OFFICIAL COORDINATION REQUEST FOR
NON-ROUTINE OPERATIONS AND MAINTENANCE

COORDINATION TITLE- 16 IHR 008 Unit 5 blade welding to reduce oil discharge
COORDINATION DATE- September 23, 2016, October 21, 2016 - Revised
PROJECT- Ice Harbor
RESPONSE DATE- ~~October 7, 2016~~ October 26, 2016

Description of the problem

COE NWW is assembling a plan to block the turbine blades on Ice Harbor Unit 5 making it effectively a fixed blade turbine. Unit 5 consistently leaks oil and this will no longer occur once the hub is drained and the blades are welded into a fixed position. The unit 5 blades will be welded within the 1% turbine efficiency operating range as specified in the Fish Passage Plan (FPP). The blades will be blocked/welded in similar fashion to Ice Harbor unit 2 and several other Kaplan runners in the Federal Columbia River Power System. The project would like to start as soon as possible to get this work completed while crews are available before all resources are allocated to the long term navigation lock outage beginning in December.

Discussion on Proposed Action

The COE is wanting to coordinate this blade welding decision with Regional Fishery Managers prior to undertaking the work. Unit 5 is the lowest priority unit for operations during the fish passage season (see Table IHR-4 below from 2016 FPP). Unit 2 is currently out of service (OOS) for installation of the new turbine runner**.** Unit 3 is scheduled to be replaced after unit 2 is completed, but will remain in service until unit 2 begins operating. Therefore, there will be 4 units operating ahead of unit 5 at all times per the FPP, including during installation of the new turbine runners.

Table IHR-4. Ice Harbor Dam Turbine Unit Operating Priority Order.

Season	Operation	Unit Priority Order
Fish Passage Season March 1 – November 30	Single-Unit Operation w/ NO Line Switching. ** Line Switching must occur prior to resuming normal priority order below.*	1,2,6,5
	Multiple-Unit Operation	1,3,6,4,2,5
		Unit 1 OOS and NO Line Switching: 2,3,6,4,5
Winter Maintenance December 1 – end of February	Single-Unit Operation w/ NO Line Switching	Any order for units 1,2,5,6
	Multiple-Unit Operation	Any Order

With STSs (submerged traveling screens) in place at 97 feet of head, unit 5 currently operates within the range of 9,425 – 14,864 cfs (see Table IHR-8 from 2016 FPP). Assuming the same head, this range will be limited to approximately 13,411-14,669 cfs if the blades are welded at the proposed fixed blade angle of 24 degrees. Based on the information we have, the 24 degree blade angle would appear to be at or near the best operating point for fish. As with any "fixed" blade unit, the Project should strive to operate as close to the peak efficiency of the fixed blade curve as possible. The performance drops off steeply to either side of the fixed blade peak efficiency point and conditions for fish would be expected to degrade significantly as efficiency drops.

Table IHR-8. Ice Harbor Dam Turbine Units 4, 5 and 6 Power (MW) and Flow (cfs) at Upper and Lower Limits of the ±1% Peak Efficiency Range.

Project Head (ft)	Turbine Units 4, 5 and 6							
	with STSs				No STSs			
	1% Lower Limit		1% Upper Limit		1% Lower Limit		1% Upper Limit	
	(MW)	(cfs)	(MW)	(cfs)	(MW)	(cfs)	(MW)	(cfs)
85	**58.9**	**9,369**	**93.1**	**14,810**	**62**	**9,745**	**110.7**	**17,413**
86	59.7	9,380	94.4	14,824	62.8	9,756	112.3	17,430
87	60.6	9,390	95.7	14,838	63.7	9,767	113.8	17,447
88	61.4	9,400	97	14,851	64.5	9,777	115.3	17,462
89	62.2	9,410	98.2	14,864	65.4	9,787	116.8	17,477
90	**63**	**9,419**	**99.5**	**14,876**	**66.3**	**9,797**	**118.3**	**17,492**
91	63.7	9,416	100.7	14,885	67	9,794	119.8	17,503
92	64.5	9,414	102	14,895	67.8	9,792	121.3	17,515
93	65.2	9,411	103.2	14,904	68.6	9,789	122.7	17,525
94	65.9	9,409	104.5	14,912	69.3	9,787	124.2	17,535
95	**66.6**	**9,406**	**105.7**	**14,921**	**70.1**	**9,784**	**125.7**	**17,545**
96	67.5	9,416	106.7	14,892	70.9	9,794	126.8	17,512
97	68.3	9,425	107.7	14,864	71.8	9,804	128	17,479
98	69.1	9,434	108.6	14,836	72.7	9,813	129.2	17,446
99	69.9	9,442	109.6	14,809	73.5	9,822	130.3	17,414
100	**70.7**	**9,451**	**110.6**	**14,782**	**74.4**	**9,831**	**131.5**	**17,382**
101	71.4	9,446	112.9	14,939	75.1	9,825	134.2	17,567
102	72	9,441	115.1	15,093	75.7	9,820	136.9	17,748
103	72.7	9,436	117.4	15,224	76.4	9,815	139.6	17,926
104	73.3	9,431	119.7	15,392	77.1	9,810	142.3	18,100

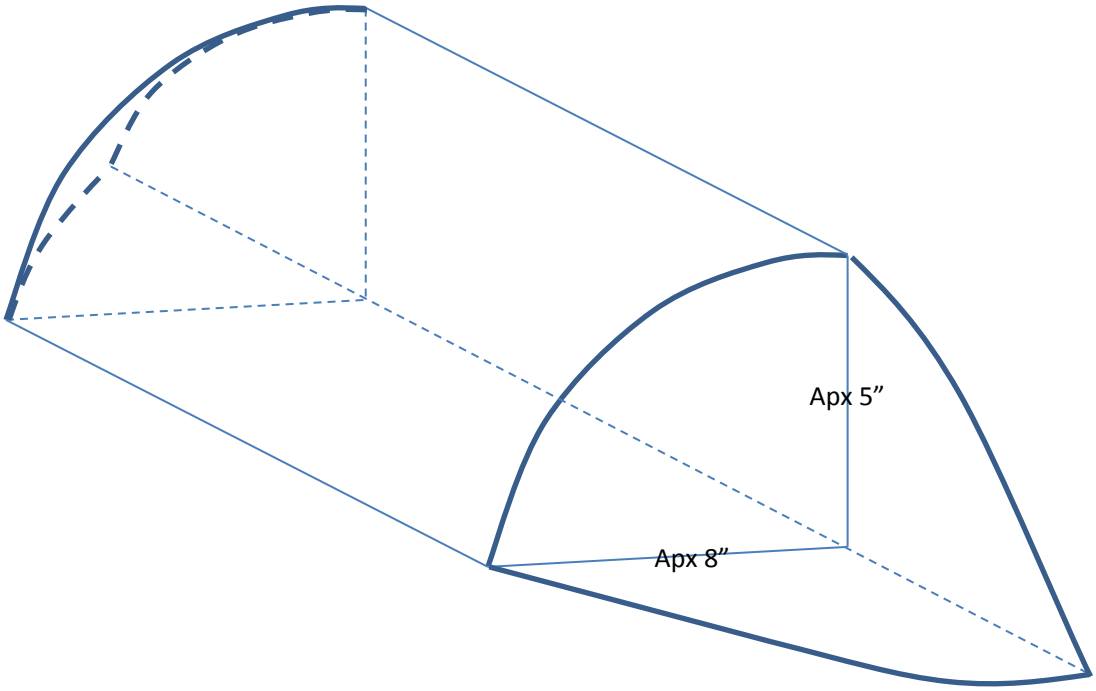
The decision to fix the blades at 24 degree blade angle between the peak and upper 1% of the Kaplan operating range is based on past modeling and CFD (Computational Fluid Dynamics) data of similar Kaplan turbines, however, a report for best operating point of Ice Harbor units 4 - 6 does not exist as the information is currently unknown.

The best operating point determinations consider stay vane and wicket gate alignment, model bead strike and change in direction scores for stay vane/wicket gate and runner passage, uniformity of flow through the draft tubes and pressure. We have no runner bead data for units 4 - 6 however, based on other Kaplan runner investigations the runner bead scores are generally best within a region between peak efficiency and the upper 1 percent limit. Aligned wicket gate and stay vane alignment will reduce wicket gate contact; the best distributor alignment occurs well beyond the current upper 1%. Draft tube conditions generally improve with increased flow; the best draft tube conditions occur near or beyond the upper 1 percent. Turbine pressures are investigated through CFD and sensor fish data collection of prototype units, we have neither for Ice Harbor units 4 - 6. Turbine pressures become more severe with high flow and higher heads. However, based on the large diameter of Units 4 - 6 we expect very low fish mortality caused by turbine pressures at the selected blade angle of 24 degrees.

Blade Blocking Alternatives: Two alternatives for locking the blades to a fixed position have been developed. One includes boring into the runner hub at the trunnion/hub interface and inserting dowels into the bore to prevent blade movement. The second includes welding blocks to the hub, one above and one beneath the runner blade downstream of the trunnion/hub interface. This simple welded block configuration has been used to block Unit 2 and Unit 3 at Ice Harbor. The two blocks prevent blade movement in either direction (see Figure 1). The more or less square blocks extend into the flow path 4 to 6 inches. The corners of the blocks have been beveled at approximately 45 degrees. The “hydraulic shape” of these previous block designs is somewhat crude and show significant signs of cavitation.

Blade Blocking Recommendation: Doweling the trunnion/hub interface would most likely prevent the turbine runner from ever being reverted back to a Kaplan runner without major rehabilitation. Also, this approach has been attempted on a previous project and has proven not feasible, as it is difficult to bore the dowel hole with the precision required. The two block approach with improvement is therefore recommended. The new block will be longer in the direction of flow with a smaller cross section exposed to the flow. All corners would be rounded smoothly with a large radius, and both the leading and trailing edge of the block will be tapered providing for a more streamlined shape to reduce the likelihood of fish impact and to minimize cavitation (see Figure 2).

CONCEPT SKETCH



PREVIOUS BLOCKS USED

Type of outage required: Unit 5 is currently OOS and will remain so until blade welding is completed.

Impact on facility operation: The range of operation of unit 5 will be narrowed by blocking the blades, reducing maximum powerhouse capacity by about 3,000 cfs. Ice Harbor dam spillway does not generate high dissolved gas levels; therefore, this additional spill is unlikely to affect TDG meaningfully. Three functioning Kaplan turbines within the powerhouse are required to maintain full flexibility of operations. Therefore, the decrease in range of unit 5 should not affect operations during juvenile spill and lower summer flows because it is lowest priority and should not need to be utilized at these times. Therefore, blocking the blades on unit 5 will have very little impact on facility operation for fish passage.

Dates of impacts/repairs: Repairs are tentatively scheduled to start in late October and are expected to take 2 - 3 months. During this time period, unit 5 will remain OOS.

Length of time for repairs: Approximately 2 - 3 months

Expected impacts on fish passage: Fish Passage Efficiency (FPE) is greater than 90% at Ice Harbor during the fish passage season. Unit 5 is the lowest priority unit and is expected to be in operation less than 25% (using 10 year flow data) of the passage season. Furthermore, based on turbine model investigations it is believed non-bypassed fish will tend to pass through the turbine runner from the mid blade region to blade periphery, with very few of the turbine passed fish passing near the runner hub. Unit 5 is near the north end of the power powerhouse in close proximity to the RSW. Flow approaching Unit 5 is heavily influenced by RSW operations and it is believed that a large percentage of the fish approaching the North end of the powerhouse will pass through the RSW. ~~Unit 5 is the lowest priority unit during fish passage season,~~ ~~therefore~~ Therefore fixing the blades at a 24 degree angle will cause minimal effects on fish passage. Should unforeseen problems arise with other turbine units, resulting in the need to rely on unit 5 as a high priority unit, Regional coordination to discuss alternative scenarios will be undertaken.

Comments from agencies

-----Original Message-----
From: Trevor Conder - NOAA Federal [mailto:trevor.conder@noaa.gov]
Sent: Monday, September 26, 2016 11:42 AM
To: Bailey, John C NWW <John.C.Bailey@usace.army.mil>
Cc: Gary Fredricks - NOAA Federal <gary.fredricks@noaa.gov>; Bill Hevlin - NOAA Federal <bill.hevlin@noaa.gov>; Setter, Ann L NWW <Ann.L.Setter@usace.army.mil>; Mackey, Tammy M NWP <Tammy.M.Mackey@usace.army.mil>; Lorz, Tom <lort@critfc.org>; Moody, Gregory P NWW <Gregory.P.Moody@usace.army.mil>

Subject: [EXTERNAL] Re: MOC 16 IHR 008 Unit 5 blad welding to reduce turbine oil discharge

John,

We are requesting some additional information and more discussion on this coordination. Since the MOC indicates the welded blocks will protrude from the runner into the flow potentially impacting juvenile and adult salmonids, and it will likely be a relatively long time until this runner is replaced, we will need to make sure we are taking the appropriate steps to insure we are providing adequate protection for fish given these conditions and time constraints. First, we would like to see a detailed drawing of the blocking and welding schematic that is planned with reference to example photos of completed blade welding from LGR unit 1, and/or IHR unit 2. Also, the MOC does not give a very detailed estimate of the pressures that are expected to occur with the proposed blade angle. I understand that we don't have precise information on pressure for this specific unit, but it would be helpful if the Corps could provide a range of expected pressures so we can weigh those impacts against strike, shear, and other hydraulic impacts.

It seems the 24 degree angle was selected from experience with TSP work, but the Corps should consider including a discussion of the estimated project survival differences considering the spillway survival at IHR is relatively high, so welding the last on unit at a more conservative (lower) blade angle, would likely result in more fish going through the spillway during high flows. Based on the available data, IHR does not have substantial tailrace issues during high flows like we see at other projects, and routing more fish through the spillway at max capacity will likely result in higher survival than putting those fish through unit 5 near the upper 1% with crude blocks protruding into the flow. Please consider these issues and resend the MOC with the drawings, photos, estimated pressures, and we will review and comment on those again. Thanks

-Trevor

-----Original Message-----
From: Barnes, Charles A NWW
Sent: Thursday, September 29, 2016 2:29 PM
To: Nelson, Shawn L NWW <Shawn.L.Nelson@usace.army.mil>; Ahmann, Martin L NWW <Martin.L.Ahmann@usace.army.mil>; Renholds, Jon F NWW <Jon.F.Renholds@usace.army.mil>
Cc: Shutters, Marvin K NWW <Marvin.K.Shutters@usace.army.mil>; Bailey, John C NWW <John.C.Bailey@usace.army.mil>
Subject: RE: Ice unit 5

Jon and I just talked to Trevor Conder. We (mostly Jon) further explained why we are going with the 24 degree angle. Trevor was okay with the angle once we gave him a more detailed explanation of our thoughts on pressure and he suggested adding further explanation to the MOC to clarify for other folks.

They are still concerned about the style of the blocks. I told him HDC is designing the blocks with more focus on tapering edges and reducing surfaces that may injure fish. He requested that NOAA be kept in the loop on the design as we move forward.

We have not received any comments other than NOAA's at this time.

Chuck

-----Original Message-----

From: Barnes, Charles A NWW
Sent: Friday, October 21, 2016 11:49 AM
To: Bailey, John C NWW <John.C.Bailey@usace.army.mil>
Subject: Response to NOAA comments

Estimated Pressure:
Similar flows (to 24 degree blade angle in unit 5) through units 1-3 at Ice Harbor are not expected to cause significant pressure-related injuries to fish based on CFD analysis. Pressure analyses for units 4-6 have not been completed. However since units 4-6 have a 20 inch larger diameter, similar flows will result in lower velocities within the runner (than units 1-3), which in turn results in higher nadir pressures and less pressure-related injuries to fish. Therefore considering the expected reduction of strike from lower blade angle operating points the selected 24 degree blade angle is expected to be close to the optimum for fish passage based on the information available. Also, the additional approximately 4 kcfs increase over the low 1% of the Kaplan operating range is minimal compared to what is already passed through spill during the high flow conditions when this unit is expected to operate.

Final results

Please email or call with questions or concerns.
Thank you,

Chuck Barnes
Fishery Biologist
US Army Corps of Engineers
Walla Walla District
201 N Third Ave
Walla Walla WA 99362
charles.a.barnes@usace.army.mil

509-527-7257