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10 CFR 50.54(f)

Date: September 30, 2021
Serial: RA-21-0230

United States Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555-0001

H. B. ROBINSON STEAM ELECTRIC PLANT, UNIT NO. 2
DOCKET NO. 50-261/RENEWED LICENSE NO. DPR-23

Subject: Final Supplemental Response to NRC Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors"

The purpose of this submittal is to provide the Duke Energy, LLC (Duke Energy) final supplemental response for H.B. Robinson Steam Electric Plant Unit No. 2 (HBRSEP, Unit No. 2), to Generic Letter (GL) 2004-02, dated September 13, 2004, "Potential Impact of Debris Blockage on Emergency Recirculation during Design Basis Accidents at Pressurized-Water Reactors."

On May 14, 2013, Duke Energy submitted a letter of intent per SECY-12-0093, "Closure Options for Generic Safety Issue – 191 (GSI-191), Assessment of Debris Accumulation on Pressurized-Water Reactor Sump Performance" indicating HBRSEP, Unit No. 2 would pursue Closure Option 2 – Deterministic of the SECY recommendations (refinements to evaluation methods and acceptance criteria) (ML13141A283). The Attachment to the submittal contained commitments to complete measurements for insulation replacement and to complete any necessary insulation replacements or remediation, or other identified plant changes. The measurements for insulation replacement were completed on April 15, 2015. However, because of the Duke Energy decision to address closure of GL 2004-02 using a deterministic approach, no replacement or remediation of insulation was necessary. The deterministic assessment of the maximum quantity of in-vessel fiber and debris precludes the need for plant changes or other corrective actions to ensure system functionality. The final outstanding issue for HBRSEP, Unit No. 2 with respect to GL 2004-02, is the in-vessel downstream effects evaluation, which addresses that long-term core cooling (LTCC) can be adequately maintained for all postulated accident scenarios that require sump recirculation.

The in-vessel downstream effects evaluation has been completed for HBRSEP, Unit No. 2, and is documented in the enclosure to this letter. This satisfies the GSI-191 commitment identified in the May 14, 2013, Closure Option letter.

This letter contains one new regulatory commitment. Duke Energy will update the current licensing basis (UFSAR) in accordance with 10 CFR 50.71(e) following NRC acceptance of the final supplemental response for HBRSEP, Unit No. 2. This will be completed by June 16, 2023, six months after completion of the next scheduled refueling outage.

If you have any questions, please contact David Hall, Manager of Nuclear Support Services, at (843) 951-1358.

I declare under penalty of perjury that the foregoing is true and correct. Executed on the 30th day of September 2021.

Sincerely,

Ernest J. Kapopoulos, Jr.
Site Vice President

Enclosure: Final Supplemental Response to Generic Letter 2004-02

c: L. Dudes, NRC Regional Administrator, Region II
T. Hood, NRC Project Manager, NRR
M. Fannon, NRC Senior Resident Inspector, HBRSEP

U.S. Nuclear Regulatory Commission
Enclosure to Serial: RA-21-0230
(29 pages, including this cover sheet)

H. B. ROBINSON STEAM ELECTRIC PLANT, UNIT NO. 2

Final Supplemental Response to Generic Letter 2004-02

ENCLOSURE

ENCLOSURE – HBRSEP, Unit No. 2 FINAL SUPPLEMENTAL RESPONSE TO GL 2004-02

The following information is provided based on NRC Generic Letter 2004-02 Final Submittal Response Guidance and Template Section 5 of PWROG-16073-P, Revision 0, “TSTF-567 Implementation Guidance, Evaluation of In-Vessel Debris Effects, Submittal Template for Final Response to Generic Letter 2004-02 and FSAR Changes”, February 2020.

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1 Overall Compliance

NRC Issue:

Provide information requested in GL 2004-02, "Requested Information." Item 2(a) regarding compliance with regulations. That is, provide confirmation that the [Emergency Core Cooling System (ECCS)] ECCS and [Containment Spray System (CSS)] CSS recirculation functions under debris loading conditions are or will be in compliance with the regulatory requirements listed in the Applicable Regulatory Requirements section of this generic letter. This submittal should address the configuration of the plant that will exist once all modifications required for regulatory compliance have been made and this licensing basis has been updated to reflect the results of the analysis described above.

<u>RNP Response</u>:

In accordance with SECY-12-0093 and as identified in Duke-Energy letter to NRC dated May 14, 2013, H.B. Robinson Steam Electric Plant Unit No. 2 (HBRSEP, Unit No. 2) has elected to pursue GSI-191 Closure Option 2 – Deterministic and identified in-vessel downstream effects as the last outstanding issue.

Topical Report (TR) WCAP-17788-P, Rev. 1 provides evaluation methods and results to address in-vessel downstream effects. As discussed in NRC “Technical Evaluation Report of In-Vessel Debris Effects,” (ADAMS Accession No. ML19178A252), the NRC staff has performed a detailed review of WCAP-17788-P. Although the NRC staff did not issue a Safety Evaluation for WCAP- 17788, as discussed further in “U.S. Nuclear Regulatory Commission Staff Review Guidance for In-Vessel Downstream Effects Supporting Review of Generic Letter 2004-02 Responses” (ADAMS Accession No. ML19228A011), the staff expects that many of the methods developed in the TR can be used by PWR licensees to demonstrate adequate long-term core cooling (LTCC). Completion of the analyses demonstrate compliance with 10 CFR 50.46, “Acceptance criteria for emergency core cooling systems for light-water nuclear power plants,” (b)(5), “Long- term cooling,” as it relates to in-vessel downstream debris effects for HBRSEP, Unit No. 2.

1.1 Overview of HBRSEP, Unit No. 2 Resolution to GL 2004-02

<u>Summary or Actions Completed to Address GL 2004-02</u>

On May 14, 2013, (HBRSEP, Unit No. 2) submitted RNP-RA/13-0048, H. B. Robinson Steam Electric Plant, Unit No. 2 PATH FORWARD FOR RESOLUTION OF GSI-191 WITH ATTACHED H.B. ROBINSON STEAM ELECTRIC PLANT, UNIT NO. 2 GENERIC LETTER 2004-02 SUPPLEMENTAL RESPONSE” dated May 14, 2013. The changes that were implemented and identified in the HBRSEP, Unit No. 2 remain valid.

The following remaining actions to close GL 2004-02 have been completed and are included in this enclosure:

1. Characterization of ECCS Sump Strainer Bypass test results:

   As stated in HBRSEP, Unit No. 2 May 14, 2013 response, additional strainer bypass 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 provided in this response and used to compute the in-vessel debris limits applicable to HBRSEP, Unit No. 2.

2. Calculation of In-Vessel Effects:

   Calculation (Ref. RNP-M/MECH-1941, Rev. 1, RNP In-Vessel Downstream Effects (IVDE) Calculation") and is submitted as basis for in In-vessel debris limit is Completion of the analyses demonstrate compliance with 10 CFR 50.46, "Acceptance criteria for emergency core cooling systems for light-water nuclear power plants," (b)(5), "Long- term cooling," as it relates to in-vessel downstream debris effects for HBRSEP, Unit No. 2.

<u>Summary of Margins and Conservatisms for Completed Actions for GL 2004-02</u>

The HBRSEP, Unit No. 2 Path Forward for Resolution of GSI-191 also identified multiple conservatisms in the approach to address GSI-191. The conservatisms identified in the HBRSEP, Unit No. 2 response remain valid. The following conservatisms are associated with the in-vessel effects:

- The effective surface area of the plant strainer and the test module (four Top Hats) are 4178 ft² and 121.24 ft², respectively. Bypass testing was performed in accordance with the ALION Test Plan submitted on November 26, 2012 using a ratio based on 4000 ft² strainer. This incorporates margin into the results (Ref. 3.2, ALION-REP-ENGR-8707-04).

- In the Westinghouse analysis for K_{max} for which Long Term Core Cooling (LTCC) can be assured assumes that Sump Switch Over (SSO) starts 20 minutes after the initiation of a LOCA. The earliest possible time SSO occurs for HBRSEP, Unit No. 2 is > 20 minutes and may take up to 2,460 seconds (41 minutes) from the initiation of the LOCA event (Ref. UFSAR Section 15.6.5.2.2, Table 15.6.5-3). This time includes 1,260 sec (21 min) to achieve low level in the RWST plus a 20 minute Time Critical Operator Action allowed for operators to align the Low Head Safety Injection Pumps to the ECCS Sump and start the pumps. This creates margin in the earliest allowable time in which the inlet to the core can be blocked.

- Alternate Flow Path Resistance (AFP)

HBRSEP, Unit No. 2 is a Westinghouse downflow barrel/baffle plant. The Proprietary analyzed AFP resistance is provided in Table 6-2 of WCAP-17788-P Volume 4, Rev. 1. The Proprietary HBRSEP, Unit No. 2 specific AFP resistance is provided in Table RAI-4.2-24. The HBRSEP, Unit No. 2 specific AFP resistance is Less than the analyzed value; therefore, the HBRSEP, Unit No. 2 AFP resistance is bounded by the resistance applied to the AFP analysis. This provides conservatism in the analyzed amount of fiber debris that can enter the core through the alternate flow path (m_{split}).

- Plant Rated Power

HBRSEP, Unit No. 2 has a rated thermal power of 2,339 MWt. HBRSEP, Unit No. 2 is a Westinghouse 3-Loop PWR Downflow Plant and the applicable analyzed thermal power is 2951 as provided in WCAP-17788-P, Rev. 1, Volume 4, Table 6-2. The HBRSEP, Unit No. 2 rated thermal power is less than the analyzed power; therefore, this parameter is bounded by the WCAP-17788-P, Rev. 1, Volume 4 alternate flow path analysis which provides conservatism in the earliest time the inlet to the core can become blocked (t_{block})

1.2 Correspondence Background

Generic Letter 2004-02 Correspondences		
Document Date	**ADAMS Accession Number**	**Document**
9/13/2004	ML042360586	NRC GL 2004-02
3/4/2005	ML050740377	RESPONSE TO NRC GL-04-002
06/03/2005	ML051520544	ROBINSON AND HARRIS RAI
07/19/2005	ML052070685	RESPONSE TO NRC RAI RELATED TO GENERIC LETTER 2004-02
09/01/2005	ML052490343	RESPONSE TO NRC GENERIC LETTER 2004-02
02/08/2006	ML060370460	REQUEST FOR ADDITIONAL INFORMATION
03/28/2006	ML060870274	ALTERNATIVE APPROACH FOR RESPONDING TO THE NRC REQUEST FOR ADDITIONAL INFORMATION LETTER RE: GENERIC LETTER 2004-02.
07/13/2006	ML061990251	SUPPLEMENTAL RESPONSE TO NRC GL 2004-02
11/07/2006	ML063190401	SUPPLEMENTAL RESPONSE TO NRC GENERIC LETTER 2004-02
12/21/2006	ML063460258	ALTERNATIVE APPROACH FOR RESPONDING TO THE NUCLEAR REGULATORY COMMISSION REQUEST FOR ADDITIONAL INFORMATION LETTER REGARDING GENERIC LETTER 2004-02
07/27/2007	ML072110261	IR 05000261-07-003
03/07/2008	ML080730290	SUPPLEMENTAL RESPONSE TO GL-04-002

Generic Letter 2004-02 Correspondences		
Document Date	ADAMS Accession Number	Document
07/25/2008	ML081900649	REQUEST FOR ADDITIONAL INFORMATION, SUPPLEMENTAL RESPONSE TO GENERIC LETTER 2004-02
12/17/2008	ML083570469	RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION
12/03/2009	ML093310294	REQUEST FOR ADDITIONAL INFORMATION REGARDING SUPPLEMENTAL RESPONSE TO GENERIC LETTER 2004-02
02/26/2010	ML100570357	REQUEST FOR ADDITIONAL TIME TO RESPOND TO A REQUEST FOR ADDITIONAL INFORMATION DATED DECEMBER 3, 2009, REGARDING GL 2004-02
02/26/2010	ML100570368	RESPONSE TO REQUEST FOR ADDTIONAL TIME TO RESPOND TO A REQUEST FOR ADDITIONAL INFORMATION DATED DECEMBER 3, 2009, REGARDING GL 2004-02
03/30/2010	ML100920053	RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION PERTAINING TO GL-04-002
06/09/2010	ML101310029	GENERIC LETTER 2004-02 SUPPLEMENTAL RESPONSE
09/29/2010	ML102720541	SUBMITTAL OF RESULTS OF ADDITIONAL HEAD LOSS TESTING AND SUPPLEMENTAL INFORMATION REGARDING GL 2004-02.
10/08/2010	ML102720541	SUPPLEMENTAL RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION PERTAINING TO NRC GENERIC LETTER 2004-02
11/26/2012	ML12331A175	DRAFT BYPASS FIBER QUANTITY TEST PLAN
11/26/2012	ML12331A178	MEETING SLIDES RE GSI-191 STRAINER FIBER BYPASS TEST PLAN SLIDES
05/14/2013	ML13141A283	PATH FORWARD FOR RESOLUTION OF GSI-191 WITH ATTACHED H.B. ROBINSON STEAM ELECTRIC PLANT, UNIT NO. 2 GENERIC LETTER 2004-02 SUPPLEMENTAL RESPONSE

1.3 General Plant System Description

HBRSEP, Unit No. 2 is a Westinghouse three loop Pressurized Water Reactor (PWR) design. The Residual Heat Removal System (RHR) provides Low Head Safety Injection. The Safety Injection Pumps (SI) provide High Head Safety Injection (HHSI) and the Containment Spray Pumps (CS) provide Containment Spray. These systems pumps are started following a Loss of Coolant Accident (LOCA). Initially, two RHR, two HHSI and two CSS pumps take suction from the Refueling Water Storage Tank (RWST). When the RWST level reaches the low level set point, the RHR pumps are manually stopped and are realigned to take suction from the post LOCA containment sump. Once the RHR switchover to recirculation is complete, the CS and HHSI pumps take suction from the RHR pump discharge.

When the RWST level reaches low-low level, the RHR pumps are realigned to take suction from the containment sump. There are two independent containment sump suctions (One for each RHR train) located on the lowest floor elevation in the containment exclusive of the reactor cavity, and they are located outside the secondary shield wall.

The HBRSEP, Unit No. 2 Nuclear Steam Supply System is a three loop PWR. The system consists of one reactor vessel (RPV), three steam generators (SGs), three reactor coolant pumps (RCPs), one pressurizer (PZR) and the Reactor Coolant System (RCS) piping. The NSSS system is located inside Primary Shield Wall and Reactor Coolant Pump Bays.

The HBRSEP, Unit No. 2 ECCS Sump is located just outside the entry of the Regenerative Heat Exchanger Room. Water from a break inside the Primary and Secondary Shield Walls would flow downward and fill the Reactor Cavity Sump up to the 228' Containment Floor elevation. It would pass through 2 ft x 2 ft square drainage openings in the Secondary Shield Wall (20 total) and spill onto the outer containment floor. To get to the ECCS Sump, the flow must follow the circumference of the outer containment area. Two large pipes, are located 18’ apart, provide suction from the ECCS Sump to the RHR pumps at the 206'-9" elevation.

1.4 General Description of Containment Sump Strainers

As stated in HBRSEP, Unit No. 2 Supplemental Response Serial: RNP-RA/08-0026, dated March 7, 2008, the HBRSEP, Unit No. 2 containment sump strainers are as described in response to 3j Screen Modification Package.

2 General Description and Schedule for Corrective Actions

NRC Issue:

Provide a general description of actions taken or planned, and dates for each. For actions planned beyond December 31, 2007, reference approved extension requests or explain how regulatory requirements will be met as per "Requested Information" Item 2(b). That is provide a general description of and implementation schedule for all corrective actions, including any plant modifications, that you identified while responding to this generic letter. Efforts to implement the identified actions should be initiated no later than the first refueling outage starting after April 1, 2006. All actions should be completed by December 31, 2007. Provide justification for not implementing the identified actions during the first refueling outage starting after April 1, 2006. If all corrective actions will not be completed by December 31, 2007, describe how the regulatory requirements discussed in the Applicable Regulatory Requirements section will be met until the corrective actions are completed.

RNP Response:

RNP has performed analyses to determine the susceptibility of the ECCS and CSS recirculation functions for HBRSEP, Unit No. 2 to the adverse effects of post-accident debris blockage and operation with debris-laden fluids. These analyses conform, to the greatest extent practical, to the NEI 04-07 methodology (Nuclear Energy Institute (NEI) guidance report NEI 04-07, "Pressurized Water Reactor Sump Performance Evaluation Methodology," Revision 0) as approved by the NRC FSE dated December 6, 2004 (Safety Evaluation by the Office of Nuclear Reactor Regulation to NRC Generic Letter 2004-02, Revision 0, December 6, 2004"). As of 09-30-2021, HBRSEP, Unit No. 2 has completed the following GL 2004-02 actions, analyses and modifications:

1. 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 4,178 square feet and nominal 3/32 in circular openings. Flow areas where water enters contain debris bypass eliminators. These bypass eliminators consist of a knitted stainless steel wire mesh designed to minimize the total fibrous debris bypass (Ref. EC 263481).

2. The Containment Spray Pump Seal was changed to replace the disaster bushing with one that is compatible with downstream particulate debris (Ref. EC 263481).

3. Latent debris was sampled and characterized, including Containment spray pump seal was changed to replace the disaster bushing with one compatible with downstream particulate debris (Ref EC 263481).

4. Debris generation and debris transport analyses were developed and documented in calculations RNP-M/MECH-1761 and RNP-M/MECH-1762.

5. Ex-vessel downstream effects analysis is documented in RNP-M/MECH-1784.

6. GSI-191 Debris Head loss Calculation through the ECCS Sump Screen documented in RNP-M/MECH-1764.

7. Net positive suction head (NPSH) analysis accounting for the new debris loaded strainer is documented in RNP-M/MECH-1637.

8. A new lower Spray Additive Tank level was established to minimize the generation of chemical debris (Ref. EC 290437).

9. Procedural controls were established to control aluminum and latent debris in containment within analyzed limits (PLP-006).

10. The insulation specification was revised to control the insulation material and volume in the zone of influence (ZOI) (Ref. L2-M-039, AR225568, EC 282791, EC 278704).

11. Evaluation of In-Vessel Downstream Effects (Ref. RNP-M/MECH-1941)

Duke-Energy has no outstanding corrective actions associated with GL 2004-02 for HBRSEP, Unit No. 2.

3 Specific Information for Review Areas

As stated in HBRSEP, Unit No. 2 Supplemental Response dated [March 7, 2008] [and amended on [May 14, 2013] as well as subsequent RAI responses submitted on [December 17, 2008], and [March 30, 2010], HBRSEP, Unit No. 2 has addressed review areas [3.a through 3.m], and only the outstanding review areas [3.n through 3.p] are addressed in this submittal.

3.n Downstream Effects – Fuel and Vessel

NRC Issue:

The objective of the downstream effects, fuel and vessel section is to evaluate the effects that debris carried downstream of the containment sump screen and into the reactor vessel has on core cooling. Show that the in-vessel effects evaluation is consistent with, or bounded by, the industry generic guidance (WCAP-16793), as modified by NRC staff comments on that document. Briefly summarize the application of the methods. Indicate where the WCAP methods were not used or exceptions were taken, and summarize the evaluation of those areas.

RNP Response:

Topical Report WCAP-17788-P, Rev. 1 provides evaluation methods and results to address in- vessel downstream effects. As discussed in NRC “Technical Evaluation Report of In-Vessel Debris Effects,” (ADAMS Accession No. ML19178A252), the NRC staff has performed a detailed review of WCAP-17788-P. Although the NRC staff did not issue a Safety Evaluation for WCAP-17788-P, as discussed further in “U.S. Nuclear Regulatory Commission Staff Review Guidance for In-Vessel Downstream Effects Supporting Review of Generic Letter 2004-02 Responses” (ADAMS Accession No. ML19228A011), the staff expects that many of the methods developed in the TR may be used by PWR licensees to demonstrate adequate LTCC. Duke-Energy used methods and analytical results developed in WCAP-17788-P, Rev. 1 to address in-vessel downstream debris effects for H.B. Robinson Unit 2 and has evaluated the applicability of the methods and analytical results from WCAP-17788-P, Rev. 1 for H.B. Robinson Unit 2.

3.n.1 Sump Strainer Fiber Penetration:

HBRSEP, Unit No. 2 performed Plant-Specific Penetration Testing in accordance with the ALION test plan submitted on November 26, 2012.

Prototypical bypass testing of the new ECCS Sump Strainers installed at HBRSEP, Unit No. 2 are equipped with debris bypass eliminators was completed in 2013 with results documented in (ALION Test Report, ALION-REP-ENGR-8707-04, Revision 0, “Robinson Nuclear Plant: Bypass Fiber Quantity Test Report” dated July 8, 2013).

The test was conducted in accordance with (ALION Test Plan, ALION-PLN-ENGR-8707-02, Revision 2, “Robinson Nuclear Plant: Bypass Fiber Quantity Test Plan” dated January 5, 2013).

3.n.1.1 Test Flume Design

The test array (Figure 1) and layout was a double-ring tophat, with debris bypass eliminators installed horizontally in an Alion test tank. The test configuration included Four prototype Top Hat Strainers located horizontally in the test tank with gaps included to represent fit-up allowances for the full scale.

Figure 1 Test Array (Ref. 3.2, ALION-REP-ENER-8707-04, Figure 2.1.2)

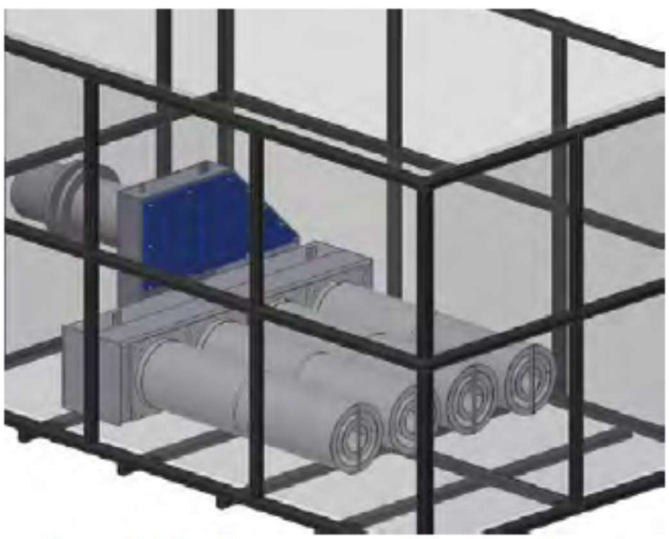

Figure 2.1.2 - Arrangement of the Test Array in the Test Tank

Bypass testing measured the bypassed fiber quantity using test conditions that conservatively maximized fiber bypass. Fiber debris loading and flow through the test array was established to model the debris load and approach velocities for the full scale plant ECCS operations. Process fiber was incrementally, added per the Test Plan until the maximum fiber load was achieved. These additions simulated the worst-case scenario for fiber bypass by maintaining the fiber concentration in the test tank at, or below, the concentration in the actual sump pool, thus, preventing early bed formation. Bypass fiber was captured using downstream 5-micron nominal microfiber filter bags via 100% pass through alignment in the flow stream.

3.n.1.2 Test Flow Rate

The bypass test was conducted with an initial approach velocity equal to 1.5 x the design approach velocity. Once the debris bed was verified, the flow was reduced to 1 x the design approach velocity. After approximately 11 hours, all pumps were stopped and the system was aligned to simulate piggyback mode (RHR pump in series with the SI pump) for hot leg injection via an SI pump with flow re-established based on hot leg injection at 0.17 x design approach velocity.

Test flow rate was scaled down from the full scale ECCS flow rate and full scale ECCS Sump Strainer surface area to achieve the approach velocities. Bypass testing was carried out for a minimum period of 11 hours after which, the pumps were stopped for 6 minutes and then restarted to simulate switchover to hot leg injection.

3.n.1.3 Debris Preparation

The debris load with identified fibrous debris source terms which were used for the bypass test were based on the calculated debris generation and transport to the sump screen. The debris types include

- NUKON®
- Temp-Mat
- Kaowool
- Unibestos
- Low Density Fiberglass (LDFG)

NUKON was used throughout testing as the surrogate debris for Temp-Mat and LDFG. This is conservative as previous Alion experience has shown NUKON to result in higher bypass quantities than Temp-Mat. NUKON also has characteristically smaller diameter (7 um versus 9 um). For low density fibrous debris, the mass was determined by multiplying the volume of fiber by the density of NUKON (2.4 lb/ft^3) and for high-density debris, the mass was determined by multiplying the volume of fiber by the density of Temp-Mat (11.8 lb/ft^3) (Ref. 3.3, Appendix I).

NUKON® was the surrogate utilized during testing to represent the different fibrous types. The testing debris load was calculated and scaled for the test and divided into twelve (12) additions totaling a theoretical bed thickness of 0.582 inches. The debris loads were calculated based on the screen surface area of the test array and the as-fabricated density for NUKON® of 2.4 lb/ft^3 (Ref. 3.2, Section 3.2).

NUKON® “fines” and “smalls” were created according to the current revision of the Nuclear Energy Institute (NEI) Zone of Influence (ZOI) Fibrous Debris Preparation guidelines (Ref. 3.2, Section 3.2).

Initially, the NUKON® “fines” were introduced into the test tank over the course of five additions. After the NUKON® “fines” were in the test tank, seven additions of NUKON® “smalls” were added. Each of these batches was added to the test tank, followed by a

minimum five pool turnover hold period. During the hold period, the test tank was gently stirred to ensure that all debris would reach the test array and the formation of the debris bed was not disturbed (Ref. 3.2, Section 3.2).

It was assumed that 10% of the total volume of Unibestos is in fibrous form. Unibestos is the trade name for a calcium-silicate material containing asbestos fibers. Alion's experiences with various calcium- silicate materials have shown that they contain a 0-4% fibrous component. Therefore, it is conservative to assume 10% of the total volume of Unibestos will be in fibrous form (Ref. 3.2, Section 3.5).

3.n.1.4 Debris Introduction

Debris load and transport fraction inputs were provided from [H.B. Robinson Unit 2] calculations (Ref. 4.1 & 4.2). These inputs were scaled for the test.

For low density fibrous debris, the mass was determined by multiplying the volume of fiber by the density of NUKON (2.4 lb/ft^3) (Ref. 3.3. Appendix I).

For high-density fibrous debris, the mass was determined by multiplying the volume of fiber by the density of Temp-Mat (11.8 lb/ft^3) (Ref. 3.3. Appendix I).

The scaled mass was determined by multiplying the calculated transported mass by the scaling factor (0.0303) which is equal to the ratio of the full scale/reduced scale strainer surface area.

The scaled volume was determined by dividing the scaled mass by the density of NUKON (2.4 lb/ft^3) rather than that of Temp-Mat due to previous testing observations regarding the destroyed density of Temp-Mat.

The bed thickness was determined by dividing the scaled volume by the prototype strainer area (121.2 ft^2).

Table A1-2 of the Test plan is reproduced below to show how the total amount of fiber added to the test tank was scaled (Ref.3.3, Appendix I).

Debris Type	Volume Generated	Transport Fraction		Volume Transported	Scaled *** Transport	Surrogate Material	Material Density	Scaled Transport
Nukon	164.8 ft³	38%	(Smalls)	62.62 ft³	1.898 ft³	NUKON	2.4 lb/ft³	4.6 lb
		17%	(Fines)	28.02 ft³	0.849 ft³			2.0 lb
Temp Mat	16.3 ft³	38%	(Smalls)	6.19 ft³	0.188 ft³	NUKON	11.8 lb/ft³	2.2 lb
		17%	(Fines)	2.77 ft³	0.084 ft³			1.0 lb
Nukon or Temp Mat	0.8 ft³	38%	(Smalls)	0.30 ft³	0.009 ft³	NUKON	11.8 lb/ft³	0.1 lb
		17%	(Fines)	0.14 ft³	0.004 ft³			0.0 lb
Temp Mat or Kaowool	4.6 ft³	63%	(Smalls)	2.90 ft³	0.088 ft³	NUKON	11.8 lb/ft³	1.0 lb
		22%	(Fines)	1.01 ft³	0.031 ft³			0.4 lb
Unibestos	32.2 ft³	85%	(Fines)	2.74 ft³**	0.083 ft³	NUKON	2.4 lb/ft³	0.2 lb
Fiberglass (assume LDFG)	11.8 ft³	63%	(Smalls)	7.43 ft³	0.225 ft³	NUKON	2.4 lb/ft³	0.5 lb
		22%	(Fines)	2.60 ft³	0.079 ft³			0.2 lb
Latent Fibers	60 lb *	100%	(Fines)	25.00 ft³	0.758 ft³	NUKON	2.4 lb/ft³	1.8 lb
Total				141.72 ft³	4.294 ft³	Total		14.1 lb
* Latent fiber is treated as LDFG and scaled directly from the mass given as an input in the Enercon Design Input Letter. The volume is calculated using the density of NUKON								
** This value included 10% fbrous assumption								
*** The scaled trasport fraction is 0.0303								

3.n.1.5 Fiber Debris, Preparation and Size Distribution

Per Section 4.2 of the Alion Test Report (Ref. 3.2), Nukon fiber was prepared in accordance with NEI ZOI Fibrous Debris Preparation Procedure. Two fibrous debris classifications were used for the tests. “fines” characterized as Classes 1-3 in NUREG/CR-6224 and “smalls” characterized as Classes 4-6 in NUREG/CR-6224. Classes 1-3 “fines” were used to represent the laten debris source term for the test.

The “small fines” were broken into 17% “fines” and 38% “smalls” for destroyed NUKON® and Temp- Mat insulation and 22% “fines” and 63% “smalls” for Kaowool, Unibestos and fiberglass debris.

NUKON® “fines” were the surrogate used to represent the fibrous portion of the Unibestos material. All fibrous debris used during testing was NUKON®.

Alion debris preparation procedure ALION-SPP-LAB-2352-22 was used to produce fiber “fines” and smalls, which were prepared according to a modified version of the current revision of the NEI ZOI Fibrous Debris Preparation. This procedure produced the required size distribution of fiber “fines” and “smalls” that transported and readily dispersed in the testing medium.

All fiber was baked on a single side for 6 to 8 hours. Fibrous “fines” were cut, weighed out and then separated with a commercially available pressure washer. Fibrous “smalls” were cut, pulled apart to separate the layers, soaked in water, and stirred until the pieces were fully saturated. The fiber was re- suspended before being added to the test tank. Photographs of representative samples of NUKON® and “smalls” are included as Figure 4.2.1 and Figure 4.2.2, respectively.

Figure 2 *(Ref. ALION-REP-ENER-8707-04, Figure 4.2.1 & 4.2.2)*

Figure 4.2.1- Prepared Bypass Test NUKON® "fines"

Figure 4.2.2- Prepared Bypass Test NUKON® "smalls"

3.n.1.6 Debris Introduction

Per Section 4.3 of the Alion Test Report (Ref. 3.2), Processed fiber was incrementally, added per the Test Plan, until the scaled maximum fiber load (14.1 lb) from Table 4.3.1 was achieved. These additions simulated the worst-case scenario for fiber bypass by maintaining the fiber concentration in the test tank at, or below, the concentration in the actual sump pool, thus preventing an early bed formation. Bypassed fiber was captured using downstream 5-micron nominal microfiber filter bags via a 100% pass through alignment in the flow stream. After each fiber batch was added to the test tank, and the stabilization criteria were satisfied, the filter bag was removed, processed, and analyzed as per the Filter Bag Preparation and Processing Procedure.

Fiber was added to the tank in twelve (12) additions to maintain the fibrous debris concentration in the test tank at, or below, the plant fiber. Debris additions were added to the test tank upstream of the test array in an area of high flow to ensure even transport and suspension. As fiber was added to the test tank, the plant fiber concentration was maintained to ensure a prototypical quantity of fiber bypass was achieved.

The theoretical bed thickness after all fiber additions was 0.582 inches. The test tank was allowed to run for at least five (5) pool turnovers following each addition and manual stirring and agitation was done in an attempt to ensure that all fiber reached the test array. Some of the fiber would not sink or transport, and this fiber was collected and reintroduced into the tank. Full screen coverage was not observed, as shown in Figure 3. Similarly, the inner surface area also had exposed screen area after all fiber additions.

Figure 3 *(Ref. ALION-REP-ENER-8707-04, Figure 4.3.1)*

Figure 4.3.1 - Incomplete Coverage on top hat array

3.n.1.7 Transport Efficiency

Per Section 4.4 of the Alion Test Report (Ref. 3.2), After each fiber addition, the test was continued until head loss had stabilized and a minimum of five pool turnovers had passed, which met the criteria outlined in the Test Plan. After the final fiber addition, the test tank was circulated for a minimum of five pool turnovers before proceeding onto time holds.

At the completion of each fiber addition step in the test matrix, settled debris was also agitated manually to ensure that debris reached the test array. Stirring was provided through use of mechanical mixers or a wooden oar, and was conducted carefully to avoid disturbing the debris bed on the test array. After the last fiber addition, stirring was performed to ensure all settled debris reached the test array.

Some fiber would not transport to the test array after being re-suspended, or would not sink after the initial fiber addition and manual agitation (Figure 4).

To aid in transport, the floating fiber that accumulated throughout the test was removed, beaten using a power drill, and re-introduced into the tank after the last fiber addition reached stability. The amount of fiber removed was enough to fill twelve, 5-gallon buckets, each with approximately three gallons of water and floating fiber. These twelve buckets were split into two additions containing six buckets each, and re-introduced into the tank over the course of one hour. This process was repeated after the first debris removal did not result in complete fiber transport.

Figure 4 *(Ref. ALION-REP-ENER-8707-04, Figure 4.4.1)*

Figure 4.4.1 - Fiber "smalls" That Would Not Transport or Sink

Once the fiber had transported, the filter bags were switched out every 30 minutes for the first 2 hours. Then, each filter bag was changed out every hour until two consecutive filter bag visually appeared to contain no fiber. After the start of the third one-hour bag change (also known as the 7th post-add change), more floating debris was removed and the test was allowed to continue. The transition box was vented, and the main pump was switched to the auxiliary pump. The debris that was removed was reintroduced after the 7th post-add change at the start of the first auxiliary pump filter bag change.

3.n.1.8 Capture/Quantification of Bypassed Debris

Per Section 3.4 of the Alion Test Report (Ref. 3.2), Five (5) micron microfiber filter bags were used during testing (Figure 5). Filter bag capture efficiencies are 96.30% with a 95% confidence interval. This information was used for calculating how much bypass fiber is collected in the filters. Before use, the 5-micron microfiber filter bags were prewashed to remove any loose material. Prior to testing, a set of filter bags were used to completely filter out any 5-micron or larger latent debris that was present in the test tank and would have affected the post-test mass of the testing filter bags. A total of twenty-six (26) filter bags were used during testing, with the initial bag being used as a control filter bag. The control filter bag was isolated prior to debris introduction, in order to determine the background weight gain. The filter bags were dried and weighed before and after testing, with the weight gain being attributed to the captured fiber.

Figure 5 *(Ref. ALION-REP-ENER-8707-04, Figure 3.4.1&3.4.2)*

Figure 3.4.1 - 5-micron microfiber Filter Bag

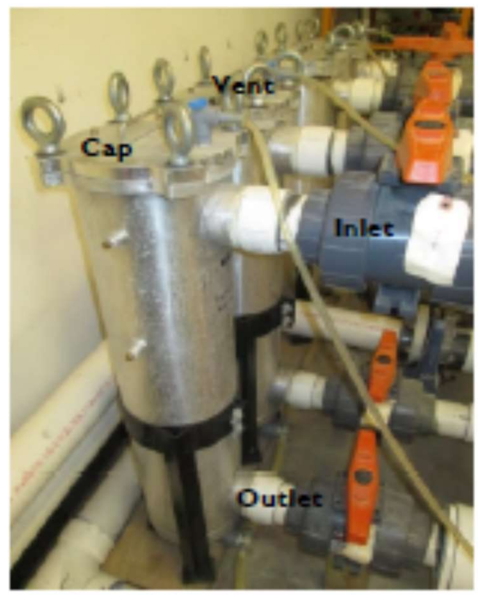

Figure 3.4.2 - Filter Housing "I"

After each fiber batch was added to the test tank, and the stabilization criteria were satisfied, the filter bag was removed, processed, and analyzed. Once all the fiber was added as per the Test Plan, the time criterion was satisfied, and the consecutive filter bags were clean, the pump was secured off. Lastly the final filter bags were removed and processed per the Filter Bag Preparation and Processing Procedure. The filter bags were placed in an oven at 200°F for a minimum of 24 hrs. To qualify as dry, the filter bags were weighed so that three successive weights (measured 2 hrs. apart after the initial 24 hr. dry time) were within a 0.08 g range. The pre-test filter bag weights were subtracted from these final post-test weights to determine the mass of the bypassed fiber within each bag.

3.n.1.9 Characterization of Captured Downstream Debris

Per Section 6.0 of the Alion Test Report (Ref. 3.2), The weights (pre-test and post-test) and calculated fiber mass were calculated by subtracting the last recorded pre-test

weight from the last recorded post-test weight. These values were taken from the Filter Preparation and Filter Processing logs. This same method of analysis and calculation was performed on each filter bag. Table 6-2 in the test report shows how Filter Bag 233 results were calculated.

(Ref. ALION-REP-ENER-8707-04, Table 6.2)

Table 6.2- Example of Filter Bag Weights, Drying Times, and Mass of Fiber Collected

Pre-Test	Filter 233	
	Drying Time	Mass
	(hr:min)	*(g)*
1st Weight	47:32	185.85
2nd Weight	51:31	185.84
3rd Weight	71:15	185.85
Post-Test	**Filter 233**	
	Drying Time	**Mass**
	(hr:min)	*(g)*
1st Weight	109:50	209.74
2nd Weight	113:47	209.72
3rd Weight	116:49	209.75
Collected Fiber	**Filter 233**	
Fiber Mass (g)	23.90	

3.n.1.10 Bypass Test Results

The Bypass Test Report examined fiber bypass amounts from three different scenarios. For each scenario the total bypass quantity, mass of bypassed fiber after the pump switchover, and bypass per unit area using a test array area of 121.24 ft^2 were calculated:

1. Most conservative - This value does not include the mass of the control bag (1.68 g) in the final bypass mass.
2. Less conservative - Any bags that have a weight gain less than the control bag (1.68 g) is assumed to contain no debris and the mass will be adjusted to zero. The control bag is not included in this mass.
3. Least conservative - The mass of the control bag (1.68 g) is subtracted from the mass of all bags; any negative values will be adjusted to zero. The control bag is not included in this mass.

The results for scenario 1 are used since they represent the most conservative amount of debris bypass. The total measured mass of bypassed fiber from the test report was 80.87 grams using a filter bag of 96.3% efficiency (Ref ALION-REP-ENER-8707-04, Section 6.0) out of a total 14.1 lb of fiber loaded in the test tank. Thus, the

Sump Strainer bypass fraction is

$$\text{Bypass Fraction} = \frac{\frac{80.87\ g}{0.963}}{(14.1\ \text{lb})\left(\frac{453.6\ grams}{lb}\right)} = 0.01313$$

The low bypass fraction is attributed to the use of debris bypass eliminators.

The bypass fraction of 0.01313 is used to compute the downstream in-vessel effects (Ref. 4.3).

The mass of bypassed fiber per square foot of the test array area is calculated to be 0.667024 grams/ft^2. Therefore, the total mass of bypassed fiber using a (96.30%) filter bag efficiency (C.E.) for the total effective plant strainer screen area (4,178 ft^2) is 2,893.9 grams. This is calculated below.

$$\frac{Bypassed\ Fiber\ Mass}{ft^2} = \frac{Bypass\ Mass}{Test\ Array\ Area} = \frac{80.87\ \text{g}}{121.24\ ft^2} = \frac{0.667024\ g}{ft^2}$$

$$Bypass\ Mass = \frac{Bypassed\ Fiber\ Mass}{ft^2} x\ RNP\ Screen\ Area\ x\ \frac{1}{C.E}$$

$$Bypass\ Mass = \frac{0.667024\ g}{ft^2}\ x\ 4{,}178\ ft^2 \text{x}\ \frac{1}{0.963} = 2{,}893.9\ g$$

Since [HBRSEP, Unit No. 2] has 157 Fuel Assemblies, this comes to 18.43 g/FA which exceeds the NRC approved allowable 15 g/FA as determined in WCAP-16793-NP-A, Rev. 2, “Evaluation of Long Term Cooling Particulate, Fibrous, and Chemical Debris in the Recirculating Fluid”. As a result Robinson selects to use the alternative in-vessel downstream effects methodology outlined in WCAP-17788-P, Rev. 1 to define the fibrous debris limit applicable to Robinson.

3.n.2 Applicability to WCAP-17788 Methods and Analysis Results

From WCAP-17788-P, Revision 1, Volume 1, Section 6.5.2.2:

The values for t_{block} as well as the correlations used to calculate K_{split} and m_{split} are dependent on plant type and the number of fuel assemblies. Therefore, the plant design must be one of the plant types listed below

- B&W Design
- Westinghouse Up flow BB Design
- Westinghouse Downflow BB Design
- CE Design

HBRSEP, Unit No. 2 is a Westinghouse 3-Loop PWR Downflow Barrel/Baffle configuration. Alternate Flow Path is through the Upper Head Spray Nozzles (UHSNs). The design parameters for RNP are incorporated into the PWROG WCAP-17788-P methodology. The Robinson parameters are listed in Volume 6, Revision 1 Table RAI-6.4-3 (Page A-22) as a Downflow Barrel/Baffle Alternate Flow Path, T-Hot plant, smallest hole diameter is 0.25 in with UHSN Flow Area of 4.12 in^2 and Upper Downcomer Flow Area of 3,703.7 in^2.

The spray nozzles provide a flow path between the top of the downcomer and upper head. The size of the spray nozzles are indicated by the upper head temperature during normal operation. There are two categories: T-cold and T-hot plant types. Robinson is a T-Hot plant type. The T-hot design has smaller nozzle openings and will not provide as much bypass flow due to high resistance to flow as the T-cold design such that the upper head temperature is consistent with the hot side (i.e., hot leg) temperature.

3.n.3 Fuel Design

HBRSEP, Unit No. 2 has 157 fuel assemblies, AREVA type fuel (Ref. UFSAR Section 4.1.1), Fuel Assembly Pitch is 8.466 in and Fuel Assembly Size is 15x15 inches (Ref. UFSAR Table 4.1.2-1).

3.n.4 WCAP-17788 Debris Limit

The Proprietary total in-vessel (core inlet and heated core) fibrous debris limit contained in Section 6.5 of WCAP-17788-P Volume 1, Rev. 1 applies to Robinson Unit 2.

3.n.5 Methodology used to calculate the fibrous debris amounts

As described in Section 3.n.1 of this submittal, HBRSEP, Unit No. 2 assumes that all fibrous debris calculated to penetrate the strainer reaches the reactor vessel.

The amount of fibrous debris calculated to arrive at the reactor vessel is determined for HBRSEP, Unit No. 2 following the method described in WCAP-17788-P Volume 1, Rev. 1, Section 6.5.

Hot Leg Break Methodology: The detailed methodology is provided in WCAP-17788-P, Volume 1, Section 6.0, Revision 1 and is summarized in Section 5.1 of RNP-M/MECH-1941, Revision 1, “In-Vessel Downstream Effects (IVDE) Calculation” (Ref. 4.3, RNP-M/MECH-1941, Rev. 1, RNP In-Vessel Downstream Effects (IVDE) Calculation)

Cold Leg Break Methodology: The method for calculating debris limits inside the Reactor Vessel for Cold Leg Break is provided in Volume 3 of WCAP-17788-NP, Revision 1 and is summarized in Section 5.2 1 of (Ref. 4.3, RNP-M/MECH-1941, Rev. 1, RNP In-Vessel Downstream Effects (IVDE) Calculation).

3.n.6 Confirmation that the maximum combined amount of fiber that may arrive at the core inlet and heated core for Hot Leg Break is below the WCAP-17788 fiber limit.

As shown in the sump strainer fiber penetration section, the HBRSEP, Unit No. 2 maximum amount of fiber calculated to potentially reach the reactor vessel is 18.43 g/FA (Ref. 4.3, RNP-M/MECH-1941, Rev. 1, RNP In-Vessel Downstream Effects (IVDE) Calculation), which is less than the Proprietary in-vessel fibrous debris limit provided in Section 6.5 of WCAP-17788-P Volume 1, Rev. 1.

3.n.7 Confirmation that the core inlet fiber amount is less than the WCAP-17788-P, Rev. 1 threshold

HBRSEP, Unit No. 2 is a Westinghouse, 3-Loop (PWR), Downflow Baffle Barrel design with AREVA fuel. The applicable WCAP-17788-P, Rev. 1, Volume 1 core inlet fiber threshold is provided in Table 6-5 for Framatome (Areva fuel) of WCAP-17788-P, Rev. 1, Volume 1. The core inlet fiber amount for HBRSEP, Unit No. 2 is calculated to be 18.33 g/FA which is less than the applicable WCAP-17788-P, Rev. 1, Volume 1 core inlet fiber threshold (Ref. 4.3, RNP-M/MECH-1941, Rev. 1, RNP In-Vessel Downstream Effects (IVDE) Calculation)

3.n.8 Confirmation that the earliest sump switchover (SSO) time is 20 minutes or greater

As shown in UFSAR Section 15.6.5.2.2, UFSAR Table 15.6.5-3, The earliest possible time SSO occurs for HBRSEP, Unit No. 2 is > 20 minutes and may take up to 2,460 seconds (41 minutes) from the initiation of the LOCA event. This time includes 1,260 sec (21 min) to achieve low level in the RWST plus a 20 minute Time Critical Operator Action allowed for operators to align the Low Head Safety Injection Pumps to the ECCS Sump and start the pumps.

3.n.9 Predicted chemical precipitation timing from WCAP-17788-P, Rev. 1, Volume 5 testing and the specific test group considered to be representative of the pant.

Chemical precipitation timing is dependent on the plant buffer, sump pool pH, volume and temperature, and debris types and quantities. Table 3-1 summarizes the key chemical precipitation parameters and values for HBRSEP, Unit No. 2 and compares them to test group 45 from WCAP-17788-P, Rev. 1, Volume 5. Based on the comparison in Table 3-1, test group 45 is representative of HBRSEP, Unit No. 2 and the predicted chemical precipitation timing (t_{chem}) is 24 hours.

Table 3-1 Key Parameter Values for Chemical Precipitation Timing

Parameter	HBRSEP Unit 2 Values (Ref. 4.3)	Test Group 45 Value(1)
Buffer	NaOH	NaOH
pH	9.415	9.3
Minimum Sump Volume (ft^3)	23,765	22,691
Max Sump Pool Temperature (°F)	263.93	264.6
CalSil (g) (Notes 1, 2 & 3)	48.8	45.243
E-glass (g)	21.1	28.8601
Silica (g)	0	0
Mineral Wool (g)	0	0
Al Silicate (g)	1.83	2.06
Concrete (g)	0.0075	0.0083
Interam (g)	0	0
Al (ft^2)	0.083	0.167
Galvanized Steel (ft^2)	0.689	0.760

Notes:

1. Test Group 45 data comes from Tables F-1 and F-4 in WCAP-17788-P, Volume 5, in the Group 45 column, with the exception of the minimum sump volume, which was taken from the "Total Recirculation Water Volume – Minimum" value from Robinson's response to WOG-05-429.

2. The scaled debris quantity of Cal-Sil is 122 grams. It is determined that 40% minimizes silicate inhibition and maximizes chemical product formation in the WCAP-16785 model (Ref. RNP-M/MECH-1800). Based on this, use 48.8 grams.

3. Silicate inhibition of aluminum corrosion was credited in the determination of chemical precipitate quantities as described in WCAP-16785-NP. The limiting debris quantity was determined to be approximately 40% of the design basis Cal-Sil debris load (Ref. RNP-RA/08-0026).

3.n.10 Confirmation that chemical effects will not occur earlier than latest time to implement BAP mitigative measures

As described in UFSAR Section 6.2.1.1.3.3, HBRSEP, Unit No. 2 performs injection realignment to mitigate the potential for boric acid precipitation no later than 11 hours, which is less than the chemical precipitation time of 24 hours.

3.n.11 WCAP t_{block} value for the RCS design category

HBRSEP, Unit No. 2 is a Westinghouse 3-Loop Down Flow Plant. Based on WCAP-17788-P, Rev. 1, Volume 1, Table 6-1, t_{block} for HBRSEP, Unit No. 2 is 260 minutes.

3.n.12 Confirmation that chemical effects do not occur prior to T_{block}

The earliest time of chemical precipitation for HBRSEP, Unit No. 2 was determined to be 24 hours, which is greater than the applicable t_{block} value of 260 minutes.

3.n.13 Plant rated thermal power compared to the analyzed power level for the RCS design category

HBRSEP, Unit No. 2 has a rated thermal power of 2,339 MWt. HBRSEP, Unit No. 2 is a Westinghouse 3-Loop PWR Downflow Plant and the applicable analyzed thermal power is 2,951 MWt as provided in WCAP-17788-P, Rev. 1, Volume 4, Table 6-2. The HBRSEP, Unit No. 2 rated thermal power is less than the analyzed power; therefore, this parameter is bounded by the WCAP-17788-P, Rev. 1 alternate flow path analysis.

3.n.14 Plant Alternative Flow Path (AFP) resistance compared to the analyzed AFP resistance for the pant RCS design category.

HBRSEP, Unit No. 2 is a Westinghouse downflow barrel/baffle plant. The Proprietary analyzed AFP resistance is provided in Table 6-2 of WCAP-17788-P Volume 4, Rev. 1. The Proprietary HBRSEP, Unit No. 2 specific AFP resistance is provided in WCAP-17788-P Volume 4, Rev. 1, Table RAI-4.2-24. The HBRSEP, Unit No. 2 specific AFP resistance is less than the analyzed value; therefore, the HBRSEP, Unit No. 2 AFP resistance is bounded by the resistance applied to the AFP analysis.

3.n.15 Consistency between the minimum ECCS flow per FA assumed in the AFP analyses and that at the plant.

HBRSEP, Unit No. 2 is a Westinghouse downflow barrel/baffle plant. The AFP analysis for Westinghouse downflow plants analyzed a range of recirculation flow rates from 8 – 40 gpm/FA, as shown in Table 6-2 of WCAP-17788-P Volume 4, Rev. 1. The HBRSEP, Unit No. 2 ECCS recirculation flow rate corresponding to the worst-case GSI-191 hot leg break scenario is 24.65 gpm/FA] (Ref. 4.3, RNP-M/MECH-1941, Rev. 1, RNP In-Vessel Downstream Effects (IVDE) Calculation) which is within the range of ECCS recirculation flow rates considered in the AFP analysis.

3.n.16 Summary

The comparison of key parameters used in the WCAP-17788 AFP analysis to the HBRSEP, Unit No. 2 specific values is summarized in Table 3. Based on these comparisons HBRSEP, Unit No. 2 is bounded by the key parameters and the WCAP-17788 methods and results are applicable.

Table 3 Key Parameter Values for In-Vessel Debris Effects			
Parameter	**WCAP-17788 Value**	**HBRSEP, Unit No. 2 Value**	**Evaluation**
Maximum Total In-Vessel Fiber Load (g/FA)	WCAP-17788-P, Rev. 1, Volume1, Section 6.5	18.43	Maximum in-vessel fiber load is less than WCAP-17788 limit
Maximum Core Inlet Fiber Load (g/FA)	Table 6-5 for Framatome (Areva fuel) of WCAP-17788-P, Rev. 1, Volume 1	18.33	Maximum core inlet fiber load is less than WCAP-17788 threshold
Minimum Sump Switchover Time (min)	20	41	Later switchover time results in a lower decay heat at the time of debris arrival, reducing the potential for debris induced core uncovery and heat up.
Minimum Chemical Precipitate Time (hr)	(4.33 hrs) (t_{block})	24	Potential for complete core inlet blockage due to chemical product generation would occur much later than assumed.
Maximum Hot Leg Switchover Time (hr)	24 (t_{chem})	11	Latest hot leg switchover occurs well before the earliest potential chemical product generation
Related Thermal Power (MWt)	2,951	2,339	Lower rated thermal power results in lower decay heat.
Maximum AFP Resistance	Table 6-2 of WCAP-17788-P Volume 4, Rev. 1	Table RAI-4.2-24 of WCAP-17788-P, Volume 4, Rev. 1	AFP resistance is less than the analyzed value, which increases the effectiveness of the AFP.
Minimum ECCS Recirculation Flow (gpm/FA)	8	24.65	Maximum debris bed resistance at the core inlet occurs at lower flow rates (Note 1).
Notes: 1. It should be noted that the flow rate used to compute the in-vessel fiber limit is 3,870 gpm and is greater than the flow rate used to compute the scaled down approach velocity in the bypass tests which was 3,820 gpm. This was done for conservatism since a greater flow rate will cause more fiber to enter the core sooner.			

3.o Chemical Effects

NRC Issue:

The objective of the chemical effects section is to evaluate the effect that chemical precipitates have on head loss and core cooling.

1) Provide a summary of evaluation results that show that chemical precipitates formed in the post-LOCA containment environment, either by themselves or combined with debris, do not deposit at the sump screen to the extent that an unacceptable head loss results, or deposit downstream of the sump screen to the extent that long-term core cooling is unacceptably impeded.

RNP Response:

The HBRSEP, Unit No. 2 chemical effects analysis of the sump strainers was submitted in Supplemental Response March 7, 2008 and amended on December 17, 2008 as well as subsequent RAI responses submitted on March 30,2010. The HBRSEP, Unit No. 2 sump strainer chemical effects analysis is unchanged.

The HBRSEP, Unit No. 2 in-vessel chemical effects analysis is described in Sections 3.1.9 through 3.1.10.

3.p Licensing Basis

NRC Issue:

The objective of the licensing basis section is to provide information regarding any changes to the plant licensing basis due to the sump evaluation or plant modifications.

1) Provide the information requested in GL 04-02 Requested Information Item 2(e) regarding changes to the plant licensing basis. The effective date for changes to the licensing basis should be specified. This date should correspond to that specified in the 10 CFR 50.59 evaluation for the change to the licensing basis.

RNP Response:

Duke Energy's 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 (ML080730290), discussed the licensing bases changes that had been implemented associated with the resolution of the sump issues considered in GSI-191 and GL 2004-02. The HBRSEP, Unit No. 2, UFSAR has been updated in Revision 21 to show the modified containment sump configuration. A license amendment to change the Technical Specifications to account for the new sump strainer design was approved by the NRC in License Amendment No. 213, dated April 4, 2007.

Duke Energy will update the current licensing basis (Updated Final Safety Analysis Report) in accordance with 10 CFR 50.71(e) following NRC acceptance of the final supplemental response for RNP.

4 References

1. NRC Correspondence

   1.1. RNP-RA/13-0048, H. B. Robinson Steam Electric Plant, Unit No. 2 PATH FORWARD FOR RESOLUTION OF GSI-191 WITH ATTACHED H.B. ROBINSON STEAM ELECTRIC PLANT, UNIT NO. 2 GENERIC LETTER 2004-02 SUPPLEMENTAL RESPONSE" dated May 14, 2013

   1.2. DRAFT BYPASS FIBER QUANTITY TEST PLAN, November 26,2012 (ADAMS Accession Number ML12331A175)

   1.3. MEETING SLIDES RE GSI-191 STRAINER FIBER BYPASS TEST PLAN SLIDES, November 26, 2012, (ADAMS Accession Number ML12331A178)

   1.4. RNP-RA/10-0104, SUPPLEMENTAL RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION PERTAINING TO NRC GENERIC LETTER 2004-02, October 08,2010

   1.5. RNP-RA/10-0007, H. B. Robinson Steam Electric Plant, Unit No. 2 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 March 30, 2010

   1.6. RNP-RA/08-0124, H. B. Robinson Steam Electric Plant, Unit No. 2 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

   1.7. RNP-RA/08-0026, H. B. Robinson Steam Electric Plant, Unit No. 2 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

   1.8. RNP-RA/06-0106, H. B. Robinson Steam Electric Plant, Unit No. 2 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 November 07, 2006

   1.9. RNP-RA/06-0067, H. B. Robinson Steam Electric Plant, Unit No. 2 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 July 13, 2006

   1.10. RNP-RA/05-0088, H. B. Robinson Steam Electric Plant, Unit No. 2 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 September 1, 2005

2. NRC

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

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

2.3. Safety Evaluation by the Office of Nuclear Reactor Regulation to NRC Generic Letter 2004-02, Revision 0, December 6, 2004"

2.4. NRC Letter to Carolina Power & Light Company, June 9, 2010, ML101310029, GENERIC LETTER 2004-02 SUPPLEMENTAL RESPONSE

2.5. SUMMARY OF PUBLIC MEETING WITH DUKE ENERGY CONCERNING GL 2004-02 AND NRC STAFF REVIEW OF DRAFT PROPOSED STRAINER FIBER BYPASS TEST PLAN, December 12, 2012, (ADAMS Accession Number ML12332A193)

3. Bypass Testing

3.1. Enercon Report, PER003-PR-001, Revision 2, "Robinson Unit 2 Sump Strainer Fibrous Debris Bypass Summary Report" dated April 18, 2007

3.2. ALION Test Report, ALION-REP-ENGR-8707-04, Revision 0, "Robinson Nuclear Plant: Bypass Fiber Quantity Test Report" dated July 8, 2013

3.3. ALION Test Plan, ALION-PLN-ENGR-8707-02, Revision 2, "Robinson Nuclear Plant: Bypass Fiber Quantity Test Plan" dated January 5, 2013

4. HBRSEP, Unit No. 2 Calculations

4.1. RNP-M/MECH-1761, Rev. 7, RNP Containment Vessel GSI- 191 Debris Generation Calculation

4.2. RNP-M/MECH-1762, Rev. 2, RNP Containment Vessel GSI 191 Debris Transport Calculation

4.3. RNP-M/MECH-1941, Rev. 1, RNP In-Vessel Downstream Effects (IVDE) Calculation

4.4. RNP-M/MECH-1784, Rev. 5, Post-LOCA Sump Downstream Effects Evaluation

4.5. RNP-M/MECH-1786, Rev. 2, Hydraulic Analysis of Top Hats and Containment Sump Structure

4.6. RNP-M/MECH-1792, Rev. 0, Transient pH Analysis of Containment Spray and ECCS Sump

4.7. RNP-M/MECH-1637, Rev. 16, CS/SI/RHR System Hydraulic Model.

4.8. RNP-M/MECH-1760, Rev. 4, Post-LOCW A Containment Water Level

4.9. RNP-M/MECH-1622, Rev. 1, LOCA Containment Flood Depth

5. Industry

5.1. PWROG-16073-P, Revision 0, "TSTF-567 Implementation Guidance, Evaluation of In-Vessel Debris Effects, Submittal Template for Final Response to Generic Letter 2004-02 and FSAR Changes", February 2020.

5.2. WCAP-17788-P, Revision 1, "Comprehensive Analysis and Test Program for GSI-191 Closure (PA-SEE-1090)

5.3. Nuclear Energy Institute (NEI) guidance report NEI 04-07, "Pressurized Water Reactor Sump Performance Evaluation Methodology," Revision 0