



UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

January 18, 2024

Mr. James Barstow
Vice President, Nuclear Regulatory
Affairs and Support Services
Tennessee Valley Authority
1101 Market Street, LP 4A-C
Chattanooga, TN 37402-2801

SUBJECT: WATTS BAR NUCLEAR PLANT, UNITS 1 AND 2 – REVISION TO THE
REACTOR VESSEL MATERIAL SURVEILLANCE CAPSULE WITHDRAWAL
SCHEDULE (EPID L-2023-LLA-0039)

Dear Mr. Barstow:

By letter dated March 20, 2023, the Tennessee Valley Authority (TVA) submitted a license amendment request (LAR) to the U.S. Nuclear Regulatory Commission (NRC) to increase the number of tritium producing burnable absorber rods at Watts Bar Nuclear Plant (Watts Bar), Units 1 and 2. The LAR also included a request for staff review and approval for a revision to the reactor vessel material surveillance capsule withdrawal schedule for Watts Bar, Units 1 and 2. The revised schedule was submitted in accordance with Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, Appendix H, "Reactor Vessel Material Surveillance Program Requirements," III.B.3. TVA concluded that the proposed withdrawal schedule revision meets the criteria in American Society for Testing and Materials (ASTM) E-185-82, "Standard Practice for Conducting Surveillance Tests for Light-Water Cooled Nuclear Power Reactor Vessels," and therefore, does not require a license amendment.

The NRC staff has reviewed TVA's withdrawal schedule revision request and concludes, as set forth in the enclosed safety evaluation, that the modified surveillance capsule withdrawal schedules for Watts Bar, Units 1 and 2, are acceptable for implementation and satisfy the requirements of Appendix H to 10 CFR Part 50 and ASTM E185-82.

Sincerely,

David J. Wrona, Chief
Plant Licensing Branch II-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. 50-390 and 50-391

Enclosure: Safety Evaluation

cc: Listserv



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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO REVISION TO REACTOR VESSEL SURVEILLANCE CAPSULE

REMOVAL SCHEDULE FOR

TENNESSEE VALLEY AUTHORITY

WATTS BAR NUCLEAR PLANT, UNITS 1 AND 2

DOCKET NOS. 50-390 AND 50-391

1.0 INTRODUCTION

By letter dated March 20, 2023 (Agencywide Documents Access and Management System Accession No. ML23079A270), Tennessee Valley Authority (TVA, the licensee) submitted a license amendment request (LAR) to revise Watts Bar Nuclear Plant (Watts Bar or WBN), Units 1 and 2, Technical Specification (TS) 4.2.1, "Fuel Assemblies," to change the number of tritium producing burnable absorber rods (TPBARs) that can be irradiated from 1,792 TPBARs to 2,496 TPBARs for each unit. Additionally, this LAR also proposed a supporting change to Watts Bar, Units 1 and 2, TS 5.9.6, "Reactor Coolant System (RCS) Pressure and Temperature Limits Report (PTLR)."

As a result of this LAR, the licensee stated that a revision to the capsule withdrawal schedule for Watts Bar, Units 1 and 2, is required due to the updated plant-specific neutron fluence that was addressed as part of the LAR. Thus, TVA requested revision of the reactor vessel material surveillance capsule withdrawal schedule for Watts Bar, Units 1 and 2, in accordance with Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," Appendix H, "Reactor Vessel Material Surveillance Program Requirements," Section III.B.3.

2.0 REGULATORY EVALUATION

The regulations and guidance relevant to this request are given below.

Section I of Appendix H to 10 CFR Part 50, which states, in part:

The purpose of the [reactor vessel] material surveillance program required by this appendix is to monitor changes in the fracture toughness properties of ferritic materials in the reactor vessel beltline region of light water nuclear power reactors which result from exposure of these materials to neutron irradiation and

the thermal environment. Under the program, fracture toughness test data are obtained from material specimens exposed in surveillance capsules, which are withdrawn periodically from the reactor vessel.

Section III.B.1 of Appendix H to 10 CFR Part 50, which states, in part:

The design of the surveillance program and the withdrawal schedule must meet the requirements of the edition of the ASTM E 185 that is current on the issue date of the ASME code [American Society of Mechanical Engineers *Boiler and Pressure Vessel Code*] to which the reactor vessel was purchased; for reactor vessels purchased after 1982, the design of the surveillance program and the withdrawal schedule must meet the requirements of ASTM E 185-82. For reactor vessels purchased in or before 1982, later editions of ASTM E 185 may be used, but including only those editions through 1982.

Section III.B.3 of Appendix H to 10 CFR Part 50, which states:

A proposed withdrawal schedule must be submitted with a technical justification as specified in §50.4. The proposed schedule must be approved prior to implementation.

The U.S. Nuclear Regulatory Commission (NRC, the Commission) Administrative Letter 97-04, "NRC Staff Approval for Changes to 10 CFR Part 50, Appendix H, Reactor Vessel Surveillance Specimen Withdrawal Schedules" (ML031210296), states, in part:

The Commission found that while 10 CFR Part 50, Appendix H II.B.3 requires prior NRC approval for all withdrawal schedule changes, only certain changes require license amendments as the process to be followed for such approval. Specifically, those changes that do not conform to the ASTM standard referenced in Appendix H (ASTM E-185, "Standard Practice for Conducting Surveillance Tests for Light-Water Cooled Nuclear Power Reactor Vessels") will require approval by the license amendment process, whereas changes that conform to the ASTM standard require only staff verification of such conformance.

NUREG-1801, Revision 2, "Generic Aging Lessons Learned (GALL) Report" (ML103490041), which lists generic aging management reviews of systems, structures, and components (SSCs) that may be in the scope of license renewal and identifies aging management programs that are determined to be acceptable to manage aging effects of these SSCs.

3.0 TECHNICAL EVALUATION

3.1 Licensee's Proposal for Watts Bar, Unit 1

In the TPBAR LAR, the licensee provided Table 4.3-3, "Proposed Revision to the WBN Unit 1 Surveillance Capsule Removal Schedule." The licensee explained that the changes to the withdrawal schedule for Capsule V is necessary due to the plant-specific neutron fluence that was addressed as part of the LAR. Specifically, the licensee proposed to withdraw Capsule V after 24.1 effective full-power years (EFPY) of plant operation with a predicted capsule fluence of 5.44×10^{19} neutrons per square centimeter (n/cm²).

3.2 NRC Staff Review for Watts Bar, Unit 1

Watts Bar Updated Final Safety Analysis Report (UFSAR) section 5.2.4.3 indicates that the Watts Bar, Unit 1, Irradiation Surveillance Program conforms with ASTM E-185-82, "Recommended Practice for Surveillance Tests for Nuclear Reactor Vessels," and 10 CFR Part 50, Appendix H.

The licensee provided updates to the capsule lead factor, removal time, and capsule fluence for previously withdrawn and tested surveillance capsules (i.e., Capsules U, W, X, and Z) based on the updated plant-specific evaluation (i.e., WCAP-18769-NP, Revision 1, "Watts Bar Units 1 & 2 Reactor Vessel Integrity Evaluations for the 2496 TPBAR Implementation Project") that was submitted with the LAR. The NRC staff finds these updates related to capsule lead factor, removal time and capsule fluence for the U, W, X, and Z capsules to be acceptable because they are associated with refined fluence evaluations that impact surveillance capsules that have already been withdrawn and tested in accordance with an approved capsule withdrawal schedule, and the testing results have been previously reported in accordance with Appendix H to 10 CFR Part 50.

As of September 2023, the licensee has withdrawn and tested a total of four surveillance capsules (i.e., Capsules U, W, X, and Z) for Watts Bar, Unit 1. The test results from the latest withdrawn surveillance capsule (i.e., Capsule Z) are documented in WCAP-16760, Revision 0, "Analysis of Capsule Z from the Tennessee Valley Authority, Watts Bar Unit 1 Reactor Vessel Radiation Surveillance Program," dated November 2007 (ML073200241). This report indicates that the calculated neutron fluence at the vessel inner radius at the end of 40 years of plant operation (i.e., 32 EFPY) is 1.75×10^{19} n/cm². Per Revision 13 of the Watts Bar, Unit 1, Pressure and Temperature Limits Report (PTLR), Capsule Z received a neutron fluence of 2.40×10^{19} n/cm² after an irradiation time of 9.37 EFPY. In the case of a four-capsule withdrawal schedule, Table 1 of ASTM E185-82 indicates that the fourth capsule be removed at a time when the neutron fluence projected for the capsule is between the limiting fluence value projected for the reactor vessel at end-of-licensed plant life (i.e., 40 years of operation) but not greater than two times that value. The NRC staff noted that the withdrawal and testing of Capsule Z fulfilled the requirements for this fourth capsule specified by Table 1 of ASTM E185-82 for the current operating license period (i.e., 40 years).

Based on a review of the surveillance capsules that have already been withdrawn and tested for Watts Bar, Unit 1, the NRC staff notes that withdrawing additional capsules are not needed to satisfy the requirements of Appendix H to 10 CFR Part 50 and ASTM E 185-82 for the current operating license period (i.e., 40 years). As such, the licensee's compliance with Appendix H to 10 CFR Part 50 and ASTM E 185-82 with respect to the current operating license period for Watts Bar, Unit 1, forms no part of the NRC staff's evaluation of the licensee's proposed revision to the withdrawal schedule for surveillance Capsule V, which is discussed below.

Given that there is the potential for the licensee to pursue license renewal in the future for Watts Bar, the NRC staff understands the requested revision of the reactor vessel material surveillance capsule withdrawal schedule for Watts Bar, Unit 1, to be proactively addressing surveillance data needs to support the potential for pursuit of license renewal and, therefore, addresses the request based on this understanding.

The NRC staff notes that NUREG-1801, Revision 2, provides the recommendation of aging management programs that the staff determined are adequate for the period of extended operation. Specifically, NUREG-1801, Revision 2, section XI.M31, "Reactor Vessel

Surveillance,” recommends that the “program withdraws one capsule at an outage in which the capsule receives a neutron fluence of between one and two times the peak reactor vessel wall neutron fluence at the end of the period of extended operation.”

In its submittal, the licensee stated that the projected maximum neutron fluence calculated for the potential license renewal period (i.e., 48 EFPY) at Watts Bar, Unit 1, is 2.73×10^{19} n/cm² (E>1 MeV). The NRC staff notes that the proposed withdrawal of surveillance Capsule V with a removal time of 24.1 EFPY would equate to Capsule V being exposed to a neutron fluence of 5.44×10^{19} n/cm² (i.e., ~1.99 times the maximum fluence expectations for 60 years of operation), which is consistent with the recommendations in Section XI.M31 of NUREG-1801, Revision 2.

The proposed revised withdrawal schedule for surveillance Capsule V accomplishes addressing (1) the underlying purpose of Appendix H to 10 CFR Part 50 (i.e., monitor changes in the fracture toughness properties of the reactor pressure vessel), and (2) recommendations in NUREG-1801, Revision 2, for the period of extended operation (i.e., 60 years). Therefore, the NRC staff finds that the licensee’s proposed revised withdrawal schedule for surveillance Capsule V is acceptable. The NRC staff concludes that the withdrawal and testing of surveillance Capsule V supplements the requirements of the reactor vessel material surveillance program for the current license period at Watts Bar, Unit 1. The NRC staff notes that a report containing the test results for surveillance Capsule V must be reported to the NRC within 18 months of the capsule withdrawal in accordance with Section IV.A of Appendix H to 10 CFR Part 50.

3.3 Licensee’s Proposal for Watts Bar, Unit 2

In the LAR, the licensee provided Table 4.3-4, “Proposed Revision to the WBN Unit 2 Surveillance Capsule Removal Schedule.” The licensee explained that the changes to the withdrawal schedule for Capsules W and X are necessary due to the plant-specific neutron fluence that was addressed as part of the LAR. Specifically, the licensee proposed to withdraw Capsule W after 6.8 EFPY of operation with an expected capsule neutron fluence of 1.93×10^{19} n/cm², and Capsule X between 6.8 EFPY and 13.8 EFPY of operation with an expected neutron fluence of 1.93×10^{19} n/cm² to 3.86×10^{19} n/cm².

3.4 NRC Staff Review for Watts Bar, Unit 2

Watts Bar UFSAR section 5.2.4.3 indicates that the Watts Bar, Unit 2 Irradiation Surveillance Program conforms with ASTM E-185-82 and 10 CFR Part 50, Appendix H.

ASTM E185-82 establishes the criteria for determining the minimum number of capsules that are to be removed in accordance with a withdrawal schedule and the number of capsules that are to be tested. The intent of the standard is to obtain a set of test data over a range of neutron fluences for the reactor vessel that bounds the current licensed operation of the plant. Table 1 of ASTM E185-82 recommends that a minimum of three, four, or five surveillance capsules be removed from the vessels, based on the limiting amount of RT_{NDT} shift (limiting Δ RT_{NDT}) that is projected to occur at the clad-vessel interface location of the reactor vessel at the end-of-licensed plant life.

Table 1 of ASTM E185-82 also provides specific criteria for removal of surveillance capsules. The removal times are based on criteria that the surveillance capsules be removed after a certain amount of power operation has elapsed or at various times when the reactor vessel shell

is projected to achieve certain levels of neutron fluence. For plants with projected RT_{NDT} shifts (i.e., ΔRT_{NDT}) less than 100 degrees Fahrenheit (56 degrees Celsius), three capsules are to be removed from the reactor vessel, and at least the first two capsules are expected to be tested (for dosimetry, tensile-ductility, Charpy-V impact toughness, and alloying chemistry). With respect to the current operating term, the Watts Bar Unit 2 reactor vessel has a limiting ΔRT_{NDT} value less than 100 degrees Fahrenheit.

In the case of a three-capsule withdrawal schedule, as is the case for Watts Bar, Unit 2, Table 1 of ASTM E185-82 recommends that the first capsule be scheduled for withdrawal at 6 EFPY or at the time when the accumulated neutron fluence of the capsule exceeds 0.50×10^{19} n/cm², whichever comes first. The first capsule (Capsule U) was withdrawn at approximately 2 EFPY, when the fluence reached 0.5×10^{19} n/cm², in accordance with ASTM E185-82. The test results from Capsule U are documented in WCAP-18518, Revision 0, "Analysis of Capsule U from the Watts Bar Unit 2 Reactor Vessel Radiation Surveillance Program" (ML20107F717).

In the case of a three-capsule withdrawal schedule, Table 1 of ASTM E185-82 indicates that the second capsule be scheduled for withdrawal at 15 EFPY or at a time when the accumulated neutron fluence of the capsule corresponds to the approximate end of license fluence (i.e., 40 years of operation) at the reactor vessel inner wall location, whichever comes first. For Watts Bar, Unit 2, the neutron fluence corresponding to 32 EFPY (i.e., 40 years of operation) at the reactor vessel inner wall location calculated by licensee is projected to 1.93×10^{19} n/cm², as documented in the LAR. In order to comply with ASTM E185-82, the licensee proposed that Capsule W be withdrawn at the refueling outage nearest to but following 6.8 EFPY of operation in order to achieve a neutron fluence of 1.93×10^{19} n/cm². The NRC staff finds the proposed withdrawal schedule change for Capsule W to be acceptable because it is consistent with Table 1 of ASTM E185-82 for the second capsule in a three-capsule surveillance program. The staff noted that the withdrawal of Capsule Z as backup to Capsule W was previously determined to be acceptable in an NRC safety evaluation dated November 14, 2022 (ML22293A408), because the composition, thermal exposure, and projected neutron fluence for the two capsules are equivalent. The staff's conclusion regarding Capsule Z serving as a backup for Capsule W continues to remain valid.

In the case of a three-capsule withdrawal schedule, Table 1 of ASTM E185-82 indicates that the third capsule be removed at a time when the neutron fluence projected for the capsule is between the limiting fluence value projected for the reactor vessel at end of license (i.e., 40 years of operation), but not greater than two times that value. In order to comply with ASTM E185-82, the licensee proposed that Capsule X be withdrawn between 6.8 EFPY and 13.8 EFPY of operation in order to achieve a neutron fluence of 1.93×10^{19} n/cm² to 3.86×10^{19} n/cm². The NRC staff finds the proposed withdrawal schedule change for Capsule X to be acceptable because it is consistent with Table 1 of ASTM E185-82 for the third capsule in a three-capsule surveillance program.

4.0 CONCLUSION

Based on the above evaluation, the NRC staff concludes that the proposed revised surveillance capsule withdrawal schedule for surveillance Capsule V for Watts Bar, Unit 1 to be tested following its withdrawal after 24.1 EFPY of plant operation with a capsule fluence of 5.44×10^{19} n/cm² is acceptable; therefore, the NRC staff approves this surveillance capsule withdrawal schedule. However, the NRC staff does not make any conclusion regarding the future use of the subject capsule in any potential future licensing applications or license periods.

Based on the above evaluation, the NRC staff also concludes that the proposed and revised surveillance capsule withdrawal schedule for (1) surveillance Capsule W for Watts Bar, Unit 2 to be tested following its withdrawal after 6.8 EFPY of operation with an expected capsule neutron fluence of 1.93×10^{19} n/cm² and (2) surveillance Capsule X for Watts Bar, Unit 2 to be tested following its withdrawal between 6.8 EFPY and 13.8 EFPY of operation in order to achieve a neutron fluence of 1.93×10^{19} n/cm² to 3.86×10^{19} n/cm² is acceptable; therefore, the NRC staff approves this surveillance capsule withdrawal schedule because the proposed withdrawal schedule is consistent with ASTM E185-82. Additionally, the staff's conclusion and approval, as documented in safety evaluation dated November 14, 2022 (ML22293A408), that the designation of Capsule Z as a backup to Capsule W remains valid due to the composition, thermal exposure, and projected neutron fluence for these two capsules being equivalent.

Principal Contributors: E. Haywood, NRR
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Date: January 18, 2024

SUBJECT: WATTS BAR NUCLEAR PLANT, UNITS 1 AND 2 – REVISION TO THE REACTOR VESSEL MATERIAL SURVEILLANCE CAPSULE WITHDRAWAL SCHEDULE (EPID L-2023-LLA-0039) DATED JANUARY 18, 2024

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