Lessons learned.

Maintenance woes.

By

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George was uncomfortable, sitting in the control room at Kabonga, a large low head close-coupled powerplant, where 5 Kaplan turbines had been operating for about 10 years. He was busy copying powerplant operating and basic data into his notebook. Despite the air conditioning, the temperature was well over 40 degrees. Also, three lights on the control panel were blinking red, and the operator was not taking any action. After completing his task, he asked the operator why he was not concerned about the warnings, which indicated fires in the areas of the turbine governors. The operator replied that in summer, these lights were always on.

Not satisfied with the answer, George walked down onto the turbine floor, and looked at the governors. All seemed in order, but the temperature was even higher than in the control room. Further investigation revealed that the air ventilation ducts above the governors had been stuffed with rags, cutting off the air supply, hence the excessive temperature. Following the ductwork, he found that the same duct supplied air to the local control booths at each generator, where other operators were sitting in relative comfort. This did not bode well for his work, which consisted of adding propeller units in two of the 5 empty bays, provided for future plant expansion. George made a note to ensure that the new units were equipped with extra controls and protection equipment. They were commissioned about 36 months later, with all financing provided by an international bank, since local currency was not convertible.

25 years later George received a call from Bill, the retired mechanical engineer who had worked as the senior mechanical consultant on the project, who advised that Kabonga Unit 6 had “blown up” and he was trying to find out more details from the turbine manufacturer. A week later, Bill called with the details. Apparently, the plant operators had great difficulty keeping the equipment operating due to a lack of spare parts, exacerbated by non-convertibility of the local currency. Even governor oil was impossible to obtain, and it tended to “disappear”. The result was predictable, low oil in the governor caused an alarm in the control room, and further loss of oil caused a unit trip. The low oil float switch solenoids were by-passed. There were two over-speed switches on the unit. A mechanical device connected to the shaft, to initiate headgate closure on excessive over-speed, above the normal unit full load trip shut-down over-speed, and a similar electronic device operating off the generator. Both speed switches had also been by-passed when they had failed, since replacement parts were not obtainable, and the units had to be kept operating.

Eventually the inevitable happened. With insufficient oil in the governor, control was lost on initiating a shut-down. The unit went to runaway, at almost twice normal synchronous speed. Flow through the unit increased by 60% to just under 600m^3/s. Unfortunately, the emergency head-gate closure in the control room was also out of order. The headgates were operated with a hydraulic cylinder hoist, and over the years the seals had worn causing the gate to drift down. The limit switch used to keep the gate open had also failed, and was not operational. To prevent the gates closing, they had been dogged with steel beams. The chief operator had to climb the stairs to the deck of the dam, and then up into the hoist house on a tower about 20m. above deck, lift the gates, climb down, remove the dogging beams, climb up, and close the gate. 15 minutes after the unit went to runaway the headgate was successfully closed. Damage to the turbine was severe.

On going to runaway, a propeller unit will speed up and ride up on the draft tube water column, causing the unit to lift and sometimes impact the headcover. At Kabonga, there are two headcovers, an outer headcover from the stay ring over the wicket gates, and an inner headcover from inside the wicket gates to the shaft. The inner headcover received the full impact from the runner, after which the runner bounced down, and rose again to hit the headcover. This motion continued until eventually the bolts holding the headcover failed, the headcover lifted by about 300mm, and the turbine pit flooded. Also, the harmonic waterhammer in the draft tube due to the motion of the runner, ruptured the casing around the draft tube door. The whole powerhouse flooded to tailwater, just below generator level, and all units were stopped.

Lessons learned.

There are two lessons from this unfortunate incident. The first is quite obvious, alarms and controls must not be by-passed. They are a vital part of powerplant safety. The second lesson is not so obvious. Many powerplants are built in developing countries where the local currency is not convertible into Euros, Dollars or Yen. The plants obtain financing for construction from international development banks, and sometimes for a few years of training for the local operators, as was the case at Kabonga. After about 5 years, the plants are usually cast adrift to operate on their own. The problem now arises in obtaining hard currency for spare parts. In many cases this is just not obtainable, resulting in a gradual deterioration of the plant, and occasionally a spectacular failure as at Kabonga. The solution – continue international bank financing for the purchase of spare parts.
