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L-24-094

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10 CFR 50 Appendix H

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

**Subject:**

Beaver Valley Power Station, Unit Nos. 1 and 2  
Docket No. 50-334, License No. DPR-66  
Docket No. 50-412, License No. NPF-73  
Reactor Vessel Surveillance Capsule Withdrawal Schedule

In accordance with 10 CFR 50 Appendix H, Section III, paragraph B.3, Vistra Operations Company LLC (VistraOps) requests approval of a modified reactor vessel surveillance capsule withdrawal schedule for Beaver Valley Power Station, Unit No. 2 (BVPS-2). Surveillance capsule A, which is comprised of previously irradiated Beaver Valley Power Station, Unit No. 1 (BVPS-1) surveillance materials, unirradiated BVPS-1 surveillance materials, and materials from the Fort Calhoun and St. Lucie surveillance programs, was installed in the BVPS-2 reactor vessel so that end of license extension fluence values would be accrued more efficiently. As a result, the withdrawal schedule for BVPS-1 surveillance capsule A is tracked on the BVPS-2 surveillance capsule withdrawal schedule. The VistraOps evaluation of the proposed change to the BVPS-2 reactor vessel surveillance capsule withdrawal schedule is attached.

VistraOps requests approval of the revised reactor vessel surveillance capsule withdrawal schedule by October 1, 2024 to support the withdrawal of a surveillance capsule scheduled to occur during the fall refueling outage (2024).

There are no regulatory commitments contained in this submittal. If there are any questions, or if additional information is required, please contact Mr. Jack Hicks, Senior Manager, Licensing, at (254) 897-6725 or [jack.hicks@luminant.com](mailto:jack.hicks@luminant.com).

Sincerely,

A handwritten signature in blue ink, appearing to read "Barry N. Blair". The signature is fluid and cursive, written over a light blue circular stamp or watermark.

Barry N. Blair

**Attachment:**

Evaluation of Proposed Changes to Beaver Valley Power Station, Unit No. 2, Reactor Vessel Surveillance Capsule Withdrawal Schedule

Beaver Valley Power Station, Unit Nos. 1 and 2

L-24-094

Page 2

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

Evaluation of Proposed Changes to Beaver Valley Power Station, Unit No. 2,  
Reactor Vessel Surveillance Capsule Withdrawal Schedule  
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## 1.0 SUMMARY DESCRIPTION

Pursuant to the surveillance program criteria of 10 CFR 50 Appendix H, "Reactor Vessel Material Surveillance Program Requirements," Section III, paragraph B.3, Vistra Operations Company LLC (VistraOps) is requesting approval of a proposed change to the Beaver Valley Power Station, Unit No. 2 (BVPS-2) reactor vessel material irradiation surveillance capsule withdrawal schedule. The request is also submitted to satisfy BVPS-2 renewed operating license condition 2.K, "Capsule Withdrawal Schedule," that states:

For the renewed operating license term, all capsules in the reactor vessel that are removed and tested must meet the test procedures and reporting requirements of American Society for Testing and Materials (ASTM) E 185-82 [Conducting Surveillance Tests for Light-Water Cooled Nuclear Power Reactor Vessels] to the extent practicable for the configuration of the specimens in the capsule. Any changes to the capsule withdrawal schedule, including spare capsules, must be approved by the NRC prior to implementation.

The BVPS-2 reactor vessel surveillance capsule withdrawal schedule will be revised to remove surveillance capsule A from the schedule. The proposed change to the reactor vessel surveillance capsule withdrawal schedule is consistent with the recommendations specified in ASTM E185-82 and the end-of-life capsule withdrawal requirements in NUREG-1801, Revision 2, "Generic Aging Lessons Learned (GALL) Report," Section XI.M31, "Reactor Vessel Surveillance."

## 2.0 REQUIREMENTS

10 CFR 50 Appendix H, requires nuclear power plant licensees to implement reactor vessel surveillance programs to "monitor changes in the fracture toughness properties of ferritic materials in the reactor vessel beltline region...which result from exposure of these materials to neutron irradiation and the thermal environment." 10 CFR 50 Appendix H, Section III, paragraph B.1 states in part that the design of the surveillance program and the withdrawal schedule must meet the requirements of the edition of the ASTM E185 that is current on the issue date of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) to which the reactor vessel was purchased. The rule permits the use of later editions of ASTM E185, but including only those editions through 1982 (that is, ASTM E185-82).

10 CFR 50 Appendix H, Section III, paragraph B.3, requires prior Nuclear Regulatory Commission (NRC) approval of a proposed reactor vessel surveillance capsule withdrawal schedule prior to implementation. NRC Administrative Letter 97-04, "NRC Staff Approval for Changes to 10 CFR 50, Appendix H, Reactor Vessel Surveillance Specimen Withdrawal Schedules," dated September 30, 1997, specifies that changes to reactor vessel surveillance capsule withdrawal schedules that do not conform to ASTM E185 require approval by the

license amendment process, whereas changes that conform to the ASTM standard require only staff verification of such conformance. The proposed change to the BVPS-2 surveillance capsule withdrawal schedule conforms to ASTM E185-82, and therefore, a license amendment is not required for this proposed change.

### 3.0 PROPOSED CHANGES

The current surveillance capsule withdrawal schedule and the proposed modified schedule are provided below.

The current BVPS-2 Updated Final Safety Analysis Report (UFSAR) Table 5.3-6, "Reactor Vessel Material Irradiation Surveillance Schedule," is as follows:

<b>Capsule</b>	<b>Capsule Location</b>	<b>Lead Factor</b>	<b>Withdrawal EFPY<sup>(1)</sup></b>	<b>Fluence (n/cm<sup>2</sup>, E &gt; 1.0 MeV)</b>
U	343°	2.95	1.25 EFPY (EOC 1)	0.610 x 10 <sup>19</sup>
V	107°	3.41	6.00 EFPY (EOC 5)	2.62 x 10 <sup>19</sup>
W	110°	3.12	9.85 EFPY (EOC 8)	3.68 x 10 <sup>19</sup>
X	287°	3.45	14.02 EFPY (EOC 11)	5.58 x 10 <sup>19</sup>
Y	290°	2.97	26.46 EFPY (EOC 20)	8.97 x 10 <sup>19</sup>
Z	340°	2.86	Standby <sup>(2)</sup>	---
A	107°	2.21	32 <sup>(3)</sup>	---

Notes:

1. Effective full-power years (EFPY) from plant startup. End-of-cycle (EOC).
2. Capsule Z should remain in the reactor to provide fluence monitoring or future testing.
3. Supplemental Capsule A contains Beaver Valley Unit 1 initially unirradiated material specimens, as well as previously irradiated material specimens from Beaver Valley Unit 1, St. Lucie, and Fort Calhoun. Supplemental Capsule A was inserted in the vacant Capsule V location at the end of Cycle 8. In order to be consistent with the "Materials Reliability Program: Coordinated PWR Reactor Vessel Surveillance Program (CRVSP) Guidelines (MRP-326)" recommendation, Capsule A is to be removed and tested when it reaches a fluence value equivalent to the peak 80-year vessel fluence for Beaver Valley Unit 1. This is expected to occur at approximately 32 EFPY.

The proposed BVPS-2 surveillance capsule withdrawal schedule is as follows:

Capsule	Capsule Location	Lead Factor	Withdrawal EFPY <sup>(1)</sup>	Fluence (n/cm <sup>2</sup> , E > 1.0 MeV)
U	343°	2.95	1.25 EFPY (EOC 1)	0.610 x 10 <sup>19</sup>
V	107°	3.41	6.00 EFPY (EOC 5)	2.62 x 10 <sup>19</sup>
W	110°	3.12	9.85 EFPY (EOC 8)	3.68 x 10 <sup>19</sup>
X	287°	3.45	14.02 EFPY (EOC 11)	5.58 x 10 <sup>19</sup>
Y	290°	2.97	26.46 EFPY (EOC 20)	8.97 x 10 <sup>19</sup>
Z	340°	2.86	Standby <sup>(2)</sup>	---

Notes:

1. Effective full-power years (EFPY) from plant startup. End-of-cycle (EOC).
2. Capsule Z should remain in the reactor to provide fluence monitoring or future testing.

#### 4.0 TECHNICAL EVALUATION

In 1996, a pressurized thermal shock (PTS) evaluation of the Beaver Valley Power Station, Unit No. 1 (BVPS-1) beltline plate material was performed that identified that the end of license BVPS-1 reference temperature for pressurized thermal shock (RTPTS) values were approaching the current PTS screening criteria identified in 10 CFR 50.61. As a result of this evaluation, the decision was made to broaden the fracture toughness data set to be used in future surveillance evaluations. This increase in the data set was accomplished by assembling surveillance capsule A, which is comprised of previously irradiated BVPS-1 surveillance materials, unirradiated BVPS-1 surveillance materials, and materials from the Fort Calhoun and St. Lucie surveillance programs.

Because the capsule lead factors are significantly higher in the BVPS-2 reactor vessel than they are in the BVPS-1 reactor vessel, and since the inlet temperature is approximately the same at BVPS-2 as it is at BVPS-1, supplemental capsule A was installed in the BVPS-2 reactor vessel so that end of license extension fluence values would be accrued more efficiently. As a result, the withdrawal schedule for BVPS-1 surveillance capsule A is tracked on the BVPS-2 surveillance capsule withdrawal schedule.

The current BVPS-2 surveillance capsule withdrawal schedule was approved by the NRC in a safety evaluation dated July 17, 2014 (ML13242A266).

Since the BVPS-1 PTS concern was identified in 1996, additional evaluation identified that the limiting BVPS-1 reactor vessel beltline material is not as brittle as originally anticipated. In a safety evaluation dated July 2, 2018 (ML18164A082), the NRC approved revised RTPTS

values for BVPS-1. The revised RTPTS values were calculated using revised unirradiated nil-ductility reference temperature (RTNDT) values that were calculated in accordance with ASME Code, Subarticle NB-2331, paragraph (a)(4). The revised BVPS-1 RTPTS values meet the PTS screening criteria identified in 10 CFR 50.61 through the end of the renewed operating license. Because this additional evaluation has identified that the BVPS-1 reactor vessel beltline material is not as brittle as originally anticipated, the PTS concern that surveillance capsule A was designed to alleviate is no longer applicable to BVPS-1 and it is no longer necessary to test surveillance capsule A.

Regarding the proposed removal of surveillance capsule A from the BVPS-2 capsule withdrawal schedule, compliance with the requirements of 10 CFR 50, Appendix H; 10 CFR 50, Appendix G; and 10 CFR 50.61 for the BVPS-1 60-year life were evaluated as described below.

#### 10 CFR 50, Appendix H

The underlying purpose of 10 CFR 50, Appendix H, is to monitor changes in the fracture toughness properties of ferritic materials from exposure to neutron irradiation and the thermal environment in the reactor vessel beltline region of light-water nuclear power reactors. The fracture toughness data obtained from the material surveillance program is subsequently used to assess the integrity of the reactor vessel.

With respect to the reactor vessel surveillance program, 10 CFR 50 Appendix H, Section III, paragraph B, requires in part that the design of the surveillance program and the withdrawal schedule must meet the requirements of the edition of the ASTM E185 that is current on the issue date of the ASME Code to which the reactor vessel was purchased. For reactor vessels purchased in or before 1982, later editions of ASTM E185 may be used, but including only those editions through 1982. This requirement is applicable to the original 40-year license period for BVPS-1.

For the period of extended operation, Section XI.M31 of NUREG-1801, Revision 2, provides guidance regarding reactor vessel surveillance programs, including recommended capsule withdrawal schedules.

Supplemental capsule A is not required to meet the requirements of ASTM E185-82 for the original 40-year license period nor NUREG-1801 Section XI.M31 for the period of extended operation.

For BVPS-1, Westinghouse Report WCAP-18102-NP, Revision 2, identifies that the change in the reference temperature of the limiting material at 50 effective full power years (EFPY) (60-year end-of-life) is greater than 200°F. For reactor vessels that are in this category, ASTM E185-82 recommends that for the original 40-year plant license term, a minimum of five capsules are to be withdrawn, with the final capsule having a fluence of between one and two times the projected end-of-life fluence of the reactor vessel.

Five of the eight BVPS-1 reactor vessel surveillance capsules (V, U, W, Y, and X) have been withdrawn and tested. Capsule X was withdrawn at the end of cycle 22, meeting the

surveillance capsule withdrawal requirements for the original 40-year end of life that are defined in the 1982 edition of ASTM E185. The most recently withdrawn surveillance capsule (capsule X) was irradiated to a fluence level approximately equal to 42.24 EFPY of plant operation (linearly interpolated from WCAP-18102 Table 2-5).

A sixth BVPS-1 surveillance capsule (capsule Z) is scheduled to be withdrawn after 39 EFPY, which corresponds to the peak vessel fluence at the end of the 60-year license renewal period,  $5.89 \times 10^{19}$  n/cm<sup>2</sup> (E > 1.0 MeV). This meets the end-of-life capsule withdrawal requirements contained in NUREG-1801, Section XI.M31.

Even without the mechanical testing of surveillance capsule A, the neutron fluence exposure of the BVPS-1 reactor vessel will be bounded by the fluence level of the most recently tested surveillance capsule. The current analysis of record for BVPS-1 reactor vessel integrity, WCAP-18102-NP, Revision 2, utilizes the surveillance capsule X data that bounds the projected peak fluence value for the BVPS-1 reactor vessel through a projected 42.24 EFPY of plant operation. In accordance with the NRC-approved surveillance capsule withdrawal schedule, capsule Z will be withdrawn and tested at 39 EFPY of plant operation, and the BVPS-1 analysis of record for reactor vessel integrity will be updated to incorporate the results of surveillance capsule Z. At the withdrawal date, the capsule Z fluence will bound the projected peak reactor vessel fluence at the end of the 60-year license renewal period for BVPS-1.

In addition to the in-vessel capsules, neutron fluence at BVPS-1 is also monitored through the use of an ex-vessel neutron dosimetry (EVND) system. In accordance with ASTM E2956-14, "Standard Guide for Monitoring the Neutron Exposure of LWR Reactor Pressure Vessels," the BVPS-1 ex-vessel neutron dosimetry is replaced and analyzed every five refueling cycles. The results of the EVND analyses are evaluated against the current fluence projections to identify significant differences between the measured and projected values. The BVPS-1 EVND was last removed and replaced during the spring 2021 refueling outage.

Therefore, it is concluded that the capsule withdrawal requirements of ASTM E185-82 have been met for BVPS-1 through the end of its 40-year life, and that the capsule withdrawal requirements of NUREG-1801 Section XI.M31 will be met for BVPS-1 for the 60-year life, without the testing of surveillance capsule A.

The fracture toughness data obtained from the material surveillance program that is required by 10 CFR 50 Appendix H is subsequently used to assess the integrity of the reactor vessel as required by 10 CFR 50 Appendix G and 10 CFR 50.61. Since the withdrawal and testing of surveillance capsule A is not needed to meet the requirements of 10 CFR 50 Appendix H or NUREG-1801, it is concluded that the testing of surveillance capsule A is not needed to meet the requirements of 10 CFR 50 Appendix G or 10 CFR 50.61. The following discussion identifies that the requirements of 10 CFR 50 Appendix G and 10 CFR 50.61 will continue to be met even without the mechanical testing of surveillance capsule A.

## Appendix G to 10 CFR 50

The underlying purpose of Appendix G to 10 CFR 50 is to provide an acceptable margin of safety against brittle failure of the reactor coolant system during any condition of normal operation to which the pressure boundary may be subjected over its service lifetime.

### Appendix G to 10 CFR 50 – Upper-Shelf Energy (USE)

10 CFR 50 Appendix G requires that Charpy upper shelf energy must account for the effects of neutron radiation. Specifically, 10 CFR 50 Appendix G.IV.A.1.a requires that reactor vessel beltline materials “must maintain Charpy upper-shelf energy throughout the life of the vessel of no less than 50 ft-lb (68 J)....”

The BVPS-1 USE values are documented in Westinghouse letter LTR-SDA-17-017, Revision 0, which utilizes material properties taken from WCAP-18102-NP. The BVPS-1 USE values are determined for both the beltline and extended beltline materials at 50 EFPY (which bounds the expected fluence levels at the end of the period of extended operation). LTR-SDA-17-017 identifies that the USE values for all the extended beltline materials will be maintained at no less than 50 ft-lb through the remainder of the 60-year life at BVPS-1. With respect to USE, the limiting BVPS-1 plate material (for plate B6903-1) uses surveillance data (Position 2.2 in Regulatory Guide (RG) 1.99, Revision 2). Section 2.2 of RG 1.99 identifies that USE determined from surveillance data should be used in preference to USE determined using Position 1.2 of RG 1.99, Revision 2.

Additionally, in accordance with the NRC-approved surveillance capsule withdrawal schedule, BVPS-1 surveillance capsule Z will be withdrawn after 39 EFPY, and the USE evaluation will be updated in accordance with BVPS-1 Technical Specification 5.6.4. The fluence exposure of capsule Z will bound the fluence received by the BVPS-1 reactor vessel at the end of the 60-year license renewal period ( $5.89 \times 10^{19}$  n/cm<sup>2</sup>).

Since all the BVPS-1 reactor vessel materials are projected to meet the 10 CFR 50 Appendix G USE criteria through the end of the 50-year life, and since surveillance capsule Z will provide surveillance data that bounds the reactor vessel fluence at the end of the 60-year life, it is concluded that the Charpy USE requirements of 10 CFR 50 Appendix G are met for BVPS-1 without the testing and analysis of supplemental capsule A.

### Appendix G to 10 CFR 50 – Pressure-Temperature Limits

10 CFR 50 Appendix G requires that for reactor vessel beltline materials, the values of RTNDT must account for the effects of neutron radiation, including the results of the surveillance program of Appendix H. Specifically, Appendix G requires that pressure and temperature limits must be established for the reactor coolant pressure boundary during normal and hydrostatic or leak rate testing conditions.

The current BVPS-1 pressure and temperature (P-T) limits are applicable through 50 EFPY (end of license extension) and are documented in the BVPS-1 pressure and temperature limits



report (PTLR). The latest revision to the BVPS-1 PTLR incorporated the results of the surveillance capsule X analysis. The P-T limit curves generated are based on the limiting cylindrical beltline material (lower shell plate B6903-1). WCAP-18102-NP, Revision 2, provides the technical basis for the current BVPS-1 P-T limits. Table 7-2 and Table 7-3 of WCAP-18102-NP, Revision 2, document the adjusted RTNDT values for the BVPS-1 P-T limits. Note (d) of Table 7-2 and Note (d) of Table 7-3 identify that the adjusted reference temperature (ART) values were calculated in accordance with the methodology contained in RG 1.99, Revision 2, and therefore account for the effects of neutron irradiation as required by 10 CFR 50 Appendix G.

Future updates to the BVPS-1 PTLR must be performed in accordance with Technical Specification 5.6.4, which requires that all PTLR updates must be performed in accordance with the methodology identified in WCAP-14040-A, Revision 4. Section 2.4 of WCAP-14040-A, Revision 4, identifies that the adjusted reference temperature for each material in the beltline region is calculated in accordance with RG 1.99, Revision 2. It is therefore concluded that all future PTLR updates for BVPS-1 (including surveillance capsule Z at 39 EFPY) will account for the effects of neutron irradiation as required by 10 CFR 50 Appendix G without the testing of supplemental surveillance capsule A. BVPS Technical Specification 5.6.4 provides the necessary administrative controls to ensure that any required pressure and temperature limit changes will be implemented in accordance with approved methodology, such that the requirements for P-T limits in Appendix G are satisfied.

#### 10 CFR 50.61

The underlying purpose of 10 CFR 50.61 is to prevent potential failure of the reactor vessel as a result of PTS.

10 CFR 50.61 requires in part that the RTPTS values for the reactor vessel beltline materials using the end-of-life fluence values must be less than 270°F for plates, forgings, and axial weld materials, and less than 300°F for circumferential weld materials.

The current BVPS-1 RTPTS values are documented in Appendix E of WCAP-18102-NP, Revision 2. All the BVPS-1 reactor vessel beltline materials remain below the 10 CFR 50.61 screening criteria through the end of the 60-year license renewal period. The NRC reviewed and approved the RTPTS values contained in Revision 1 of WCAP-18102-NP in a safety evaluation dated July 2, 2018 (ML18164A082). There were no changes made to Appendix E between Revision 1 and Revision 2 of WCAP-18102-NP. It is therefore concluded that the RTPTS values for the BVPS-1 beltline materials are compliant with the requirements of 10 CFR 50.61 through the end of the license renewal period. Not performing the mechanical testing of capsule A will not affect the validity of the BVPS-1 RTPTS values.

Additionally, the limiting BVPS-1 beltline material (lower shell plate B6903-1) has 11.9 degrees of margin to the 10 CFR 50.61 screening criterion for RTPTS. RTPTS values are updated when surveillance capsules are withdrawn and analyzed because the projected fluence values used to calculate RTPTS are updated to account for actual fluence exposure from historical plant operation. When BVPS-1 surveillance capsule Z is withdrawn and tested in approximately 2027, the RTPTS values will also be updated based on historical plant

operation. It is anticipated that the updated RTPTS values will not significantly differ from the projected BVPS-1 RTPTS values. Therefore, it is expected that the BVPS-1 RTPTS values will remain below the 10 CFR 50.61 screening criteria even after the surveillance capsule Z testing and analysis.

## 5.0 CONCLUSION

The proposed surveillance capsule schedule change (removal of surveillance capsule A from the BVPS-2 surveillance capsule withdrawal schedule) is acceptable because BVPS-1 will remain compliant with 10 CFR 50 Appendix H, ASTM E185-82, and NUREG-1801 Section XI.M31. The surveillance capsule testing and withdrawal requirements of 10 CFR 50 Appendix H are met without the mechanical testing of surveillance capsule A, and therefore the actions after capsule withdrawal and testing that are defined in 10 CFR 50 Appendix G and 10 CFR 50.61 will also be met without the mechanical testing of surveillance capsule A. Current USE and P-T limits remain applicable and appropriate for use at BVPS-1 through the end of the 60-year license renewal period. Due to the additional evaluation that was documented in ML18164A082, the PTS concern that initiated the development of supplemental capsule A is no longer applicable for the BVPS-1 60-year license renewal period, and it is no longer necessary to test surveillance capsule A. It is concluded that surveillance capsule A can be removed from the BVPS-2 surveillance capsule withdrawal schedule.

## 6.0 REFERENCES

1. Westinghouse Report WCAP-18102-NP, Revision 2, "Beaver Valley Unit 1 Heatup and Cooldown Limit Curves for Normal Operation," March 2021 [ML21113A044].
2. Electric Power Research Institute, "Materials Reliability Program: Coordinated PWR Reactor Vessel Surveillance Program (CVRSP) Guidelines (MRP-326, Revision 1)," June 2021.
3. Letter from Robert G. Schaaf (NRC) to Eric A. Larson (FirstEnergy Nuclear Operating Company), "Beaver Valley Power Station, Units 1 and 2 – Revision to Reactor Vessel Surveillance Capsule Withdrawal Schedule," July 17, 2014 [ML13242A266].
4. ASTM E185-82, "Standard Practice for Conducting Surveillance Tests for Light-Water Cooled Nuclear Power Reactor Vessels, E 706."
5. NUREG-1801, Revision 2, "Generic Aging Lessons Learned (GALL) Report," December 2010 [ML103490041].
6. ASTM E2956-14, "Standard Guide for Monitoring the Neutron Exposure of LWR Reactor Pressure Vessels."
7. Westinghouse Letter LTR-SDA-17-017, Revision 0, "Beaver Valley Unit 1 Upper-Shelf Energy Values," November 16, 2017.

8. Westinghouse Report WCAP-14040-A, Revision 4, "Methodology Used to Develop Code Overpressure Mitigating System Setpoints and RCS Heatup and Cooldown Limit Curves," May 2004 [ML050120209].