**Grand Coulee Dam**

**The Dam Engineers**

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**Project Description**

The Bureau of Reclamation handles storage, diversion and development of our nation's water resources to provide us with irrigation, drinking water, and power while preserving the water environment we have. A large part of this involves building and maintaining the hydroelectric dams that provide us with power. Constant improvements to the efficiency of these massive power producing structures is essential in order to maximize the energy potential within the water behind these dams. Some of this water is used to cool heat generating systems within the dam. An optimum cooling of these systems along with a minimum amount of water used to cool can be obtained if a flow monitoring system is installed. Producing a design, which satisfies the needs of the dam and the needs of the customer, requires a thorough understanding of how individual systems operate within the dam and as a whole.

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**Project Overview**

**Area 1 - Upper Guide/Thrust Bearing**

**Area 2 - Air Housing Coolers**

**Area 3 - Lower Guide Bearing**

**Area 4 - Turbine Guide Area**

**Area 5 - Main Cooling Water Supply and Jet Pump**

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**Lower Guide Area**

The lower guide bearing is a journal style bearing like the upper guide bearing. The lower guide bearing also provides axial alignment at its vertical location on the shaft. The lower guide bearing is located within the lower oil pot. Heat is generated due to the friction between the lower guide bearing and its contact surfaces when the shaft rotates. The oil in the oil pot lubricates the lower guide bearing and dissipates heat generated when the shaft rotates. A cooling coil within the oil pot cools the oil in the oil pot. The cooling coil is supplied with cooling water from the main cooling supply. Both the cooling water and oil circuits must be monitored for optimization.

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**The Turbine Bearing**

The turbine guide bearing is a journal style bearing located just above the turbine impeller and is the lowest guide bearing on the turbine shaft. This guide bearing, unlike the other two guide bearings, is not located within an oil pot. The oil supplied to the turbine guide bearing comes from an oil sump. There are two pumps (AC & DC) used to transfer the oil to the oil guide bearing. The AC pump is used when the turbine is running and the DC pump is used when the unit has to be shut down. After shut down occurs the DC pump provides oil to the bearing while the turbine spins down to a stop. The oil is pumped from the oil sump and into a shell in tube heat exchanger. The oil is then sent through a filter before it reaches the turbine guide bearing. The oil drains from the turbine guide bearing back into the oil sump carrying heat away from the bearing. The heat is dissipated from the oil within the main cooling exchanger. The heat exchanger is supplied with cooling water from the main cooling supply. Both cooling water and oil circuits must be monitored for optimization.

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**Air Housing**

The air housing is comprised of eight air-to-water heat exchangers located around the stator-housing circumference. These heat exchangers are all fed from the main cooling water supply. The cooling water is dispersed to these eight heat exchangers through an inlet manifold. After the cooling water has passed through the heat exchangers it is collected in an exit manifold then flows to the cooling water return circuit. These heat exchangers dissipate heat generated in the air housing by the stator. Fans that are external to the air housing circulate air into the housing, through the heat exchangers, and exhaust outside the dam. Optimization of this sub-system must involve quantified cooling water use within the eight heat exchangers and temperature differences within the air housing or across the heat exchangers.

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**Main WaterSupply**

The jet pump uses the high-pressure water dropping from the head bay (water up stream of the dam) to scavenge water from the tail bay (water downstream from dam). The jet pump reduces the amount of upstream water needed for system cooling. The main cooling water supply comes from the scroll case. The main cooling water supply is monitored to quantify total head bay water used for system cooling. The jet pump's scavenger circuit from the tail bay is monitored to quantify the amount of water saved from the head bay for system cooling. The combination of monitoring these two circuits allows for a maximum use of water for cooling from the tail bay and a minimum amount of water used for cooling from the head bay.

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**Specifications**

After justification and analysis the customer needs were identified and listed in customer needs table. The needs were ranked based on their relative importance in order to prioritize the changes that needed to be implemented to the design to satisfy the needs in the most efficient way. The resulting needs were weighted and analyzed by comparing them to the metric specified in order to design the most efficient turbine. The main focus in our design is to monitor the flow in the cooling system of each generator, in order to optimize the use of water. In order to achieve a design that satisfies customer needs the use of a trade-offs needs to be considered. Some of the piping has been changed accordingly to meet the specifications of the measuring device. This might increase the cost of the project, but it would increase the accuracy of the readings. The SCADA system will have to be adjusted so that the flow can be monitored. That will require new displays on the SCADA board and additional data acquisition cards, which will also increase the cost, but will ease the monitoring of the flow.

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**Recommendations**

From the pool of flow meters available as possible candidates to measure the flow of the main cooling water supply and the flow through the jet pump, only a few were taken into consideration. Below is a summary of the reasoning behind the selections that were made. The table on the right was used to narrow down the options available. Pitot tubes were ruled out because of the possibility of clogging of the tube with debris in the river water. Target meters, rotameters and vortex meters were not considered because they require a target, drag disk or a bluff body suspended in the water stream that eventually can be carried away with the stream or get clogged with debris. Positive displacement meters and turbine meters require moving parts, which considerably decreases the flow meter life time, are hard to maintain and increase the risk of obstructing the flow in case of catastrophic failure. Coriolis flow meters was not considered by the same reason Pitot tubes were ruled out, they require a U-shaped flow tube to be placed inside the pipe which will obstruct the flow. It also needs to be mounted no closer than 30 pipe diameters from a pump or elbow, which is impossible in this design. The elbow flow meter was not considered because of its low accuracy in measurements (5-10% of full span). The orifice and nozzle flow meters were eliminated because of their vulnerability to clogging and they have high head loss. No devices used for this project to measure the flow are electromagnetic or ultrasonic flowmeters.

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**Acknowledgements**

Bureau of Reclamation:

Erica Carlin - LPH/PGP Main Sap
Mark Borden - LPH/PGP Mechanical Engineer

Washington State University Mechanical Engineering Department:

Dr. Charles Pezeshki – Dr. Chuck/Big Dog Yoda

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**Bureau of Reclamation: Mark Borden - LPH/PGP Mechanical Engineer**