VIRGINIA ELECTRIC AND POWER COMPANY
RICHMOND, VIRGINIA 23261

February 25, 2021

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

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VIRGINIA ELECTRIC AND POWER COMPANY
SURRY POWER STATION UNITS 1 AND 2
NRC GENERIC LETTER 2004-02, "POTENTIAL IMPACT OF DEBRIS BLOCKAGE ON EMERGENCY RECIRCULATION DURING DESIGN BASIS ACCIDENTS AT PRESSURIZED-WATER REACTORS"
FINAL SUPPLEMENTAL RESPONSE

The purpose of this submittal is to provide the Virginia Electric and Power Company (Dominion Energy Virginia) final supplemental response for Surry Power Station Units 1 and 2 (SPS 1 and 2) to Generic Letter (GL) 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation during Design Basis Accidents at Pressurized-Water Reactors," dated September 13, 2004.

On May 14, 2013, Dominion Energy Virginia submitted a letter of intent per SECY-12-0093, "Closure Options for Generic Safety Issue – 191, Assessment of Debris Accumulation on Pressurized-Water Reactor Sump Performance," indicating that SPS 1 and 2 would pursue Closure Option 2 – Deterministic of the SECY recommendations (refinements to evaluation methods and acceptance criteria). The final outstanding issue for SPS with respect to GL 2004-02 is the in-vessel downstream effects evaluation to demonstrate long-term core cooling (LTCC) can be adequately maintained for postulated accident scenarios that require sump recirculation.

The in-vessel downstream effects evaluation has been completed for SPS 1 and 2 and is documented in the enclosure to this letter. This satisfies the final GSI-191 commitment identified in the May 14, 2013 Closure Option letter.

Beyond the changes evaluated in the enclosure to this letter, Dominion Energy Virginia is evaluating replacement of the existing sodium hydroxide buffering agent at SPS 1 and 2. That replacement project will include an evaluation of the GL 2004-02 licensing basis.

This response constitutes Dominion Energy Virginia's final supplemental response to GL 2004-02 for SPS 1 and 2.

Should you have any questions or require additional information, please contact Mr. Gary D. Miller at (804) 273-2771.

Respectfully,

Mark D. Sartain
Vice President – Nuclear Engineering and Fleet Support

Commitment contained in this letter:

1. Dominion Energy Virginia 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 SPS 1 and 2

Enclosure: Final Supplemental Response to GL 2004-02

COMMONWEALTH OF VIRGINIA)
)
COUNTY OF HENRICO)

The foregoing document was acknowledged before me, in and for the County and Commonwealth aforesaid, today by Mark D. Sartain, who is Vice President – Nuclear Engineering and Fleet Support of Virginia Electric and Power Company. He has affirmed before me that he is duly authorized to execute and file the foregoing document in behalf of that Company, and that the statements in the document are true to the best of his knowledge and belief.

Acknowledged before me this 25th day of February, 2021.

My Commission Expires: 12/31/24.

CRAIG D SLY
Notary Public
Commonwealth of Virginia
Reg. # 7518653
My Commission Expires December 31, 2024

Craig D Sly
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Enclosure

FINAL SUPPLEMENTAL RESPONSE TO GL 2004-02

Virginia Electric and Power Company
(Dominion Energy Virginia)
Surry Power Station Units 1 and 2

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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.*

Dominion Energy Virginia Response:

In accordance with SECY-12-0093, and as identified in the May 14, 2013 Dominion Energy Virginia letter to the NRC (ADAMS Accession No. ML13140A095), Surry Power Station Units 1 and 2 (SPS 1 and 2) elected to pursue Generic Safety Issue (GSI)-191 Closure Option 2 – Deterministic. Topical Report (TR) WCAP-17788-P, Rev. 1, "Comprehensive Analysis and Test Program for GSI-191 Closure (PA-SEE-1090)," 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. 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 many of the methods developed in the TR can be used by pressurized water reactor (PWR) licensees to demonstrate adequate long-term core cooling (LTCC). Completion of the analyses demonstrates 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 SPS 1 and 2. By letter dated August 13, 2015 (ADAMS Accession No. ML15232A026), SPS revised its commitment for resolving in-vessel downstream effects to specifically state it would demonstrate compliance with WCAP-17788-P in-vessel debris acceptance criteria.

1.1 Overview of Surry Power Station Resolution of GL 2004-02

On February 29, 2008 (ADAMS Accession No. ML080650562), Dominion Energy Virginia submitted a Supplemental Response to GL 2004-02 for SPS 1 and 2 that provided specific information regarding the methodology SPS used for demonstrating compliance with the applicable regulations, as well as the corrective actions that had either been implemented or planned to support the resolution of GSI-191. By letter dated February 27, 2009 (ADAMS Accession No. ML090641018), SPS updated its

Supplemental Response for Units 1 and 2 to provide information regarding the analyses performed and the corrective actions taken that had not been completed at the time of the 2008 response. The content and level of detail provided were consistent with the NRC guidance provided in the NRC letter dated November 21, 2007, "Revised Content Guide for Generic Letter 2004-02 Supplemental Responses," (ADAMS Accession No. ML073110389). Additional information was provided in Surry letters dated December 17, 2009 (ADAMS Accession No. ML093521426) and April 13, 2010 (ADAMS Accession No. ML1010140082) in response to an NRC request for additional information (RAI). Dominion Energy Virginia committed to address the resolution of downstream in-vessel effects for SPS 1 and 2 following the issuance of revised WCAP-16793, "Evaluation of Long-Term Cooling Considering Particulate, Fibrous and Chemical Debris in the Recirculating Fluid," and the associated NRC Safety Evaluation Report (SER).

By letter dated May 14, 2013 (ADAMS Accession No. ML13140A095), SPS provided its resolution plan for resolving downstream in-vessel effects pursuant to the PWROG comprehensive program underway to develop new acceptance criteria for in-vessel debris (i.e., WCAP-17788-P). That letter also included a summary of the corrective actions and analyses that had been implemented for SPS 1 and 2 to address GSI-191, as well as inherent margins and conservatisms included in the analyses. The plant analyses, modifications, margins, and conservatisms summarized and updated in the SPS May 14, 2013 correspondence remain valid.

Finally, by letter dated August 13, 2015 (ADAMS Accession No. ML15232A026), SPS committed to developing plans for demonstrating compliance with WCAP-17788-P in-vessel debris acceptance criteria and to communicate that plan to the NRC in a final updated supplemental response to support GL 2004-02 closure. This effort has been completed and the resolution of in-vessel downstream effects is provided in Section 3.n below. This analysis does not credit alternate flow paths (AFPs) and conservatively assumes all fibrous debris that enters the reactor vessel will accumulate at the core inlet, even though, in reality, some fraction of fibrous debris will penetrate the core inlet or bypass the core inlet via AFPs.

1.2 Correspondence Background

Table 1 provides a list of pertinent correspondence issued by the NRC or submitted by Dominion Energy Virginia for SPS 1 and 2 associated with GL 2004-02.

TABLE 1 – GENERIC LETTER 2004-02 CORRESPONDENCE

Document Date	ADAMS Accession Number	Document
September 13, 2004	ML042360586	NRC GL 2004-02
March 4, 2005	ML050630559	First response to GL 2004-02
September 1, 2005	ML052500378	Follow-up response to GL 2004-02

TABLE 1 – GENERIC LETTER 2004-02 CORRESPONDENCE		
Document Date	**ADAMS Accession Number**	**Document**
November 1, 2005	ML053060266	Request for NRC approval of Dominion Topical Report for GOTHIC containment analysis methodology
January 31, 2006	ML060370098	License Amendment Request (LAR) to: 1) revise Recirculation Spray (RS) pump start times in response to a design basis accident (DBA), 2) replace the containment analysis methodology, and 3) revise the Loss of Coolant Accident (LOCA) Alternate Source Term (AST) analysis
February 9, 2006	ML060380017	First NRC RAI on GL 2004-02 response
February 23, 2006	ML060540421	Supplemental response for LAR to provide revised marked-up TS pages
March 28, 2006	ML060870274	NRC Alternate Approach for GL 04-02 response
June 21, 2006	ML061720499	Response to NRC RAI on LAR
July 28, 2006	ML062120719	Second supplemental response to NRC on LAR
August 30, 2006	ML062420511	NRC approval of Dominion Topical Report for GOTHIC containment analysis methodology
October 3, 2006	ML062270208	LAR to revise Technical Specifications (TS) Surveillance Requirements (SRs) for inspection of the containment sump trash racks, screen, and pump wells
October 12, 2006	ML062920499	NRC issuance of License Amendments (LAs) 250/249 for SPS 1 and 2, respectively, to revise the method for starting the inside and outside RS (IRS and ORS, respectively) pumps, implement the GOTHIC containment analysis, and revise the Alternate Source Term analysis
March 28, 2007	ML070871222	First RAI response to NRC regarding sump inspection LAR
June 19, 2007	ML071710608	Second RAI response to NRC regarding sump inspection LAR
October 15, 2007	ML072690396	NRC issuance of LAs 255/254 for SPS 1 and 2, respectively, to revise TS SRs for inspection of

TABLE 1 – GENERIC LETTER 2004-02 CORRESPONDENCE		
Document Date	**ADAMS Accession Number**	**Document**
		the containment sump trash racks, screen, and pump wells
October 22, 2007	ML072950501	LAR to permit the use of alternate GOTHIC analysis methodology
November 2, 2007	ML073100827	First RAI response to NRC regarding LAR to use alternate GOTHIC analysis methodology
November 9, 2007	ML073130676	Second RAI response to NRC regarding LAR to use alternate GOTHIC analysis methodology
November 15, 2007	ML073120506	NRC issuance of LAs 256/255 for SPS 1 and 2, respectively, to permit the use of alternate GOTHIC analysis methodology
November 21, 2007	ML073110389	NRC Revised Content Guide
December 19, 2007	ML090860438	Draft Benchtop Test Plan for determining chemical effects
February 29, 2008	ML080650562	Supplemental Response to GL 2004-02
April 2, 2008	ML080940287	LAR to delete the Containment Spray (CS) and RS subsystems' minimum flow values from the Design Features section of the SPS TS
December 10, 2008	ML082682183	NRC issuance of LAs 262/262 for SPS 1 and 2, respectively, to delete the CS and RS subsystems' minimum flow values from the Design Features section of the TS
February 27, 2009	ML090641018	Updated Supplemental Response to GL 2004-02
June 18, 2009	ML091540954	Second NRC RAI on GL 2004-02 response
September 11, 2009	ML092540513	Request for submittal schedule extension
December 17, 2009	ML093521426	Response to second NRC RAI
April 13, 2010	ML1010140082	Supplemental response to second NRC RAI
May 14, 2013	ML13140A095	GSI-191 Closure Option
August 13, 2015	ML15232A026	Regulatory Commitment Change Letter

1.3 General Plant System Description

SPS 1 and 2 are Westinghouse three-loop pressurized water reactors (PWRs). The Nuclear Steam Supply System (NSSS) consists of one reactor pressure vessel (RPV), three steam generators (SGs), three reactor coolant pumps (RCPs), one pressurizer and the Reactor Coolant System (RCS) piping. SPS 1 and 2 have subatmospheric containments that are highly compartmentalized, i.e., there are distinct robust structures surrounding the major components (steam generators, pressurizer, RCPs, etc.) of the RCS. The containment compartmentalization slows the transport of debris to the sump.

The SPS Emergency Core Cooling System (ECCS) and containment heat removal systems (i.e., Containment Spray (CS) and Recirculation Spray (RS) Systems) include several pumps that reduce containment temperature and pressure and remove core heat following a DBA. Following a design basis loss of coolant accident (LOCA), RCS pressure will drop, resulting in a safety injection (SI) signal, and containment pressure will rise, resulting in a consequence limiting safeguards (CLS) high-high containment pressure signal. The SI and RS systems use the containment sump water following a LOCA to facilitate LTCC and to maintain subatmospheric conditions and decay heat removal in the containment, respectively.

The SI signal starts the High Head SI (HHSI) and Low Head SI (LHSI) pumps, which inject water from the Refueling Water Storage Tank (RWST) into the RCS cold legs. Each SPS unit has three HHSI (Charging) pumps and two LHSI pumps. When the RWST water level reaches the low-low setpoint, the SI system swaps automatically from injection to recirculation mode. The HHSI pumps swap suction from the RWST to the LHSI pump discharge. The LHSI pumps swap suction from the RWST to the containment sump and deliver flow to both the RCS cold legs and the suction of the HHSI pumps. Later, in recirculation mode operation, SI flow is redirected to the RCS hot legs to preclude exceeding boron solubility limits. The SI system does not have heat exchangers between the containment sump and the RCS. The SI system depends on the RS system to cool the containment sump water sufficiently to provide adequate net positive suction head (NPSH) margin for the LHSI pumps operating in recirculation mode.

The RS system is the long-term containment heat removal system. The RS system assists in depressurizing the containment to subatmospheric conditions consistent with the assumptions for containment leakage in the dose consequences analyses. The RS system consists of four pumps (two inside containment and two outside containment) that start on delay timers after a CLS signal, take suction directly from the containment sump, discharge to a dedicated heat exchanger that is cooled by the Service Water (SW) system, and spray the sump water into the containment via dedicated spray headers. The two IRS pumps (located inside the containment sump) start on a CLS high-high containment pressure signal coincident with a 60% RWST wide range level signal to ensure sufficient water is available to meet strainer submergence requirements. The two ORS pumps (located outside containment) are started after a 120-second time delay from the CLS signal coincident with a 60% RWST wide range level signal.

The SPS design also includes two Containment Spray (CS) pumps that are started by the CLS signal. The CS pumps draw water from the RWST and deliver flow to spray headers to lower the containment pressure and temperature before the RS pumps start. The CS pumps are operated until the RWST is empty.

1.4 General Description of Containment Sump Strainers

As discussed in the SPS 1 and 2 Supplemental Response dated February 29, 2008 and Updated Supplemental Response dated February 27, 2009, two new separate strainer assemblies have been designed and installed to address RS and LHSI system requirements. The strainers were provided by Atomic Energy Canada, Ltd. (AECL). The design has independent strainers for the RS and LHSI systems with the LHSI strainer mounted on top of the RS strainer. The entire containment sump strainer assembly is raised off of the floor. The bottom of the RS strainer is six inches off the floor. The LHSI strainer is located on top of the RS strainer and sits approximately 19 inches off the floor. Since the strainer is raised off the floor, heavy pieces of debris are prevented from reaching the fins and blocking them.

The RS and LHSI strainers are designed and fabricated to the requirements of ASME Section III, Subsection NF, Class 3. The material used in the construction of the strainer assemblies is austenitic stainless steel. The strainer assemblies are capable of withstanding the full debris loading in conjunction with design basis conditions without collapse or structural damage.

- <u>RS Strainer</u> - One strainer assembly is provided for both the IRS and ORS System pumps. The RS strainer assembly consists of two trains that traverse along the containment wall on both sides of the sump. The strainer assembly consists of a number of modules that channel water to the pumps' suction. Each suction opening is connected to the modules which form the strainer header. Modules are connected to each other by flexible metal seals. Seal closure frames with Metex seals are installed over the existing flexible metal seals. The seal closure frame assemblies form the seal between adjacent strainer modules. Each module contains a number of fins which filter the water flowing into the modules. Each fin contains a number of holes 0.0625-inch (nominal) in diameter. Perforations on the strainer fins prevent particles larger than 0.06875-inch (0.0625-inch plus 10 percent) from entering the RS System. The total perforation area is large enough to allow sufficient flow to the suction of the RS pumps to meet NPSH requirements.

  For the ORS pumps, the strainer header is connected to each suction opening by a flanged transition adapter. The outer diameter (OD) of the strainer header is machine cut and slip-fitted into the adapter thus ensuring that gaps between the piping and the adapter do not exceed 0.0625 inches. For the IRS pumps, the strainer header was connected to the pump well by installing a new casing.

The suction lines between the containment sump and the ORS pumps are cross connected. This design feature was originally provided to ensure a supply of water to each pump in the event that the suction of either pump became clogged.

- LHSI Strainer - The design of the LHSI strainer assembly is similar to the design of the RS strainer assembly. The LHSI strainer assembly is designed to provide filtered borated water to both LHSI pumps during the recirculation mode. The strainer assembly consists of a number of modules that channel water to the pump suction. Modules are connected to each other by flexible metal seals. Seal closure frames with Metex seals are installed over existing flexible metal seals. The seal closure frame assemblies form the seal between adjacent strainer modules. Each module contains a number of fins which filter the water flowing into the modules. Each fin contains a number of holes 0.0625-inch (nominal) in diameter. Perforations on the strainer fins prevent particles larger than 0.06875-inch (0.0625-inch plus 10 percent) from entering the LHSI System. The total perforation area is large enough to allow sufficient flow to the suctions of the LHSI pumps to meet NPSH requirements.

  The LHSI strainer assembly consists of two trains which traverse along the containment wall on both sides of the sump. Each suction opening is connected to the modules via the strainer header. The strainer header is connected to each suction opening by a flanged transition adapter. The OD of the strainer header is machine cut and slip-fitted into the adapter thus ensuring the gaps between the piping and the adapter do not exceed 0.0625 inches.

  A 12-inch line provides a cross connection between the two 12-inch lines on the suction of the LHSI pumps. Each of the two 12-inch LHSI suction pipes has its own suction opening connected to the strainer header. The strainer header is slip fit into the suction opening located in the containment sump via a flanged transition adapter piece.

Since the installation of the strainers, inspections have identified gaps in the strainers larger than the allowable 0.0625-inch gap size. Consequently, particles larger than 0.06875 inches were evaluated in response to the identified gaps in the strainer assembly. As part of the evaluation, it was assumed that 1% of the total generated particles between 0.06875 inches (0.0625 inches plus 10 percent) and 0.1375 inches (0.125 inches plus 10 percent) would pass through the strainer. It was determined that these particles would not impact the performance of downstream components.

The surface areas for the containment sump strainers are summarized in Table 2.

TABLE 2 – CONTAINMENT SUMP STRAINER SURFACE AREA

Strainer	Surface Area (ft^2)
Unit 1 RS Strainer	~5750
Unit 2 RS Strainer	~5800
Unit 1 LHSI Strainer	~2200
Unit 2 LHSI Strainer	~2240

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.

Dominion Energy Virginia Response:

Dominion Energy Virginia performed analyses to determine the susceptibility of the ECCS and RS functions for SPS 1 and 2 to the adverse effects of post-accident debris blockage and operation with debris-laden fluids. The analyses considered postulated DBAs for which the containment sump recirculation mode of these systems is required. Mechanistic analyses supporting the evaluation satisfied the following areas of the NRC approved methodology in the Nuclear Energy Institute (NEI) 04-07, "Pressurized Water Reactor Sump Performance Evaluation Methodology" Guidance Report (GR), as submitted by NEI on May 28, 2004 (Reference 4.1), as modified by the NRC Safety Evaluation (SE) dated December 6, 2004 (Reference 4.2):

Break Selection
Debris Characteristics
Debris Transport
Vortexing
Debris Source Term
Upstream Effects

Debris Generation and Zone of Influence
Latent Debris
Head Loss
NPSH Available
Structural Analysis

Detailed analyses of debris generation and transport were performed to ensure that a bounding quantity and a limiting mix of debris are assumed at the containment sump strainer following a DBA. Using the results of the analyses, conservative evaluations and strainer testing were performed to determine worst-case strainer head loss and downstream effects. Chemical effects bench-top tests conservatively assessed the solubilities and behaviors of precipitates and applicability of industry data on the dissolution and precipitation tests of station-specific conditions and materials. Reduced-scale testing was performed by AECL using two separate test rigs, and multi-loop testing established the influence of chemical products on head loss across the strainer surfaces by simulating the plant-specific chemical environment present in the water of the containment sump following a LOCA.

In addition, numerous plant modifications were completed for SPS 1 and 2 in support of GSI-191 resolution including the following:

- New containment sump strainers (with corrugated, perforated stainless steel fins) were installed in the containment sump for SPS 1 and 2. The total surface area of the Unit 1 RS strainer is approximately 5750 ft^2, and the total surface area of the LHSI strainer is approximately 2200 ft^2. The total surface area of the Unit 2 RS strainer is approximately 5800 ft^2, and the total surface area of the Unit 2 LHSI strainer is approximately 2240 ft^2. These strainers replaced the previous containment sump screens, which had a surface area of approximately 158 ft^2.
- Microtherm insulation installed within the break zone of influence (ZOI) was removed from the SPS 1 containment.
- A drain was installed in the Primary Shield Wall of the Incore Sump Room to reduce the water holdup volume and increase the total volume of water available for strainer submergence and recirculation.
- Engineered Safeguards Features (ESF) circuitry was added to start the RS pumps on a high-high Containment Pressure CLS signal coincident with an RWST Level Low signal. The IRS pumps now receive an immediate start signal once the coincidence logic is satisfied, and the ORS pumps will start following a timer delay of 120 seconds once the coincident logic is satisfied.

- Insulation inside the containment that could contribute to spray or submergence generated debris that was determined to be damaged, degraded, or covered with an unqualified coating system was removed or jacketed with a jacketing system qualified for DBA conditions.

- The containment sump level transmitters were modified to protect them from clogging due to debris. Specifically:
  - Level transmitters located within the sump were modified by drilling holes through stilling wells at various locations to prevent the element from clogging.
  - Level transmitters located above the containment floor were provided with debris shields to protect them from containment spray generated debris.

- Air ejectors were re-installed on the SPS 1 and 2 LHSI pump cans.

In addition to the modifications listed above, the following actions were completed in support of GSI-191 resolution:

- Debris generation and debris transport analyses were completed. These analyses contain:
  - Break selection criteria
  - Calculation of amount and type of debris generated for limiting breaks
  - Breakdown of debris sizes
  - Physical debris characteristics (i.e. density, fiber size, particulate size)
  - Calculation of amounts of each debris type postulated to reach the ECCS strainer

- Analysis of water hold-up in containment was performed to identify locations where water will be blocked from reaching the RS and LHSI strainers.

- The SPS 1 and 2 TS were revised to change the method for starting the IRS and ORS pumps in response to a DBA. The RS pump start, which was based on a time delay following a CLS High-High containment pressure setpoint, was revised to start on a coincident CLS High-High pressure signal and RWST Level Low signal. The TS were also revised to increase the containment air partial pressure limits to provide analytical margin, including NPSH margin, for the RS and LHSI pumps, and to provide new containment sump inspection requirements associated with the new strainers.

- A downstream effects analysis was performed for clogging/wear of components in ECCS and RS flow streams downstream of the LHSI and RS strainers.

- The LOCTIC containment analysis methodology for analyzing the response to postulated pipe ruptures inside containment, including a LOCA and a main steam line break (MSLB), was replaced with the NRC-approved GOTHIC evaluation methodology discussed in Dominion Topical Report DOM-NAF-3-0.0-P-A. The change to the GOTHIC code provides margin in LOCA peak containment pressure and other accident analysis results.

- The SPS 1 and 2 LOCA AST analysis was revised to include the effects from changing the RS pump start methodology and from the other modifications associated with the GSI-191 project.
- Procedures and programs were revised and developed to ensure future changes to the plant are evaluated for their effects on the ability of the new containment strainers to perform their design function.
- Operators were trained on the operation of the RS and LHSI systems with respect to the new containment strainers.
- A Finite Element Analysis (FEA) was completed that demonstrated the acceptability of the 18-inch band spacing on the SPS insulation jacketing.

To ensure the modifications implemented and the analyses performed effectively addressed uncertainties with sufficient margin, the following margins and conservatisms were incorporated into the GSI-191 corrective actions as detailed below:

- Testing and analyses for strainer head loss and vortexing were performed with the following conservatisms:
  - A reduced-scale test tank was used to determine debris strainer design size and fin pitch by measuring debris head loss. The small diameter of the tank and the constant stirring ensured that a minimal amount of the debris settled on the floor of the tank thus maximizing the amount of debris and subsequent head loss across the test fins. Settling of small debris in containment is expected to be significant especially in areas remote from the strainer.
  - The maximum head loss is dependent on formation of a thin-bed on the strainer surface. Formation of a thin-bed is dependent on a small quantity of fiber mixing with the particulate on the strainer. Additional fiber beyond the minimum quantity required for the thin-bed tends to produce lower head losses. Thin-bed formation conservatively used the minimum quantity of fiber necessary to form a thin-bed in combination with the maximum large break (LB) LOCA particulate load. This conservative combination is very unlikely to occur at the strainer for either a small break LOCA or a LBLOCA.
  - Vortexing analysis and testing showed no vortexing with a strainer that has zero submergence (water level at the top of the strainer). The submergence at the beginning of recirculation is at least three inches for the RS strainer and eight

inches for the LHSI strainers. Submergence increases as RWST water continues to be sprayed into containment.

  - Maximum head loss is calculated at the minimum containment sump water level. The minimum water level only occurs at the beginning of recirculation, and water level increases as additional RWST water is sprayed into containment. The maximum head loss will not be established until a significant period of time after RS pump start and, based on head loss testing, will not occur until well after the approximately 2 hours required for all of the RWST water to be pumped into containment.
  - Head loss testing involved adding all of the particulate to the test tank prior to the addition of any fiber, and then adding fiber in increments to gradually build a thin-bed on the strainer. An actual break is much more likely to mix all of the available fiber and particulate together in the sump pool so that they arrive at the screen together. Consequently, they are unlikely to form a thin bed since there is likely to be more fiber in the mix than is necessary for thin bed formation. This will lead to lower head losses.

- Test evaluations demonstrated that a fully formed thin-bed of debris requires significant time (hours) to form and that formation of a thin-bed is dependent upon disturbing settled debris throughout the test tank. Consequently, a worst-case thin bed of debris would be difficult to form and would not be expected to form until several hours after sump recirculation is initiated. Significant debris settling and sump water subcooling occurs during the formation of a debris bed so additional NPSH margin is available for chemical effects head loss. However, as a conservative measure, chemical effects testing began with an established debris thin bed on the strainer fins and was conducted for the 30-day mission time.
- The debris load in head loss testing was taken from the debris transport calculation, which conservatively credits no particulate settling.
- Debris introduction procedures in chemical effects testing ensured minimum near-field settling and resulted in conservatively high debris bed head losses.
- Debris introduction was accomplished in a carefully controlled manner to result in the highest possible head loss.
- Only fines of fibrous debris were used in head loss testing as if all the fibrous debris erosion, which is expected to take a considerable amount of time, occurred at the start of recirculation.
- Debris bed formation during testing included agitating (or "stirring") the settled debris to ensure maximum debris on the strainer. However, any turbulence in post-LOCA

containment sump water is expected to be localized to limited areas of the strainers. Consequently, much of the sump water will be quiescent, which would promote debris settling.

- Particulate settling in head loss testing was conservatively minimized through the use of a lower density walnut shell particulate as a surrogate for the higher density epoxy coating particulate that may be present in post-LOCA sump water.
- Downstream effects analyses (components) were completed consistent with WCAP-16406-P, Rev. 1, "Evaluation of Downstream Sump Debris Effects in Support of GSI [Generic Safety Issue]-191," to identify any wear, blockage or vibration concerns with components and systems due to debris-laden fluids. Significant conservatisms are inherent in these analyses, which provide reasonable assurance that downstream component clogging will not occur, and downstream component wear will not significantly affect component or system performance. The downstream wear analysis used the LBLOCA particulate load to determine abrasive and erosive wear. This is a conservative particulate loading, in view of the following:
    - Much of the particulate included in the analysis is unqualified coating that is outside the break zone of influence (ZOI). This unqualified coating is assumed to dislodge due to exposure to the containment environment. However, such dislodgement is likely only after many hours and days, if at all.
    - The low velocity of the sump water column and the significant number of surfaces throughout containment promote significant settling of particulate in containment. Settled coating will not be drawn through the sump strainer since the bottom of the RS strainer is located approximately six inches above the containment floor and the bottom of the LHSI strainer is located approximately 19 inches above the containment floor.
    - The analysis assumes 100% strainer bypass of particulate thereby conservatively maximizing the effects of downstream wear.
- Chemical effects testing results were conservative based upon the following conditions:
    - Aluminum corrosion amounts were calculated at high pH (pH 9 at 77 °F), where aluminum corrosion and release rates are high. Testing was performed at neutral pH (pH 7 at 77 °F), where aluminum solubility is low to encourage aluminum compound precipitation. Sump water pH is expected to be approximately pH 8 at 77 °F in the long-term.
    - The minimum sump water volume at specified post-LOCA times was used to maximize the calculated sump aluminum concentrations.

  - The analysis of aluminum load conservatively does not account for the possible inhibitory effect of silicate or other species on aluminum corrosion.

  - The rate of corrosion is maximized by not assuming development of passive films, i.e., no aluminum oxides remain adhered to aluminum surfaces. The formation of passive films could be credited to decrease the corrosion and release rates at long exposure times. Consequently, it is conservative to assume that all aluminum released by corrosion enters the solution.

  - All aluminum released into the solution is conservatively assumed to transport to the debris-bed instead of plating out on multiple surfaces throughout containment. During bench-top testing, aluminum plated out on glass beakers and, during reduced-scale testing, aluminum plated out on fiber. It is reasonable to expect that a portion of the aluminum ions released into solution will plate out on some of the multiple surfaces in containment prior to arriving at the debris-bed on the strainer.

  - Chemical effects test evaluations conservatively neglect the effect of the presence of oxygen in the sump water. The corrosion rate of aluminum in aerated pH 10 alkaline water can be a factor of two lower than that measured in nitrogen-deaerated water. This data is in NUREG/CR-6873, "Corrosion Rate Measurements and Chemical Speciation of Corrosion Products Using Thermodynamic Modeling of Debris Components to Support GSI [Generic Safety Issue]-191."

- NPSH margins were determined with the following conservatisms:

  - The calculation of NPSH available used the NRC-approved methodology in Topical Report DOM-NAF-3, Rev. 0.0-P-A, "GOTHIC Methodology for Analyzing the Response to Postulated Pipe Ruptures Inside Containment," September 2006. The methodology includes assumptions that minimize the contribution of containment accident pressure to the calculated NPSH margin and maximize the sump water temperature (and, thus, the vapor pressure of the pumped fluid).

  - The NPSH analysis includes conservatisms that ensure a minimum containment water level is used. Conservative assumptions are made for water hold-up in spray system piping, water trapped from transport to the containment sump in volumes (e.g., the refueling canal and reactor cavity), condensation films on heat structures, films on platforms and equipment that form after spray is initiated, other losses, and spray water droplets in the atmosphere. The following conservatisms were also applied to the available water sources:

    - No contribution from the chemical addition tank;

  - o Assumed an initial RWST volume less than the TS minimum of 387,100 gallons;
  - o The containment sump is empty at the start of the LOCA (normal operation maintains approximately 500 gallons in the pit); and
  - o +2.5% RWST wide range level uncertainty is applied in determining the initiation of RS and LHSI recirculation (the minimum NPSH available for the LHSI pump occurs right after recirculation mode transfer to the sump).

- Analyses were performed to identify the limiting set of conditions (break location, plant operating conditions, equipment performance, single failure) that produces the minimum NPSH available for each pump (LHSI, IRS, and ORS). This deterministic approach ensured that all variables were biased in their most adverse direction. For scenarios other than the most limiting case identified for each pump, additional NPSH margin exists.

- For evaluation of short-term pump NPSH margins, the maximum debris bed head loss from the test program was compared to the minimum NPSH available that occurs during a transient time when a debris bed is just beginning to form on the strainer fins. Testing performed by AECL showed that several hours to days are required to reach the maximum debris bed head loss that was used in the short-term NPSH margin evaluation.

- There is conservatism in the methodology used for scaling strainer debris bed head loss from test temperatures to higher specified sump temperatures. The debris bed will expand slightly when head loss is lower, i.e., at the higher sump temperature, the bed would be expected to be slightly more porous than at the lower test temperature. The assumption of a purely linear relationship between head loss and viscosity for scaling to higher temperatures is conservative.

- Aluminum release analysis was conducted using the release rate equation developed by AECL, which can be more conservative under certain conditions than the release rate equation specified by Equation 6-2 of WCAP-16530-NP. The results of the application of the AECL release rate model were compared to the WCAP-16530-NP model results using SPS aluminum inventories and were found to predict a greater 30-day release of aluminum.

<u>Resolution of Downstream Effects – Fuel and Vessel</u>: This item is dispositioned in Section 3.n below.

With the completion of the downstream effects analysis for the fuel and vessel, Dominion Energy Virginia has effectively resolved the issues identified in GL 2004-02 for SPS 1 and 2 and is in compliance with the applicable regulations.

3 Specific Information for Review Areas

As stated in the SPS 1 and 2 Supplemental Response dated February 29, 2008 (ADAMS Accession No. ML080650562), as amended on February 27, 2009 (ML090641018), December 17, 2009, (ADAMS Accession No. ML093521426), April 13, 2010, (ADAMS Accession No. ML1010140082), May 14, 2013 (ADAMS Accession No. ML13140A095), and August 13, 2015 (ADAMS Accession No. ML15232A026), SPS has addressed review areas 3.a through 3.m; therefore, 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.*

Dominion Energy Virginia Response:

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. 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 may be used by PWR licensees to demonstrate adequate LTCC. Dominion Energy Virginia used methods and analytical results developed in WCAP-17788-P, Rev. 1, to address in-vessel downstream debris effects for SPS 1 and 2 and has evaluated the applicability of the methods and analytical results from WCAP-17788-P, Rev. 1 for SPS.

3.n.1 Sump Strainer Fiber Penetration

An engineering evaluation was performed to determine a conservative estimated cumulative fiber bypass fraction for the SPS 1 and 2 containment sump strainers to facilitate the evaluation of the in-vessel debris effects for NRC GL 2004-02.

From the debris generation and transport analyses performed for SPS 1 and 2, Dominion Energy Virginia conservatively determined the types and quantities of fibrous debris that could be transported to the strainers, as documented by letter dated February 29, 2008 (ML080650562). The fibrous debris sources considered in these analyses include asbestos, Thermal Wrap, TempMat, fiberglass, PAROC/mineral wool, Thermal Insulating Wool, and latent fiber. The total fibrous debris quantity from these sources that could potentially reach the sump strainer was conservatively bounded by the SPS tested quantity of 1,230.7 pounds-mass (lbm). For the downstream in-vessel effects analysis, additional fiber was added for conservatism.

The strainer fiber bypass testing performed by AECL for the strainer design installed at SPS did not measure the cumulative quantities of fiber bypassed after each fiber addition to the test tank. The testing used a "grab sample" method that looked at fiber mass in a water sample taken downstream of the strainer fins at discrete points in time. This testing provided insights that long-term strainer bypass was low but did not provide insights into bypass occurring early in ECCS operation. Consequently, data was not available for the quantity of bypassed fiber as the debris bed is forming, and thus cumulative fiber bypass fractions could not be determined. Lastly, the mix of fibrous insulation types has significantly changed, which impacts the theoretical debris bed thickness for determination of fiber bypass fraction.

However, other plants in the industry have performed strainer bypass testing with downstream continuous on-line filters that were able to determine cumulative fiber bypass fractions for various debris bed thicknesses. Consequently, Dominion Energy Virginia performed an evaluation to develop an engineering basis for the use of cumulative fiber bypass data from other plants to apply to the AECL strainers installed at SPS Units 1 and 2. As noted above, SPS has two hydraulically independent strainers that serve the LHSI system and the RS system pumps, respectively. Since only the LHSI strainer delivers sump water to the reactor vessel, the bypass fraction was only determined for the LHSI strainer.

General Strainer Bypass Characteristic

Based on review of strainer bypass testing data for the Point Beach and South Texas Project (STP) plants (References 4.6 and 4.15, respectively), it was observed that as a debris bed forms and continues to build on a strainer, the filtration efficiency will plateau at nearly 100%. Each of these tests was performed with continuous on-line filters downstream of the strainer assemblies to ensure a cumulative fiber bypass fraction could be determined. The filtration efficiency behavior is also consistent with that indicated in the bypass testing results for SPS that was performed by AECL. However, since the AECL tests were based only on grab samples taken at specific turnover intervals for the fiber additions, it was necessary to utilize other industry testing that used continuous on-line fiber bypass capture to determine cumulative bypass fractions for the SPS 1 and 2

LHSI strainers. It is noted AECL test reports determined that "Fiber bypass concentrations show a near exponential decreasing trend with time." The quantity of fiber that came through was so low that a scanning electron microscope evaluation was required for accurate determination of fiber concentration and size. Considering these results, there is reasonable engineering justification for applying corrected industry strainer bypass test results, including appropriate conservatism, to the SPS 1 and 2 LHSI strainers.

Review of Industry Test Data and NRC Staff Guidance for Strainer Fiber Bypass

Using NRC staff guidance for strainer fiber bypass and industry strainer bypass test results and approach velocity from Point Beach and Vogtle, respectively (References 4.4 through 4.10), a cumulative strainer bypass fraction was developed for SPS. Consistent with NRC staff guidance (Reference 4.3), the largest fibrous debris amount for each plant that could transport to the sump strainers was assumed and included fiber transport and erosion based on the bounding fiber break. Application of Point Beach strainer bypass data to the SPS LHSI strainers was based on fiber bypass at various tested and extrapolated theoretical debris bed thicknesses (derived from fiber mass per strainer area).

SPS has a higher approach velocity than Point Beach so it was necessary to apply a correction factor to scale the Point Beach data to the higher velocity. Vogtle plant tests that recorded bypass fractions at various velocities were used to derive the correction factor (Reference 4.10). Bypass mass, normalized by flow rate, was determined in the Vogtle test report to be linearly related to approach velocity. This supported the calculation of cumulative bypass fractions for the Vogtle strainers at flow rates comparable to SPS and Point Beach. A cumulative bypass correction factor could then be determined at a given debris bed thickness by scaling the Vogtle data at the SPS velocity to the Point Beach test velocity. This methodology is based on the premise that the impact of approach velocity on the filtering efficiency of a debris bed is not strongly dependent on the specific strainer design.

The geometry for the Performance Contracting Incorporated (PCI) furnished Point Beach disk strainer was compared with the AECL furnished SPS fin strainers and was assessed to be conceptually equivalent in their hydraulic performance characteristics. Both strainers have a central collection duct that receives filtered water from perforated sheets that is delivered to ECCS pump suctions. Debris-laden water flowing to the strainers in both designs will generally be in a perpendicular direction to the perforations.

Debris bed formation on the strainers at Point Beach and SPS is expected to be relatively uniform due to the use of internal flow restrictions to ensure even distribution of flow through entire strainer surfaces. The AECL strainer hydraulic reports (Reference 4.15) discuss the use of internal flow restrictions in the SPS strainers.

With regard to the sacrificial area of the SPS strainer, it was assumed the area would be available for formation of the fibrous debris beds as this would minimize the thickness of the calculated theoretical debris bed, which would result in a larger cumulative bypass fraction for the maximum debris load at SPS.

The case that resulted in the maximum design flow rate for the SPS strainer was selected to provide the highest approach velocity. For SPS, which uses separate strainers for the RS system and the LHSI system, the maximum flow rate is assumed for LHSI and only one of the two RS system trains is assumed to be in service. This maximizes the fibrous debris available for transport to the LHSI strainer.

The strainer perforation size for Point Beach (0.066") is slightly larger than for the SPS strainer (0.0625"), which has a conservative influence on cumulative bypass fraction when applying the Point Beach test results to SPS.

Conservatisms Applied

Conservatisms applied when determining the cumulative bypass fraction for SPS include the following:

- Maximum strainer design flow rates were used that result in the highest calculated approach velocities and cumulative bypass fractions.

- SPS has a slightly smaller perforation size (0.0625") as compared to the Point Beach strainer (0.066") that was used for bypass test data applied to SPS.

- Point Beach test results for Nukon only insulation were used since they provided slightly higher bypass than for other limited insulation mixes that were tested.

- When theoretical debris bed thicknesses were calculated, designated sacrificial areas were included to minimize the thicknesses, which results in higher cumulative bypass. Also, the fiber quantities identified in the strainer head loss testing were used, which exceeds the current fibrous insulation inventories of record for SPS.

- A percentage of the total fiber load on the SPS strainer includes intact pieces that do not erode and, as such, do not contribute to strainer fiber bypass. This contrasts with the Point Beach and Vogtle bypass tests that used shredded fiber, all of which may contribute to strainer bypass.

A comparison of the Point Beach and SPS critical parameters for sump strainer bypass testing is provided in Table 3. A summary of fiber load, debris bed thickness, and velocity adjusted bypass fraction is provided in Table 4.

TABLE 3 – CRITICAL PARAMETER COMPARISON FOR SUMP STRAINER BYPASS TESTING

Parameter	Point Beach Value			Surry Power Station Value
Strainer Manufacturer	PCI			AECL
Strainer Perforation Size	0.066”			0.0625”
Strainer Area[1]	1904.6 ft^2			2194/2241 ft^2
Flow Rate through Single Strainer Train	2300 gpm (test scaled)			4100 gpm
Approach Velocity[2]	0.0027 ft/sec			0.00416 ft/s
Nominal Theoretical Debris Bed Thickness	1.5”		0.60”	0.382”
Debris Type and Quantity (% Fiber Mass Type[3])	Test 1	Test 2	Test 3	
Fiberglass[4]	40.7%	28.8%	100%	13.6%
Mineral Wool	59.3%	67.7%	0%	0%
Mineral Fiber	0%	0%	0%	0%
Temp-Mat	0%	3.5%	0%	48.5%
Paroc	0%	0%	0%	0%
Asbestos	0%	0%	0%	37.9%
Cumulative Tested Bypass	2.01%	2.42%	5.61%	N/A

Notes:

1. The sacrificial area is not deducted since it is more conservative to use the maximum area available when calculating the theoretical fiber bed thickness. A thinner bed thickness results in a higher cumulative fiber bypass fraction. Also, there is no need for comparison of surface areas since the terminal Point Beach cumulative bypass fractions are not being applied to the AECL strainers. Determination of cumulative bypass fractions is only being based on a theoretical debris bed thickness comparison with Point Beach and each plant.
2. For Surry, the approach velocity is based on the unit with the smaller strainer area to provide the bounding largest velocity for both units.
3. Actual fiber quantities are not provided as there is no intent to apply the terminal Point Beach cumulative bypass fractions to the AECL strainers. The bypass fraction for SPS is derived by comparison of theoretical bed thicknesses.
4. For SPS, all low density (2.4 lbm/ft^3) fiber types were listed together as “Fiberglass.”

SPS has a theoretical debris bed thickness of 0.382”, for which the cumulative bypass fraction at that bed thickness is calculated using the Point Beach Test 3 curve fitted equation:

Cumulative Fiber Bypass = 0.040303*(bed Thickness)$^{-0.758434}$ = 0.040303*(0.382)$^{-0.758434}$ = 8.4%.

Since the approach velocity for the SPS strainers (0.00416 ft/s) is significantly greater than for the Point Beach data (0.0027 ft/s), a correction factor was applied to the cumulative bypass fraction. The Dominion Energy engineering evaluation includes a spreadsheet that developed cumulative bypass fraction correction factors from the Alden Test Report for Vogtle (Reference 4.10) that may be applied to the Point Beach derived cumulative bypass fraction for SPS. The spreadsheet determined that a correction factor of 1.442 is applicable for a debris bed thickness of 0.382" in order to scale to a velocity of 0.0043 ft/s. This higher velocity is a test point for Vogtle and bounds the SPS strainer velocity. Therefore, the cumulative fiber bypass for the SPS strainers is 8.4% x 1.442 = **12.1%.**

TABLE 4 - SUMMARY OF FIBER LOAD, DEBRIS BED THICKNESS, AND VELOCITY ADJUSTED BYPASS FRACTION

Strainer Characteristic	SPS 1 and 2
Fiber Load, lbm	526.08
Theoretical Debris Bed Thickness, inches	0.382
Cumulative Bypass Fraction, percent	12.1

The data in Table 4 was used to perform the evaluation of in-vessel effects discussed below.

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

SPS 1 and 2 are Westinghouse 3-loop PWR designs with a downflow barrel/baffle reactor vessel design configuration. However, as discussed further below, SPS is considering converting from a Westinghouse "downflow" vessel design to a Westinghouse "upflow" vessel design. Consequently, the WCAP-17788 methods and analysis results are provided for both configurations. Per Section 3.0 of the NRC Staff Review Guidance (Reference 4.3), it is necessary to confirm that SPS is within the key parameters of the WCAP-17788-P, Rev. 1 methods and analysis. Each of the key parameters is discussed below.

3.n.3 Fuel Design

SPS 1 and 2 currently use Westinghouse 15x15 Upgrade Fuel assemblies with Optimized ZIRLO™ cladding. SPS Unit 1 is currently irradiating Framatome AGORA-5A-I fuel lead test assemblies (LTAs). Consequently, the SPS in-vessel debris load was calculated for both Westinghouse 15x15 Upgrade Fuel and Framatome AGORA-5A-I fuel assemblies. The SPS core contains 157 fuel assemblies.

3.n.4 WCAP-17788 debris limit

As part of its Subsequent License Renewal (SLR) effort, SPS is planning to convert from a Westinghouse downflow barrel/baffle reactor vessel design to a Westinghouse upflow design to minimize baffle jetting issues. The potential design changes in vessel flow along with two different fuel product types result in four potential configurations and associated fibrous debris limits. As a result, SPS evaluated the following four scenarios against the Proprietary total in-vessel (core inlet and heated core) fibrous debris limits contained in WCAP-17788-P, Volume 1, Rev. 1, for Westinghouse fuel, and against Reference 4.11, Table 7-2, for Framatome fuel as noted below:

1. Downflow and Westinghouse fuel – (WCAP-17788-P, Volume 1, Rev. 1, Table 6-3)
2. Downflow and Framatome fuel – (Reference 4.11, Table 7-2)
3. Upflow and Westinghouse fuel – (WCAP-17788-P, Volume 1, Rev. 1, Table 6-3)
4. Upflow and Framatome fuel – (Reference 4.11, Table 7-2)

3.n.5 Methodology Used to Calculate the Fibrous Debris Amounts

The amount of fibrous debris calculated to arrive at the reactor vessel was determined for SPS following the method described in WCAP-17788-P, Volume 1, Rev. 1, Section 6.5. Specifically, an engineering calculation was performed to determine the core inlet fibrous debris load for the Hot Leg Break (HLB) for SPS 1 and 2. The calculation included the following design inputs and assumptions:

Design Inputs

1. Plant Type - The reactor vessel design for both SPS units is a Westinghouse downflow barrel/baffle reactor vessel design. Conversion of both units to an upflow design is being planned as a part of the SLR effort. Therefore, evaluations for both downflow and upflow configurations were performed.

2. Fuel Type, Vendor, and Number of Assemblies - The fuel type currently used at SPS is Westinghouse 15x15 Upgrade fuel. Framatome AGORA-5A-I fuel LTAs are currently being irradiated in SPS Unit 1. Therefore, evaluations for both Westinghouse 15x15 Upgrade fuel and Framatome AGORA-5A-I fuel assemblies were performed. Regardless of fuel assembly type, the SPS cores contain 157 fuel assemblies. Evaluations were performed for full cores of each type of fuel assembly and no mixed-core evaluations were performed as these types of core loadings would be bounded by the full core evaluations.

3. Core Thermal Power - The licensed core thermal power is 2587 MWt (MUR power level). However, most safety analyses are conducted at a core thermal power of 2597 MWt, which is 100.387% of the licensed core thermal power. This thermal power includes instrument uncertainty.

4. Initial Sump Fiber Load - The total fine mass at the LHSI and RS strainers including fines generated due to erosion is 142.46 lbm. Only the debris loading at the LHSI strainer is of concern, as the debris at this strainer may bypass the strainer and enter the reactor vessel. Debris loading at the RS strainer is neglected, as debris that bypasses the RS strainer does not reach the reactor vessel internals. The assumed debris loading of the LHSI strainers is 40% of the full debris loading at the LHSI/RS strainers. Therefore, the total debris loading used in the calculation is 56.98 lbm (= 142.46 lbm * 0.4). On a per fuel assembly basis, the initial sump fiber load is 164.62 g/FA (= [56.98 lbm * 453.592 g/lbm] / 157 assemblies).

5. Active Sump Volume - The active sump volume, also referred to as the active recirculation volume, is the volume of liquid in the containment sump which actively participates in the recirculation process. This volume acts as the system inventory when calculating the concentration of debris to be injected into the RCS. A conservatively low sump volume was used that accounts for potential holdup areas within containment.

6. Time of Sump Switch Over - The time of sump switchover (SSO), also known as sump recirculation activation or recirculation mode transfer (RMT), is the time at which fiber is injected into the reactor vessel. The minimum time of sump switchover is 30.3 minutes based on the RMT setpoint of 13.5% RWST level and accounting for instrument uncertainty.

7. Emergency Core Cooling System (ECCS) Flow Rates Following SSO - The ECCS flow rate after the time of SSO (i.e., during recirculation mode) is used to calculate the rate of fiber injection into the reactor vessel. Both minimum and maximum ECCS flow rates were analyzed. The minimum LHSI recirculation mode flow rate is 2900.4 gpm with one operable LHSI train. The maximum cold leg recirculation flow rate is 4100 gpm, assuming two operable trains.

8. Recirculation Spray System (RSS) Flow Rates Following SSO - For conservatism, RSS flow rates were set to zero gpm. This ensures all fiber not caught on the sump screen is injected into the reactor vessel.

9. Time of Hot Leg Switch Over (HLSO) - SPS Emergency Procedure 1/2-E-1 notes the transfer to hot leg recirculation must be completed within 9 hours post-LOCA.

10. Time Step - A time step of 100 seconds was used in the calculation for the iterative solution.

11. Time to Chemical Effects, t_{chem} - The time to chemical effects, t_{chem}, is the time at which chemical precipitates affect the formed debris bed. Per Table 4.4-1 of Reference 4.12, the time at which chemical effects affect the debris bed is 24 hours for SPS 1 and 2. Therefore, a maximum value of 24 hours was used in the calculation.

12. Maximum Core Inlet Resistance (K_{max}), Time for Core Inlet Blockage (t_{block}), Inlet Debris Limit, and In-Core Fiber Limit - K_{max} is the maximum core inlet resistance prior to complete core inlet blockage. The time for core inlet blockage, t_{block}, is the minimum acceptable time of complete core inlet blockage. As previously noted, SPS Unit 1 is currently irradiating AGORA-5A-I fuel LTAs, which is a Framatome fuel product. The Framatome products tested as a part of the GSI-191 testing program had the FUELGUARD debris filter. The AGORA-5A-I fuel design has the TRAPPER coarse mesh debris filter and was not part of the WCAP-17788-P testing program.

    Framatome performed an evaluation to determine acceptable core inlet fiber loads for the AGORA-5A-I assembly in Reference 4.11. Framatome expects the fiber limit for the AGORA-5A-I fuel product with the coarse mesh TRAPPER debris filter to lie between the debris limits for HTP fuel with the FUELGUARD debris filter and the GAIA fuel with the GRIP debris filter as noted in Reference 4.11, Table 7-2.

    As the core inlet debris limits for the TRAPPER coarse mesh filter cannot be determined without hydraulic testing, the more conservative limits for the GRIP filter were used for the TRAPPER coarse mesh filter in this analysis. Table 5 summarizes K_{max}, t_{block}, and core inlet debris limits for the various configurations.

TABLE 5: K_{max}, t_{block}, AND INLET DEBRIS LIMITS FOR VARIOUS CONFIGURATIONS/FUEL VENDORS

Configuration	Fuel Vendor	K_{max}	t_{block} (min)	Inlet Debris Limit (g/FA)
Downflow	Westinghouse	4.75×10^5	260	WCAP-17788-P, Vol. 1, Table 6-3
Downflow	Framatome [TRAPPER coarse mesh]			Ref. 4.11, Table 7-2
Upflow	Westinghouse	5.0×10^5	143	WCAP-17788-P, Vol. 1, Table 6-3
Upflow	Framatome [TRAPPER coarse mesh]			Ref. 4.11, Table 7-2

Note the values for K_{max} do not change for fuel type as they are a function of plant configuration, not fuel type/filter type.

13. Sump Strainer Bypass Fraction - Bypass fraction is defined as the portion of debris transported to the sump strainer that is not collected on the sump strainer, and instead penetrates through the sump strainer and into the reactor vessel through the ECCS. As noted in Table 4 above, a cumulative bypass percentage of 12.1% was calculated for the LHSI strainer for SPS.

14. Fuel Assembly Pitch - The fuel assembly pitch is the same for both Westinghouse 15x15 Upgrade Fuel and AGORA-5A-I fuel.

Assumptions

1. The fiber and particulate are well mixed in the sump fluid such that a homogeneous mixture is present at the time of sump recirculation. Therefore, the debris transport is proportional to ECCS flow rate.

2. No debris is held up in any location other than the sump strainer(s), core inlet, or within the core. Further, no settling of debris was credited in any location of the RCS. Therefore, the maximum amount of debris reaches the core.

3. Chemical precipitates were assumed to form at 24 hours.

4. The fiber is in its constituent form, i.e., individual fibers. This is consistent with maximum transport assumptions.

5. Westinghouse calculated an SPS-specific Alternate Flow Path (AFP) resistance due to the conversion of SPS 1 and 2 to upflow barrel/baffle reactor vessel design plants. The SPS-specific AFP resistance is less than the value analyzed in WCAP-17788-P, Volume 4; therefore, the SPS AFP resistance is bounded by the AFP resistance applied to 3-Loop Upflow designs in WCAP-17788-P, Volume 4. Regardless, AFPs are not credited in the SPS analysis. It is expected the debris bed at the core inlet will not be uniform due to the variations in flow velocities at the core inlet. Therefore, it will take more debris than determined by WCAP-17788-P to result in activation of the AFPs and redirection of some flow and debris to the heated core. Because of the non-physical nature of the assumption of a uniform debris bed (which remains conservative in other aspects), debris bypassing the core inlet and entering the heated core was not credited. Therefore, as further discussed below, the values for "M_{split}" in the calculation were set to zero.

6. It was assumed that no debris exits the break, i.e., once it is in the RCS, it stays in the RCS. Therefore, the maximum amount of debris reaches the core.

7. It was assumed that sump debris will build-up across the core inlet in a uniform manner, and blockage is only considered at the core inlet. This is a simplifying, conservative assumption.

Analysis

The design inputs and assumptions listed above were used in the core inlet debris fiber calculation based on the methodology outlined in WCAP-17788-P, Volume 1, Section 6.5.5.

WCAP-17788-P, Volume 1, Section 6.5.1 defines the HLB debris as the sum of the fiber that is captured at the core inlet and the in-core fiber:

$M_{f,\ HLB} = M_{f,\ CI} + M_{f,\ in\text{-}core}$

Where:

- $M_{f,\ HLB}$ is the total fiber mass for the hot leg break
- $M_{f,\ CI}$ is the mass of fiber at the core inlet
- $M_{f,\ in\text{-}core}$ is the mass of fiber in the heated core

The mass of fiber that reaches the heated core can travel through two paths, either the AFP or from the hot leg post-HLSO:

$M_{f,\ in\text{-}core} = M_{f,\ AFP} + M_{f,\ CE}$

Where:

- $M_{f,\ AFP}$ is the mass of fiber that reaches the core through the AFP, and
- $M_{f,\ CE}$ is the mass of fiber that reaches the core via the core exit (i.e., fiber injection post-HLSO)

The above quantities were determined iteratively at each time step. The calculation was terminated at the time at which the sump fiber load was less than or equal to 1% of the initial sump fiber load.

As noted above, AFPs were not credited in the analysis. Therefore, $M_{f,\ AFP}$ will always equal zero. If the termination criteria is reached before the time of HLSO, then $M_{f,\ CE}$ will also equal zero. If that is the case, then the $M_{f,\ in\text{-}core}$ term is zero, and the total mass of fiber for the HLB is simply the fiber at the core inlet.

Acceptance Criteria

The total core inlet fiber must be less than or equal to the core inlet fiber load limits included in WCAP-17788-P for Westinghouse fuel or Reference 4.11, Table 7-2 for Framatome AGORA-5A-I fuel.

3.n.6 Confirm 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

Using the design inputs and assumptions noted above, the fiber debris quantity calculation determined the total injected fiber amount is 19.72 g/FA for all four fuel configurations and fuel types. This value is less than the Proprietary in-vessel fibrous debris limits provided in Section 6.5 of WCAP-17788-P, Vol. 1, Rev. 1, for the Westinghouse fuel and reactor vessel flow configurations. However, the calculated Framatome AGORA-5A-I fuel core inlet fiber values are not bounded by the limits provided in Reference 4.11, Table 7-2, for Framatome downflow and upflow plant configurations.

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

The applicable core inlet fiber thresholds for Westinghouse 15x15 Upgrade Fuel and Framatome AGORA-5A-I fuel are provided in WCAP-17788-P, Rev. 1, Table 6-3, and Reference 4.11, Table 7-2, respectively. The core inlet fiber amount for SPS 1 and 2 was calculated to be 19.72 g/FA for the four potential configurations. This value is less than the Proprietary in-vessel fibrous debris limits provided in Section 6.5 of WCAP-17788-P, Vol. 1, Rev. 1, for Westinghouse fuel with downflow and upflow reactor vessel flow configurations. However, the Framatome AGORA-5A-I fuel core inlet fiber values are not bounded by the limits provided in Reference 4.11, Table 7-2, for Framatome downflow and upflow plants.

Per the NRC guidance provided in Reference 4.3, "licensees may justify that a non-uniform debris bed will form at the core inlet allowing adequate flow to assure LTCC, even though the average debris load per FA metric is exceeded." Following a LOCA, but before debris arrival, the flow rates across the core inlet are not uniform due in part to variations in the core power among the various assemblies. These variations set up the flow patterns prior to debris arrival. Flow is the highest in the high-power assemblies and somewhat lower in the average power assemblies. When debris begins to arrive, the core inlet flow patterns define where the debris first begins to accumulate. Debris laden fluid from the downcomer preferentially delivers debris to the higher power fuel assemblies. The clean water from the baffle and lower power core region dilutes the debris delivered to the average core. This flow pattern also tends to keep debris from the core periphery. As debris begins to accumulate on a subset of assemblies, debris laden fluid will begin to divert to adjacent assemblies without debris. For a fixed amount of debris, a distribution of debris will be established across the core inlet with thicker beds near the higher power assemblies and thinner beds near lower power assemblies at the core periphery, thereby resulting in a non-uniform debris bed in the core.

The debris accumulation discussed above is consistent with the discussion in the NRC

Review Guidance (Reference 4.3) and Technical Evaluation Report (Reference 4.13) and supports the buildup of debris to the core inlet fiber thresholds. The addition of debris beyond this threshold will tend to push the additional debris towards the assemblies with lower amounts of debris. At some point, enough debris will be added to the RCS that the resistance at the core inlet could be high enough to reverse the flow in the baffle region such that debris can bypass the core inlet and reach the heated core. As described in WCAP-17788-P, provided the total amount of fiber to the RCS remains less than or equal to the value provided in WCAP-17788-P, Section 6.5, LTCC will be assured. As shown in Tables 6 and 7, the total in-vessel fiber load is less than the value provided in WCAP-17788-P, Section 6.5, which assures LTCC. Therefore, use of Framatome AGORA-5A-I fuel in both upflow and downflow configurations is acceptable for SPS.

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

The earliest possible SSO time for SPS is 30.3 minutes based on the RMT setpoint of 13.5% RWST level and accounting for instrument uncertainty.

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 plant

Chemical precipitation timing is dependent on the plant buffer, sump pool pH, volume and temperature, and debris types and quantities. PWROG-16073 (Reference 4.12) identifies Test Group 16 as representative of SPS, and the predicted chemical precipitation timing (t_{chem}) is 24 hours.

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

SPS performs injection realignment to mitigate the potential for boric acid precipitation no later than 9 hours, which is less than 24 hours.

3.n.11 WCAP-17788 t_{block} value for the RCS design category

SPS is a Westinghouse 3-loop downflow vessel design. Based on WCAP-17788-P, Rev. 1, Volume 1, Table 6-1, t_{block} for SPS is 260 minutes. Should SPS convert to an upflow vessel design, the t_{block} value for SPS would be 143 minutes.

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

The earliest time of chemical precipitation for SPS was determined to be 24 hours, which is greater than the applicable t_{block} values of either 260 or 143 minutes.

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

The SPS licensed core thermal power is 2587 MWt (MUR power level). However, most safety analyses are conducted at a core thermal power of 2597 MWt, which is 100.387% of the licensed core thermal power. This thermal power includes instrument uncertainty.

The applicable analyzed thermal power provided in WCAP-17788-P, Rev. 1, Volume 4, Tables 6-1 and 6-2 is 3658 MWt for Upflow plants and 2951 MWt for Downflow plants, respectively. Therefore, the SPS rated thermal power is less than the analyzed power for both Upflow and Downflow configurations and is therefore bounded by the WCAP-17788-P, Rev. 1, alternate flow path analysis.

3.n.14 Plant alternate flow path (AFP) resistance compared to the analyzed AFP resistance for the plant RCS design category

AFP resistance is not credited for SPS Units 1 and 2. Nevertheless, an unadjusted AFP resistance was calculated for both the downflow and upflow barrel/baffle reactor vessel designs as noted in Tables 6 and 7, respectively. As seen in Table 6, the downflow unadjusted AFP resistance is unbounded for t_{block} analysis, which is the limiting AFP resistance. The SPS Units 1 and 2 downflow unadjusted AFP resistance is shown in WCAP-17788-P, Volume 4, Table RAI-4.2-24, which is greater than the analyzed value in WCAP-17788-P, Volume 4. PWROG-16073-P (Reference 4.12), Section 4.5.1.4, notes that margin between the core power level and the analyzed power level may be credited to offset the unbounded unadjusted AFP resistance. The maximum power level analyzed for Westinghouse downflow plants is 2951 MWt [WCAP-17788-P, Volume 4, Table 6-2]. The SPS core thermal power level including calorimetric uncertainty is 2597 MWt, a difference of 354 MWt (= 2951 MWt – 2597 MWt). As described in WCAP-17788-P, Volume 4, RAI 4.2, AFP resistance and core power are related. AFP resistance may be adjusted or scaled to account for differences in core power from the plant being analyzed and the WCAP-17788-P analyzed power level. The adjusted AFP resistance for SPS in Table RAI-4.2-24 is based on a thermal power of 2587 MWt, which does not account for calorimetric uncertainty. An adjusted AFP resistance may be calculated for the core power level including uncertainty (2597 MWt) using Equation RAI-4.2-22 for the downflow configuration:

$$\left(\frac{K}{A^2}\right)_{Surry\ Downflow\ Adjusted} = \left(\frac{K}{A^2}\right)_{Surry\ Downflow\ Unadjusted} * \frac{\left(P_{plant}\right)^2}{\left(P_{Downflow\ model}\right)^2}$$

The adjusted SPS downflow AFP resistance, 3363.95 ft^{-4}, is bounded by the WCAP-17788-P analyzed value.

Dominion Energy Virginia is planning to convert SPS 1 and 2 to an upflow barrel/baffle reactor vessel design as part of planned modifications in support of SLR. Consequently, an SPS-specific AFP resistance was also calculated for the barrel/baffle region to reflect the converted upflow plant configuration. As expected, the SPS-specific AFP resistance for the barrel/baffle region is similar to other Westinghouse 3-loop converted upflow plants provided in Table RAI-4.2-24 of WCAP-17788-P Volume 4, Rev. 1. The SPS-specific AFP resistance is less than the analyzed value; therefore, the Surry AFP resistance is bounded by the resistance applied to the 3-loop converted upflow AFP analysis.

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

AFP resistance is not credited for SPS 1 and 2. SPS 1 and 2 have downflow barrel/baffle reactor vessel design configurations. However, conversion to upflow barrel/baffle plants is planned in support of SLR. The AFP analysis for Westinghouse upflow and downflow plants analyzed a range of ECCS recirculation flow rates as shown in Tables 6-1 and 6-2, respectively, of WCAP-17788-P, Volume 4, Rev. 1. The minimum SPS ECCS recirculation flow rate analyzed is 18.47 gpm/FA. The SPS ECCS recirculation flow rate corresponding to the most limiting fiber injection hot leg break scenario is 26.11 gpm/FA. These flow rates are within the range of ECCS recirculation flow rates considered in the AFP analysis for both the upflow and downflow configurations.

3.n.16 Summary

The comparison of key parameters used in the WCAP-17788 analyses to the SPS specific values is summarized in Tables 6 and 7 for Westinghouse downflow and upflow configurations, respectively.

Table 6: WCAP-17788 Downflow Analysis Values vs. Surry Plant Values

Parameter	WCAP-17788 Value	Surry Value	Evaluation
Maximum Total In-Vessel Fiber Load [g/FA]	Volume 1, Section 6.5	< than the WCAP-17788 value	Maximum in-vessel fiber load is less than WCAP-17788 limit.
Maximum Core Inlet Fiber Load [g/FA]	Volume 1, Table 6-3	19.72	The core inlet fiber limits for Westinghouse fuel are bounded. The core inlet fiber limits for Framatome fuel are unbounded. See evaluation in Section 3.n.7 above for resolution.
Minimum Sump Switchover Time [min]	20	30.3	Later switchover time results in a lower decay heat at the time of debris arrival, reducing the potential for debris induced core uncovery and heatup.

Parameter	WCAP-17788 Value	Surry Value	Evaluation
Minimum Chemical Precipitate Time [hr]	2.4 (t_{block})	24 (t_{chem})	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})	9	Latest hot leg switchover occurs well before the earliest potential chemical product generation.
Rated Thermal Power [MWt]	2951	2597	Lower rated thermal power results in lower decay heat.
*Maximum AFP Resistance [ft^{-4}]	Volume 4, Table 6-2	WCAP-17788-P Volume 4, Table RAI-4.2-24	AFP resistance for Westinghouse downflow plants is unbounded. See evaluation in Section 3.n.14 above for disposition.
ECCS Recirculation Flow Rate [gpm/FA]	Volume 4, Table 6-2	26.11	SPS ECCS recirculation flow rate corresponding to the most limiting fiber injection hot leg break scenario is within the analyzed flow range.

* Reference 4.12, Page 4-11, states that the **unadjusted** AFP resistance should be compared to the analyzed value from WCAP-17788-P. Note the value selected for maximum AFP resistance corresponds to the maximum AFP resistance for the t_{block} analysis from WCAP-17788-P, Volume 4, Table RAI-4.2-24. This value was selected for comparison to the plant-specific AFP resistance as it is the more limiting maximum AFP resistance value.

Table 7: WCAP-17788 Upflow Analysis Values vs. Surry Plant Values

Parameter	WCAP-17788 Value	Surry Value	Evaluation
Maximum Total In-Vessel Fiber Load [g/FA]	Volume 1, Section 6.5	< than the WCAP-17788 value	Maximum in-vessel fiber load is less than WCAP-17788 limit.
Maximum Core Inlet Fiber Load [g/FA]	Volume 1, Table 6-3	19.72	The core inlet fiber limits for Westinghouse fuel are bounded. The core inlet fiber limits for Framatome fuel are unbounded. See evaluation provided in Section 3.n.7 above for disposition.
Minimum Sump Switchover Time [min]	20	30.3	Later switchover time results in a lower decay heat at the time of debris arrival, reducing the potential for debris induced core uncovery and heatup.
Minimum Chemical Precipitate Time [hr]	2.4 (t_{block})	24 (t_{chem})	Potential for complete core inlet blockage due to chemical product generation would occur much later than assumed.

Parameter	WCAP-17788 Value	Surry Value	Evaluation
Maximum Hot Leg Switchover Time [hr]	24 (t_{chem})	9	Latest hot leg switchover occurs well before the earliest potential chemical product generation.
Rated Thermal Power [MWt]	3658	2597	Lower rated thermal power results in lower decay heat.
*Maximum AFP Resistance [ft^{-4}]	Volume 4, Table 6-1	118.085	AFP resistance is less than the analyzed value, which increases the effectiveness of the AFP.
ECCS Recirculation Flow Rate [gpm/FA]	Volume 4, Table 6-1	26.11	SPS ECCS recirculation flow rate corresponding to the most limiting fiber injection hot leg break scenario is within the analyzed flow range.

* Reference 4.12, Page 4-11, states the **unadjusted** AFP resistance should be compared to the analyzed value from WCAP-17788-P.

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.

Dominion Energy Virginia Response:

The SPS chemical effects analysis of the sump strainers was submitted in Supplemental Response dated February 29, 2008, and supplemented on February 27, 2009, and December 17, 2009. The SPS sump strainer chemical effects analysis is unchanged.

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.

Dominion Energy Virginia Response:

Dominion Energy Virginia's February 29, 2008 supplemental response, as updated by letter dated February 27, 2009, discussed the licensing bases changes that had been implemented for SPS Units 1 and 2 associated with the resolution of the sump issues considered in GSI-191 and GL 2004-02 in the form of Updated Final Safety Analysis Report (UFSAR) revisions, analysis methodology changes, and license amendment requests. These changes are summarized below:

UFSAR

The SPS 1 and 2 UFSAR has been revised to reflect the installation of the new containment strainers for the RS and LHSI pumps, as well as the adoption and application of the GOTHIC code for containment analysis. An additional UFSAR change was made to establish the limit for the long-term containment sump pH to 9.0 from 9.5 at 77 °F to be consistent with the calculation of sump aluminum load.

Dominion Energy Virginia 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 SPS 1 and 2

Containment Analysis Methodology

The method for performing SPS containment analyses for analyzing the response to postulated pipe ruptures inside containment was changed by converting from the Stone and Webster LOCTIC computer code to the Generation of Thermal-Hydraulic Information for Containments (GOTHIC) code. In a letter dated November 1, 2005 (Serial No. 05-745) (ADAMS Accession No. ML053060266), Dominion submitted Topical Report DOM-NAF-3, "GOTHIC Methodology for Analyzing the Response to Postulated Pipe Ruptures Inside Containment," which documents the Dominion methodology for analyzing the containment response to postulated pipe ruptures using the GOTHIC code. The NRC approved Topical Report DOM-NAF-3 in a letter dated August 30, 2006 (ADAMS Accession No. ML062420511). SPS plant-specific applications of the DOM-NAF-3 methodology to effect GSI-191 changes associated with the RS pump start method and the containment air partial pressure operating limits, as noted below, were then implemented through the license amendment process.

License Amendment Requests

A number of license amendment requests have been approved by the NRC in support of the installation of the new strainers and the resolution of GSI-191 and NRC GL 2004-02 as follows:

1. SPS License Amendments 250/249 dated October 12, 2006 (ADAMS Accession No. ML062920499) approved the following items:
    - Revise the method for starting the IRS and ORS pumps in response to a design basis accident (DBA). Previously, the SPS RS pumps were started by delay timers that were initiated when the containment pressure reached the Consequence Limiting Safeguards (CLS) High-High containment pressure setpoint. The license amendment request changed the start of the RS pumps to the receipt of a CLS High-High pressure signal coincident with a refueling water storage tank (RWST) Level Low signal. The IRS pumps now receive an immediate start signal once the coincidence logic is satisfied, and the ORS pumps start following a timer delay of 120 seconds once the coincident logic is satisfied. This change ensures that adequate water volume is available to submerge the new containment sump strainer, prior to the pumps taking suction from the strainer, and meets the safety analysis acceptance criteria. The revised TS surveillance requirements verify that each RS pump automatically starts on a CLS High-High test signal coincident with the receipt of an RWST Level Low test signal and are consistent with Improved Standard Technical Specifications Change Traveler, TSTF-286-A, Revision 2 and NUREG 1431, "Westinghouse Owners Group Standard Technical Specifications," Revision 3, March 31, 2004. A plant modification associated with the license amendment request was required to install the new RS pump start circuitry.
    - Replace the LOCTIC containment analysis methodology for analyzing the response to postulated pipe ruptures inside containment, including loss of coolant accident (LOCA) and main steam line break (MSLB) events, with the NRC-approved GOTHIC evaluation methodology discussed in Dominion Topical Report DOM-NAF-3-0.0-P-A. The change to the GOTHIC code provides margin in LOCA peak containment pressure and other accident analysis results.
    - Increase the TS containment air partial pressure operating limits based on the GOTHIC containment analyses.
    - Revise the LOCA Alternate Source Term (AST) analysis to include the effects from changing the RS pump start methodology and from the other modifications associated with the GSI-191 project.

    Implementation of this change was completed during the fall 2006 refueling outage for SPS Unit 2 and during the fall 2007 refueling outage for SPS Unit 1.

2. SPS License Amendments 255/254 dated October 15, 2007 (ADAMS Accession No. ML072690396) revised the TS surveillance requirements related to inspection of the

containment sump trash racks and screens, IRS pump wells, and ORS and LHSI pump suction inlets. The new sump strainer design uses modular strainer assemblies and hard-piped connections for the RS and LHSI pumps to meet the new design requirements and eliminates the sump trash racks and screens. Therefore, the specific TS surveillance discussion associated with the inspection of the containment sump trash racks and screens, pump wells, and pump suction inlets was replaced with inspection requirements more appropriate to the new containment sump strainer design. Implementation of this change was completed for both units during the fall 2007 SPS Unit 1 refueling outage.

3. SPS License Amendments 256/255 dated November 15, 2007 (ADAMS Accession No. ML073120506) permit the use of an alternate GOTHIC containment analysis methodology to that previously approved. Specifically, the alternate GOTHIC containment analysis reduced certain overly conservative assumptions to more realistically, yet conservatively, address expected plant conditions in containment following a LOCA. The alternate method relaxed some of the conservatisms in the NPSH analysis methodology in Topical Report DOM-NAF-3-0.0-P-A. The alternate methodology was used to develop revised design inputs for the hydraulic analysis of the RS strainer during early RS pump operation after a LOCA. Implementation of this change was completed for both units during the fall 2007 SPS Unit 1 refueling outage.

4. SPS License Amendments 262/262 dated December 10, 2008. (ADAMS Accession No. ML082682183) deleted the Containment Spray (CS) and RS subsystem minimum flow values from the Design Features section of the Surry TS. These values are not required to be contained in the TS and were revised based on the containment analysis methodology changes that were implemented to resolve GSI-191 sump performance issues. The minimum flow requirements for the CS and RS systems are contained in the UFSAR.

4 References

4.1 NEI 04-07, Revision 0, "Pressurizer Water Reactor Sump Performance Evaluation Methodology," May 2004.

4.2 NRC SER for NEI 04-07, "Safety Evaluation by the Office of Nuclear Reactor Regulation Related to NRC Generic Letter 2004-02, Nuclear Energy Institute Guidance Report (Proposed Document Number NEI 04-07), 'Pressurized Water Reactor Sump Performance Evaluation Methodology'," dated December 6, 2004.

4.3 NRC Staff Review Guidance for In-Vessel Downstream Effects Supporting Review of Generic Letter 2004-02 Responses, ADAMS Accessions No. ML19228A011, September 2019.

4.4 AREVA Calculation 32-9201054-000; "PWR Strainer Fiber Bypass Length Distribution" (Framatome Proprietary).

4.5 AREVA Summary Test Report 66-9199574-000, "Fiber Bypass Size Characterization Test Report."

4.6 Alden Test Report 1142PBNBYP-R2-01, "Point Beach Large Scale Fibrous Debris Penetration Test Report."

4.7 Alden Calculation 1142PBNBYP-600-00, "Fibrous Debris Penetration Model for Point Beach Calculation."

4.8 NextEra Energy Point Beach Letter No. NRC 2017-0045; "Updated Final Response to NRC GL 2004-02," December 29, 2017.

4.9 NRC Document ML15320A087 – "Vogtle GSI-191 Resolution Plan and Current Status NRC Public Meeting," November 5, 2015.

4.10 Alden Test Report 1130VNPBYP-R2-00-NONQA "Vogtle Nuclear Plant Fiber Penetration Testing."

4.11 Framatome Calculation, FS1-0046625, Rev. 1, "GSI-191 In-Vessel Debris Limits for Framatome Fuel," March 2020 (Framatome Proprietary).

4.12 PWROG-16073-P, Rev. 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.

4.13 NRC Memorandum, ADAMS Accession No. ML19178A252, "Technical Evaluation Report of In-Vessel Debris Effects," June 2019.

4.14 WCAP-17788-P, Rev. 1, "Comprehensive Analysis and Test Program for GSI-191 Closure (PA-SEE-1090)," December 2019.

4.15 SU-CALC-MEC-SUR1-34325-AR-001, Rev. 7 w/Add. A and SU-CALC-MEC-SUR2-34325-AR-001, Rev. 5 w/Add. A