The overstressed generator bracket.

by

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George looked up to see Karl standing in the office doorway with a roll of drawings and a sheaf of paper. Karl spoke first “George, that bracket for Eagle Falls I just checked, is way overstressed and will fail”. At this, George was surprised. He had asked Karl to verify the stresses in a large steel bracket supporting a 200MW hydro generator, as was the custom at the consulting company – all critical components of manufacturer’s equipment was routinely checked, such as generator brackets. Errors were rare, but the check added assurance that failures resulting in a catastrophe during commissioning would not occur.

The generator bracket supported a 420 ton generator rotor, vertical shaft and a Francis turbine runner. It was shaped like a spider, with a central hollow cylinder. Around the cylinder there were two rings, welded to the cylinder and to the flanges of six I-beam arms extending outwards to rest on the powerhouse concrete plinth, just below the generator.

“Karl, you are dealing with a well-known generator manufacturer who has been in business almost since Edison invented the light bulb, you must have a decimal error in your calculations, so check your numbers and come back later” George replied. Next day Karl returned and advised that the result was the same, an overstressed bracket. George checked the calculations with Karl, and had to agree that the results were correct. The overstress was at the junction between the central cylinder and the radial arms, where the arm flanges were welded to the two rings around the cylinder. From a casual look at the bracket, the dimensions appeared to be reasonable, but the steel thickness seemed minimal.

George phoned the Ed, the chief electrical engineer and appraised him of the situation. Ed’s reaction was as expected, there must be something wrong with the calculations. Eventually George was able to convince Ed that the manufacturer had to be informed, and George was allowed 10 minutes at a forthcoming meeting with the manufacturer. George made his presentation to the manufacturer’s electrical engineers, who unfortunately could not understand the details. They were incredulous, but eventually assured George that his concerns would be passed on to the engineering department.

Six months went by before there was a reply. George received a new drawing showing a much reinforced and deeper bracket, with the steel thickness more than doubled in several critical areas. Karl checked the stresses and found them to be satisfactory. Of course, George wanted to know what had gone wrong. This was a major manufacturer, and one did not expect such mistakes. At the next meeting with the manufacturer, George arrived at the morning coffee break, and asked a few pointed questions. After some discussion, one of the engineers advised that the error had caused consternation in the engineering department. They had found that all

their generator brackets had been “drawn” by a senior technical draftsman who had been with the manufacturer for many years. No stress analysis had been undertaken. As time passed, and generators became larger, the draftsman had simply extrapolated from previous designs to produce something that “looked right”.

The manufacturer had to engage the services of a structural engineering consultant to review the design of all recently manufactured generator brackets, a task which required many months. The consultant re-designed the Eagle Falls bracket, and an agreement was reached with the consultant to provide structural services for future units. Very fortunately, only one other bracket was found to be slightly overstressed, the owner was advised, and reinforcing plates were added. At Eagle Falls, the rotating weight supported by the bracket, at almost 500 tons, was over twice as heavy, and the bracket was about 40% larger than any previous bracket provided by the manufacturer. The bending moment in the bracket was 4 times larger than anything built previously, and the draftsman had just not realized the extent of extra steel required.

Lessons learned.

Consultants or Owners engineers should verify the design of all critical components provided by contractors, where failure of such components would result in a significant delay or additional cost to the development. Such components would include crane beams, both on the crane bridge and in the powerhouse superstructure steel. Also, other components such as the lower structural beams in gates, Tainter gate arms, and gate hoist superstructure steel for stress at hoist motor stalling torque, should all be checked. For generator brackets, the deflection should also be determined, since there is a limit imposed by the turbine runner seals. If Karl had not discovered the error at Eagle Falls, the bracket would have deflected so much that either the turbine runner would have settled to rest on the draft tube cone, or the generator would have dropped onto the brake rim, and considerable delay would have occurred while the bracket was being reinforced.

With the current preference for “design-build” hydro plants, where designers are working within a fixed cost, it is becoming essential for the Owner’s engineer to check stresses in critical components provided by manufacturers and contractors.