of the oil.

The technology behind the system

The Hydro System uses a patented technique that consists of a hydroscopic polymeric bead matrix (held between two conducting permeable surfaces) containing charged groups that serve as a conducting medium for measuring a relative change in the solvent properties of oil. The beads expand when they come in contact with water, creating a relative change in the electrical properties across the two conducting surfaces. Water can be detected as droplets, as an emulsion, or fully dissolved, without the need for calibration or reference standards. The sensor can be calibrated using new oil with no water, or the utility can heat the oil to drive off the water.

Sensitivity and detection limits for this method depend on the oil's composition

and additive package. The beads compete with the oil for water and, in certain formulations, the system can detect water below 100 percent saturated relative humidity. Detecting water before it reaches a fully saturated condition (before dropping out as emulsified or free water) provides an early indication of potential contamination problems. (See Figure 2.)

The Hydro System consists of a sensing element, a mechanical interface (that secures to the oil pot or reservoir), and a signal-conditioning unit with a light-emitting diode (LED) display that indicates oil condition. The display can be calibrated to show relatively low amounts of water in percent. For more immediate measurements, an output device of a 4 to 20 milliamps (mA) signal allows for easy interfacing to plant annunciation and supervisory control and data acquisition (SCADA) systems. Temperature has little effect on the device, and utilities can add alarm and trip settings.

If the hydroscopic beads become saturated with water, the sensor must be replaced. However, the cost is only about $25 per sensor in quantities less than ten.

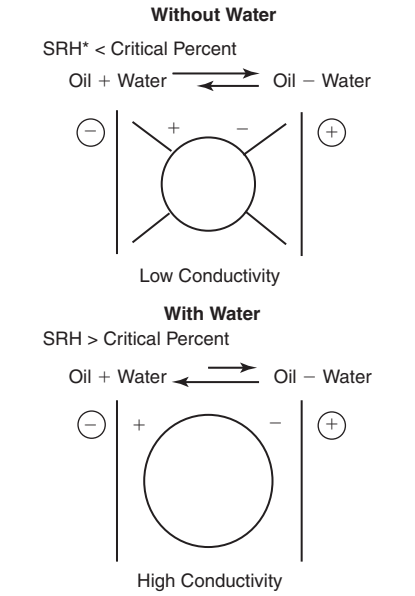

Figure 2: In the absence of water (top), the hydroscopic polymeric beads, held between conducting permeable surfaces, have no reaction. When water is present (bottom), the beads expand and compete with the oil for water.

Cost benefits

Preventive maintenance in hydro generators extends lubricant life and preserves the performance and longevity of expensive equipment. In addition to lost revenue and potential bearing damage, hydro project owners must consider the costs associated with recycling or filtering contaminated oil. As a result of the minor coolant leak that occurred at the Moccasin project, Hetch Hetchy had to recycle the contaminated oil through a centrifugal device to avoid the loss of several hundred gallons of food-grade turbine oil, estimated at more than $7 per gallon. By comparison, installation of the Hydro System costs about $900 per turbine.

By the end of 2005, Hetch Hetchy also plans to install the system at 124-MW Kirkwood and 170-MW Holm. ■

Mr. Gass may be reached at Hetch Hetchy Water & Power, P.O. Box 188, Moccasin, CA 95347; (1) 209-989-2130; E-mail: mgass@sfwater.org. Mr. Hedges may be reached at Voelker Sensors Inc., 3790 El Camino Real, Suite 336, Palo Alto, CA 94306; (1) 650-361-0570; E-mail: joe@vsi-oil.com.