**OFFICIAL COORDINATION REQUEST FOR**

**NON-ROUTINE OPERATIONS AND MAINTENANCE**

**COORDINATION TITLE-** 19 IHR 020 Unit 4 blade locking to reduce oil discharge

**COORDINATION DATE-** December 3, 2019

**PROJECT- Ice Harbor**

**RESPONSE DATE-** December 6, 2019 COB

**Description of the problem**

COE NWW is assembling a plan to hydraulically lock the turbine blades on Ice Harbor Unit 4 making it effectively a fixed blade turbine. Unit 4 has been repaired and OOS for much of 2019 due to oil leak related issues. Specifically, work has entailed replacement of blade seal packing with SST chevron packing, resealing of the runner hub cone, replacement of the runner hub drain valve, and pressure testing of the runner to shaft connection. The oil will not be present to leak once the hub is drained and the blades are hydraulically locked in a fixed position. The unit 4 blades will be locked within the 1% turbine efficiency operating range as specified in the Fish Passage Plan (FPP). The blades will be locked at the same angle as Ice Harbor units 5, 6; with an angle of 23.85. The project has started the preparation work and would like to get this work completed prior to December 12.

**Discussion on Proposed Action**

The COE is wanting to coordinate this blade locking decision with Regional Fishery Managers prior to undertaking the work. Unit 4 is the second lowest priority unit for operations during the fish passage season (see Table IHR-4 below from 2019 FPP). Unit 3 is currently out of service (OOS) for installation of the new turbine runner**.**

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

|  |  |  |
| --- | --- | --- |
| **Season** | **Operation** | **Unit Priority Order** |
| March 1 –  November 30  Fish Passage Season | Single-Unit Operation w/ NO Line Switching | 1, 2, 6, 5 |
| Single-Unit Operation AFTER Line Switching  Or, Multiple-Unit Operation | 1, 2, 3, 6, 4, 5 |
| December 1 –  end of February  Winter Maintenance | Single-Unit Operation w/ NO Line Switching | Any order for Units 1, 2, 5, 6, 4 |
| Single-Unit Operation AFTER Line Switching  Or, Multiple-Unit Operation | Any Order |

With STSs (submerged traveling screens) in place at 97 feet of head, unit 4 currently operates within the range of 9,425 – 14,864 cfs (see Table IHR-5 from 2019 FPP). Assuming the same head, this range will be limited to approximately 13,327-13,960 cfs with the blades locked at a 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 will 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-5. Ice Harbor Dam Turbine Unit Power (MW) and Flow (cfs) at ±1% of Peak Turbine Efficiency (Lower and Upper Limits of 1% Range) and Operating Limits.**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Project** | **IHR Unit 4 - with STS** | | | | | | **IHR Unit 4 - No STS** | | | | | |
| **Head** | **1% Lower Limit** | | **1% Upper Limit** | | **Operating Limit** | | **1% Lower Limit** | | **1% Upper Limit** | | **Operating Limit** | |
| **(feet)** | **MW** | **cfs** | **MW** | **cfs** | **MW** | **cfs** | **MW** | **cfs** | **MW** | **cfs** | **MW** | **cfs** |
| **85** | 58.9 | 9,369 | 93.1 | 14,810 | 121.8 | 20,745 | 62.0 | 9,745 | 110.7 | 17,413 | 121.8 | 19,401 |
| **86** | 59.7 | 9,380 | 94.4 | 14,824 | 122.7 | 20,569 | 62.8 | 9,756 | 112.3 | 17,430 | 122.7 | 19,283 |
| **87** | 60.6 | 9,390 | 95.7 | 14,838 | 123.4 | 20,392 | 63.7 | 9,767 | 113.8 | 17,447 | 123.4 | 19,162 |
| **88** | 61.4 | 9,400 | 97.0 | 14,851 | 124.2 | 20,212 | 64.5 | 9,777 | 115.3 | 17,462 | 124.2 | 19,039 |
| **89** | 62.2 | 9,410 | 98.2 | 14,864 | 124.9 | 20,034 | 65.4 | 9,787 | 116.8 | 17,477 | 124.9 | 18,905 |
| **90** | 63.0 | 9,419 | 99.5 | 14,876 | 125.6 | 19,747 | 66.3 | 9,797 | 118.3 | 17,492 | 125.6 | 18,752 |
| **91** | 63.7 | 9,416 | 100.7 | 14,885 | 126.2 | 19,569 | 67.0 | 9,794 | 119.8 | 17,503 | 126.2 | 18,599 |
| **92** | 64.5 | 9,414 | 102.0 | 14,895 | 126.9 | 19,389 | 67.8 | 9,792 | 121.3 | 17,515 | 126.9 | 18,445 |
| **93** | 65.2 | 9,411 | 103.2 | 14,904 | 127.2 | 19,159 | 68.6 | 9,789 | 122.7 | 17,525 | 127.2 | 18,242 |
| **94** | 65.9 | 9,409 | 104.5 | 14,912 | 127.2 | 18,893 | 69.3 | 9,787 | 124.2 | 17,535 | 127.2 | 18,004 |
| **95** | 66.6 | 9,406 | 105.7 | 14,921 | 127.2 | 18,633 | 70.1 | 9,784 | 125.7 | 17,545 | 127.2 | 17,771 |
| **96** | 67.5 | 9,416 | 106.7 | 14,892 | 127.2 | 18,396 | 70.9 | 9,794 | 126.8 | 17,512 | 127.2 | 17,560 |
| **97** | 68.3 | 9,425 | 107.7 | 14,864 | 127.2 | 18,165 | 71.8 | 9,804 | 127.2 | 17,353 | 127.2 | 17,353 |
| **98** | 69.1 | 9,434 | 108.6 | 14,836 | 127.2 | 17,938 | 72.7 | 9,813 | 127.2 | 17,150 | 127.2 | 17,150 |
| **99** | 69.9 | 9,442 | 109.6 | 14,809 | 127.2 | 17,717 | 73.5 | 9,822 | 127.2 | 16,952 | 127.2 | 16,952 |
| **100** | 70.7 | 9,451 | 110.6 | 14,782 | 127.2 | 17,499 | 74.4 | 9,831 | 127.2 | 16,757 | 127.2 | 16,757 |
| **101** | 71.4 | 9,446 | 112.9 | 14,939 | 127.2 | 17,251 | 75.1 | 9,825 | 127.2 | 16,573 | 127.2 | 16,573 |
| **102** | 72.0 | 9,441 | 115.1 | 15,093 | 127.2 | 17,009 | 75.7 | 9,820 | 127.2 | 16,393 | 127.2 | 16,393 |
| **103** | 72.7 | 9,436 | 117.4 | 15,244 | 127.2 | 16,771 | 76.4 | 9,815 | 127.2 | 16,216 | 127.2 | 16,216 |
| **104** | 73.3 | 9,431 | 119.7 | 15,392 | 127.2 | 16,539 | 77.1 | 9,810 | 127.2 | 16,042 | 127.2 | 16,042 |
| **105** | 74.0 | 9,426 | 121.9 | 15,538 | 127.2 | 16,312 | 77.8 | 9,805 | 127.2 | 15,872 | 127.2 | 15,872 |

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 index testing of units 5, 6 undertaken in March 2019. The report summary from this index testing is attached with this MOC email for your review.

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. 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.

**Type of outage required:**  Unit 4 is currently OOS and will remain so until hydraulic blade locking is complete.

**Impact on facility operation:** The range of operation of unit 4 will be narrowed by blocking the blades, reducing maximum powerhouse capacity by about 3,000 cfs. This will leave one functional Kaplan turbine within the powerhouse [Unit 1 which has a reduced operating range of 60-85 MW] to maintain flexibility of operations until Unit 3 runner replacement is completed. The decrease in range of unit 4 should not affect operations during juvenile spill and lower summer flows because it is lowest priority and should be minimally utilized. Therefore, locking the blades on unit 4 will have very little impact on facility operation for fish passage. If funding is available, during summer 2020 the unit will be unwatered an a modified seal type blade packing will be installed in 1-2 blades to test performance and determine if all blades should have the new packing installed which would then allow Kaplan operation again for unit 4. In the meantime, the project will implement maintenance similar to that being done on units 5, 6. This will entail tapping the hub quarterly to remove any leakage of water into the hub.

**Dates of impacts/repairs:** Repairs have already begun and are scheduled to be completed by December 12.

**Length of time for repairs:** Approximately7-10 days

**Expected impacts on fish passage:** Fish Passage Efficiency (FPE) is greater than 90% at Ice Harbor during the fish passage season. Unit 4 is the second 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. 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**

**Final results**

Please email or call with questions or concerns.

Thank you,

Ann Setter