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May 27, 2021
L-21-105

10 CFR 50.54(f)

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Subject:
Beaver Valley Power Station, Unit Nos. 1 and 2
Docket No. 50-334, License No. DPR-66
Docket No. 50-412, License No. NPF-73
Response to Request for Additional Information Regarding Generic Letter 2004-02 (EPID L-2017-LRC-0000)

This submittal provides additional information that supplements the November 30, 2020 (Accession No. ML20335A564), Energy Harbor Nuclear Corp. response to close GL 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors," dated September 13, 2004 (Accession No. ML042360586), for the Beaver Valley Power Station, Units 1 and 2. In a March 23, 2021 email (Accession No. ML21082A494), the Nuclear Regulatory Commission (NRC) staff indicated that additional information was required to confirm the Energy Harbor Nuclear Corp. evaluation. The Energy Harbor Nuclear Corp. response to the March 23, 2021 request for additional information is attached.

There are no regulatory commitments contained in this submittal. If there are any questions or if additional information is required, please contact Mr. Phil H. Lashley, Manager - Fleet Licensing, at (330) 696-7208.

I declare under penalty of perjury that the foregoing is true and correct. Executed on May 27, 2021.

Sincerely,

Matthew J. Enos

Attachment:

Energy Harbor Nuclear Corp. Response to March 23, 2021 Request for Additional Information, Related to Closure of Generic Letter 2004-02

cc: NRC Region I Administrator
NRC Resident Inspector
NRR Project Manager
Director BRP/DEP
Site BRP/DEP Representative

Each NRC request for additional information (RAI) is provided below in bold text and followed by the Energy Harbor Nuclear Corp. response for Beaver Valley Power Station, Unit Nos. 1 and 2 (BVPS-1 and BVPS-2).

RAI 1

Provide details on how the Foamglas (pg 18 of 62, table 3.b-2) is accounted for in the unit 1 Loop large break loss of coolant accident (LOCA) break headloss test. Is the Foamglas characterized as fiber or particulate? State which test accounts for the debris term that includes Foamglas debris.

Response:

Foamglas® insulation debris was not explicitly utilized in the BVPS-1 sump strainer head loss tests. However, the surrogate material used to represent coatings debris, ground silica, is a suitable surrogate for Foamglas® particulate debris based on the debris characteristics, discussed below.

Foamglas® insulation is a lightweight, rigid material composed of millions of completely sealed glass cells. Foamglas® insulation is rated to 900 degrees Fahrenheit (°F), and its all-glass, closed-cell structure requires no binders or fillers; therefore, Foamglas® is characterized as a particulate with respect to debris generation. The microscopic density of Foamglas® (156 pound mass per cubic feet [lbm/ft^3]) is comparable to that of ground silica (165 lbm/ft^3). The particle size of ground silica (1 to 100 microns) is conservative with respect to the characteristic size of Foamglas®; Reference 5 lists the characteristic size of cellular glass as 0.05 to 0.08 inches (1270 to 2032 microns) with respect to pore size, with the grain size undefined. Smaller particles in a debris bed cause greater head loss than do larger particles; therefore, assuming a smaller particle size than that listed in Reference 6 is conservative.

Reference 2 states that BVPS-1 Head Loss Test 6 is the bounding head loss test. This test included a scaled quantity of ground silica representative of 6.035 ft^3 of fine particulate debris.

The maximum volume of debris represented by ground silica is generated by a reactor coolant system (RCS) loop break and includes 1.191 ft^3 of qualified coatings, 0.433 ft^3 of unqualified coatings, and 0.447 ft^3 of Foamglas® (converted from an as-fabricated volume of 9.3 ft^3 using the Reference 5 mean as-fabricated density of 7.5 lb/ft^3 and the microscopic density of 156 lb/ft^3). The total debris volume of 2.071 ft^3 is bounded by the quantity of ground silica used in Test 6, which as previously stated, represents 6.035 ft^3 of fine particulate debris.

<u>RAI 2</u>

Provide the test number that bounded the 24 lb of Thermal Wrap for unit 2 (pg 19 of 62, table 3.b-3) estimated to transport to the strainer for the 6-inch pressurizer power operated relief valve inlet break. The NRC staff noted that Test 1A included 17 lb of Temp-Mat "fines" and 17 lb of "smalls". The staff understands that the Thermal Wrap is all assumed to be "fines" (24 lb) per table 3.e-14.

Response:

The Test 1A debris mixture included a combination of fibrous and particulate debris that bounds both the RCS loop break and pressurizer surge line break and has the highest fibrous debris load of head loss tests performed for BVPS-2. As explained below in more detail, the power-operated relief valve (PORV) line break debris generation and transport analysis has been revised to decrease an overconservative input assumption in accordance with Reference 6 and justify that Test 1A bounds the results of the debris generation and transport analysis of the PORV inlet piping break.

<u>Debris Size Distributions Utilized in the Debris Generation Analyses</u>

High energy line break (HELB) scenarios listed in Reference 2 utilize a four-size debris distribution for fibrous debris; however, the PORV line break scenario was not addressed. In Reference 1, the PORV line break scenario was included. The scenario utilizes a two-size distribution developed by Reference 5; the two size classes are then converted to corresponding size classes in the Alion four-size distribution to be consistent with the size classes used for the other HELB scenarios, but noting that 100% of the small fines debris were assumed to be fines.

Alion Four-Size Distribution

This size distribution was developed by Alion Science & Technology Corporation, who initially performed the debris generation and transport analyses. These are described in detail in Tables 3.c-1 and 3.c-2 of Reference 2. The "fines" and "smalls" described in this RAI are the two smallest size classifications of this four-size distribution.

NEI 04-07 Two-Size Distribution

The PORV line break scenario utilized the Reference 5 two-size distribution. Reference 5 defines the two size categories of "small fines" and "large pieces." Small fines are defined in part as any material that could transport through gratings, trash racks, or radiological protection fences by blowdown, containment sprays, or post-accident pool flows. This guideline assumes the largest openings of the gratings, trash racks, or radiological protection fences to be less than 4 inches by 4 inches. The remaining material that cannot pass through gratings, trash racks, and radiological protection fences is classified as large pieces. For fibrous insulation material, the large pieces are assumed to be jacketed or canvassed, hence not subjected to further erosion.

Conversion from NEI 04-07 Two-Size to Alion Four-Size Distribution

Reference 6, p. II-7 describes debris generation testing results which can be used to determine a conservative quantity of fines (individual fibers) from a given quantity of small fines debris as follows.

> In the debris generation tests conducted during the DDTS [Drywell Debris Transport Study], 15 to 25 percent of the debris from a completely disintegrated TPI [Transco Products, Inc.] fiberglass blanket was classified as nonrecoverable. The nonrecoverable debris either exited the test chamber through a fine-mesh catch screen or deposited onto surfaces in such a fine form that it could not be collected by hand (it was collected by hosing off the surfaces). Therefore, it would be reasonable to assume that 25 percent of the baseline small fine debris (that is, F_{ZOI}) is in the form of individual fibers and that the other 75 percent is in the form of small-piece debris.

Revised PORV Line Break Size Distribution Assumptions

The debris transport analysis of the PORV line break from which Table 3.e-14 was based has been revised to incorporate this assumption that small fines as defined by Reference 5 consist of 25 percent (%) fines and 75% smalls. A 100% transport fraction is applied to both fines and smalls for the PORV line break. The previous analysis assumed that small fines consisted of 100% fines and 0% smalls, with 100% transport to the sump strainers.

<u>Debris Generation and Transport Analyses of PORV Inlet Piping Break</u>

Thermal Wrap insulation installed on the PORV inlet piping is secured with Sure-Hold® bands, where practical. Consistent with the zone of influence (ZOI) specified for Jacketed Nukon™ with Sure-Hold® bands in Reference 6, a 2.4 diameter (D) ZOI was applied to Thermal Wrap insulation secured in this manner. Insulation in the 2.4D ZOI is assumed to fail as small fines.

For components of complex geometry or areas with tight clearances, some portions of Thermal Wrap insulation were not able to be secured in this manner. A 17.0D ZOI is applied to Thermal Wrap not secured with Sure-Hold® bands. The portion of this insulation inside a 7.0D ZOI is conservatively assumed to fail as 100% small fines, as the Alion four-size distribution assumes no large pieces are formed in this region. For standard Thermal Wrap insulation inside the 17.0D ZOI and outside the 7.0D ZOI, the size distribution recommended by Reference 5, of 60% small fines and 40% large pieces was applied.

The size distributions and debris volumes applicable to each ZOI discussed above are summarized in Table RAI 2-1.

Table RAI 2-1: Debris Size Distributions Used for PORV Line Break Debris Analysis				
Fibrous Debris Source	ZOI	Debris Size	% Distribution	Debris Total (ft^3)
Thermal Wrap (Sure-Hold Bands)	2.4D	Small Fines	100%	0.73
Thermal Wrap (Standard)	< 7.0D	Small Fines	100%	4.18
Thermal Wrap (Standard)	7.0 – 17.0D	Small Fines	60%	6.67
		Large Pieces	40%	4.45

A 0% transport fraction was applied to large pieces, as they are not exposed to containment spray and all flow paths to the sump pass through floor grating. Reference 6 states that erosion of large pieces is negligible when using the Reference 5 two-size distribution.

100% of small fines are assumed to transport to the sump strainers. The total volume of Thermal Wrap small fines is:

Thermal Wrap (small fines) = 0.73 ft^3 + 4.18 ft^3 + 6.67 ft^3 = 11.58 ft^3

The Reference 6 size distribution for small fines debris (25% fines, 75% small pieces) is applied to the volume of Thermal Wrap small fines to give the volume of fines and small pieces that may be compared to the tested debris loads.

Thermal Wrap (fines) = 0.25 x 11.58 ft^3 = 2.89 ft^3
Thermal Wrap (small pieces) = 0.75 x 11.58 ft^3 = 8.69 ft^3

11.5 ft^3 of latent fiber fines, applied to all break scenarios, was applied to the PORV piping break. The calculated volume of fibrous fines is the sum of Thermal Wrap fines and latent fiber fines, calculated below:

Fibrous Fines = 2.89 ft^3 + 11.5 ft^3 = 14.4 ft^3

The calculated debris quantities, both volume and mass, for the PORV inlet piping break are presented in Table RAI 2-2. Both Thermal Wrap and latent fiber masses are based on a bulk density of 2.4 lb/ft^3, as recommended by Reference 6.

Table RAI 2-2: Calculated PORV Line Break Debris Loads		
Debris Size	Volume (ft^3)	Mass (lb)
Fibrous Fines	14.4	34.6
Fibrous Small Pieces	8.69	20.9
Total Fibrous Debris	23.1	55.5

<u>Test 1A Fibrous Debris Quantities and Characteristics</u>

The fibrous debris load of Test 1A consisted of a combination of Nukon™ and Temp-Mat insulation. Nukon™ insulation is added to Test 1A as a surrogate to represent latent fiber and a small quantity of Thermal Wrap insulation. Head loss testing was performed by Alion Science and Technology and therefore is based on the four-size distribution that includes fines and smalls. Debris representing latent fiber consisted of 100% fines, while the debris representing Thermal Wrap and Temp-Mat insulation consisted of 50% fines and 50% smalls.

The fibrous debris loads added to Test 1A were representative of the following debris quantities, obtained by dividing the scaled debris loads used for testing by the scaling factor of 0.0556.

Test 1A unscaled fibrous fines mass = (Nukon™ Fines + Temp-Mat Fines) / 0.0556
= (1.76 lb + 0.92 lb) / 0.0556 = 48.2 lb

Test 1A unscaled fibrous debris mass = Unscaled Fibrous Fines + (Nukon™ Smalls + Temp-Mat Smalls) / 0.0556
= 48.2 lb + (0.09 lb + 0.92 lb) / 0.0556
= 66.4 lb

<u>Comparison of Tested versus Calculated Debris Loads</u>

A comparison of the debris loads is presented in the table below to demonstrate that the BVPS-2 Head Loss Test 1A is bounding with respect to the debris loads expected to transport to the strainers following a PORV inlet piping break. Reference 3 implies that the following quantities of fibrous debris must be bounded by the head loss test:

- Total Fibrous Debris (latent fiber + Thermal Wrap Fines + Thermal Wrap Smalls): The NRC guidance states that the maximum debris load should include 100% of the debris from the break being tested.

- Fibrous Debris Fines (latent fiber + Thermal Wrap Fines): Test 1A was performed to determine whether the bounding debris load was sufficient to form a thin bed. The NRC guidance states,

> A representative portion of the fibrous debris should be rendered into very fine pieces for maximum debris load testing. For thin bed testing, the finest fibrous debris present in the plant-specific debris size distribution should be used unless another approach is justified on a plant-specific basis.

The tested and calculated debris loads are compared in Table RAI 2-3, which demonstrates that Test 1A bounds the calculated fibrous debris load of a PORV inlet piping break, with margin.

Table RAI 2-3: Comparison of Tested vs. Calculated Debris Loads

Debris Load	Fibrous Fines (lb)	Total Fibrous Debris (lb)
BVPS-2 Head Loss Test 1A	48.2	66.4
Calculated for PORV Line Break	34.6	55.5
Margin (% of tested debris load)	> 28%	> 16%

Nukon™ insulation is a suitable surrogate for both latent fiber and Thermal Wrap insulation. Temp-Mat insulation is used in Test 1A but is not generated from a PORV inlet piping break. By applying the following concept from Reference 3, it can be judged that, for a low-fiber test such as Test 1A (with an equivalent bed thickness of 0.07 inch), the use of Temp-Mat instead of Nukon™ is acceptable due to its lower porosity.

> High-density fiberglass insulations, such as Temp-Mat, are substantially less porous than Nukon™; therefore it could take a lesser thickness of Temp-Mat to cause effective filtration than for Nukon™. It seems to take some compression of Nukon™ to effectively filter calcium silicate, where less compression may be needed for Temp-Mat.

In the presence of fine particulate, a less porous fibrous debris mat has a higher propensity to form a thin bed and therefore achieve maximum head loss. Furthermore, the Test 1A debris load represents a considerable quantity of particulate insulation and coatings debris above that which is calculated for a PORV inlet piping break. Test 1A was also performed prior to a significant reduction of tags and labels in BVPS-2 containment; this increases the effective strainer area and allows for additional fibrous debris margin, if credited.

<u>Conclusions and Updates</u>

In conclusion, the PORV inlet piping break is adequately represented by the BVPS-2 Head Loss Test 1A due to the tested quantity of fibrous fines and total fibrous debris exceeding that which was calculated in the debris generation and transport analyses, with margin. The surrogate debris combination of Temp-Mat and Nukon™ is acceptable to represent a debris mixture of Thermal Wrap insulation and latent fiber debris due to the higher propensity to generate a thin bed effect and thus to represent maximum strainer head loss conditions.

The debris transport table for the 6-inch PORV inlet piping break (Table 3.e-14), is revised as shown below to reflect the size distribution outlined in the discussion above.

Table 3.e-14, Overall Debris Transport
(6-Inch Power Operated Relief Valve Inlet Piping Break) - BVPS-2

Debris Type	Debris Size	Debris Quantity Generated	Debris Transport Fraction	Debris Quantity at Sump
RMI	Small Pieces (<4 inch)	2,605.7 ft^2	100%	2,605.7 ft^2
	Large Pieces (≥4 inch)	1,064.3 ft^2	0%	0 ft^2
	Total	3,670.0 ft^2		2,605.7 ft^2
Thermal Wrap™	Fines	2.9 ft^3	100%	2.9 ft^3
	Small Pieces	8.7 ft^3	100%	8.7 ft^3
	Large Pieces	4.5 ft^3	0%	0 ft^3
	Total	16.1 ft^3		11.6 ft^3
Coatings Inside ZOI	Total (Fines)	19.4 lbm	100%	19.4 lbm
Exposed Unqualified Coatings Outside ZOI	Total (Fines)	177.8 lbm	100%	177.8 lbm
Dirt/Dust	Total (Fines)	156.4 lbm	100%	156.4 lbm
Latent Fiber	Total (Fines)	11.5 ft^3	100%	11.5 ft^3
Miscellaneous Debris	Total	59.0 ft^2	100%	59.0 ft^2

<u>RAI 3</u>

Verify that the Unit 2 limiting headloss values from Table AI-4 (referenced RAI responses in ML102770023, pg 98 of 136) are the limiting values used in the Unit 2 net positive suction head calculations.

Response:

Yes, that is correct. The BVPS-2 limiting headloss values for Table AI-4 are the limiting values used in the BVPS-2 net positive suction head calculations.

<u>RAI 4</u>

Provide information regarding the testing and calculations that support the determination of core inlet debris amounts as described in the following sub-bullets. The staff recognizes that the debris amounts submitted by the licensee demonstrate significant margin to the analyzed limit. The staff questions are intended to assure understanding of the methodology used, and that combined, the issues would not result in a significant change in the calculated amount of fibrous debris that could reach the core.

a. The evaluation of the test flow rate for penetration testing for Unit 1 (pg 42 of 62) states that a higher flow rate forces large fibers onto the strainer earlier in the scenario which increases the filtration efficiency of the debris bed. This is not consistent with the fact that testing has consistently shown that higher flow rates lead to increase penetration. The discussion under (1) contradicts empirical findings from strainer penetration testing. The discussion under (2) did not clearly state the test flow rate and compare this to the plant flow rate. The baseline for the 30% flowrate increase is unclear. Provide the plant and test flow rates, and discuss what the 30% flow increase is referenced to.

Response:

<u>Description of 30% Flow Rate Increase During Bypass Testing</u>

Debris was added in three batches. After both the second and third batches were added, the flow rate was maintained at 181 gallons per minute (gpm) to allow the debris bed to form in a conservative manner, with the smallest fibers being deposited on the strainer first. Once the debris was deposited on the strainer, the flow rate was increased to 237 gpm, or approximately 30%, to replicate higher flow rate conditions that may force additional debris through the strainer.

<u>Tested Flow Rate</u>

The maximum flow rate through the prototype strainer achieved during strainer bypass testing was 237 gpm. The plant flow rate corresponding to the maximum scaled flow rate of 237 gpm is derived below:

$$Equivalent\ Tested\ Flow\ Rate = (Scaled\ Test\ Flow\ Rate)\frac{Effective\ Plant\ Strainer\ Area}{Prototype\ Strainer\ Area}$$

Prototype Strainer Area = 76.60 ft^2

Effective Plant Strainer Area
= (Plant Strainer Area) – (Misc. Debris Packing Ratio)(Misc. Debris Load)

Plant Strainer Area = 3,493 ft^2
Miscellaneous Debris Load = 341 ft^2 (Maximum Calculated)
Misc. Debris Packing Ratio$^{(1)}$ = 0.75

Effective Strainer Area = 3,493 ft^2 – 0.75(341 ft^2) = 3,237 ft^2

$$Equivalent\ Tested\ Flow\ Rate = (237\ gpm)\frac{3{,}237\ ft^2}{76.60\ ft^2} = \mathbf{10{,}015\ gpm}$$

(1) A Miscellaneous Debris Packing Ratio of 0.75 is recommended by Reference 6 to account for overlap of tags and labels on the strainer.

The flow rate scaling originally used for bypass testing was based on an effective strainer area of 3,086 ft^2. A reduction of tags and labels in the BVPS-1 containment since performance of bypass testing has reduced the miscellaneous debris load and allowed for crediting an increased effective strainer area.

<u>Plant Flow Rate: Pressurizer Safety Valve Inlet Piping Break</u>

The plant flow rate is the sum of the recirculation spray (RS) portion of the containment spray system (CSS) and emergency core cooling system (ECCS) flow rates. Per the recommendation of Reference 4, a minimum CSS flow rate was assumed since it diverts a fraction of the debris that bypasses the strainer back to the sump. A maximum ECCS flow rate was credited since this maximizes the injection rate of fibrous debris into the core.

The bounding BVPS-1 in-vessel downstream effects (IVDE) case (pressurizer safety valve inlet piping break) assumes a maximum ECCS flow rate of 3,899 gpm and a minimum CSS flow rate of 5,848 gpm for a total sump flow rate of 9,747 gpm. Both flow rates include a 5% margin from design basis values; a 5% reduction for CSS flow, and a 5% increase for ECCS flow.

The sump strainer flow rate of 9,747 gpm utilized in the limiting IVDE evaluation is bounded by the 10,015 gpm equivalent strainer flow rate achieved during strainer bypass testing. No adjustments to the pressurized safety valve (PSV) piping break IVDE results are required.

Plant Flow Rate: Double-Ended Hot Leg Break

The hot leg break case used a maximum ECCS flow rate (with 5% margin) of 5,303 gpm. The minimum CSS flow rate is the same as that used for the PSV piping break (5,848 gpm). This results in a total sump strainer flow of 11,151 gpm. This is 11.3% greater than the equivalent tested flow rate of 10,015 gpm.

The following demonstrates the impact that a 11.3% increase in strainer flow rate would have on the results of the hot leg break IVDE evaluation.

Fiber bypass testing results from the Vogtle Supplemental Response (Reference 8) are presented graphically in Figures RAI 4-1 and RAI 4-2 below.

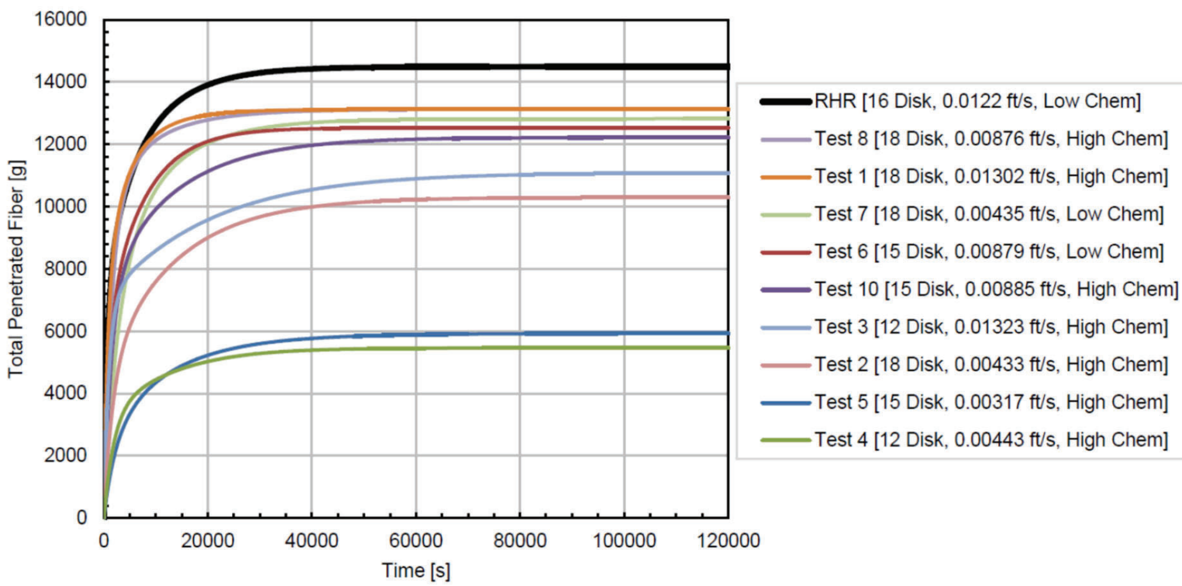

Figure RAI 4-1: Comparison of Vogtle Test Cases – Total Penetrated Fiber at Plant Scale (Reference 8)

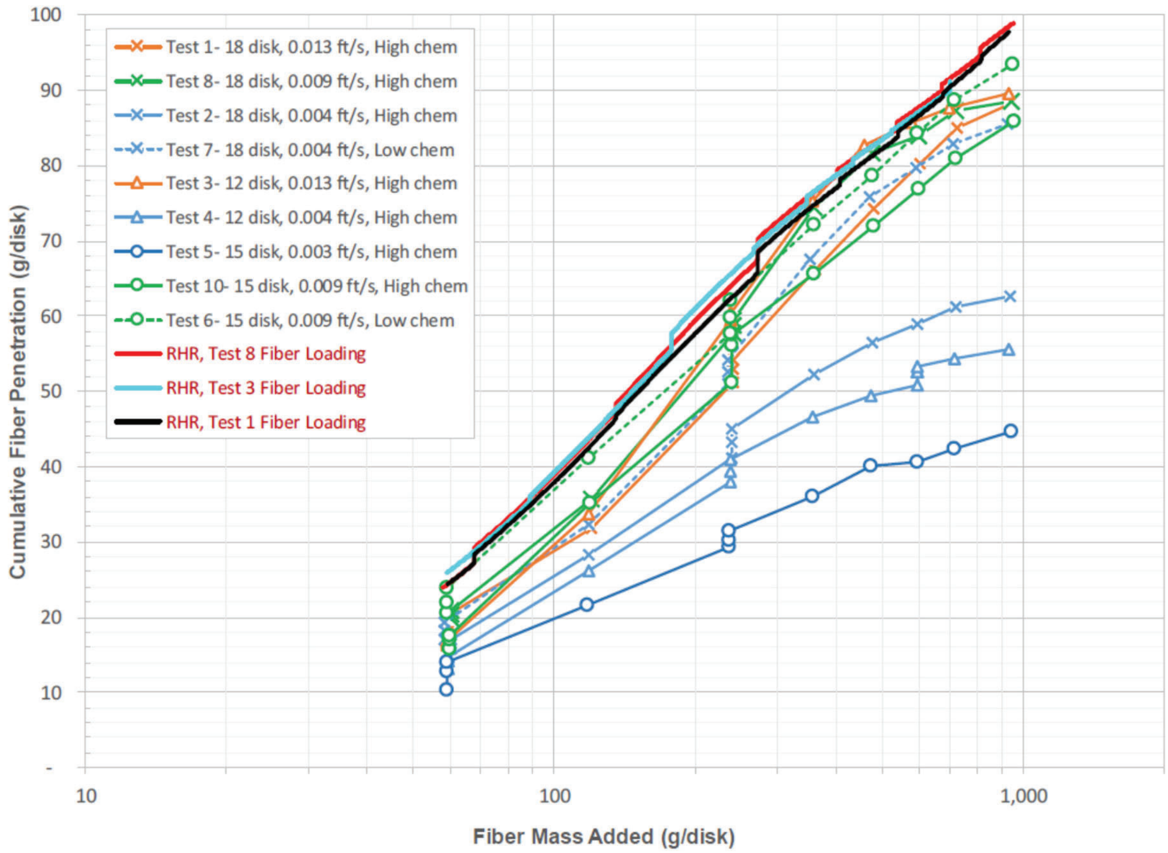

Figure RAI 4-2: Comparison of Vogtle Test Cases – Penetrated Fiber per Disk at Test Scale (Reference 8)

Pertinent data is summarized in Table RAI 4-1, using a visual approximation of the maximum quantities of total penetrated fiber (to the nearest 100 grams [g]) from Figure RAI 4-1 and penetrated fiber per disk (to the nearest 0.5g) from Figure RAI 4-2.

Table RAI 4-1: Vogtle Fiber Bypass Testing Data

Test Strainer Number of Disks	Vogtle Bypass Test No.	Approach Velocity (ft/sec)	Plant Scale Total Penetration Fiber (g)	Test Scale Cumulative Fiber Penetration (g/disk)
12	4	0.00443	5,500	55
	3	0.01323	11,000	89
15	5	0.00317	5,900	44.5
	10	0.00885	12,200	86
18	2	0.00433	10,300	62.5
	8	0.00876	13,100	88.5
	1	0.01302	13,100	88.5

All tests referenced in this table have identical water chemistry (that is, High Chem.) and used a debris load corresponding to a 1 inch thick debris bed. The only differences between tests examined were the number of disks on the test strainer and the strainer approach velocities. The following data presented on the figures was not considered:

- Tests 6 and 7 use different water chemistry than all other tests.
- The lines labeled “RHR” in both figures do not correspond to test data but rather the model developed by Vogtle from the test data to quantify the RHR fiber penetration under prototypical plant conditions. Only test data is considered in this comparison.
- Data for Tests 9, 11, and 12 were not provided in Reference 8.

Table RAI 4-2 compares the increase in fiber penetration to the increase in flow rate between sets of tests that use strainers with the same number of disks to the total penetrated fiber.

Table RAI 4-2: Comparison of Vogtle Bypass Test Results

No. of Disks	Vogtle Tests Compared	% Increase Approach Velocity	% Increase Total Penetrated Fiber	% Increase Cumulative Fiber Penetration
12	Tests 4 & 3	199%	100%	62%
15	Tests 5 & 10	179%	107%	93%
18	Tests 2 & 8	102%	27%	42%
18	Tests 8 & 1	49%	0%	0%
18	Tests 2 & 1	201%	27%	42%

The results of Vogtle fiber penetration testing show that a given percentage increase in approach velocity yields an increase in fiber penetration, but of lesser magnitude. The following is true for the pairs of tests listed in Table RAI 4-2:

% increase in approach velocity > % increase in total penetrated fiber
% increase in approach velocity > % increase in cumulative fiber penetration

Since approach velocity is directly proportional to plant flow rate, it is conservative for the BVPS-1 IVDE analysis to assume the following:

% increase in BVPS-1 plant flow rate = % increase in BVPS-1 core inlet fiber at t_{block}
% increase in BVPS-1 plant flow rate = % increase in BVPS-1 in-core fiber

The maximum hot leg break flow rate is 11.3% higher than the analyzed flow rate. Therefore, a 11.3% increase in grams of fiber per fuel assembly for both core inlet fiber at t_{block} and in-core fiber for the hot leg break analysis is conservative.

<u>Conclusions</u>

The core inlet and in-core fiber loads for the hot leg break will not exceed those of the PSV piping break when accounting for a 11.3% increase in both values due to a tested flow rate that is 11.3% less than that analyzed in the BVPS-1 IVDE evaluation. The tested flow rate bounds that used for the IVDE evaluation of the PSV piping break. In conclusion, the margin to the Reference 4 fibrous debris limits for the break that generates the maximum quantities of fibrous debris at the core inlet and heated core remain as given in Reference 1.

b. For the Unit 2 penetration testing, small pieces of fiber were included (pg 49 and 50 of 62). The results calculated a percent bypass fraction by subtracting the

small pieces from the total. This is acceptable from a penetration bypass fraction calculation perspective. Provide the basis for the assumption that the small pieces of fiber did not capture or otherwise reduce the amount of fine fiber available to penetrate the strainer in a non-prototypical manner.

Response:

During BVPS-2 strainer penetration (bypass) testing, debris was added in three batches. All fine debris was added in the first two batches while the small debris was added in the third batch. After each batch addition, flow rate was maintained at 132 gpm (52% of maximum) for a minimum of 5 pool turnovers. The flow rate was then increased to the maximum of 254 gpm and maintained for an additional 5 pool turnovers before the next debris addition. All fine debris would already have been deposited on the strainer and exposed to maximum flow conditions at the time of small debris addition. Therefore, the small debris would not capture or reduce the quantity of fines available for penetration.

The containment sump penetration (bypass) testing for BVPS-2 utilized a 50 percent fines and 50 percent smalls debris loading for fibrous debris (represented by Temp-Mat and Nukon™). The high energy line break debris generation analysis performed for BVPS-2 concludes that a distribution of 20 percent fines and 80 percent smalls will be present during an actual event. Therefore, the testing methodology provided margin to the analyzed debris generation sizes and loading expected during an event.

In conclusion, the 5.8% bypass fraction used in the BVPS-2 IVDE evaluation, conservatively developed from prototype strainer bypass testing, bounds the bypass fraction from an actual event.

c. In the calculation of the fiber amount arriving at the core, it was assumed that some fiber bypassed the core and recirculated via the RSS (pg 50 of 62). Provide the assumptions for flowrates through the ECCS and the RSS. Also provide the basis for the assumption that the RSS will start and run for the period of time assumed in the analysis.

Response:

Per the recommendation of Reference 4 Section 6.5.2, the IVDE evaluation biases the ECCS flow to a maximum value and RSS flow to a minimum value with the intention of maximizing the quantity of bypassed fibrous debris delivered to the reactor vessel and core. Flow rates for each IVDE case examined are provided below, with corresponding assumptions.

BVPS-1 Hot Leg Break: ECCS Flow = 5,303 gpm, RSS Flow = 5,848 gpm

ECCS flow is based on maximum safeguards, nondegraded pump flow with a fully depressurized RCS. This corresponds to 988 gpm high-head safety injection and 4,062 gpm low-head safety injection flow, for a total of 5,050 gpm maximum ECCS flow. A 5% margin is added, resulting in the assumed flow rate of 5,303 gpm.

CSS flow rate is based on single train operation with degraded pump performance. The minimum flow rate between the two trains is 6,155 gpm. A 5% margin is subtracted, resulting in the assumed flow rate of 5,848 gpm.

BVPS-1 Pressurizer Safety Valve Inlet Piping Break:

ECCS Flow = 3,899 gpm, RSS Flow = 5,848 gpm

The pressurizer safety valve inlet piping break is a 6-inch small break LOCA located above the RCS loop piping. The RCS will remain above atmospheric pressure for this scenario and ECCS flow will be reduced. The MAAP-DBA containment analysis program was utilized to evaluate this break and track various parameters over time, including ECCS flow rate. This analysis is biased towards maximum ECCS flow and predicts a cold leg recirculation flow rate of 3,713 gpm. A 5% margin is added, resulting in the assumed flow rate of 3,899 gpm.

The CSS flow rate is assumed equal to that of the BVPS-1 Hot Leg break scenario.

BVPS-2 Hot Leg Break: ECCS Flow = 6,280 gpm, RSS Flow = 3,022 gpm

The maximum safeguards, non-degraded ECCS pump flow rate of 6,229 gpm is slightly less than the maximum ECCS flow rate used in the Reference 4 thermal-hydraulic analysis of 40 gpm per fuel assembly (40 gpm/FA x 157 fuel assemblies = 6,280 gpm). The maximum thermal hydraulic analysis flow rate of 6,280 gpm was assumed for this analysis to provide margin while remaining within the key parameters of the thermal hydraulic model.

BVPS-2 emergency operating procedures require operation of one RSS pump if containment pressure reaches (-1) pounds per square inch gage (psig). Therefore, RSS flow is based on the minimum flow of a single degraded RSS pump. The lowest flow rate among the four BVPS-2 RSS pumps is 3,182 gpm. A margin of 5% is subtracted, resulting in the assumed flow rate of 3,022 gpm.

The BVPS-1 and BVPS-2 IVDE evaluations start at the earliest time of ECCS sump switchover, with a 5% margin subtracted relative to the time after LOCA initiation, which is when the earliest ECCS switchover occurs. Until that time, it is assumed that all fibrous debris is present in the sump recirculation pool. The analysis thus assumes the RSS pumps start at the time of ECCS sump switchover. This is conservative because both the RSS pump start and ECCS sump switchover are activated on refueling water storage tank level and the RSS pump start setpoint is at a higher tank level than ECCS switchover. Therefore, after an actual event, a fibrous debris bed is likely to form on the sump strainer before ECCS sump switchover with all bypassed fibrous debris recirculated back to the sump via the RSS flow path.

All IVDE evaluations are run to the time of hot leg switchover and meet the termination criteria provided in Reference 4 prior to this time. Both BVPS-1 and BVPS-2 licensing bases require that the pumps that perform the long-term ECCS and RSS functions operate for 30 days post-LOCA. The previous GL 2004-02 supplemental responses and RAI responses in Reference 1, Reference 2, and Reference 7 have demonstrated that pump net positive suction head, RSS pump and component wear, and structural loading of the sump strainer remain within limits for the 30-day mission time.

References

1. Energy Harbor Nuclear Corp. letter to NRC L-20-162, Supplemental Response to NRC Generic Letter 2004-02, dated November 30, 2020 (ADAMS Accession No. ML20335A564).

2. FENOC Letter to NRC L-09-152, Supplemental Response to Generic Letter 2004-02 (TAC Nos. MC4665 and MC4666), dated June 30, 2009 (ADAMS Accession No. ML091830390).

3. NRC Staff Review Guidance Regarding Generic Letter 2004-02 Closure in the Area of Strainer Head Loss and Vortexing, dated March 2008 (ADAMS Accession No. ML080230038).

4. PWROG Topical Report WCAP-17788-P, Volume 1, Revision 1, Comprehensive Analysis and Test Program for GSI-191 Closure (PWROG Project Authorization PA-SEE-1090), dated December 12, 2019.

5. Nuclear Energy Institute 04-07, Pressurized Water Reactor Sump Performance Evaluation Methodology, Volume 1, Pressurized Water Reactor Sump Performance Evaluation Methodology, Revision 0, dated December 2004 (ADAMS Accession No. ML050550138).

6. Nuclear Energy Institute 04-07, Pressurized Water Reactor Sump Performance Evaluation Methodology, Volume 2, Safety Evaluation by the Office of Nuclear Reactor Regulation Related to NRC Generic Letter 2004-02, Revision 0, dated December 6, 2004 (ADAMS Accession No. ML043280007).

7. FENOC letter to NRC L-10-115, Response to Request for Additional Information related to Generic Letter 2004-02 (TAC Nos. MC4665 and MC4666), dated September 28, 2010 (ADAMS Accession No. ML102770023).

8. Vogtle Electric Generating Plant – Units 1 & 2 Supplemental Response to NRC Generic Letter 2004-02, Enclosures 1, 3, 4, & 5 – Introduction and Overall Summary, Risk Quantification, Defense-In-Depth & Safety Margin and Supplemental Response to NRC Generic Letter 2004-02 (ADAMS Accession No. ML 18193B165).