

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

TOPICAL REPORT (TR) BAW-1543 REVISION 4, SUPPLEMENT 7,

“SUPPLEMENT TO THE MASTER INTEGRATED REACTOR VESSEL

SURVEILLANCE PROGRAM”

PRESSURIZED WATER REACTOR OWNERS GROUP

PROJECT NO. 694

1.0 INTRODUCTION AND BACKGROUND

By letter dated January 23, 2015 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML15033A086), and supplemented by letter dated August 4, 2016 (ADAMS Accession No. ML17256A514), the Pressurized Water Reactor (PWR) Owners Group (PWROG), submitted for U.S. Nuclear Regulatory Commission (NRC) approval, Technical Report BAW-1543, Revision 4, Supplement 7, "Supplement to the Master Integrated Reactor Vessel Surveillance Program." The revisions contained in this supplement address changes to surveillance capsule withdrawal schedules. BAW-1543, Revision 4, Supplement 7, reported the essential features of the Master Integrated Reactor Vessel Surveillance Program (MIRVP) for all operating Babcock and Wilcox (B&W) 177-fuel assembly (FA) plants and those participating Westinghouse Electric Company (Westinghouse) plants having B&W-fabricated reactor vessels (RVs). These RVs include seven B&W-designed 177-FA plants and six Westinghouse designed plants with B&W-fabricated RVs. The program was built upon the integrated surveillance program (ISP) developed by the B&W Owner's Group (B&WOG) for the B&W 177-FA plants. All 13 reactors are of the same basic design concept: PWR, operating at about 550° F and 2250 pounds per square inch (psi) nominal inlet temperature and pressure, and with low enrichment fuel (approximately 2 to 4 percent enrichment).

The irradiation schedules for the MIRVP include the plant-specific capsules, supplementary weld metal surveillance capsules and higher neutron fluence supplementary weld metal surveillance capsules. All the irradiations, with the exception of Capsule W1 and the Westinghouse plant-specific capsules, are performed in the B&W host reactors, Crystal River, Unit 3 and Davis-Besse. The Westinghouse plant-specific capsules are irradiated in their respective plants. Capsule W1, of Westinghouse design, was irradiated in Surry, Unit 2. This capsule was created to provide a comparison between the effects of the irradiation environments on the test data between the Westinghouse-designed and the B&W-designed RVs to determine whether the data could be used interchangeably between the designs.

The MIRVP is an ISP that was developed to include all PWRs in the United States that contain Linde 80 submerged-arc welds. NRC staff found that the ISP criteria, as provided by Appendix H to Title 10 to the *Code of Federal Regulations* (10 CFR), Part 50, "Reactor Vessel Material Surveillance Program Requirements," were met for the MIRVP. Highlights of changes between the NRC-approved revisions to the MIRVP include:

- By letter dated June 11, 1991, BAW-1543, Revision 3, was approved for use by the NRC.
- BAW-1543, Revision 4, was the same as the approved Revision 3 with the exception of updated withdrawal schedules for some units.

- BAW-1543, Revision 4, Supplement 1, contained quantitative information which was, in general, neutron fluence dependent and, therefore, subject to change. This revision reflected revised neutron fluence values for some units and revised some withdrawal schedules to comply with the 1973 Edition of American Society for Testing and Materials (ASTM) Standard E 185, "Standard Recommended Practice for Surveillance Tests for Nuclear Reactor Vessels" (ASTM E 185-73). It was anticipated that future updates to BAW-1543(NP) would only involve changes to the Revision 4 Supplement.
- BAW-1543(NP), Revision 4, Supplement 2, reflected the revised neutron fluence values and the revised withdrawal schedules.
- Revising BAW-1543, Revision 4, Supplement 2 with Revision 4, Supplement 3, the B&WOG deleted Rancho Seco, Ginna, and Zion, Units 1 and 2, from the program. In addition, the B&WOG updated the surveillance capsule status and the peak end-of-license neutron fluences for several plants.
- In BAW-1543, Revision 4, Supplement 4, the B&WOG incorporated the disposal plan for stored capsules, updated the status for various capsules, and incorporated current neutron fluence levels.
- BAW-1543, Revision 4, Supplement 5 modified the previous supplement to include a commitment regarding Capsules OC1-D and OC3-F; however, that commitment could not be met because these capsules could not be removed from Crystal River, Unit 3. The NRC staff approved the revised withdrawal schedules for Oconee, Units 1, 2, and 3, and Three Mile Island, Unit 1, in this submittal.
- BAW-1543, Revision 4, Supplement 6 reflecting updates that were made to neutron fluence values and to the surveillance capsule withdrawal schedules.

PWROG submitted BAW-1543, Revision 4, Supplement 7, which reflects a change in status of surveillance capsules A2 and A4 to "withdrawal not planned" and a change in status of surveillance capsule TE1-C to "withdrawn and tested."

2.0 REGULATORY REQUIREMENTS

The nuclear power plant licensees are required by Appendix H to 10 CFR Part 50 to implement RV material 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." Two specific alternatives are provided with regard to the design of a facility's RV surveillance program which may be used to address the requirements of Appendix H to 10 CFR Part 50. The first alternative is the implementation of a plant-specific RV surveillance program consistent with the requirements of ASTM E-185, "Standard Practice for Conducting Surveillance Tests for Light-Water Cooled Nuclear Power Reactor Vessels." In the design of a plant-specific RV surveillance program, a licensee may use the edition of ASTM E-185 that was current on the issue date of the American Society of Mechanical Engineers Code to which the RV was purchased, or later editions through the 1982 edition. The second alternative provided in Appendix H to 10 CFR Part 50 is the implementation of an ISP. An ISP is defined in Appendix H to 10 CFR Part 50 as occurring when, "the representative materials chosen for surveillance for a reactor are irradiated in one or more other reactors that have similar design and operating features."

3.0 TECHNICAL EVALUATION

3.1 Changes to Capsule TE1-C

Table 1-6, "Summary Status of the B&W Surveillance Capsules," and Table 1-7, "Summary Status of the Westinghouse Surveillance Capsules," of BAW-1543, Revision 4, Supplement 7, summarizes the status of the MIRVP ISP and plant-specific surveillance capsules. In this submittal, Table 1-6 was revised to reflect a change in status of Capsule TE1-C to withdrawn and tested. Appendix H to 10 CFR Part 50 requires that within one year of capsule withdrawal, the test results must be submitted to the NRC in a technical summary report. In BAW-1543, Revision 4, Supplement 6, Capsule TE1-C was identified as "removed, will be disposed." By letter dated March 17, 2000, the B&WOG Reactor Vessel Working Group informed the NRC staff of its plans to begin the disposal of all B&W plant-specific and intact B&W standby capsules. The letter stated that the existing B&W plant-specific standby capsules either did not contain weld materials or were not expected to contribute significantly to the Linde 80-weld metal surveillance database.

The Davis-Besse capsule, TE1-C, was in storage and was part of the disposal plan. This capsule was a standby capsule in the Davis-Besse Appendix H program for the original operating period. However, as a result of license renewal activities, the status of capsule TE1-C was changed from standby to being scheduled for withdrawal and testing to meet the recommendations in the aging management program of the Generic Aging Lessons Learned (GALL) Report. The Davis-Besse renewed operating license was received on December 8, 2015, and cited the following Appendix H summary technical report: AREVA report ANP-3339, Revision 0, "Davis-Besse Unit 1 Reactor Vessel Material Surveillance Program: Analysis of Capsule TE1-C." Therefore, the staff has concluded that revision to Table 1-6 for the change in status for Capsule TE1-C was accurate and consistent with the requirements of Appendix H to 10 CFR Part 50.

3.2 Changes to Capsules A2 and A4

BAW-1543, Revision 4, Supplement 6, Table VI, "Summary Status of the B&W Surveillance Capsules," stated that the withdrawal of Capsules A2 and A4 were scheduled for the end of cycle 29 at a target neutron fluence of 6.6×10^{19} n/cm² (neutrons/centimeter squared) for each capsule. The scheduled capsule withdrawals in Table 1-3, "Capsule Insertion and Withdrawal Schedule for Crystal River Unit 3," and Table 1-7 of BAW-1543, Revision 4, Supplement 7, for Capsules A2 and A4 were revised from "end of twenty-ninth cycle" to "withdrawal not planned."

A staff request for additional information (RAI) regarding Capsules A2 and A4 was necessary to complete review of the submittal. Specifically, the NRC staff requested a list of the materials contained in Capsules A2 and A4; identification of other ISP plants with the same weld material heat numbers as the surveillance capsule materials; and a description of how the proposed revision to change the status of these capsules to "withdrawal not planned" will continue to meet the objectives of MIRVP through the period of extended operation.

By letter dated August 4, 2016, the PWROG responded with details regarding the MIRVP. There are a total of eight HUPCAP supplemental capsules in the program, which includes Capsules A2 and A4. Table 2-1 identifies the Linde 80 weld metals that are in Capsules A2 and A4.

**Table 2-1
Linde 80 Weld Metals Included in the MIRVP Supplemental A2 and A4 Capsules**

Capsule	Linde 80 Weld ID	Weld Wire Heat	Capsule	Linde 80 Weld ID	Weld Wire Heat
A2	SA-1101	71249	A4	WF-25	299L44
	SA-1135	61782		WF-67	72442
	SA-1526	299L44		WF-70	72105
	SA-1585	72445		---	---

Table 2-2 identified a listing of the plants participating in the MIRVP with reactor vessel beltline weld materials containing the same weld wire heats found in the MIRVP Capsules A2 and A4 listed in Table 2-1.

Table 2-2

Plants Participating in the MIRVP with Reactor Vessel Beltline Welds Containing the Same Weld Wire Heats Found in MIRVP Supplemental A2 and A4 Capsules

Weld Wire Heat	Linde 80 Weld ID	Reactor Vessel Containing Linde 80 Beltline Weld
61782	SA-847 SA-1135	R.E. Ginna, Point Beach Unit 1 Oconee Unit 1
71249	SA-1101 SA-1229	R.E. Ginna, Point Beach Unit 1, Turkey Point Unit 3, Turkey Point Unit 4 Oconee Unit 1
72105	WF-70	Oconee Unit 3, Three Mile Island Unit 1, Turkey Point Unit 4
72442	SA-1484 WF-67	Point Beach Unit 2, Turkey Point Unit 3 Oconee Unit 3, Turkey Point Unit 4
72445	SA-1585 SA-1650	Oconee Unit 1, Surry Unit 1, Surry Unit 2 Surry Unit 1
299L44	SA-1526 WF-25	Surry Unit 1, Three Mile Island Unit 1 Oconee Unit 1, Oconee Unit 2, Three Mile Island Unit 1

Table 2-3 identified alternate sources of Linde 80 surveillance weld metals with the same weld wire heats as the weld metals included in Capsules A2 and A4.

Table 2-3

Alternate Sources of Linde 80 Surveillance Weld Metals with Weld Wire Heats Included in MIRVP Supplemental Capsules A2 and A4

Weld Wire Heat	Linde 80 Weld ID	Alternate Source Reactor Vessel Surveillance Programs (RVSP)
61782	SA-1036	R.E. Ginna Plant-Specific RSVP
72445	SA-1263	Point Beach Unit 1 Plant-Specific RVSP
71249 72442	SA-1101 WF-67	Supplemental Capsule "A" for Point Beach Unit 1 & Unit 2 (Installed in Point Beach Unit 2)
299L44	SA-1526	Surry Unit 1 Plant-Specific RVSP
71249	SA-1101	Turkey Point Unit 3 Plant-Specific RVSP (Note 1)
71249	SA-1094	Turkey Point Unit 4 Plant-Specific RVSP
299L44 72442 72105	WF-25 WF-67 WF-70	MIRVP Supplemental Capsules A1 & L2 Irradiated in Davis-Besse (Note 2)

Note 1: Turkey Point Unit 3 plant-specific Capsules T, V, and X contain the Linde 80 weld metal. As documented in Table 1-8 of BAW-1543, Revision 4, Supplement 7, these three (3) capsules have been removed and tested.

Note 2: MIRVP Supplemental Capsules A1 & L2 contain the same weld metals as MIRVP Supplemental Capsule A4.

In BAW-1543, Revision 4, Supplement 7, the PWROG compared the projected 60-year neutron fluences for the MIRVP member plants to available data for the Linde 80 weld metals. Table 1, "Minimum Recommended Number of Surveillance Capsules and Their Withdrawal Schedule," in ASTM E185-82 is applicable for 32 effective full-power years (EFPY), which corresponds to the original licensed period of 40 years of operation. For the period of extended operation, from 40 to 60 years, the GALL Report (Section XI.M31) states, "The plant-specific or integrated surveillance program shall have at least one capsule with a projected neutron fluence equal to or exceeding the 60-year peak reactor vessel wall neutron fluence prior to the end of the period of extended operation. 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 and tests the capsule in accordance with the requirements of ASTM E 185-82." The GALL report also addresses alternative dosimetry for plants without in-vessel capsules (which contain dosimetry). All the Westinghouse-designed plants participating in the MIRVP have in-vessel capsules, and therefore do not need to address ex-vessel dosimetry. The B&W-designed plants have ex-vessel dosimetry in place. Therefore, the dosimetry aspects of the MIRVP surveillance programs are consistent with the GALL report and are adequate for the period of extended operation.

In addition to dosimetry, surveillance programs monitor changes in fracture toughness of the ferritic beltline materials through the periodic testing of the test specimens in the surveillance capsules. In the RAI response, the PWROG stated that the, "expectation of the time of

withdrawal and target neutron fluence of the MIRVP Capsules A2 and A4 was selected to generate irradiated high copper Linde 80 weld metal data at a neutron fluence level to support license extension beyond 40-years for the Westinghouse-designed plants with RVs containing high copper Linde 80 weld metals.” The PWROG noted that, “The B&W-designed plants also have B&W-fabricated reactor vessels that contain high copper Linde 80 weld metals; however these reactor vessels are expected to reach much lower fluences than the Westinghouse-designed plants at end of license (EOL), thus the data from the MIRVP capsules A2 and A4 is not useful to the B&W-fabricated plants (i.e., the data would be greater than two (2) times the expected 60-year fluences).”

The Westinghouse plants in the MIRVP have plant-specific reactor vessel material surveillance programs. The plant-specific surveillance programs at the Point Beach, Units 1 and 2 are the only Westinghouse units that identify Capsules A2 and A4 as part of their RV material surveillance programs. MIRVP Capsule A2 contains Linde 80 weld wire heat numbers 61782 and 71249, which are also found in the Point Beach, Unit 1 beltline; MIRVP Capsule A4 contains Linde 80 weld wire heat number 72442, which is in the Point Beach, Unit 2 reactor vessel beltline. Staff reviewed the availability of other capsules with matching heat numbers to those contained in Capsules A2 and A4 and identified the following:

- Weld wire heat number 61782 is included in the R. E. Ginna Nuclear Power Plant (Ginna) plant-specific Appendix H program,
- Weld wire heat number 71249 is included in the Point Beach, Unit 1 and Point Beach, Unit 2 plant-specific Capsule A, Turkey Point, Unit 3 and Turkey Point, Unit 4 plant-specific surveillance programs, and
- Weld wire heat number 72442 is included in the Point Beach, Unit 1 and Point Beach, Unit 2 plant-specific Capsule A.

Based on the current withdrawal schedules, the Point Beach, Unit 1 and Point Beach, Unit 2 plant-specific Capsule A and Turkey Point, Unit 4 plant-specific Capsule X are scheduled to be withdrawn at 43 EFPY ($\sim 5.07E19$ n/cm²) and 38.1 EFPY ($\sim 9.297E19$ n/cm²) respectively.

High neutron fluence capsule test data for weld wire heat 61782 is currently available from the Ginna Capsule N. The PWROG indicated that these capsules are expected to have neutron fluences similar to (or exceeding) that of the neutron fluence at the planned withdrawal time reported in BAW-1543, Revision 4, Supplement 6-A for the MIRVP Capsules A2 and A4. Therefore, the NRC staff finds that the withdrawal and testing of these surveillance capsules provides the necessary data to support Appendix H programs for Point Beach, Unit 1 and Point Beach, Unit 2 through the period of extended operation and adequately replaces the testing of Capsules A2 and A4. The PWROG further states, “To provide clear direction on when the Westinghouse plant-specific RVSP capsules are to be removed, Table 1-7 of BAW-1543, Revision 4, Supplement 7 will be updated to reflect the target withdrawal EFPY of the remaining capsules, consistent with the current NRC accepted withdrawal schedules.”

Therefore, upon the aforementioned update of the target neutron fluences and corresponding EFPY for the remaining capsules, the NRC staff concludes that the weld heats in Capsules A2 and A4 exist in other MIRVP surveillance capsules and those data appropriately represent the materials in Capsules A2 and A4. In summary, the NRC staff finds that the change in status of Capsules A2 and A4 to “withdrawal not planned” is acceptable and consistent with the requirements of Appendix H to 10 CFR Part 50.

4.0 CONCLUSION

Based on its review of BAW-1543, Revision 4, Supplement 7, the NRC staff found that the updates to the MIRVP capsule withdrawal tables and the change in status for Capsules TE1-C, A2 and A4 are acceptable for the B&W-designed 177-FA plants and the Westinghouse-designed plants with B&W-fabricated reactor vessels. The NRC staff determined that BAW-1543, Revision 4, Supplement 7, including the update of Table 1-7 as described above, complies with Appendix H to 10 CFR Part 50. Therefore, the NRC staff approves the revisions contained in BAW-1543, Revision 4, Supplement 7.

5.0 REFERENCES

ASTM Standard E185-82, "Standard Practice for Conducting Surveillance Tests for Light-Water Cooled Nuclear Power Reactor Vessels," American Society for Testing and Materials, Philadelphia, Pennsylvania, 1982.

Code of Federal Regulations, Title 10, Part 50, Appendix H, Reactor Vessel Material Surveillance Program Requirements [60 FR 65476, Dec. 19, 1995; 68 FR 75390 Dec. 31, 2003; 73 FR 5723, Jan. 31, 2008].

U.S. Nuclear Regulatory Commission, NUREG-1801, Revision 2, "Generic Aging Lessons Learned (GALL) Report," dated December 2010 (ADAMS Accession No. ML103490041).

BAW-1543, Revision 4, Supplement 7, "Supplement to the Master Integrated Reactor Vessel Surveillance Program," dated January 23, 2015 (ADAMS Accession No. ML15033A087) (Proprietary).

Safety Evaluation BAW-1543(NP), Revision 4, Supplement 6, "Supplement to the Master Integrated Reactor Vessel Surveillance Program" (ADAMS Accession No. ML071770640).

Safety Evaluation BAW-1543(NP), Revision 4, Supplement 5, "Supplement to the Master Integrated Reactor Vessel Surveillance Program" (ADAMS Accession No. ML051380565).

Safety Evaluation BAW-1543(NP), Revision 4, Supplement 4, "Supplement to the Master Integrated Reactor Vessel Surveillance Program" (ADAMS Accession No. ML012880488).

Safety Evaluation BAW-1543(NP), Revision 4, Supplement 3, "Supplement to the Master Integrated Reactor Vessel Surveillance Program" (ADAMS Accession No. ML993190051).

Safety Evaluation BAW-1543(NP), Revision 4, Supplement 2, "Supplement to the Master Integrated Reactor Vessel Surveillance Program" (ADAMS Legacy Accession No. ML970750004).

BAW-1543(NP), Revision 4, Supplement 1, "Master Integrated Reactor Vessel Surveillance Program" (ADAMS Legacy Accession No. ML9302190137).

BAW-1543(NP), Revision 4, "Master Integrated Reactor Vessel Surveillance Program" (ADAMS Legacy Accession No. ML9608090073).

Safety Evaluation BAW-1543(NP), Revision 3, "Revision 3 to Master Integrated Reactor Vessel Surveillance Program" (ADAMS Legacy Accession No. ML9105140288).

AREVA report ANP-3339, Revision 0, "Davis-Besse Unit 1 Reactor Vessel Material Surveillance Program: Analysis of Capsule TE1-C (ADAMS Accession No. ML16224A240).

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