Hybrid Index Testing Procedure

Introduction

Index testing is completed in one of two methods:

1. Traditional Method requires the test engineers to be onsite to take the measurements as the operators make the changes to the wicket gate and blade angle, and then by a tedious regimen of watching and waiting to allow the parameters with long-time constants to settle out to steady-state conditions before recording not just one, but multiple individual readings of all parameters every 30 seconds for 5-minutes, with a 3-minute wait after each gate and/or blade movement.
2.
3. Software Method - With the advancement of software and digital governors it is possible for a software solution that changes the blade angle off of cam position. The software changes the blade angle and adjust the wicket gates to maintain the operator's selected flow rate. The software makes many different blade angle adjustments around the existing cam curve till the most efficiency blade angle and wicket gate position is determined for the flow and head condition. As the flow and head conditions change the software repeats the process. Overtime the full flow and head ranges are covered and plant's controls can be updated with the new cam curve. The software can remain in place to monitor efficiency changes in the unit long term and alarm out to the operators of drops in efficiency.

The Dorena project schedule requires the index testing to begin as soon as possible. However, flows available to complete the index testing is limited to storm events especially at higher head conditions. Because of the distance to the site and short scheduling timeframe caused by unpredictable storms the project needs an alternative method to complete the index testing.

The Hybrid Index Testing is intended to be completed the same as the Traditional Method with the operators performing the test. The difference is the plant's controls will record the results of the tests in 1 sec data points to be analyzed offsite. This procedure is intended to provide the operators the direction needed to complete the test in a safe manner to themselves and the project while ensuring the data is collected that can be used for offsite analysis.

Control Background

The plant will record the following in 1 sec time periods:

1. **T_Stamp** **Time and Date**
2. Res_Lvl Reservoir Elevation
3. **TlRace_Lvl_Ups** **Tailrace Elevation Upstream of Fish Screen**
4. TlRace_Lvl_Dws Tailrace Elevation Downstream of Fish Screen
5. SH_Ups_Pres Penstock Pressure in Siphon before units' bifurcation, upstream of valve
6. SH_Dws_Pres Penstock Pressure in Siphon before units' bifurcation,, downstream of valve
7. **Pen_Flow** **Penstock Flow, only one turbine operates at a time**
8. **U1_Ups_Pres** **Kaplan Pressure directly upstream of scroll case**
9. U1_Dws_Pres Kaplan Pressure directly downstream of runner

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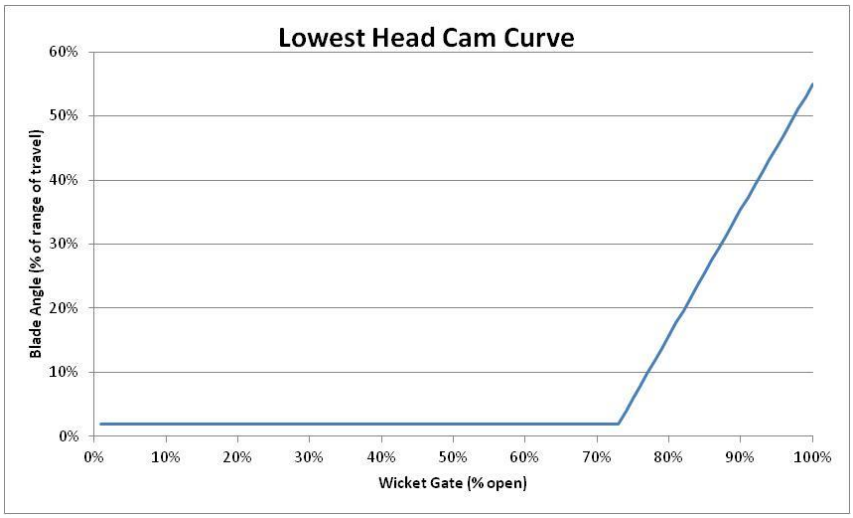
10. **U1_WGP** **Kaplan Wicket Gate % of stroke length**
11. **U1_RBP** **Kaplan Blade position % of stroke length**
12. **U1_MW** **Kaplan Power**
13. **U2_Ups_Pres** **Francis upstream pressure reading in the scroll case**
14. U2_Dws_Pres Francis draft tube pressure reading
15. U2_WGP Francis Wicket gate % of stroke length
16. **U2_MW** **Francis Power**

The project is currently setup to be ran in two modes. In the automatic mode the operators select the flow rate and the controls adjust the wicket gate and blade angle per the Kaplan cam curve. In the manual mode the operators can adjust the wicket gate and the blade angle which will result in a different flow rate. In the manual mode as the flow rate changes the USACE gate will automatically adjust to maintain constant river flows (Jeff please confirm).

Procedure

Initial Conditions

1. Verify the following before beginning index testing
   - 1.1. Call USACE to make them aware of the testing and the effects of flow transferring between the USACE gate and the project turbine.
   - 1.2. Identify that day's maximum flow rate authorized by the USACE to be used in the index testing
   - 1.3. Identify the Blade angles and the wicket gate positions to be used in this set of index testing. For each test the blade angle will be set constant and the wicket gate will change to at least 7 positions.
     - 1.3.1. The wicket gate positions start with the lowest and increase until all positions are complete or until the maximum flow rate is reached.
     - 1.3.2. The following curve is the cam curve for the lowest head condition, cam curves for higher head conditions should be used in developing the blade angle and wicket gate positions for those head conditions.



     - 1.3.3. Example for this Low head condition

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Test #	Blade Percentage	Wicket Gate Percentage
Test 1 (Cam Curve)	2%	10%
	2%	30%
	2%	50% (stop @ max flow)
	2%	60% (stop @ max flow)
	2%	70% (stop @ max flow)
	2%	80% (stop @ max flow)
	2%	90% (stop @ max flow)
	2%	100% (stop @ max flow)
Test 2	6%	10%
	6%	30%
	6%	50% (stop @ max flow)
	6%	60% (stop @ max flow)
	6%	70% (stop @ max flow)
	6%	80% (stop @ max flow)
	6%	90% (stop @ max flow)
	6%	100% (stop @ max flow)
Test 3	10%	10%
	10%	30%
	10%	50% (stop @ max flow)
	10%	60% (stop @ max flow)
	10%	70% (stop @ max flow)
	10%	80% (stop @ max flow)
	10%	90% (stop @ max flow)
	10%	100% (stop @ max flow)
Test 4	14%	10%
	14%	30%
	14%	50% (stop @ max flow)
	14%	60% (stop @ max flow)
	14%	70% (stop @ max flow)
	14%	80% (stop @ max flow)
	14%	90% (stop @ max flow)
	14%	100% (stop @ max flow)
Test 5	18%	10%
	18%	30%
	18%	50% (stop @ max flow)
	18%	60% (stop @ max flow)
	18%	70% (stop @ max flow)
	18%	80% (stop @ max flow)
	18%	90% (stop @ max flow)
	18%	100% (stop @ max flow)
Test 6	22%	10%
	22%	30%
	22%	50% (stop @ max flow)
	22%	60% (stop @ max flow)

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Test #	Blade Percentage	Wicket Gate Percentage
	22%	70% (stop @ max flow)
	22%	80% (stop @ max flow)
	22%	90% (stop @ max flow)
	22%	100% (stop @ max flow)

1.4. Call Lee to review test positions

1.5. Review safety items

Test

2. With the controls in automatic decrease the flow rate till the desired wicket opening for the first test is reached.
3. Take the controls out of automatic
4. Adjust the blade angle for the first test position
5. If needed fine adjust the wicket gate position for the first test position

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6. Hold the positions for the first test until the flow, pressure, tailrace and power readings stabilize. In past operations this has taken 2.5 min after the wicket gate and blade angle were finished moving.
7. Once the flow, pressure, tailrace and power readings have stabilized record the time for the test position.
8. After 3 min of steady state conditions, record the end time of the test position, move the wicket gate to the next position.
9. Repeat steps 6-8 until maximum flow rate is reached or wicket gate opening is 100%. Note the maximum flow rate allowed for the test, when the wicket gate opening reaches this maximum flow rate that will be the last position for that test set.

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10. Position the wicket gate to lowest opening position for the next test.
11. Position the blade angle for the next test position
12. Repeat steps 6-9 for the new blade angle position

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13. Repeat steps 10-12 for all blade angles to be tested

Post Test

14. Download table of 1 second data points and provide to team for analysis, include in the email the beginning and end time for each test position (each blade angle and wicket gate position).
15. Call Lee to review test procedures

Cautions

Any Wicket Gate or Blade angle position that causes unusual noise or vibrations must be avoided.

Lee I am looking to you to put in what items the operators need to be aware of to prevent damaging the equipment.