**Disclosure of Hydroelectric Generation and Transmission Equipment Issues**

**at Rocky Reach and Rock Island Projects.**

**ROCK ISLAND HYDROELECTRIC PROJECT:**

**Current Unit Status:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Unit | Status as of today’s date | Description | Outage Start | Expected Return |
| B-1 | Out of Service | Turbine replacement |  | Nov 2019 |
| B-2 | Out of Service | Turbine replacement |  | Jun 2019 |
| B-3 | Out of Service | Turbine replacement |  | Apr 2019 |
| B-4 | Out of Service | Turbine replacement |  | Feb 2019 |
| B-5 | In Service | Unit Modernization | Sep 2020 | Aug 2021 |
| B-6 | Out of Service | Unit Modernization |  | May 2017 |
| B-7 | In Service | Unit Modernization | May 2017 | May 2018 |
| B-8 | In Service | Unit Modernization | Sep 2021 | Sep 2022 |
| B-9 | In Service |  |  |  |
| B-10 | In Service |  |  |  |

**Background**

Rock Island Powerhouse No. 1 consists of 10 generating units. The four original units (B1-B4) were installed in the 1930’s and an additional six units were added in the 1950’s. Three of the four original units at Powerhouse No. 1 (B1, B3 and B4) have upgraded generator stators and have their original generator rotors and turbine runners. Units B9 and B10 were rehabilitated with new stators, turbines and governor and excitation systems.

A second powerhouse (Powerhouse No. 2) was built in the late 1970’s with eight generating units.

**Rock Island B2 Turbine Corrosion Fatigue**

**Issue**

During the Unit B2 generator stator replacement work, fatigue cracks were observed on the blades of the turbine. From October 2015 through January 2016, District maintenance staff made repeated attempts to grind out the cracks and repair the resulting excavations with various welding procedures. After each repair procedure, inspections resulted in the observation of new fatigue cracks. Engineering analysis indicated the B2 turbine is experiencing a phenomenon known as Corrosion Fatigue. The turbines of Units B1, B3 and B4 are of similar design and vintage as Unit B2. These three units were taken out of service and inspected to determine if similar cracking exists in their turbine runner blades. These turbines also had significant cracking due to Corrosion Fatigue. All four turbines, B1 through B4 will remain out of service until the District can design, procure and install replacement turbine runners.

**Remedy**

The District has completed the development of specifications for the procurement of turbine runners for units B1 through B4. Competitive bids were received on December 22, 2016 and the contract awarded to Andritz Hydro in a Special Commissioner meeting on December 30, 2016. The contract award also included a construction schedule in which all four units are returned to service by the end of 2019. In the best case scenario, the District estimates the first turbine to be on-site and ready for installation by October 2018. The first three turbines will be replaced nearly concurrently with each unit requiring approximately 6 months each to complete. The last installation of the four turbines will begin shortly after the first unit installation and commissioning is complete in March 2019.

**1) Expected case scenario (as of December 30 2016)**: All four of the B1 through B4 units will remain out of service until such time the respective turbine is replaced. Each unit is scheduled for turbine replacement and will be returned to service, with the last turbine replacement being complete in December 2019. This scenario performs work on the first three units concurrently with the turbine replacement schedule as follows:

UNIT START DATE RETURN TO SERVICE DATE

B4 out of service until Feb 2019

B3 out of service until Apr 2019

B2 out of service until Jun 2019

B1 out of service until Nov 2019

2**) Worst case scenario (as of December 30 2016)**: The worst case scenario may occur if working on three units concurrently cannot be safely supported. In this event, the turbine replacement schedule would likely revert to performing work on one unit at a time. This schedule would result as follows:

UNIT START DATE RETURN TO SERVICE DATE

B4 out of service until Feb 2019

B3 out of service until Sep 2019

B2 out of service until Mar 2020

B1 out of service until Sep 2020

**Rock Island B6/B7 Stator-Rotor Air Gap**

**Issue**

During periodic machine condition monitoring, plant staff observed deterioration of a critical clearance measurement in the generator. This clearance, referred to as the “air gap” between the rotor and the stator of the generator, has deteriorated over time and is now below acceptable reliable operating limits. Data for units B6 and B7 was evaluated and shows a deteriorating air gap clearance. B6 is out of service and is expected to remain out of service until unit rehabilitation (new turbine, new stator, new rotor poles and rim, new exciter, new Governor digital controls) is completed in May 2017.

Temporary repairs were made to the stator alignment of unit B7 and the unit was returned to service on October 14, 2016. Unit B7 will be removed from service in May 2017 to complete the unit modernization work as done on B6. Afterwards, B7 is scheduled to return to service in May 2018.

**Remedy**

To correct the deterioration of the “air gap “ in unit B6 and B7, the District intends to install a new stator, replace rotor poles and rim and reshape and align the unit to within industry standards for normal operation.

**Schedule**

Unit B6 is out of service due to air gap measurements below operating minimums. A contract for the remedy is in place and unit B6 is scheduled to return to service in May 2017. Unit B7 was recently temporarily repaired by re-aligning the stator frame to achieve acceptable air-gap measurements and returned to service on October 14, 2016. A contract for the remedy is in place and unit B7 is scheduled for stator replacement from May 15, 2017 through May 2018.

**Rock Island Tentative Generator Upgrade Outage Schedule**

UNIT START DATE RETURN TO SERVICE DATE

B6 out of service until 5/14/2017

B7 5/15/17 5/13/2018

B5 9/1/2020 8/27/2021

B8 9/6/2021 9/9/2022

**Rock Island B9/B10 Rotor Cracks**

**Background**

Rock Island Powerhouse No. 1 consists of 10 generating units. B9 had recently been upgraded with a new turbine, new stator and new rotor poles and rim which was completed on May 1, 2012. The original rotor spider was reused.

**Issue**

A routine unit warranty inspection was scheduled from March 16, 2015 to May 22, 2015 to verify all performance measures specified in the contract warranty were satisfied. On April 21, during this inspection, several cracks located in welds of the rotor were observed and documented.

**Remedy**

The contractor holding the warranty was notified of the weld defect on April 23, 2015. The Contractor reviewed inspection data and made weld repairs. As a follow up, a similar inspection was conducted for unit B10. Cracks were also detected on this rotor and repaired in a similar manner. No further remedy is expected for these concerns.

**Rocky Reach Hydroelectric Project:**

Current Unit Status:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Unit | Status as of today’s date | Description | Outage Start | Expected Return |
| C-1 | In Service |  |  |  |
| C-2 | In Service |  |  |  |
| C-3 | In Service |  |  |  |
| C-4 | In Service |  |  |  |
| C-5 | In Service |  |  |  |
| C-6 | In Service |  |  |  |
| C-7 | In Service |  |  |  |
| C-8 | Out of Service | Turbine Rehab/New Winding |  | May 2017 |
| C-9 \* | Out of Service | New Winding |  | May 2017 |
| C-9 \* | Out of Service | Turbine Rehab | Dec 2018 | Jan 2020 |
| C-10 | In Service | Turbine Rehab | Feb 2020 | Apr 2021 |
| C-11 | Out of Service | Turbine Rehab/New Winding |  | Nov 2018 |

\* Note: C-9 is expected to be back in service from May 2017 through November 2018 after new winding is completed and prior to turbine rehab.

**Rocky Reach Transformers**

**Background and Issue**

In October 2011, the main transformer of Rocky Reach unit C5 was thoroughly inspected due to concerns regarding insipient gassing observed in previous oil samples. The manufacturer of the transformer, Hyundai Heavy Industries Co. Ltd. (HHI), identified several deficiencies, made repairs and returned the transformer to service.

In August 2013, the District removed generating unit C5 from service and performed an extensive internal inspection of the main transformer with District personnel and representatives from HHI. The inspection of all coil lead attachments revealed a hot spot and damage to the X1 coil lead to main bus connection only. HHI experts were successful in repairing the faulty connection and also performed repairs to the internal blocking and wedging during the outage. C5 was returned to service in mid-September 2013 and has exhibited normal gas levels post repair. Ongoing monitoring and trending of the gas levels continues to indicate a successful repair.

Unit C5 transformer design is similar to those other transformer Units C2, C3, C4, C6 and C7. Routine monitoring of transformer oil has shown some elevated gassing levels in these other transformers, not inconsistent with the age and service, (but none at the same levels seen in C5) and do not require corrective action.

**Remedy**

In consideration of the apparent successful Hyundai repair in September 2013 of Unit C5, the District entered into a Change Order to the underlying Contract with Hyundai Corporation USA and HHI on March 13, 2014, where, in the event Units C2 –C7 transformers begin to show signs of excessive gassing (critical level 3 as defined by IEEE) within 25 years of energization of each Unit, HHI will attempt to supply onsite repair of these specific Units. The existing lifetime warranty for design defects was also defined in the Change Order as 25 years from the date of energization; in which case, the lifetime warranty for Hyundai/HHI design defects for all Rocky Reach transformers C1-C11 would begin to expire in 2021 through 2026.

**Rocky Reach C8-C11 Large Unit Turbines**

**Background**

As part of ongoing maintenance of District hydro projects, seven Kaplan style turbines (C1-C7) were rehabilitated and four fixed blade turbines (C8-C11) were converted to adjustable blade (Kaplan) at the Rocky Reach Powerhouse from 1996 to 2003 by RIVA HydroArt/Voith Hydro. The purpose of the project was modernization of the turbines to provide higher efficiency while incorporating fish friendly features with a runner blade design life of 50 years.

**Issue**

On March 25, 2013, the District’s unit C10 tripped off-line due to a blade deviation from setpoint. Initial investigation revealed an internal oil bypass condition in the turbine blade servo-motor system along with deposits of metal in the oil return basin. A partial in-place turbine disassembly identified significant wear to internal servo-motor seal rings and bushings as well as to blade trunnion bushings.

Based on initial findings, District staff determined a full generator and turbine disassembly was required to determine all possible causes of the blade deviation, oil bypass and wear conditions. During the turbine disassembly, a crack was discovered in the main servo-motor operating rod. Through engineering analysis and review with District staff, Voith Hydro and MWH Engineering, the cause of the crack was determined to be a design flaw.

On September 23, 2013, units C8, C9 and C11 were removed from service to protect the public, employees, equipment and environmental safety due to having the same turbine design and internal construction. District staff, with Voith and MWH review, proposed a temporary solution for interim operations as fixed blade (propeller) units that allows generator use until a permanent solution is designed and implemented.

This condition is unique to generating units C8-C11 and **does not** include units C1-C7.

**Remedy**

On November 8, 2013, District crews commenced with interim repairs on unit C11 consisting of welding blocks onto the turbine runner hub to lock the blades in the full steep position providing safe reliable operation as a propeller turbine. Successful operational and index testing was performed on unit C11 and modifications continued to C8, C9 and C10. Units C8-C11 will be operated as interim repaired propeller turbines until final designs and permanent repairs return them to full Kaplan operation. In September 2014, a plan was approved by the District’s Board of Commissioners to restore adjustable blade capability to C8-C11, enhancing power generation and assuring continued successful fish passage at Rocky Reach.

**Schedule**

The implementation of the interim repair program (propeller operation) was completed in April 2014. The final turbine repairs will require unit outages that are estimated to last 14 months and will include the installation of new governor control and exciter systems. Until all permanent repairs are complete, each interim repaired turbine will require an inspection at approximately 3800 hours of run time. It is estimated, but not assured, that each inspection requires a unit outage of one week (5 days).

**Rocky Reach Final Turbine Repair Outage Schedule**

See the combined Future Schedule below under Rocky Reach C8 – C11 Generator Winding Issues

**Rocky Reach C8 - C11 Generator Winding Issues**

**Background and Issue**

**C8: Out of Service**

On January 21, 2015 a strong smell of burning or hot electrical insulation was detected and unit C8 was promptly removed from service. Subsequent inspections and testing revealed strand to strand shorts in Phase B of the stator winding in the vicinity of slots 85 through 91. The burn was not confined to the jumper itself but appears to extend into the slot area. Shorts in the Phases A and C are also confirmed: Five (5) shorts in Phase A, eight (8) in Phase C, and two (2) additional shorts in Phase B. On Wednesday February 4, 2015, there was an unexpected unit rotation of C8 while it was out of service. Unit C8 was subsequently inspected for potential damage due to the unexpected unit rotation. Speed limiter indicators were measured and District staff determined the unit rotation did not exceed 115 rpm. The design for the rotor was warranted up to speeds of 160 rpm and the turbine to 227 rpm. Visual inspections of the turbine blades/liner, and the guide bearings do not indicate any damage. The rotor of C-8 was removed in April 2015 and inspections were conducted of the stator and rotor. No significant damage was observed. The stator of C8 will be rewound with new stator bars and materials within the same outage as currently in progress for the turbine repairs and currently scheduled to return to service in May 2017.

**C9: Out of Service**

Unit C9 was removed from service on July 14th, 2016 due to generator winding failure similar to C8. The stator is currently being rewound with new stator bars and materials and the unit is expected to return to service May 2017.

**C10: In Service**

On February 2, 2015 C10 was removed from service for a pre-planned inspection of the interim repairs on the turbine hub. During this outage, District staff also inspected end turns on the stator winding. A burned spot on one of the end jumpers was observed. Subsequent inspections of the burned area indicate that the burn spot on the winding insulation was due to an external heat source and not due to winding failures. However, additional testing on the stator indicates several shorts on four of the six stator circuits. Only two circuits are free of shorted strands. Additional temperature and smoke monitors were installed and frequency of personnel walk-through was increased to aid in early detection and C-10 was returned to service on May 1, 2015. On June 24, 2015 Operators observed the smell of hot insulation from the stator windings of C-10, the smoke alarms actuated and the unit was shut down. Follow up testing confirmed the presence of additional strand shorts. A contract was prepared and awarded to isolate the shorted windings and make repairs. By mid-April 2016, all attempts to repair the windings had failed and contingency plan to rewind the stator of C10 was initiated. The stator rewind and testing was completed and the unit returned to service on November 17, 2016.

**C11: Out of Service**

On November 27, 2016 unit C11 generating unit was removed from service due to activation of unit smoke alarms. Follow up inspections verified damaged windings to shorted strands and excess heat. Unit C11 is expected to remain out of service until December 2018. During this outage period, C11 windings will be replaced along with the turbine rehabilitation work.

This condition is unique to generating units C8-C11 and **does not** include units C1-C7.

**Remedy and Future Schedule**

All four units have turbine repairs planned for the final repair discussed earlier in the “C8-C11 Servo-Motor Rod” section to return to variable pitch blade Kaplan operation. These planned outages can only be done one at a time. Each generator stator is also planned to be rewound. The outage schedule for turbine repairs and rewinds is as follows:

**1) Rocky Reach Tentative Outage Schedule (Expected Case Scenario):**

UNIT DESCRIPTION START DATE RETURN TO SERVICE DATE

C8 Turbine repairs/stator rewind out of service until May 2017

C9 Stator Rewind out of service until May 2017

C9 Turbine repairs Dec 2018 Jan 2020

C10 Turbine repairs Feb 2020 Apr 2021

C11 Turbine repairs/stator rewind out of service until Nov 2018

**2) Rocky Reach Tentative Outage Schedule (Worst Case Scenario): (as of December 2016)**: The worst case scenario regarding the turbine repairs and the stator rewinds for units C8 through C11 may occur if other unit failures occur on C-9 or C-10 prior to their schedule turbine rehabilitation work. In this case, units C-9 and C-10 would remain out of service from the failure date until their scheduled completion dates of the rehab projects: (see below).

UNIT DESCRIPTION START DATE RETURN TO SERVICE DATE

C8 Turbine repairs/stator rewind out of service until May 2017

C9 Stator Rewind/ Turbine repairs from C9 failure until Feb 2020

C10 Turbine repairs from C10 failure until Apr 2021

C11 Turbine repairs/stat rewind out of service until Dec 2018

**OTHER ISSUES:**

**Transmission out of Rock Island Project:**

**Background and Issue**

Due to the December 2015 curtailment of a major industrial load near the Valhalla and McKenzie substations, the District has revised its operational protocols.  The curtailment of the large load in this vicinity requires the McKenzie - Valhalla substation 115kV tie line to be operated in an ‘open’ (disconnected) configuration when the ambient temperature is approximately 68F or higher.

This ‘open’ configuration allows the District to operate the Rock Island project normally except when Rock Island generation is above 465 MW and the ambient temperatures are above 86F (dependent on regional generation patterns, planned or emergency line outages, etc.).  The District’s preliminary studies show this condition could happen approximately 20 hours per year based on 10-years of historical data.

When the McKenzie – Valhalla 115kV tie line is operated in the ‘open’ condition and the ambient temperature is above 86F, the BPA Valhalla Substation (Rock Island) Point of Delivery will be limited to approximately 200 MW.  The other Points of Delivery will not be limited due to these conditions.

It is unknown if the major industrial load will return or remain curtailed during the term of the contract.

**Remedy**

The District has developed and implemented emergency transmission line ratings for the 115kV transmission lines that leave McKenzie substation. With the implementation of these emergency transmission line ratings, it is expected when in this ‘open’ configuration **and** the ambient temperature is above 86F, Rock Island generation may likely not have to be limited to 465 MW based on historical information for an all lines in-service condition.