OVAL TURBINE THROAT RING

George was on the phone with Bill, the operating engineer for a 6 unit, high head Francis powerplant. George was familiar with the plant since he was involved with it's design some 25 years previously. Bill was asking George to visit the plant to look at the throat ring for one of the units which had slowly distorted into a slightly oval shape over the years, and no logical reason for the distortion could be found.

When George arrived at the plant, he was shown the dewatered unit #2, where the runner had been removed for a major overhaul of the unit. The plant operators advised that careful measurements of runner lower band clearance had been made over the years, which included quarter rotations of the runner to eliminate runner distortion, indicated a slow ovalling movement, and confirmation of the suspected ovalling had now been obtained with diametrical measurements across the throat ring. The extent of the movement was very small, only a few thousands of an inch, but sufficient to indicate that if the rate of ovalling continued for about 4 more years, there was a danger of runner to throat ring contact, hence the concern. The same ovalling had been observed on unit #4, with the squeezing taking place in the longitudinal direction and enlargement in the upstream-downstream direction, in both units. Grouting plugs on the bottom stay ring in unit #2 had been removed to check the concrete, but only a small void was found, near the longitudinal axis, not in the right location to explain the distortion. George speculated that one explanation could be mild aggregate-alkali reactivity (AAR), the plant was of the right age, but the effect should be apparent on all units, and the aggregate had been tested prior to construction.

A thorough inspection of the powerhouse indicated sound concrete everywhere, with no surface "mapwork" cracking, indicative of AAR. George, being familiar with the plant design, quickly reviewed the powerhouse and turbine drawings, but could not discover any obvious reason for the distortion. And why only in two units?. He concluded that there must be something different with the two ovalling units. All six turbines were identical and built by the same manufacturer, and the concrete surounding each unit was of the same shape. A discussion with the operators revealed that units 2 and 4 were peak loaded, being started and stopped for the morning and evening peak load periods. Being high head, the spiral casings were emptied, with the turbine rotary valves closed, twice daily. The other four units were base loaded and operated continuously. George asked why the peaking duty was not rotated between units, and was advised that station service water was obtained from units 1 or 3, and with 2 units on each penstock, only units 2 and 4 could be dewatered off peak. Units 5 and 6 had been added later,

and were not been peak loaded since the automatic controls for valve closure and casing dewatering had not been added to the units.

Still George could not think of any reason for the distortion, but realized that the clue resided in the daily dewatering of the units. After much thought, he advised Bill that he had a "crazy" idea, and to bear with him as he explained. The 6 units were built into a hard granite rock excavation, and the steel spiral casings had been concreted in under no pressure, without any gap between steel and concrete. Under pressure the steel had to expand to resist the high head, and this was resisted by the rock and concrete in all directions except downstream. With units 2 and 4 being dewatered twice daily, this would relieve the longitudinal resisting force between these units, and result in sideway squeezing on units 2 and 4. Over time, the concrete could creep, the casing could deform and the result could be ovalling as measured. Yes, George admitted that the idea was far out, but it was the only explanation he could think of. Testing the concept required changing the peaking operation to a rotation of the duty among all 6 units. Bill advised that this would require some changes to the station service piping, and the addition of some controls, but it would be tried.

Two years later, George had a call from Bill, to advise that that his crazy idea was working. Peaking duty was now being rotated between units, and recent measurement of the runner lower band gap on unit #2 had indicated a small return to circularity.

Lesson learned.

There has to be a rational explanation for unexpected events. The problem is arriving at an explanation which makes sense. If a sensible explanation cannot be ascertained, try some free thinking, and don't be embarrased to voice an apparently ridiculous conclusion. Admit the fact that you may not have anything to back up the conclusion, and see if there is some way that the idea can be tested at minimal cost.

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