Lessons Learned

The Tailrace Oil Slick

The two-unit, high-head, six-jet vertical impulse-wheeled power plant had just been commissioned. It was being operated remotely from the control center over a microwave link. Carl, the commissioning engineer, was enjoying a late coffee while looking out the local control room window (strategically placed to take advantage of the beautiful view over the short tailrace channel and out to the ocean). The sun was just setting, and Carl could see a group of whales swimming past about a kilometer offshore on their annual migration.

The ocean was unusually calm, and Carl also noticed a strange, multicolored reflection off the highly aerated tailrace water. He thought nothing of it, and turned around to note with satisfaction that the control panel alarms were all dark, except for one that had just started to flicker on and off with a yellow glow, indicating low oil level in one of the turbine bearings. He made a mental note to ask an electrician to check the wiring connectors.

A few days before, the control panel had been well lit, as the commissioning team adjusted and calibrated the instruments. Now, the team had departed, leaving only a technician to complete a few odd jobs and to supervise painters still at work color-coding the piping.

Next day, Carl noted that the low oil alarm light was off, and thought nothing more of the incident.

A few days later he was again enjoying a late coffee, looking out at the setting sun, and again noted the iridescent reflection off the water. Turning around, he noted the low oil alarm for one of the units start to flicker, and suddenly realized that bearing oil must be leaking out into the tailrace water, causing the sheen. He immediately called John, the technician, to come up to the control room. When John arrived, Carl did not say anything, but pointed out the window. John looked, and exclaimed, "So that's where it's going!"

Apparently, John was in the habit of starting work early, and for the past few days had noted the yellow light on, sometimes on one unit; at other times on both units. He had then checked the bearings, which were only accessible by crawling through a manhole inside the generator casing, and down onto the turbine headcover, where headroom was just over 1 meter, in the close-coupled units. He had found that the oil levels were low, and had then added between 10 and 30 liters to bring the level up to full.

The bearing oil was contained in a doughnut-shaped pot around the shaft. John had checked for leaks in the gasket at the vertical joint in the split pot, and had felt for oil in the bottom of the headcover, but could not find any. He was puzzled about the loss. John had entered the oil addition into his logbook, but had not yet reported the loss to Carl since the plant was in the first week of operation, and he was still trying to find the leak. Moreover, the turbine bearings were only accessible when the units were shut down, hence access time was limited to an hour or so in the early morning before the units were started to meet the daily peak loads.

Carl immediately informed the consultant's resident engineer, who was still on site. Together they looked at the detailed turbine bearing drawings. They could not find anything amiss, but a call to the consultant's head office turbine expert produced a quick answer.

In vertical axis impulse units, the water falling off the runner entrains a large volume of air, which produces a small vacuum above the runner and around the shaft. In the doughnut-shaped guide bearing oil pot, the oil level at the outer circumference is subjected to powerhouse air pressure, the guide bearing rotates in the middle of the doughnut ring, and the inner circumference of the oil level is then subjected to the air pressure above the runner. To prevent migration of oil out of the pot by action of the small vacuum above the runner, there are usually two seals between the inner rim of the stationary oil pot and the rotating shaft.

In this case, in the interests of economy, the turbine manufacturer had elected to use only one seal. This design was questioned during the bid analysis, and the consultant was assured that an identical design had been operating successfully for two years at a power plant in South America. Based on this assurance, the design was accepted, and the contract awarded.

When the turbine expert was advised of the oil slick, he immediately knew the source of the problem. After some digging through files, the turbine manufacturer was able to provide the telephone number of the South American powerhouse, and a call to the operator elicited the response: "Si, senor. usamos uno 40 a 60 litros por dia!" (We use 40 to 60 liters per day.) Apparently, this use of oil had been considered normal, and no complaint had ever been made to the manufacturer.

The magnitude of the small vacuum above the runner is a function of the shape of the runner chamber, the height of the runner above tailwater, but, more importantly, the volume of water thrown off the runner. Hence, a long period of operation at high load is usually required to confirm the effectiveness of the oil pot seal. A defective seal may not be detected during commissioning.

The turbine manufacturer quickly produced an acceptable design for a second seal. It was installed, and the oil slick cleared up, much to the relief of all concerned, especially with whales swimming by only a short distance offshore.

The lesson learned: always check references given by manufacturers back to the source, particularly if the design or performance has been questioned. Don't accept a casual assurance that everything is OK. Telephone or visit the referenced power plant or equipment operator. And, beware of vague replies.
— By James L. Gordon, B.Sc., Hydropower Consultant.