Enclosure 6 to SBK-L-15073

Non-Proprietary Class 3 Westinghouse Report (PWROG-14083-NP, Revision 1)
NextEra Energy, Seabrook Unit 1
Summary Report for Applicant/Licensee Action Items 1, 2, and 7

(Non-Proprietary)

PRESSURIZED WATER REACTOR OWNERS GROUP

PWROG-14083-NP
Revision 1

WESTINGHOUSE NON-PROPRIETARY CLASS 3

NextEra Energy, Seabrook Unit 1 Summary Report for Applicant/Licensee Action Items 1, 2, and 7

Materials Committee

PA-MSC-0983 Revision 0 Tasks 3, 4, and 5

May 2015

Westinghouse

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NextEra Energy, Seabrook Unit 1 Summary Report for Applicant/Licensee Action Items 1, 2, and 7

PA-MSC-0983 Revision 0 Tasks 3, 4, and 5

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1 PURPOSE AND BACKGROUND

The scope of this effort was authorized by NextEra Energy through (Pressurized Water Reactor Owner's Group [PWROG]) Project Authorization PA-MSC-0983, Revision 0, Tasks 3, 4, and 5.

NextEra Energy Seabrook has committed to develop a Reactor Vessel Internals Inspection Program for the Seabrook Unit 1 reactor vessel internals (RVI) listed in the License Renewal Application (LRA) [1]. As a result of the U.S. Nuclear Regulatory Commission (NRC) review of MRP-227, Revision 0 [2] and subsequent Safety Evaluation (SE), Revision 1, additional requirements have been specified in MRP-227-A [3].

These responses supporting demonstration of Seabrook Unit 1 compliance with the new requirements, specifically the Applicant/Licensee Action Items (A/LAI) 1, 2, and 7, per PA-MSC-0983, Tasks 3, 4, and 5 are in subsections 2.1, 2.2, and 2.3, respectively.

The NextEra Energy Seabrook response to requests for additional information (RAI) includes revised AMR items for reactor vessel internals (revised LRA Table 3.1.2-3) [12, Enclosure 3]. The table lists baffle-edge bolts, cast lower core support column bodies and a thermal shield; however, the Westinghouse records show that these components are not present in Seabrook Unit 1. Seabrook Unit 1 design does not include baffle–edge bolts; Seabrook Unit 1 design has wrought lower core support column bodies and neutron panels.

The response to A/LAI 7 addresses the susceptibility to thermal embrittlement of the Seabrook Unit 1 cast austenitic stainless steel (CASS) component, the lower internals assembly – bottom-mounted instrumentation (BMI) column assemblies, BMI column cruciforms. Based on data from certified material test reports and guidance for the application of Hull's formula [10], the ferrite content for each of the 26 cruciform castings was calculated. For customer information, the BMI column cruciforms have a minimum ferrite content of 5.5 percent, a maximum of 15.9 percent, and a mean ferrite content of 10.2 percent, where the mean is calculated using the 26 calculated ferrite content values as unique data points. Thus, the known ferrite content values for Seabrook Unit 1, BMI column cruciforms are well below the 20 percent threshold listed in [9, Table 2].

In response to customer comment and request, a material comparison table is in Attachment 1.

Revision 1 is to resolve customer comments on Revision 0.

2 SUPPORT FOR ADDRESSING MRP-227-A SAFETY EVALUATION A/LAI 1, 2, AND 7 FOR SEABROOK UNIT 1

2.1 A/LAI 1: APPLICABILITY OF FMECA AND FUNCTIONALITY ANALYSIS ASSUMPTIONS

The SE A/LAI 1: Applicability of FMECA and Functionality Analysis Assumptions text from MRP-227-A states:

"As addressed in Section 3.2.5.1 of this SE, each applicant/licensee is responsible for assessing its plant's design and operating history and demonstrating that the approved version of MRP-227 is applicable to the facility. Each applicant/licensee shall refer, in particular, to the assumptions regarding plant design and operating history made in the FMECA and functionality analyses for reactors of their design (i.e., Westinghouse, CE, or B&W) which support MRP-227 and describe the process used for determining plant-specific differences in the design of their RVI components or plant operating conditions, which result in different component inspection categories. The applicant/licensee shall submit this evaluation for NRC review and approval as part of its application to implement the approved version of MRP-227. This is Applicant/Licensee Action Item 1" [3].

Seabrook Unit 1 Response to A/LAI 1

The process used to provide reasonable assurance that the RVI components at Seabrook Unit 1 are reasonably represented by the generic industry program assumptions (with regard to neutron fluence, temperature, stress values, and materials used in the development of MRP-227-A) [3] is:

1. Identification of typical Westinghouse-designed pressurized water reactor (PWR) RVI components (MRP-191 [4, Table 4-4]).

2. Identification of Seabrook Unit 1 RVI components.

3. Comparison of the typical Westinghouse designed PWR RVI components to the Seabrook Unit 1 RVI components:

    a. Confirmation that no additional items were identified by this comparison (primarily supports A/LAI 2).

    b. Confirmation that the materials from MRP-191 [4, Table 4-4] are consistent with Seabrook Unit 1 RVI component materials.

    c. Confirmation that the design and fabrication of Seabrook Unit 1 RVI components are the same as, or equivalent to, the typical Westinghouse-designed PWR RVI components.

4. Confirmation that the Seabrook Unit 1 operating history is consistent with the assumptions in MRP-227-A [3] regarding core loading patterns and base load operation.

5. Confirmation that the Seabrook Unit 1 RVI materials operated at temperatures within the original design basis parameters.

6. Determination of stress values based on design basis documents.

7. Confirmation that any changes to the Seabrook Unit 1 RVI components do not impact the application of the MRP-227-A [3] generic aging management strategy.

The Seabrook Unit 1 RVI components are reasonably represented by the design and operating history assumptions regarding neutron fluence, temperature, materials, and stress values in the MRP-191 generic failure modes, effects, and criticality analysis (FMECA) [4], and in the MRP-232 [7] functionality analysis based on the following:

1. Seabrook Unit 1 operating history is consistent with the assumptions in MRP-227-A [3] with regard to neutron fluence and fuel management.

    a. The FMECA and functionality analysis for MRP-227-A [3] were based on the assumption of 30 years of operation with high-leakage core loading patterns, followed by 30 years of low-leakage core fuel management strategy. As stated in [6], Seabrook Unit 1 fuel management program changed from a high to a low-leakage core loading pattern prior to 30 years of operation. By operating with a low-leakage core design prior to 30 years, Seabrook Unit 1 meets the fluence and fuel management assumptions in MRP-191 and requirements for MRP-227-A application.

    b. Seabrook Unit 1 has always operated as a base load unit. Therefore, Seabrook Unit 1 satisfies the assumptions in MRP documents regarding operational parameters affecting fluence.

2. The Seabrook Unit 1 reactor coolant system operates between T_{cold} and T_{hot} [5]. T_{cold} is no lower than 537.7°F and T_{hot} is no higher than 621.4°F [5, Table 5.1-1]. The design temperature for the vessel is 650°F [5, Table 5.3-1]. Therefore, Seabrook Unit 1 operating history is within original design basis parameters and is consistent with the assumptions used to develop the MRP-227-A [3] aging management strategy with regard to temperature operational parameters.

3. As discussed below, the Seabrook Unit 1 RVI components and materials are comparable to the typical Westinghouse-designed PWR RVI components (MRP-191 [4, Table 4-4]).

   a. Components required to be in the Seabrook Unit 1 aging management program are consistent with those contained in MRP-191, Table 4-4 [4]. No additional components were identified for NextEra Energy Seabrook by this comparison.

   b. Seabrook Unit 1 RVI component materials are consistent with, or equivalent to, those materials identified in MRP-191 [4, Table 4-4] for Westinghouse-designed plants. Where differences exist, there is no impact on the Seabrook Unit 1 RVI program or the component is already credited as being managed under an alternate Seabrook Unit 1 aging management program.

   c. Design and fabrication of Seabrook Unit 1 RVI components are the same as, or equivalent to, the typical Westinghouse-designed PWR RVI components, with the exception that Seabrook Unit 1 utilizes a double-concentric thimble tube design fabricated from wear resistant, seamless nickel alloy material (INCONEL® 600).

4. Seabrook Station is a single unit, 1,295 net megawatts electric Westinghouse 4-loop pressurized water reactor with a turbine generator built by General Electric. Two power uprates have been implemented since initial commercial operation. In Cycle 11 (2004), the rated thermal power was increased to 3587 MWt, and in Cycle 12 (2006), the rated thermal power was increased to 3648 MWt [5].

   The original Alloy X-750 guide tube assembly split pins were replaced with cold worked 316 stainless steel (SS) in 2006. Therefore, modifications to the Seabrook Unit 1 RVI made over the lifetime of the plant are those specifically directed by the original equipment manufacturer (OEM). The OEM has developed or evaluated design changes and satisfied assumptions for A/LAI 1. The design has been maintained over the lifetime of the plant as specified by the OEM, operational parameters are compliant with MRP-227-A [3] requirements with regard to fluence and temperature, and the components are consistent with those considered in MRP-191 [4]. The materials for the components are consistent with those considered in MRP-191 [4]. Therefore, the Seabrook Unit 1 RVI stress values are represented by the assumptions in MRP-191 [4], MRP-227-A [3], and MRP-232 [7], confirming the applicability of the generic FMECA.

Conclusion

Seabrook Unit 1 complies with A/LAI 1 of the NRC SE regarding MRP-227, Revision 0. Therefore, the requirement is met for application of MRP-227-A as a strategy for managing age-related material degradation in the RVI components.

2.2 A/LAI 2: PWR VESSEL INTERNAL COMPONENTS WITHIN THE SCOPE OF LICENSE RENEWAL

NRC Applicant/Licensee Action Item 2: PWR Vessel Internal Components within the Scope of License Renewal text in MRP-227-A states:

"As discussed in Section 3.2.5.2 of this SE, consistent with the requirements addressed in 10 CFR 54.4, each applicant/licensee is responsible for identifying which RVI components are within the scope of LR for its facility. Applicants/licensees shall review the information in Tables 4-1 and 4-2 in MRP-189, Revision 1, and Tables 4-4 and 4-5 in MRP-191 and identify whether these tables contain all of the RVI components that are within the scope of LR for their facilities in accordance with 10 CFR 54.4. If the tables do not identify all the RVI components that are within the scope of LR for its facility, the applicant or licensee shall identify the missing component(s) and propose any necessary modifications to the program defined in MRP-227, as modified by this SE, when submitting its plant-specific NRC-AMP. The NRC-AMP shall provide assurance that the effects of aging on the missing component(s) will be managed for the period of extended operation. This issue is Applicant/Licensee Action Item 2." [3]

Seabrook Unit 1 Response to A/LAI 2

This action item requires comparison of the Seabrook Unit 1 RVI components that are within the scope of license renewal for Seabrook Unit 1 to those components contained in MRP-191 [4, Table 4-4], as Seabrook Unit 1 has a Westinghouse plant design. The components required to be in the Seabrook Unit 1 aging management program, as described in the PWR Vessel Internals Inspection Plan [12], are consistent with those contained in MRP-191, Table 4-4 [4]. No additional components were identified in the NextEra Energy Seabrook design.

Several components have different materials than that specified in MRP-191 [4, Table 4-4], but the differences have no effect on the recommended MRP aging strategy, or aging is already managed by an alternate Seabrook Unit 1 program. Seabrook Unit 1 follows the program strategy in MRP-227-A [3], with the exception of the flux thimble tubes. Therefore, as stated in the LRA [1, Appendix B, subsection B.2.0], and in the responses to RAI 3.1.1-60-01 and 3.1.1-60-02 (dated February 3, 2011), RAI 3.1.1-60-01/02 (dated April 22, 2011), and follow-up RAI 3.1.1-60-02 (dated November 2, 2011) [8, subsection 3.1.2.1.1], Seabrook does not credit the flux thimble tube inspection program for aging management. Additionally, the Safety Evaluation Report (SER) to the LRA states that the NRC staff found that Seabrook has provided an acceptable basis such that a Flux Thimble Tube Inspection Program is not needed to manage wear or cracking of the Seabrook Unit 1 flux thimble tubes [8, subsection 3.1.2.1.1]. This supports the requirement that the NRC-AMP shall provide assurance that the effects of aging on the Seabrook Unit 1 RVI components within the scope of license renewal will be managed for the period of extended operation.

The generic scoping and screening of the RVI, as summarized in MRP-191 [4] and MRP-232 [7], to support the inspection sampling approach for aging management of the RVI specified in MRP-227-A [3], are applicable to Seabrook Unit 1 with the exception of the aging management strategy of the Seabrook Unit 1 flux thimble tubes.

Conclusion

Seabrook Unit 1 complies with A/LAI 2 of the NRC SE on MRP-227, Revision 0, and therefore meets the requirement for application of MRP-227-A as a strategy for managing age-related material degradation in reactor internals components.

2.3 A/LAI 7: PLANT-SPECIFIC EVALUATION OF CASS MATERIALS

NRC Applicant/Licensee Action Item 7: Plant-specific Evaluation of Cast Austenitic Stainless Steel (CASS) materials text in MRP-227-A states:

"As discussed in Section 3.3.7 of this SE, the applicants/licensees of B&W, CE, and Westinghouse reactors are required to develop plant-specific analyses to be applied for their facilities to demonstrate that B&W IMI guide tube assembly spiders and CRGT spacer castings, CE lower support columns, and Westinghouse lower support column bodies will maintain their functionality during the period of extended operation or for additional RVI components that may be fabricated from CASS, martensitic stainless steel or precipitation hardened stainless steel materials. These analyses shall also consider the possible loss of fracture toughness in these components due to thermal and irradiation embrittlement, and may also need to consider limitations on accessibility for inspection and the resolution/sensitivity of the inspection techniques. The requirement may not apply to components that were previously evaluated as not requiring aging management during development of MRP-227. That is, the requirement would apply to components fabricated from susceptible materials for which an individual licensee has determined aging management is required, for example during their review performed in accordance with Applicant/Licensee Action Item 2. The plant-specific analysis shall be consistent with the plant's licensing basis and the need to maintain the functionality of the components being evaluated under all licensing basis conditions of operation. The applicant/licensee shall include the plant-specific analysis as part of their submittal to apply the approved version of MRP-227. This is Applicant/Licensee Action Item 7." [3]

Seabrook Unit 1 Response to A/LAI 7

A/LAI 7, from the NRC's final SE on MRP-227, Revision 0, notes that, for assessment of CASS materials, the applicant/licensee for license renewal may apply the criteria in the NRC letter of May 19, 2000, License Renewal Issue No. 98-0030, "Thermal Aging Embrittlement of Cast Austenitic Stainless Steel Components" [9] as the basis for determining whether the CASS materials are susceptible to the thermal aging mechanism. If the application of the applicable screening criteria for the components' material demonstrates that the components are not susceptible to either thermal embrittlement (TE) or irradiation embrittlement (IE), or to the synergistic effects of TE and IE combined, then no other evaluation would be necessary. The Seabrook Unit 1 CASS reactor vessel internals components and the assessment of their susceptibility to TE are summarized in Table 2-1.

The Seabrook Unit 1 lower internals assembly – bottom-mounted instrumentation (BMI) column cruciforms are ASME SA-351, Grade CF8 material. The elemental percentages, from the certified material test reports (CMTRs) for the CASS BMI column cruciform, are input into Hull's formula (per guidance of NUREG/CR-4513 [10]) to calculate the delta ferrite content of the CASS material. The CMTRs do not list the element percentage for nitrogen; thus, per the guidance of NUREG/CR-4513, nitrogen is assumed to be 0.04 percent. The CMTRs do not list an elemental percentage for molybdenum. SA-351, Grade CF8 did not have a requirement for percent molybdenum in 1971. The 2013 Edition of the American Society of Mechanical Engineers (ASME) Code has SA-351, Grade CF8 chemistry requirements that specify a maximum of 0.5 percent molybdenum [11]; thus, this maximum value is input into Hull's formula.

There are a total of 26 BMI column cruciforms – 25 standard cruciforms and 1 special cruciform. As summarized in Table 2-1, the ferrite content is less than or equal to 20 percent; thus, based on the NRC criteria [9], the 26 Seabrook CASS BMI column cruciforms are not susceptible to TE.

The Seabrook Unit 1 reactor internals hold-down spring was manufactured from 403 SS, a martensitic stainless steel.

No martensitic precipitation hardened stainless steel (PH-SS) components were identified for the Seabrook Unit 1 reactor vessel internals.

Table 2-1 Summary of Seabrook Unit 1 CASS Components and Their Susceptibility to Thermal Embrittlement

CASS Component	Molybdenum Content	Casting Method	Calculated Ferrite Content	Susceptibility to TE (Based on NRC letter [9])
Lower Internals Assembly, BMI column cruciforms (Standard and Special)	0.5% Maximum	Static	≤ 20%(1)	26 of 26 Not Susceptible

Note:
1. Ferrite content is based on CMTR chemistry data, nitrogen 0.04 percent, and molybdenum 0.5 percent.

Conclusion

It is concluded that continued application of the MRP-227-A strategy will meet the requirement for managing age-related degradation of the Seabrook Unit 1 CASS reactor vessel internals components.

3 REFERENCES

1. NextEra Energy Seabrook, LLC, "License Renewal Application, NextEra Energy Seabrook, LLC, Et Al., Docket No. 50-443, Seabrook Station, Unit No. 1, Facility Operating License No. NPF-86."
2. *Materials Reliability Program: Pressurized Water Reactor Internals Inspection and Evaluation Guidelines (MRP-227-Rev. 0).* EPRI, Palo Alto, CA: 2008. 1016596.
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4. *Materials Reliability Program: Screening, Categorization, and Ranking of Reactor Internals Components for Westinghouse and Combustion Engineering PWR Design (MRP-191).* EPRI, Palo Alto, CA: 2006. 1013234.
5. NextEra Energy Seabrook, LLC, Seabrook Station, Table 5.1-1, Rev. 12 and Table 5.3-1, Rev. 8, "Updated Final Safety Analysis Report."
6. NextEra Energy Seabrook, LLC, Seabrook Station Report, "Updated Final Safety Analysis Report," Section 4.3 "Nuclear Design," Rev. 8.
7. *Materials Reliability Program: Aging Management Strategies for Westinghouse and Combustion Engineering PWR Internals (MRP-232, Revision 1).* EPRI, Palo Alto, CA: 2012. 1021029.
8. U.S. Nuclear Regulatory Commission Report, "Safety Evaluation Report With Open Items Related to the License Renewal of Seabrook Station," Docket Number 50-443, June 2012 (NRC ADAMS Accession No. ML12160A374).
9. NRC Letter, "License Renewal Issue No. 98-0030, "Thermal Aging Embrittlement of Cast Austenitic Stainless Steel Components"," May 19, 2000 (NRC ADAMS Accession No. ML003717179).
10. U.S. Nuclear Regulatory Commission, NUREG/CR-4513, Rev. 1, "Estimation of Fracture Toughness of Cast Stainless Steels During Thermal Aging in LWR Systems," August 1994 (NRC ADAMS Accession No. ML052360554).
11. ASME Boiler and Pressure Vessel Code, Section II, 2013 Edition, American Society of Mechanical Engineers.
12. NextEra Energy Seabrook, LLC Letter SBK-L-14089, "Response to Request for Additional Information Related to the Review of The Seabrook Station License Renewal Application – Set 21 (Tag No. ME4028)," June 24, 2014.

Attachment 1: Material Comparison Table

Attachment 1: Seabrook Unit 1 RVI Material Differences from MRP-191				
Assembly	**Subassembly**	**Component**		**Material**
Upper Internals Assembly	Mixing Devices	Mixing Devices	MRP-191	CF8
			Seabrook Unit 1	304 SS
	Upper Support Column Assemblies	Column Bases	MRP-191	CF8
			Seabrook Unit 1	304 SS
Lower Internals Assembly	Flux Thimbles (Tubes)	Flux Thimble Tubes Plugs	MRP-191	304 SS
			Seabrook Unit 1	316 SS
			Seabrook Unit 1	A 600
		Flux Thimbles (Tubes)	MRP-191	316 SS
			Seabrook Unit 1	A 600
	Lower Support Column Assemblies	Lower Support Column Bolts	MRP-191	304 SS
			Seabrook Unit 1	316 SS
	Neutron Panels/Thermal Shield	Neutron Panel Lock Caps	MRP-191	304 SS
			Seabrook Unit 1	304L SS
	Radial Support Keys	Radial Support Key Bolts	MRP-191	304 SS
			Seabrook Unit 1	316 SS