VIRGINIA ELECTRIC AND POWER COMPANY
RICHMOND, VIRGINIA 23261

February 11, 2023

10 CFR 50.55a(z)(1)

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

Serial No.: 23-014
NRA/GDM: R0
Docket Nos.: 50-280/281
License Nos.: DPR-32/37

VIRGINIA ELECTRIC AND POWER COMPANY
SURRY POWER STATION UNITS 1 AND 2
ALTERNATIVE REQUEST TO DEFER ASME CODE SECTION XI INSERVICE INSPECTION EXAMINATIONS FOR PRESSURIZER AND STEAM GENERATOR PRESSURE-RETAINING WELDS AND FULL PENETRATION WELDED NOZZLES
RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

By letter dated November 17, 2022 (Serial No. 22-114) [Agencywide Document Access and Management System (ADAMS) Accession Number ML22322A158], Virginia Electric and Power Company (Dominion Energy Virginia) requested Nuclear Regulatory Commission (NRC) approval of a proposed alternative to the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, inservice inspection (ISI) requirements for Surry Power Station (SPS) Units 1 and 2. Specifically, Dominion Energy Virginia requested approval to defer the component examinations associated with Table IWB-2500-1, Examination Category B-B, and Table IWC-2500-1, Examination Category C-A and C-B welds, associated with the steam generators and pressurizer.

By email dated January 17, 2023, the SPS NRC Project Manager provided a request for additional information (RAI) to facilitate completion of the NRC review of the proposed alternative. The Dominion Energy Virginia response to the NRC RAI is provided in the attachment. As noted in the original submittal, NRC approval of the proposed alternative is requested by April 1, 2023, to support the SPS Unit 2 spring 2023 refueling outage.

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

Respectfully,

James E. Holloway
Vice President – Nuclear Engineering and Fleet Support

Commitments made in this letter: None

Attachment:

Response to NRC Request for Additional Information

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Attachment

RESPONSE TO NRC REQUEST FOR ADDITIONAL INFORMATION

Proposed Alternative to ASME Section XI Requirements for Inservice Inspection of Pressurizer and Steam Generator Pressure-Retaining Welds and Full Penetration Welded Nozzles

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

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION SURRY POWER STATION UNITS 1 AND 2

Proposed Alternative to ASME Section XI Requirements for Inservice Inspection of Pressurizer and Steam Generator Pressure-Retaining Welds and Full Penetration Welded Nozzles

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By email dated January 17, 2023, the SPS NRC Project Manager provided a request for additional information (RAI) to facilitate completion of the NRC review of the proposed alternative. The Dominion Energy Virginia response to the NRC RAI is provided below.

NRC Comment

[P]ursuant to Title 10 of the Code of Federal Regulations, Part 50, Section 55a, Paragraph (z)(1) (10 CFR 50.55a(z)(1)), the licensee is proposing to increase the ISI interval for the PZR and SG welds of SPS, Units 1 and 2, from the current ASME Code, Section XI 10-year requirements by deferring the PZR and SG examinations for the following:

- *For SPS Unit 1, PZR and SGs: through the sixth 10-year ISI interval, and*
- *For SPS Unit 2, PZR and SGs, for the remainder of the third period of the fifth 10-year ISI interval through the sixth 10-year ISI interval*

The licensee referred to the results of the probabilistic fracture mechanics (PFM) analyses in the following Electric Power Research Institute (EPRI) non-proprietary reports as the primary basis for the deferral of the ISI examinations:

- *EPRI Technical Report 3002015905, "Technical Bases for Inspection Requirements for PWR [Pressurized Water Reactor] Pressurizer Head, Shell-to-Head, and Nozzle-to-Vessel Welds," 2019 (hereinafter referred to as "EPRI report 15905," ADAMS Accession No. ML21021A271).*
- *EPRI Technical Report 3002015906, "Technical Bases for Inspection Requirements for PWR Steam Generator Class 1 Nozzle-to-Vessel Welds and Class 1 and Class 2*

Vessel Head, Shell, Tubesheet-to-Head and Tubesheet-to-Shell Welds," 2019 (hereinafter referred to as "EPRI report 15906," ADAMS Accession No. ML20225A141).

- *EPRI Technical Report 3002014590, "Technical Bases for Inspection Requirements for PWR Steam Generator Class 1 Feedwater and Main Steam Nozzle-to-Shell Welds and Nozzle Inside Radius Sections," 2019 (hereinafter referred to as "EPRI report 14590," ADAMS Accession No. ML19347B107).*

Regulatory Basis

The NRC has established requirements in 10 CFR Part 50 to protect the structural integrity of structures and components in nuclear power plants. Among these requirements are the ISI requirements of Section XI of the ASME Code incorporated by reference in 10 CFR 50.55a to ensure that adequate structural integrity of PZR and SG vessels (including their welds) is maintained through the service life of the vessels. Therefore, the regulatory basis for the following requests for additional information (RAIs) has to do with demonstrating that the proposed alternative ISI requirements would ensure adequate structural integrity of the PZR and SG welds of SPS, Units 1 and 2, and thereby would provide an acceptable level of quality and safety per 10 CFR 50.55a(z)(1) for the welds.

NRC RAI-1

Issue

The licensee referenced probabilistic and deterministic analyses in the above EPRI reports to estimate potential fatigue growth in the subject PZR and SG welds. The licensee presented plant-specific information to demonstrate that the referenced analyses in the EPRI reports would bound the subject PZR and SG welds, including high-level results from previous ISI of the welds. The licensee also provided limited discussion of performance monitoring, primarily focused on justifying application of the EPRI analyses to the proposed ISI interval extension for the subject PZR and SG welds (i.e., that leakage would be detected).

Leveraging PFM analyses to define the basis for risk-informing inspection requirements requires knowledge of both the current and future behavior of the material degradation and the associated uncertainties applicable to the subject PZR and SG welds. Confidence in the results of these analyses hinges on the assurance that the PFM model adequately represents, and will continue to represent, the degradation behavior in the subject PZR and SG welds. The NRC staff has determined that, when considering extended examination intervals, adequate performance monitoring through inspections is needed to ensure that the PFM model continues to predict the material behavior and that novel or unexpected degradation is detected and dispositioned in a timely fashion.

In Section 5.0 of the submittal, the licensee stated SPS, Units 1 and 2, are currently in the third period of the fifth 10-year ISI interval. Unit 1 will have completed the required fifth interval ISI examinations of the PZR and SGs at the time of the approval of this request. The ISI examinations of the Unit 2 PZR and SGs for the third period, fifth interval will not be completed by the requested approval date for the proposed alternative.

The proposed alternative is to increase the inspection interval for these examination items from the current ASME Code Section XI 10-year requirement by deferring the PZR and SG examinations for the following:

- *For SPS Unit 1, PZR and SGs: through the sixth 10-year ISI interval, and*
- *For SPS Unit 2, PZR and SGs, for the remainder of the third period of the fifth 10-year ISI interval through the sixth 10-year ISI interval.*

The staff noted that some of the PZR and SGs components in SPS, Unit 2, addressed in the licensee's proposed alternative will be in operation for more than 20 years without inspections, but no performance monitoring scheme was provided for these components.

The licensee also discusses the system leakage test as "providing further assurance of safety" for the proposed alternative. However, the NRC staff notes that the visual examinations performed during system leakage tests may not provide sufficient information to ensure that the PFM model continues to predict the material behavior and that emergent degradation is discovered and dispositioned in a timely fashion. Specifically, visual examinations may not directly detect pertinent integrity conditions (e.g., presence or extent of degradation); may not provide direct detection of aging effects prior to potential loss of structure or intended function; and do not provide sufficient validating data necessary to confirm the modeling of degradation behavior in the subject PZR and SG welds.

Request

1) *Identify the PZR and SGs components in SPS, Unit 2, as requested in the proposed alternative for deferral of the examination requirements for the remainder of the third period of the fifth 10-year ISI interval through the sixth 10 year ISI interval, that would result in the components being in operation for more than 20 years without inspections.*

Dominion Energy Virginia Response

For the SG and PZR components required to be examined in accordance with the 10-year ISI Program for SPS Unit 2, the years since the last examination performed through the end of the sixth 10-year ISI interval has been identified in the table below. As shown in this table, only one examination would exceed 20 years since the last examination

performed through the end of the sixth interval. This is the main steam nozzle inside radius on SG "B" at 25 years.

ASME Category	ASME Item No.	Component ID	Component Description	Years Since Last Examination[1]
B-B	B2.11	1-04	PZR Shell to Lower Head	19
B-B	B2.11	1-07	PZR Shell to Upper Head	20
B-B	B2.12	1-02	PZR Shell Longitudinal Weld – Upper	20
B-B	B2.12	1-03	PZR Shell Longitudinal Weld – Lower	19
B-B	B2.40	1-01	SG Primary Head to Tubesheet, SG-A	14
C-A	C1.10	2-03	SG Shell to Shell, SG-A	14
C-A	C1.30	2-02	SG Shell to Tubesheet, SG-A	14
C-A	C1.10	2-05	SG Shell to Lower Transition Cone, SG-B	19
C-A	C1.10	2-06	SG Shell to Upper Transition Cone: SG-A (0" to 184") SG-B (184" to 368") SG-C (368" to 522")	20
C-A	C1.20	2-08	SG Shell to Upper Head, SG-B	20
C-B	C2.21	2-09	SG Shell to Feedwater Nozzle, SG-B	16
C-B	C2.21	2-10	SG Shell to Main Steam Nozzle, SG-B	20
C-B	C2.22	2-RC-2-02CNIR	SG Shell to Main Steam Nozzle Inside Radius, SG-B	25
C-B	C2.22	2-RC-2-02DNIR	SG Shell to Feedwater Nozzle Inside Radius, SG-B	16
Note 1 - Years since last examination through the end of the sixth 10-year ISI interval.				

2) *For the PZR and SG components in SPS, Unit 2, identified above in Part 1 provide the following:*

   a) *Describe the performance monitoring that will be implemented with this proposed alternative to ensure that the PFM model adequately represents, and will continue to represent, the degradation behavior in the subject components commensurate with the duration of the requested alternative (i.e., plant-specific end date).*

   b) *Explain how this performance monitoring will provide, over the extended examination interval, (1) direct evidence of the presence and extent of degradation, (2) validation and confirmation of the continued adequacy of the PFM model; and (3) timely detection of novel or unexpected degradation.*

   c) *If through this performance monitoring, indications are detected that exceed the acceptance standards of ASME Code, Section XI, IWB-3500, confirm that they will be evaluated as required by ASME Code, Section XI (which includes requirements for successive inspections and additional examinations) and describe other actions (if any) that may be taken in the plant's corrective action program to ensure that the integrity of the component is adequately maintained.*

Dominion Energy Virginia Response

2(a) Performance monitoring supporting this Alternative Request is based on examinations already performed for Surry Units 1 and 2. These examinations have been performed throughout the fourth and fifth intervals, as identified in the inspection history of the Alternative Request, without the detection of any degradation. Performance monitoring for all applicable welds/components will resume with the start of the seventh 10-year ISI Interval beginning May 10, 2034, in accordance with a Section XI, 10-year ISI Interval plan.

Continued examination of these PZR and SG welds across the industry will provide additional opportunities to detect known degradation mechanisms, as described in Section 6.0 the EPRI Technical Reports, and will also provide the opportunity to detect any new or unexpected degradation mechanisms that may occur in the future for the subject welds. If a new degradation mechanism is identified during continued industry examinations, SPS will follow the industry guidance to address the new degradation mechanism.

Based on the PSI (preservice inspection) and ISI scenarios for the SPS Unit 2 PZR and SG welds and the results of the deterministic fracture mechanics (DFM) and PFM analysis of EPRI Technical Reports 3002015905 [1-2], 3002015906 [1-3], and 3002014590 [1-4], SPS concludes this approach to performance monitoring is sufficient to identify degradation behavior.

2(b)(1) The performance monitoring plan provided in the response above, includes inspection sampling that will provide direct evidence of the presence and extent of any degradation over the extended examination interval for these welds.

(2) The components in the proposed alternative have operated for up to 50 years without the occurrence of any service-induced degradation. This excellent operating history is validation and confirmation of the conservative nature of the PFM and DFM models used in the EPRI Technical Reports 3002015905 [1-2], 3002015906 [1-3], and 3002014590 [1-4]. This also shows that the models will predict future behavior conservatively.

(3) The performance monitoring schedule described above will provide timely detection of any novel or unexpected degradation in these components.

2(c) If during the performance monitoring examinations describe above, indications are detected that exceed the applicable ASME Code, Section XI acceptance standards, they will be evaluated in accordance with ASME Code, Section XI requirements.

Based on the above discussion, the performance monitoring examinations for the welds covered by the proposed Alternative Request ensure the safe operation of the components for the duration of the proposed extended examination interval.

NRC RAI-2

Issue

In Section 5.0 of the submittal, the licensee stated SPS, Units 1 and 2, are currently in the third period of the fifth 10-year ISI interval. Unit 1 will have completed the required fifth interval ISI examinations of the PZR and SGs at the time of the approval of this request. The ISI examinations of the Unit 2 PZR and SGs for the third period, fifth interval will not be completed by the requested approval date for the proposed alternative.

The proposed alternative is to increase the inspection interval for these examination items from the current ASME Code Section XI 10-year requirement by deferring the PZR and SG examinations for the following:

- *For SPS Unit 1, PZR and SGs: through the sixth 10-year ISI interval, and*
- *For SPS Unit 2, PZR and SGs, for the remainder of the third period of the fifth 10-year ISI interval through the sixth 10-year ISI interval.*

Since Unit 1 did not complete the required fifth interval ISI examinations of the PZR and SGs at the time of the submittal, the staff was not able to consider these inspection results during its review. However, the staff noted in its submittal, the licensee did not explain

the actions it would take to verify the validity and applicability of the PFM analyses in the EPRI reports cited in its proposed alternative based on the potential for indications and/or flaws for the upcoming required fifth interval ISI examinations of the PZR and SGs for Unit 1.

Request

1. *Identify the PZR and SG components at Unit 1 in the scope of the proposed alternative that will be inspected prior to end of the fifth 10-year ISI interval.*

2. *For these components, discuss the process that will be used to verify the validity and applicability of the PFM analyses in the EPRI reports cited in its proposed alternative should indications and/or flaws be identified during the upcoming required fifth interval ISI examinations of the Unit 1 PZR and SGs*

Dominion Energy Virginia Response

1. All the Unit 1 PZR and SG required examinations have been completed prior to the end of the fifth 10-year ISI interval, except for the "C" SG 2-06 weld. One third of this weld length (368" to 522") was unable to be examined during the last outage of the fifth interval due to scaffolding and schedule issues. Consequently, the fifth 10-year ISI interval was extended one year to perform this examination during the spring 2024 refueling outage. This examination will satisfy the fifth 10-year ISI interval requirements.

2. No service induced flaw indications have been identified for the examinations that have been completed. If indications are detected that exceed the applicable ASME Code, Section XI acceptance standards during the examination of the remainder of the "C" SG 2-06 weld, they will be evaluated in accordance with the ASME Code, Section XI requirements.

NRC RAI-3

Issue

Section 9 of the EPRI reports for the respective components provide criteria that must be met for the report results to be applied to a specific PWR plant. One such criterion from these EPRI reports indicate that the materials of the components must be low-alloy ferritic steels that conform to the requirements of ASME Code, Section XI, Appendix G, Paragraph G-2110.

The 2019 edition of ASME Code, Section XI, Appendix G, Paragraph G-2110 indicates that Figure G-2210-1 (Figure G-2210-1M) is based on specimens of SA-533 Grade B Class 1, and SA-508-1, SA-508-2, and SA-508-3 steel. It further indicates that Figure G-

2210-1 (Figure G-2210-1M) may be used for:

1) *ferritic steels that meet the requirements of NB-2331 and have a specified minimum yield strength at room temperature of 50 ksi (350 MPa) or less, or*

2) *materials in Table G-2110-1 that meet the requirements of NB-2331.*

The staff noted fabrication materials for some of the SG and PZR components addressed in the licensee's proposed alternative are not specifically addressed in ASME Code Section XI, Appendix G, Paragraph G-2110 for development of Figure G-2210-1. Table A1 of Attachment 1 to the licensee's submittal indicates the following:

- *The SPS, Units 1 and 2, PZR upper and lower heads and nozzles are fabricated from SA-216, Grade WCC, cast carbon steel material. The PZR shells are fabricated of SA-302, grade B, carbon steel material.*

- *The SPS, Units 1 and 2, SG lower heads are fabricated of SA-216, Grade WCC, carbon steel. The tubesheets are fabricated of SA-508, Class 2a material. The SG lower shells are fabricated of SA-533, Grade A, Class 2 material.*

- *The SPS, Units 1 and 2, SG vessel upper heads and shells are fabricated of SA-533, Grade A, Class 1 material.*

- *The material for the upper head and shell material is SA-533, Grade A, Class 1.*

For these materials, the licensee's proposed alternative did not sufficiently address the information necessary to demonstrate conformance to ASME Code Section XI, Appendix G, Paragraph G-2110.

Request

For the materials in the licensee's proposed alternative that are not explicitly addressed in ASME Code Section XI, Appendix G, Paragraph G-2110 for development of Figure G-2210-1, provide sufficient justification to demonstrate the following:

(1) the requirements of NB-2331 are met, and

(2) have a specified minimum yield strength at room temperature of 50 ksi (350 MPa) or less, if the material is not identified in Table G-2110-1 of ASME Code Section XI, Appendix G.

Dominion Energy Virginia Response

Table 1 provides a summary of the various materials that apply to the alternative request and the basis for the determination that the materials conform to the requirements of ASME Code Section XI, Appendix G, Paragraph G-2110.

Table 1 - Applicable Weld Locations, Materials, and ASME Code Requirements

Weld Location	Material	Applicable ASME III Code Edition	Charpy V-Notch Code Minimum energy (ft-lb) **	Minimum Room Temp. Yield Strength (ksi)	NB-2331 RT_{NDT} Specification Min Requirement(°F)	RT_{NDT} (°F)/Basis
Pressurizer Upper Head	SA-216, Gr. WCC	1968	20	40	N/A	60/Other
Pressurizer Lower Head	SA-216, Gr. WCC	1968	20	40	N/A	60/Other
Pressurizer Shell	SA-302, Gr. B	1968	30	50	N/A	30/ BTP 5.3
Steam Generator Upper Head	SA-533, Gr. A, Cl. 1	1968	30	50	N/A	30/ BTP 5.3
Steam Generator Upper Shell	SA-533, Gr. A, Cl. 1	1968	30	50	N/A	30/ BTP 5.3
Steam Generator MFW Nozzle	SA-508, Cl. 2	1968	30	50	N/A	30/ BTP 5.3
Steam Generator MS Nozzle	SA-508, Cl. 2	1968	30	50	N/A	30/ BTP 5.3
Steam Generator Lower Head	SA-216, Gr. WCC	1974*	N/A	40	60	60/Spec
Steam Generator Lower Shell	SA-533, Gr. A, Cl. 2	1974*	N/A	70	60	60/Spec
Steam Generator Tube Sheet	SA-508, Cl. 2a	1974*	N/A	65	60	60/Spec

* Through Winter 1976 Addenda
** Values at 10°F

Applicable Code Requirements and Assessment of RT_{NDT}

For the upper portions of the SPS SGs, including the upper shell, head, Feedwater (FW) and Main Steam (MS) nozzles, and the PZRs, the applicable construction code is the 1968 Edition of ASME Section III (Ref. 2). The SPS Units 1 and 2 Inservice Inspection (ISI) Program for the fifth 10-year ISI Interval is implemented in accordance with the requirements of ASME Section XI, 2004 Edition (Ref. 6). The 2004 Edition of ASME Section XI, Appendix G, directs that Fig. G-2210-1 may be used to determine the fracture toughness, K_{IC}, for ferritic steels, which meet the requirements of NB-2331, and which has a specified minimum yield strength at room temperature of 50 ksi or less. It is noted that for the 1968 Edition of ASME Section III, Subparagraph NB-2331 had not yet been developed and Paragraph N-330 from the 1968 Code edition would have applied for Special Mechanical Properties and Tests. This paragraph required either Drop Weight or Charpy V-Notch Testing be performed to establish a ductile to brittle transition temperature for the material. The minimum energy levels, in ft-lbs, for an average of three tests were provided in Table N-421 of References 1 and 2 for carbon and alloy steels. With the exception of SA-508, Cl. 2a, and SA-533, Grade A, Cl. 2, all of the materials listed in Table 1 have a minimum room temperature yield strength of 50 ksi or less. It is also noted that for materials associated with the 1968 Code Edition in Table 1, Charpy V-Notch Testing would have been performed at 10°F per Paragraph N-331.2 of Ref. 2. A 10°F test temperature is 60°F below the original minimum specified vessel design service/test temperature of 70°F, which is reflected on the ASME N-1A Manufacturers Data Reports (Ref. 18). A longitudinal test specimen (as applicable) having standard 10 x 10 mm dimensions would have been used to perform Charpy V-Notch testing for the materials associated with the 1968 Code Edition in Table 1 based on material testing standards ASTM A-370-67 and A-370-71b (Refs. 9 and 10), which applied during the time of construction of the PZRs and original portions of the SGs at SPS.

Table 2 - Minimum Code Requirements for Charpy V-Notch Energy Average of 3 @ 10°F (Refs. 1 and 2)

Material	Min Required Energy (ft-lb)
SA-216, Gr. WCC	20
SA-302, Gr. B	30
SA-533, Grade A, Cl. 1	30
SA-508, Cl. 2	30

Considering the testing criteria previously noted and assuming the materials only achieved the minimum code required Charpy V-Notch Test energy at the standard test temperature of 10°F, the RT_{NDT} values would be as listed in Table 3 below based on the following criteria from NRC Branch Technical Position (BTP) 5-3(4) (Ref. 4):

BTP 5-3(4):

(4) If limited Charpy V-notch tests were performed at a single temperature to confirm that at least 41 J (30 ft-lbs) was obtained, that temperature may be used as an estimate of the RT_{NDT} provided that at least 61 J (45 ft-lbs) was obtained if the specimens were longitudinally oriented. If the minimum value obtained was less than 61 J (45 ft-lbs), the RT_{NDT} may be estimated as 11 °C (20 °F) above the test temperature.

Table 3 - Estimated RT_{NDT} Value

Material	Estimated RT_{NDT} Value in °F
SA-302, Gr. B	30
SA-533, Grade A, Cl. 1	30
SA-508, Cl. 2	30

Given that BTP 5-3(4) criteria would result in the same estimated RT_{NDT} values for all three materials noted above, it is considered reasonable to use an RT_{NDT} of 30°F for the above SPS PZR and SG materials, which is bounded by the conservative RT_{NDT} value of 60°F used in the EPRI evaluations (Refs. 5, 7 and 8). The SA-216, Gr. WCC, material minimum Charpy Energy requirements listed in in the 1965 and 1968 Editions of ASME III are less than the 30 ft-lb required per BTP 5.3(4). Therefore, in the absence of Certified Material Test Reports (CMTRs) demonstrating all locations for both units' PZR upper and lower heads had average Charpy Impact energies greater than 30 ft-lb at 10°F, a review of available industry fracture toughness testing data was performed, including data from the 'For Review' Version of NUREG-0577 (Refs. 15, 16 and 17). Based on this review, it was considered reasonable to assign an RT_{NDT} value of 60°F to the SA-216, Gr. WCC, PZR materials fabricated to the 1968 Edition of ASME Section III. This conclusion is based on the relatively high toughness values obtained in the industry testing documented in References 16 and 17 for similar SA-216, Gr. WCC, materials when compared to K_{IC} values calculated from the ASME Section XI reference curve (Ref. 6) for an RT_{NDT} of 60°F, which is illustrated in Figure 1. Available CMTRs for the PZR lower heads confirm an NDT temperature of 10°F for all samples and an average of three Charpy V-Notch Energy values at 10°F ranging from 23 ft-lb to 37 ft-lb. It is also noted that the available test certificates for the PZR lower head materials reference Westinghouse fabrication and material specification drawings that called for the heat treatment of these castings to be either: 1) Normalized, Quenched and Tempered, or 2) Double Normalized and Tempered (Refs. 19, 20 and 21). Therefore, the materials were not provided in the annealed form and would have improved fracture toughness consistent with the industry test data for SA-216, Gr. WCC, materials shown in

References 15, 16 and 17. The materials tested in these references would have been fabricated during the same time period as the SPS PZR materials (late 1960s or early 1970s) and had heat treatments similar to those specified for the SPS PZR heads (Refs. 16, 17). Therefore, PZR head and shell materials are assigned an RT_{NDT} value of 60°F, which is bounded by the 60°F assumption used in the EPRI Report (Ref. 5); therefore, the requirements of NB-2331 are considered met for the SA-216, Gr. WCC, material used to construct the SPS PZR heads.

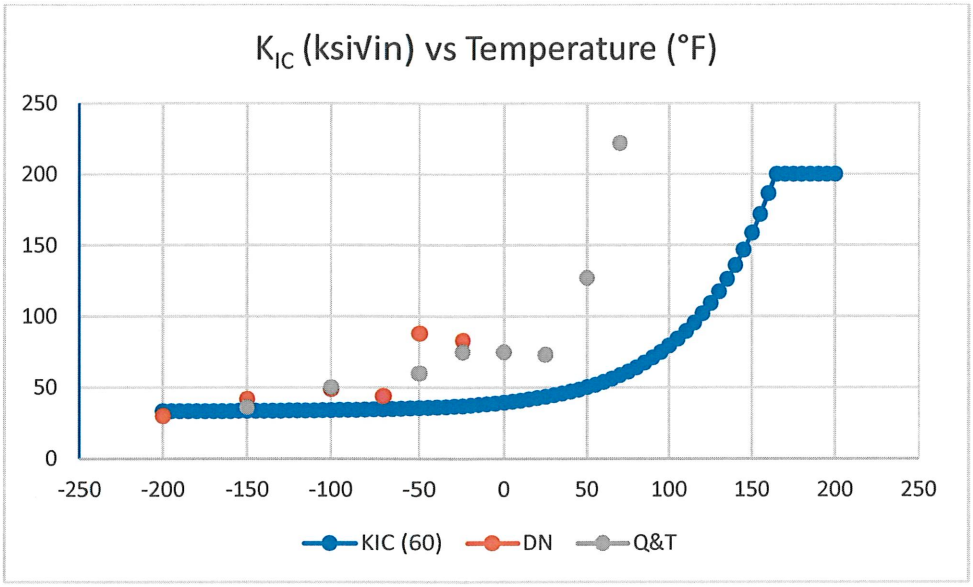
For the lower portion of the SGs that were replaced in 1980 (Unit 2) and 1981 (Unit 1), including portions of the lower shell, lower head and tubesheet, the 1974 edition of ASME Section III, up to and including the Winter 1976 Addenda, applied for the construction and analysis of the vessels (Refs. 3 and 11). Therefore, ASME Section III, Subsection NB-2331, requirements would have been met.

The material of construction for the lower shell is SA-533, Grade A, Cl. 2, which has a minimum yield strength of 70 ksi. The material of construction for the tubesheets is SA-508, Cl. 2a, which has a minimum yield strength of 65 ksi. Based on the 2004 Edition of ASME Section XI, Appendix G, Paragraph G-2110(b), additional testing would be required to use the K_{IC} curves provided in Section XI. However, based on Code Case N-890 (Ref. 12), Table 1, and NRC Regulatory Guide (RG) 1.147 (Ref. 13), both SA-533, Grade A, Cl. 2, and SA-508, Cl. 2a, materials, including their heat-affected zone and weld metal, are exempt from the requirements of G-2110(b) for obtaining fracture mechanics data provided they meet the requirements of NB-2331, which is consistent with Table G-2110-1 of the 2019 Edition of ASME Section XI (Ref. 22). The 1974 Edition of ASME Section III required compliance with Paragraph NB-2331, and it is therefore considered acceptable to use the ASME Section XI curves for fracture toughness, K_{IC}. It is noted that the applicable procurement specification for the replacement SGs (Ref. 14) required a minimum RT_{NDT} of 60°F, or lower based on the specific component and applicable design transients, for all pressure retaining materials except bolting materials. It also required an RT_{NDT} of 10°F or less for all pressure boundary weld metal. The material of construction for the SG lower head is SA-216, Gr. WCC, and it is also assigned an RT_{NDT} value of 60°F for the SGs based on the noted requirements of the procurement specification (Ref. 14). These conclusions are confirmed from available material testing reports (Ref. 21). Based on the procurement specification requirements, an RT_{NDT} of 60°F is conservatively assumed for all materials used to construct the lower portions of the SGs, including the tubesheet, which is bounded by the 60°F assumption used in the EPRI Report (Ref. 8), and the requirements of NB-2331 are met.

The results of this material review are summarized and provided in Table 1.

Figure 1

Fracture Toughness Data for SA-216, Gr. WCC -vs- ASME Section XI Reference Curve for RT_{NDT} = 60°F



DN = Double Normalized and Tempered
Q&T = Normalized, Quenched and Tempered

REFERENCES:

1. ASME Section III, 1965 Ed., through Winter 1965 Addenda.

2. ASME Section III, 1968 Ed., through Winter 1970 Addenda.

3. ASME Section III, 1974 Ed., through Winter 1976 Addenda.

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