

---

# 2008 Iron Gate Turbine Venting Study of Dissolved Oxygen Improvement

---

## Introduction

In 2005, a turbine venting system was modeled at the Iron Gate powerhouse to estimate air admission rates, dissolved oxygen (DO) uptake, and potential total dissolved gas (TDG) impacts for the observed powerhouse operating conditions. Modeled estimates of turbine air admission indicated dissolved oxygen uptake of 1.5 to 2.7 mg/L depending on turbine headcover valve operation and the potential inclusion of baffles on the turbine.

During 2008, PacifiCorp conducted field studies of turbine venting at the Iron Gate powerhouse to assess the capability of turbine venting to increase dissolved oxygen (DO) levels in the Klamath River below Iron Gate Dam. Turbine venting is currently employed to improve turbine generator stability and eliminate rough zones at low powerhouse flows during normal plant operations. The study investigated the DO increase obtained from the existing turbine venting regime and determined the additional DO benefits that could be obtained by fully opening the turbine vent valve at flows in which it is normally not fully open. The study also included measurements and analyses to assess turbine efficiency, turbine-generator vibration, power output, and turbine venting air flows.

The 2008 Turbine Venting Study was conducted August 18–21 and October 9-10 – the late summer/early fall time period – and covered the range of flow conditions that occur below Iron Gate Dam during that time period.

This memo highlights the methods and results of the study and provides recommendations for additional work. For more detailed information please refer to the Appendices.

## Methods

### *Water Quality*

The effect of turbine venting on DO and TDG was assessed with continuous and spot measurements. Continuous data were collected at two monitoring stations; the PacifiCorp water quality station at River Mile (RM) 189.85, and in the vicinity of the Blue Heron R.V. Park (RM 188.55). Continuous monitoring was supplemented by spot measurements at the Iron Gate Dam tailrace (RM 190.00), the USGS Gauging Station 11516530 (RM 189.45), and the Klamathon Bridge (RM 184.17). Turbine venting was conducted over a broader range of flows (1,000 to 1,500 cfs) than is required to be released below Iron Gate dam during the August through October period when DO levels are understood to be most critical. The Bureau of Reclamation's Biological Opinion for coho requires flow releases of between 1,000 and 1,300 cfs during this period.

Multi-parameter DataSondes were used to collect data at both of the continuous monitoring sites and for spot measurements. Prior to deployment, the instruments were

calibrated and the continuous data were recorded at 30-minute intervals. Spot measurements were made throughout the day during the test period.

#### *Turbine Performance*

Turbine performance and turbine venting air flow data were recorded concurrently with in-stream water quality parameters. Turbine performance was determined by monitoring turbine flow and power generation output. Vibration conditions of the rotor during the tests were monitored to determine the effects of air flow on rotor stability and turbine cavitation at various gate positions.

### **Results**

#### *Water Quality*

The results of the studies showed a positive improvement in DO concentration measured in the Klamath River below Iron Gate powerhouse. DO increased by up to about 2 mg/L and 20 percent saturation as a result of full air admission through the existing turbine vent valve design at turbine flows of 1,000 cfs to 1,500 cfs. The increases in DO from turbine venting were seen throughout the study area which covered approximately 6 miles below the powerhouse. In addition, Total Dissolved Gas (TDG) measurements remained below 110 percent throughout the study period. Water quality data collected during the study period is contained in Appendix A.

#### *Turbine Performance*

The test results indicated that the effect of air admission on turbine efficiency at the Iron Gate powerhouse is typical for units of this type. At lower power outputs (where the unit tends to cavitate and run roughly), the addition of air improves efficiency by up to about 5 percent. At outputs above about 8 megawatts generator output (corresponding to a turbine discharge of about 800 cfs), air admission starts to cause a drop in efficiency. The greatest effect on unit efficiency occurs at the maximum power output of 16 megawatts (corresponding to a turbine discharge of about 1500 cfs). The maximum power output of 16 megawatts is where the turbine normally operates most efficiently, compared to other lower output levels. With air off, peak efficiency is 85.5 percent, whereas with air on, it drops to 83.3 percent, a decrease of 2.2 percent. Air admission reduces the maximum power output at 1500 cfs by about 0.6 megawatts.

Turbine vibration data collected during the testing showed the turbine shaft to be stable under all tested flows and air admission settings. Further, cavitation affects appeared to be minimal and no significant wear rate increases on the turbine runner are anticipated as a result of increased turbine venting. The details of each of these tests are provided in Appendix B and Appendix C.

### **Conclusion and Recommendations**

Results to date indicate that turbine venting is an effective means for increasing DO concentrations in the Klamath River below the Iron Gate powerhouse and that turbine venting does not produce elevated TDG levels. PacifiCorp recommends implementation of enhanced turbine venting in 2009 during periods when DO levels fall below 85 percent

saturation in the Klamath River immediately below Iron Gate powerhouse. Additionally, PacifiCorp recommends further testing of turbine venting using a manifold that could provide additional air flow to the turbine draft tube. This air admission manifold is currently capped off but can be opened during the Iron Gate powerhouse annual outage in May 2009. This testing would determine if air entrainment or injection through this manifold can increase DO concentrations in the Klamath River above the levels obtained through the existing turbine vent valve system.

## **Appendices**

### Appendix A

Water Quality Monitoring During Turbine Venting Tests at the Iron Gate Powerhouse, Klamath Hydroelectric Project. Prepared by Ken Carlson (CH2M HILL) and Kaylea Foster (Mason, Bruce, & Girard). December 2008.

### Appendix B

PacifiCorp Iron Gate Project “Turbine Performance and Air Admission Test”, Revision A, October 2008, Prepared by Principia Research Corporation

### Appendix C

Vibration Analysis Report “Turbine Shaft Run-out Survey, Iron Gate Power House, Klamath, CA”- Report No. R08-2-021, November 7, 2008. Prepared by Balancing Service Co. and Ball Spin Co.