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U.S. Nuclear Regulatory Commission
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H. B. ROBINSON STEAM ELECTRIC PLANT, Unit No. 2
DOCKET NO. 50-261/RENEWED LICENSE NO. DPR-23

Path Forward for Resolution of GSI-191

References:

(1) Generic Letter (GL) 2004-02: Potenital Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors.

(2) December 23, 2010, Staff Requirements – SECY-10-0113 – Closure Options for Generic Safety Issue - 191, Assessment of Debris Accumulation on Pressurized-Water Reactor Sump Performance.

(3) October 12, 2011, Pressurized Water Reactor Owners Group (PWROG), Topical Report (TR) WCAP-16793-NP, Revision 2, "Evaluation of Long-Term Core Cooling Considering Particulate Fibrous and Chemical Debris in the Recirculating Fluid."

(4) May 4, 2012, Nuclear Energy Institute (NEI) to the U.S. Nuclear Regulatory Commission (NRC), Office of Nuclear Reactor Regulation, Director, Division of Safety Systems – Subject: GSI-191 - Current Status and Recommended Actions for Closure.

(5) July 9, 2012, SECY-12-0093 – Closure Options for Generic Safety Issue - 191, Assessment of Debris Accumulation on Pressurized-Water Reactor Sump Performance.

(6) November 15, 2012, Nuclear Energy Institute (NEI) to the U.S. Nuclear Regulatory Commission (NRC), Office of Nuclear Reactor Regulation, Director, Division of Safety Systems – Subject: GSI-191 – Revised Schedule for Licensee Submittal of Resolution Path.

(7) November 21, 2012, Nuclear Regulatory Commission Review of Generic Safety Issue-191 Nuclear Energy Institute revised Schedule for Licensee Submittal of Resolution Path.

(8) December 14, 2012, Staff Requirements – SECY-12-0093 – Closure Options for Generic Safety Issue - 191, Assessment of Debris Accumulation on Pressurized-Water Reactor Sump Performance.

(9) April 8, 2013, Final Safety Evaluation for Pressurized Water reactor Owners Group Topical Report WCAP-16793-NP, Revision 2, "Evaluation of Long-Term Cooling Considering Particulate Fibrous and Chemical Debris in the Recirculating Fluid."

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In Reference (4) NEI highlighted the current industry status and recommended actions for closure of Generic Safety Issue (GSI)-191 which were based on licensees providing a docketed submittal to the NRC by December 31, 2012 that would outline a GSI-191 resolution path and schedule pursuant to the Commission direction Reference (2). By Reference (6) NEI recommended to the NRC that licensees delay submittal of GSI-191 resolution path and schedule until January 31, 2013, or 30 days following placement of both the Commission response to Reference (5) and the NRC staff safety evaluation (SE) on Reference (3). In Reference (8) the Commission approved the staff's recommendation in Reference (5) to allow licensees the flexibility to choose any of the three options discussed in the paper to resolve GSI-191. Further the Commission encouraged the staff to remain open to staggering licensee submittals and the associated NRC reviews to accommodate the availability of staff and licensee resources. The SE Reference (9) for Reference (3) was made publicly available by NRC on April 16, 2013.

An industry template was developed by NEI for the identification of a resolution path and schedule, and to describe defense-in-depth and mitigation measures to support the proposed resolution schedule.

The NEI template was used for the development of the Enclosure to this letter for H. B. Robinson Steam Electric Plant, Unit No. 2 (HBRSEP, Unit No. 2) and provides a resolution path forward and schedule for resolution, summary of actions completed for GL 2004-02, and defense-in-depth and mitigation measures which will be established and maintained throughout the resolution period.

Summary of Regulatory Commitments can be found in the Attachment to this letter.

If you have any questions concerning this submittal, please contact Mr. Richard Hightower at (843) 857-1329.

I declare under penalty of perjury that the foregoing is true and correct. Executed On: May 14, 2013

Sincerely,

Sharon A. Wheeler-Peavyhouse

Sharon A. Wheeler-Peavyhouse
Manage – Support Services

SAW/msc

Attachment

Enclosure

c: Mr. V. M. McCree, NRC, Region II
NRC Resident Inspector, HBRSEP Unit No. 2
Ms. Araceli Billoch Colón, NRC

Evaluation

Introduction

H.B. Robinson Steam Electric Plant Unit No. 2 (HBRSEP, Unit No. 2) has selected Option 2 and intends to pursue refinements to evaluation methods and acceptance criteria. To support use of this path, and continued operation for the period required to complete the necessary analysis and testing, HBRSEP, Unit No. 2 has evaluated the design and procedural capabilities that exist to identify and mitigate in-vessel blockage. A description of these detection and mitigative measures are provided later in this document. Additionally, a summary of the existing margins and conservatisms that exist for HBRSEP, Unit No. 2 are also included in this document.

Characterization of Current Containment Fiber Status

From the current debris generation and debris transport analysis, HBRSEP, Unit No. 2 has determined that the amount of fibrous debris that could be transported to the strainers may require reduction in order to meet future fiber bypass parameters that are currently under development. HBRSEP, Unit No. 2 previously performed strainer bypass testing utilizing a generic design and approach velocities. Additional testing was conducted in April 2013 utilizing a refined test approach with more typical approach velocities for HBRSEP, Unit No. 2. The final results of this testing are expected in the first half of 2013 and will then establish a conservative quantity of fiber that could be transported to the strainers and the reactor fuel.

The fibrous debris sources considered in these analyses include (reference 3):

1. Nukon insulation
2. Temp Mat insulation
3. Unibestos insulation
4. Fiberglas insulation
5. Latent fiber

Characterization of Strainer Head Loss Status

HBRSEP, Unit No. 2 previously provided the results of strainer head loss testing, including the impact of chemical effects, in Reference letters RNP-RA/08-0026, RNP-RA/08-0124, and RNP-RA/10-0007. The results of this testing demonstrate acceptable results with regard to allowable head loss.

Characterization of In-Vessel Effects

HBRSEP, Unit No. 2 intends to follow the resolution strategy proposed by the Pressurized Water Reactor Owners Group (PWROG) for establishing in-vessel debris limits applicable to the HBRSEP, Unit No. 2.

Licensing Basis Commitments

HBRSEP, Unit No. 2 currently has a commitment to provide the NRC verification that the plant conditions are bounded by the final WCAP-16793-NP and the final NRC Safety Evaluation when they are issued (RNP-RA08-0124). As a result of the remaining open questions associated with Generic Letter GL 2004-02 for HBRSEP, Unit No. 2, and the information contained within this document, the previously established commitments are considered to be closed based on the intended direction to be taken as described in this document.

Resolution Schedule

HBRSEP, Unit No. 2 will achieve closure of GSI-191 and address GL 2004-02 per the following milestones. The dates provided are approximate and subject to change.

- Revised strainer bypass testing under more typical conditions was completed in April 2013. Completion of the test report is expected in the second quarter of 2013.
- PWROG in-vessel testing is scheduled for completion by the fall of 2014 with the NRC Safety Evaluation (SE) on the resulting WCAP expected by the fall of 2015.
- Determination of the need for additional plant modifications for insulation replacement or other remediation will begin in the fall of 2014 based on the results of revised bypass and PWROG in-vessel testing.
- Initial measurements for insulation replacement were completed in 2008. Additional measurements for insulation replacement or other remediation by the end of the first refueling outage following the issuance of the staff's safety evaluation of the results of the upcoming PWROG comprehensive test program. Test results are expected by mid-2014 with development of the staff's safety evaluation to follow. Based on these schedules it is estimated that additional measurements will take place during the spring 2015 outage.
- Design and fabrication of replacement insulation or other remediation expected to be conducted through summer of 2016.
- Installation of replacement insulation or other remediation expected to be conducted in the fall 2016 outage (third refueling outage following January 1, 2013). Should planning after the design is finalized indicate that multiple outages would be required, the insulation replacement or remediation will focus on completing the greatest quantity achievable within the fall 2016 outage duration, with the remainder to be replaced or remediated within the spring 2018 outage.
- Within six months of establishing a final determination of the scope of insulation replacement or remediation, HBRSEP, Unit No. 2 will submit a final updated supplemental response to support closure of GL 2004-02 for HBRSEP, Unit No. 2. This determination will be made following the staff's issuance of the safety evaluation of the upcoming PWROG comprehensive test program.
- HBRSEP, Unit No. 2 will update the current licensing basis (UFSAR) following NRC acceptance of the updated supplemental response for HBRSEP, Unit No. 2 and completion of the identified removal or modification of insulation debris sources in containment per plant modification procedures and processes (10 CFR 50.71(e)).

If HBRSEP, Unit No. 2 determines that the proposed testing or analysis resolution path will not be viable, then an alternate resolution path will be discussed with the NRC to gain acceptance of the proposed path and to establish an acceptable completion schedule.

Summary of Actions Completed To Address GL 2004-02

To support closure of GSI-191 and to address GL 2004-02, HBRSEP, Unit No. 2 has completed the following actions for HBRSEP, Unit No. 2:

- Replaced simple geometry Emergency Core Cooling System (ECCS) sump strainers with a filtering surface area of 100 square feet, and 7/32 inch square openings with complex geometry strainers having a filtering surface area of over 4000 square feet and nominal 3/32 in circular openings.(Engineering Change (EC) 63481)
- Containment spray pump seal was changed to replace the disaster bushing with one compatible with downstream particulate debris.(EC 63481)
- Latent debris was sampled and characterized, including debris sources such as tags and labels, etc. The plant labeling procedure was revised to preclude the replacement or introduction of any label made from material that could contribute to screen debris loading.(EC 63481)
- Debris generation and debris transport analyses were developed and documented in calculations RNP-M/MECH-1761 and RNP-M/MECH-1762.
- Ex-vessel downstream effects analysis is documented in RNP-M/MECH-1784.
- Net positive suction head (NPSH) analysis accounting for the new debris loaded strainer is documented in RNP-M/MECH-1637.
- A new lower Spray Additive Tank level was established to minimize the generation of chemical debris. (EC 90437)
- Procedural controls were established to control aluminum and latent debris in containment within analyzed limits (PLP-006).
- The insulation specification was revised to control the insulation material and volume in the zone of influence (ZOI). (L2-M-039, AR225568, EC 82791, EC 78704)

Summary of Margins and Conservatisms for Completed Actions For GL 2004-02

The following provides a summary description of the margins and conservatisms associated with the resolution actions taken to date. These margins and conservatisms provide support for the extension of time required to address GL 2004-02 for HBRSEP, Unit No. 2.

- Debris Generation – The quantity of latent debris used in analyses and testing is nearly twice the amount determined by sampling. (RNP-M/MECH-1761)
- The current bypass amount (34g per fuel assembly (FA)) is based on testing conducted at three times the plant design approach velocity (0.006 ft/s vs. 0.002 ft/s). Higher velocities lead to higher bypass. Prior bypass testing indicates a linear relationship between measured bypass and approach velocity (PER-021-LTR-001). Given a linear relationship, the current assumed bypass at HBRSEP, Unit No. 2 is very conservative. Bypass testing at more typical conditions was completed in April 2013, with the final report expected in the summer of 2013. (Enercon PER003-PR-001, Bypass based on Enercon PER003-PR-001 which determined 4.97 ft^3 bypass, UFSAR 4.0 which states HBRSEP, Unit No. 2 has 157 fuel assemblies (FA), and fiber density of 2.4 lb/ft^3 per RNP-M/MECH-1761, p. 21: 4.97 ft^3 x 2.4 lb/ft^3 x 453.6 g/lb x 1/157FA = 34.5 g/FA).
- The current in-vessel fiber limit of 15g/FA is based on testing with conservatisms as follows (based on OG-12-287):
    - **Ambient temperature:** Testing was conducted at ambient conditions (approximately 72°F). Actual plant conditions will have much higher sump temperatures in the time following the accident and prior to hot leg switch over, which is the period of interest for in-vessel debris effects. The higher temperature will minimize chemical effects

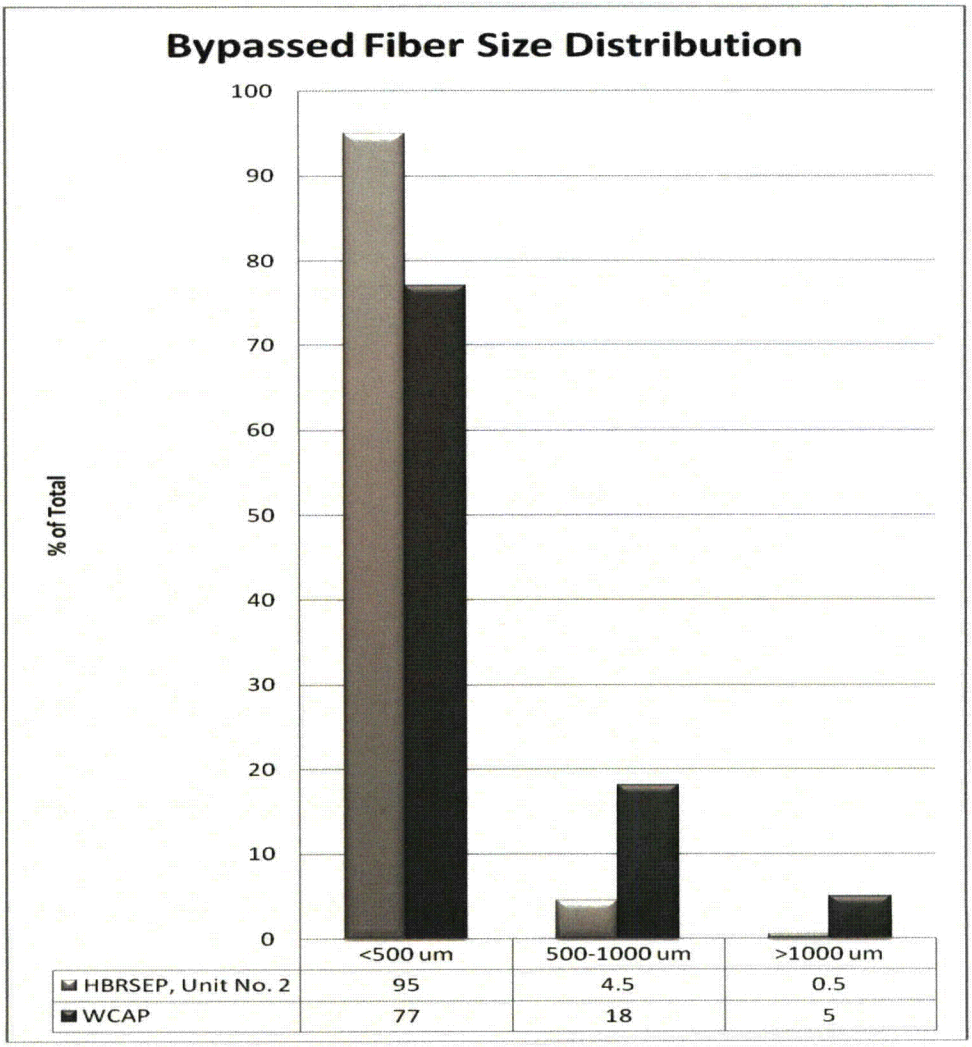
and maintain a lower water viscosity. A lower water viscosity results in a lower pressure drop through the debris bed.

- **Constant flow rate**: The HBRSEP, Unit No. 2 maximum post-Loss of Coolant Accident ECCS flow rate is 24.3 gpm/FA (3808 gpm/157 FA per RNP-M/MECH-1637, Case 3.1B). After initiation to hot leg recirculation, the maximum post-LOCA ECCS cold leg flow rate is 14.6 gpm/FA (2300 gpm/157 FA per RNP-M/MECH-1637, Case 3.3). In order to bound the majority of the operating PWR fleet, the generic hot leg FA tests used a constant flow rate value of 44.5 gpm / FA, and the available driving head calculations assumed both a water solid core and the shortest steam generator U-tubes. The maximum flow rate of 44.5 gpm ensured that the pressure differential (ΔP) due to fiber was calculated at the most limiting condition and is very conservative compared to the maximum HBRSEP, Unit No. 2 flowrate of 14.6 to 24.3 gpm (33% to 54% of the tested flowrate). FA testing performed at lower flow rates than the conservative maximum value of 44.5 gpm resulted in a lower FA ΔP. Allowing the flow rate to decrease commensurate with the buildup of debris would be more typical and result in a reduction in FA head loss.

  The highest expected core boil off rate at approximately 20 minutes after a LOCA corresponds to a core flow rate of approximately 3 gpm / FA and at one hour after the event, the decay heat has decreased to a point at which the core boil off requirement is approximately 2/3 of the boil off rate of approximately 3 gpm / FA at 20 minutes, based on a 4-loop plant. To bound the operating PWR fleet, the generic cold-leg FA test program was conducted at a constant flow rate of 3.0 gpm / FA, representing a decay heat load early in the transient (approximately 20 minutes after initiation of the postulated LOCA). Assuming this flow rate ensured the development of debris beds with maximum resistance and the highest pressure loss. Allowing the test flow rate to decrease commensurate with the buildup of debris would be more typical and result in a reduction in FA head loss while still maintaining adequate flow through the core.

- **Surrogate chemical effects**: Testing has shown an aluminum oxy-hydroxide (ALOOH) surrogate made with high purity water (used in the RCS and ECCS) was not as effective or as stable as that made with tap water (as used in the FA test program). The ALOOH surrogate is not representative of, but rather bounds, the chemical products and precipitates expected in most plants. (OG-12-287)

- **Fiber size distribution:** The fiber size distribution used in FA testing is based on PWROG strainer bypass testing samples. The HBRSEP, Unit No. 2 strainers have "bypass eliminators". The fibers that pass through the "bypass eliminators" are smaller than those making it through strainers without "bypass eliminators". Fiber characterization for HBRSEP, Unit No. 2 bypass found 95% of the fibers were shorter than 500 µm and 99.5% were shorter than 1000 µm (Enercon report PER003-PR-001). The FA testing distribution had only 77% of the fibers shorter than 500 µm and 95% shorter than 1000 µm (ref WCAP-16793-MP, Rev. 2, Table G-1), i.e. the HBRSEP, Unit No. 2 debris has only 1/10 of the longer fibers and 1/4 of the medium length fibers used in the FA testing. Because of their shorter length, the HBRSEP, Unit No. 2 fiber sizes are less likely to build a fiber bed than those used in the FA testing.



- **Recirculating Debris:** Debris that enters the RCS but does not settle or is not captured in the core, would be carried out of the break into the sump where it could settle out or be rescreened before entering the ECCS again. The testing allowed debris that passed through the fuel to be recirculated back to the fuel. Any reduction in the amount of debris entering the RCS will result in a lower core ΔP promoting adequate flow through the core to ensure long term core cooling.

Summary of Defense-In-Depth (DID) Measures

The following describes the plant specific design features and procedural capabilities that exist for detecting and mitigating fuel blockage condition.

Detection:

Core exit thermocouples (CETs) are monitored as part of the Emergency Operating Procedures (EOPs) to ensure adequate flow is reaching the core to cool the core. The CETs measure temperatures at the top of the actual core. They are used for core exit temperature indication and subcooled margin computation. Increasing CET temperature indication is monitored in the Emergency Operating Procedures. (Critical Safety Function Status Trees (CSFST), End Path Procedure (EPP)-Foldouts, Functional Restoration Procedure FRP-C.1, step 14)

Reactor vessel water level indication is monitored through the reactor vessel water level instrumentation system (RVLIS) throughout the Emergency Operating procedures (EOP's) as specific steps. RVLIS consists of two sets of three differential pressure (DP) cells to measure three level ranges:

- The Upper Range DP cell provides a measurement of reactor vessel level above the hot leg pipes when the Reactor Coolant Pumps (RCP's) are not operating.
- The Full Range provides an indication of reactor vessel level from the bottom of the reactor vessel to the top of the vessel during natural circulation conditions.
- The Dynamic Head provides an indication of reactor core and internals pressure drop for any combination of operating RCPs. Comparison of the measured pressure drop with the normal pressure drop provides an approximate indication of the relative void content of the RCS. The Dynamic Head DP cell provides reactor coolant conditions on a continuous basis during forced flow conditions. (FRP-C.1, step 11).

Increasing containment or auxiliary building radiation levels are indicated by alarms in the control room with specific procedural steps in both alarm response and EOPs for addressing the condition. Due to the sensitivity of the monitors and the low alarm setpoints, identification of degrading core conditions will occur well before a significant release of radioactivity to containment occurs.

Mitigation:

To mitigate an inadequate core flow condition the following methods are available to plant operators:

1. Transfer to hot leg injection or combined hot leg/cold leg injection flow paths: This happens after approximately 11 hours per EPP-10. Simultaneous hot and cold leg injection is done if all equipment is available. Otherwise flow is cycled between hot and cold leg injection. Transferring to hot leg injection has the potential to disturb the flow limiting debris bed that formed on the bottom of the fuel, enabling the cold leg injection flow path to once again be a viable flow path.

2. Start a reactor coolant pump (RCP): FRP-C.1, Response to Inadequate Core Cooling, provides steps to reduce core temperatures in the event of inadequate core cooling. The procedure directs verification of safety injection (SI) flow in all trains. While this is occurring, it also directs the operators to establish conditions for running an RCP while continuing with the procedure. Additional steps direct operators to reduce the RCS pressure in order for the SI accumulators and low-head SI pumps to inject. If these actions are not successful in restoring adequate core cooling (i.e., CETs are indicating a temperature greater than 1200°F), then the procedure directs starting an available RCP in one idle cooling loop. If ineffective in decreasing the CET temperature to less than

1200°F, then other available RCPs in idle cooling loops are incrementally started until a decreasing CET temperature is obtained. Operating an RCP will remove the blockage from the core to allow more normal core cooling.

3. Implementation of SAMGs or EDMGs: Severe Accident Management Guidelines (SAMG) and Extreme Damage Mitigation Guidelines (EDMG), also known as B.5.b guidelines, provide additional guidance and actions for addressing inadequate core flow conditions.

   Transfer back to injection flow path (minimum flow) if water is available in the Refueling Water Storage Tank, Volume Control Tank, or Boron Addition Tank. Bumping the RCP's, which would remove the blockage from the core to allow more normal core cooling, is also identified as a method to inject water from the cross-over leg (SAM-3).

   Alternate flow paths contained in the SAMG procedures include hot leg, cold leg and normal and alternate charging (SAM-3).

   Direction to flood containment to allow cooling the reactor by convection is provided in both the SAMG and EDMG procedures (SAM-8, EDMG-005).

   EDMG will direct the flooding of containment (which also floods the break location) to provide for partial or full core refill and subsequent cooling. The specific steps are contained within the SAMG for flooding containment. Portable fire pumps and hydrants if available can be aligned to flood containment or inject into the SI system.

PWR Owners Group letter OG-13-137 transmits DW-12-013 which includes EOP changes to address the potential for lower core region flow blockage from in-vessel debris during the cold leg recirculation phase of safety injection and includes guidance for detecting lower core region flow blockage and potential mitigating actions. Guidance from DW-12-013 will be incorporated into the site Emergency Operating Procedures.

Although these measures are not expected to be required based on the very low probability of an event that would challenge either the capability of the strainer to provide the necessary flow to the ECCS and Containment Spray systems, or result in significant quantities of debris being transported to the reactor vessel that would inhibit the necessary cooling of the fuel, they do provide additional assurance that the health and safety of the public would be maintained. These measures provide support for the extension of time required to completely address GL 2004-02 for HBRSEP, Unit No. 2.

Conclusion

HBRSEP, Unit No. 2 expects that the GSI-191 resolution path for HBRSEP, Unit No. 2 is acceptable, based on the information provided in this document. The actions taken and the execution of the actions identified in this document will result in successful resolution of GSI-191 and closure of GL 2004-02.

References

1. SECY-12-0093, Closure Options for Generic Safety Issue - 191, Assessment of Debris Accumulation on Pressurized-Water Reactor Sump Performance
2. Engineering Change 63481, Design and Installation of Containment Building ECCS Sump Strainers
3. RNP-M/MECH-1761, Rev. 5, RNP Containment Vessel GSI-191 Debris Generation Calculation
4. RNP-RA/08-0026, Supplemental Response to NRC Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation during Design Basis Accidents at Pressurized-Water Reactors" dated March 7, 2008
5. RNP-RA/08-0124, Response to Request for Additional Information Pertaining to NRC Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation during Design Basis Accidents at Pressurized-Water Reactors" dated December 17, 2008
6. RNP-RA/10-0007, Request for Additional Information (RAI), dated December 3, 2009
7. OG-12-287, Submittal of Supplement to WCAP-16793-NP, Revision 2 (PA-SEE-0312, Revision 4)
8. Enercon Report PER003-PR-001
9. CSFST, Revision 4, Critical Safety Function Status Trees
10. End Path Procedure EPP-Foldouts, Revision 34, Foldouts
11. Functional Restoration Procedure FRP-C.1, Revision 20, Response to Inadequate Core Cooling
12. Emergency Response Guideline Maintenance Item DW-12-013
13. Action Request 225568, Self-assessment 223503 Deficiency 1 Basis for Elastomer
14. Engineering Change 82791, Revision to L2-M-039
15. Engineering Change 78704, Revision to L2-M-039
16. OG-13-137, 4-5-13, Transmittal of the Approved Response for DW-12-013
17. End Path Procedure EPP-10, Revision 24, Transfer to Long Term Recirculation
18. SAM-3, Revision 1, Inject Into the RCS
19. EDMG-005, Revision 8, Containment Vessel (CV)
20. Procedure Revision Request to update procedures to incorporate DW-12-013
21. PER-021-LTR-001, Revision 3, Design Inputs for Robinson Strainer Fiber Bypass Testing

H. B. Robinson Steam Electric Plant, Unit No. 2
Generic Letter 2004-02 Supplemental Response

PLANNED ACTIONS

The following table identifies those actions committed to in this letter for HBRSEP Unit No. 2. Any other actions discussed in this submittal represent intended or planned actions. They are described to the NRC for the NRC's information and are not regulatory commitments.

PLANNED ACTIONS	Date
HBRSEP Unit No. 2 will complete measurements for insulation replacement.	May 31, 2015
HBRSEP Unit No. 2 will complete any necessary insulation replacements or remediation, or other identified plant changes.	May 31, 2018
HBRSEP Unit No. 2 will submit a final updated supplemental response to support closure of GL 2004-02.	Within 6 months of receipt of the SE for the risk-informed resolution licensing action