ATTACHMENT (5)

PRESSURIZER AS-LEFT REMNANT J-GROOVE WELD FLAW EVALUATION – NON-PROPRIETARY

Calvert Cliffs Nuclear Power Plant, LLC
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Controlled Document

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AREVA

CALCULATION SUMMARY SHEET (CSS)

Document No. 32 - 9156225 - 000 Safety Related: ☒ Yes ☐ No

Title CCNPP-2 Pressurizer - As-Left Remnant J-Groove Weld Flaw Evaluation (Non-Proprietary Version)

PURPOSE AND SUMMARY OF RESULTS:

Purpose:

This evaluation assumes flaws develop or exist in the original remnant J-groove welds associated with the pressurizer heater penetrations. In Calvert Cliffs Unit 2, leakage was identified at the pressurizer bottom head heater nozzle location N3 in February 2011. The weld attaching the outer sleeve to the cladding of the bottom head is believed to have failed. The outer sleeve-to-cladding weld is not a pressure boundary weld. It is most probable that a flaw in this weld along with a flaw that was confirmed in the pressure boundary weld at the OD of the bottom head caused the leak. An evaluation is performed in this document to demonstrate that a flaw existing in the original remnant weld will not propagate to an unacceptable size or become unstable during the life of the component. The assessment will determine if it is acceptable to continue to operate with the postulated flaw at least for one additional cycle of operation. This will be accomplished by referencing the work that was recently performed for the Unit 1 ID Temper Bead repair design (Reference [1]), and reconciling any differences in that analysis with the configurations, loading and materials present in the Unit 2 bottom head heater nozzles.

> **<u>Note:</u> The Proprietary contents of this document (proprietary to AREVA and/or others) are blanked out and marked as such, using double brackets, thus { }. The corresponding Proprietary Document is 32-9156200-001.**

Summary of Results:

The geometry, material, and loading comparisons of the Unit 1 and Unit 2 pressurizer heater sleeve-to-cladding weld attachments are summarized in Section 5.1. Utilizing the comparison, subsequent fracture mechanics was performed as documented in Section 5.2. The comparative assessment demonstrates that the conclusions of the Unit 1 pressurizer heater sleeve J-Groove weld flaw evaluation documented in Reference [1] is bounding and therefore applicable to the postulated Unit 2 pressurizer heater sleeve remnant weld flaw as well. This conclusion also applies to the plugged H3 and N3 nozzle locations of Unit 2. Therefore, it is concluded that it is acceptable to continue operation of the Unit 2 Pressurizer for at least one additional fuel cycle, with the sleeve-to-cladding weld in the as-left condition.

THE FOLLOWING COMPUTER CODES HAVE BEEN USED IN THIS DOCUMENT:

CODE/VERSION/REV	CODE/VERSION/REV
- None -	

THE DOCUMENT CONTAINS ASSUMPTIONS THAT SHALL BE VERIFIED PRIOR TO USE

☐ **YES**
☒ **NO**

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☐ Alternate Calculation

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1.0 INTRODUCTION

This evaluation assumes flaws develop or exist in the original remnant J-groove welds associated with the pressurizer heater penetrations. In Calvert Cliffs Unit 2, leakage was identified at the pressurizer bottom head heater nozzle location N3 in February 2011. The weld attaching the outer sleeve to the cladding of the bottom head is believed to have failed. The outer sleeve-to-cladding weld is not a pressure boundary weld. It is most probable that a flaw in this weld along with a flaw that was confirmed in the pressure boundary weld at the OD of the bottom head caused the leak. An evaluation is performed in this document to demonstrate that a flaw existing in the original remnant weld will not propagate to an unacceptable size or become unstable during the life of the component. The assessment will determine if it is acceptable to continue to operate with the postulated flaw at least for one additional cycle of operation. This will be accomplished by referencing the work that was recently performed for the Unit 1 ID Temper Bead repair design (Reference [1]), and reconciling any differences in that analysis with the configurations, loading and materials present in the Unit 2 bottom head heater nozzles.

2.0 METHODOLOGY / APPROACH

The evaluation documented in Reference [1] demonstrates the acceptability of the flawed J-Groove weld attaching the heater sleeve to the cladding at the ID of the CCNPP Unit 1 Pressurizer bottom head, for continued operation in the As-left condition, following the planned repair of a pressurizer heater sleeve by the ID temper bead (IDTB) weld procedure. This Unit 1 evaluation is used as the basis for qualifying the as-left condition of the postulated flawed remnant weld in Unit 2. A comparative assessment is performed, by comparing the key parameters of Unit 1 and 2, such as geometry, materials, and loading, as relevant to the subject weld attachment. This comparison is further utilized in the fracture mechanics assessment with respect to the Unit 1 analysis, as contained in Section 5.2.

3.0 ASSUMPTIONS

There are no assumptions requiring verification prior to the use of the results of this document.

3.1 Justified Assumptions

Some of the general assumptions in this assessment are as follows:

- The flaw in the remnant weld attaching the heater sleeve to the cladding of the pressurizer bottom head is assumed to be a radial crack, extending through the entire cladding thickness, in the vicinity of the nozzle penetration.

Other assumptions, if any, are included in the body of this document, consistent with the applicable context.

4.0 INPUT

This assessment utilizes inputs from several sources. The input sources used are included in the Reference Section of this document and identified in this calculation where applicable.

5.0 ASSESSMENT

The assessment is performed in two parts. First, the parameters relevant to the subject weld location are compared between Units 1 and 2. Secondly, utilizing this comparison, a fracture mechanics assessment is performed.

5.1 Comparison of Parameters Relevant to the Sleeve-to-Cladding Weld

A comparison of the geometries, materials, and the loading, relevant to the subject outer sleeve-to-cladding weld location is performed. Figures 5-1 through 5-4 identify some of the geometric features of the Unit 1 and Unit 2 nozzle designs, as relevant to the subject weld location. The details of the comparison are shown in Tables 5-1 through 5-3.

[Excerpted from Reference 7(a)]

Figure 5-1: CC Unit 1 PZR Heater Sleeve-to-Cladding Attach. Weld

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[Excerpted from Reference 7(c)]

Figure 5-2: CC Unit 2 PZR Heater Sleeve-to-Cladding Attach. Weld (Typ., except H3)

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[Excerpted from Reference 7(c)]

Figure 5-3: CC Unit 2 PZR Plug Sleeve-to-Cladding Attachment Weld at H3

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[Excerpted from References 7(d)]

Figure 5-4: CC Unit 2 PZR Heater Plug at Nozzle Location, N3

5.1.1 Comparison of Geometry

Table 5-1: Comparison of Geometry

No.	Parameter/Detail	Unit 1	Ref.	Unit 2[1]	Ref.	Remarks
1	Sleeve OD at Sleeve-Cladding Weld (except at H3), in.					
2	Sleeve ID at Sleeve-Cladding Weld (except at H3), in.					
3	Sleeve Wall Thk. (except at H3), in.					
4	Sleeve OD at Sleeve-Cladding Weld at **H3**, in.					
5	Sleeve ID at Sleeve-Cladding Weld at **H3**, in.					
6	Sleeve Wall Thk. at **H3**, in.					
7	Sleeve-Cladding Weld Type (**all** locations including H3), Typ.					
8	Cladding Thickness, in.					
9	Pressurizer Bottom Head Thickness, in.					
10	Pressurizer Bottom Head Radius, in. (to base metal ID)					

(1) In CC Unit 2, the H3 nozzle is of larger diameter compared to the other heater nozzles, and it is plugged. Also, in CC Unit 2, the N3 nozzle is plugged. However, the geometry in the vicinity of the subject sleeve-to-cladding weld remains the same as that of a typical heater nozzle (see Fig 5-4).

(2) In CC Unit 1, Nickel plating has been applied on the ID of the heater sleeve, as referenced in Ref. [7(a)] and as detailed in Reference [7(e)]. Accordingly the ID could be { } inch based on 8 mil or 6 mil plating, respectively.

5.1.2 Comparison of Materials

Table 5-2: Comparison of Materials

No.	Parameter/Detail	Unit 1	Ref.	Unit 2	Ref.	Remarks
1	Heater Sleeve Material at the Sleeve-Cladding weld location (Typ. at all locations including H3)					
2	Sleeve-to-Cladding Weld Material (Typ. at all locations including H3)					
3	Cladding Material					
4	Pressurizer Bottom Head					

5.1.3 Comparison of Loading

Table 5-3: Comparison of Loading

No.	Parameter/Detail	Unit 1	Ref.	Unit 2	Ref.	Remarks
1	Design Pressure, psia					
2	Design Temperature, °F					
3	Normal Operating Pressure, psia					
4	Normal Operating Temperature, °F					
5	Regular Temperature & Pressure Transients (Normal, Upset, Emergency, Test)					
6	Additional Insurge Transients					
7	External loads (Deadweight, seismic) on heater nozzle, and therefore at the Sleeve					

(1) Reference 5 is a common document for Calvert Cliffs Units 1 and 2. Reference 5 is referenced in Unit 1 as well as Unit 2 design documents (Ref. 1, 2, 6 for Unit 1 and Ref. 4 for Unit 2).

5.2 Fracture Mechanics Assessment

The input parameters for the fracture mechanics assessment (Reference [1]) for Unit 1 Pressurizer radial flaw, postulated in the Pressurizer head near the as-left J-groove attaching the heater sleeve to the cladding, are loading, residual stresses, and material properties. Comparative evaluation in Section 5.1 concluded that, the loading and material properties for Unit 1 and Unit 2 are similar. However, slight differences in the analyzed repairs for Unit 1 and Unit 2 do exist. For all heater sleeves penetration except the H3 sleeve penetration, as described in Reference [7(c)], the Unit 2 repair involves boring the heater sleeve penetration and attaching two sleeves, inner and outer. The outer sleeve is attached to the outer surface of the Pressurizer head using a weld pad. Also, the outer sleeve is attached to the cladding by a small AGTAW fusion weld. The inner sleeve is attached to the outer sleeve by GTAW weld at the lower end of the outer sleeve as described in Reference [7(c)].

To complete the comparative assessment between the analyzed configuration and the Unit 2 repair configuration detailed in Reference [7(c)], it is necessary to examine the effects of differences between the repair configuration (Unit 1 and Unit 2) on residual stresses and the fracture mechanics analysis. The residual stresses used in the assessment of Unit 1 repair came from simulating the welding of the as-left J-groove weld in Unit 1. In the Unit 2 repair configuration, however, big portion of the J-groove weld attaching the heater sleeve to the cladding was machined out, which would result in relieving the weld induced residual stresses, which is a major contributor to the crack driving forces that affect flaw growth and stability. Therefore, it will be conservative to evaluate the Unit 2 repair configuration using the residual stresses from the Unit 1 repair configuration. The size of the postulated flaw assumed to exist in the Pressurizer head near the as-left J-groove in the Unit 1 repair configuration is conservative. The analyzed flaw was assumed to extend in the radial direction, beyond the as left J-groove boundary, through the full thickness of the cladding. Also, the remnant heater sleeve was assumed to be cracked. Therefore, any slight geometry differences in the Unit 1 and Unit 2 heater sleeve penetration diameters is not likely to affect the crack face loading, and any effects on the postulated flaw size and shape, if any, will be minor.

Since the variations in all input parameters between the Unit 1 and Unit 2 repair configurations, as pertinent to the fracture mechanics assessment of the as-left J-groove flaw are less likely to influence the results and conclusion of such an assessment, it is concluded that the Unit 1 Pressurizer heater sleeve J-groove weld flaw evaluation documented in Reference [1] is adequate to qualify a postulated radial flaw near the as left J-groove in Unit 2 Pressurizer heater sleeve.

For the H3 sleeve penetration, Reference [7(c)] shows that the larger bore of the Unit 2 H3 sleeve penetration removed all the original J-groove weld material. Therefore, the potential for initiating a radial flaw in the Unit 2 Pressurizer lower head near the H3 sleeve penetration is greatly reduced. If a radial flaw were to be postulated in the Unit 2 Pressurizer lower head near the H3 sleeve penetration for fracture mechanics assessment, the depth of the flaw will extend through the thickness of the cladding as was considered for the Unit 1 Pressurizer analysis of the as-left J-groove weld. Also, the radial extent of the flaw from the nozzle will be of similar magnitude. The meridional stresses in the head near the Unit 2 H3 sleeve penetration is not expected to be sufficiently higher than the stresses used to analyze the Unit 1 Pressurizer as-left J-groove weld, especially since removing the original J-groove for Unit 2 H3 sleeve penetration would have relieved all the residual stresses from J-groove welding. Therefore, from the view point of fracture mechanics assessment of a radial flaw in Pressurizer lower head, the Unit 2 H3 sleeve penetration is bounded by the analysis for the Unit 1 Pressurizer as-left J-groove weld.

It is noted that the reference evaluation (Reference [1]) justified, conservatively, the Unit 1 operation for at least { } years from the time the postulated flaw formed in the low alloy steel PZR lower head. Based on the above comparative assessment, the Unit 2 operation is justified for at least one additional fuel cycle with the sleeve-to-cladding weld in the as-left condition.

6.0 CONCLUSION

The geometry, material, and loading comparisons of the Unit 1 and Unit 2 pressurizer heater sleeve-to-cladding weld attachments are summarized in Section 5.1. Utilizing the comparison, subsequent fracture mechanics was performed as documented in Section 5.2. The comparative assessment demonstrates that the conclusions of the Unit 1 pressurizer heater sleeve J-Groove weld flaw evaluation documented in Reference [1] is bounding and therefore applicable to the postulated Unit 2 pressurizer heater sleeve remnant weld flaw as well. This conclusion also applies to the plugged H3 and N3 nozzle locations of Unit 2. Therefore, it is concluded that it is acceptable to continue operation of the Unit 2 Pressurizer for at least one additional fuel cycle, with the sleeve-to-cladding weld in the as-left condition.

7.0 REFERENCES

1. AREVA Document: 32-9116467-002, CCNPP-1 PZR Heater Sleeve As-Left J-Groove Weld Flaw Evaluation for IDTB Repair.
2. AREVA Document: 08-9112221-002, Design Specification – Calvert Cliffs, Unit 1, Pressurizer Heater Sleeve and Lower Instrument Nozzle Modification.
3. AREVA Document: 32-1204049-00, Fracture Analysis of BG&E's Pressurizer Heater Nozzles.
4. AREVA Document: 08-1176078-01, Design Specification – Repair /Replacement of Pressurizer Heater Sleeves, Calvert Cliffs.
5. AREVA Document: 38-2200661-004, Design Input Information Containing "Project Specification for a Pressurizer Assembly for Calvert Cliffs Units 1 & 2," CCNPP Specification No. 8067-31-4, Revision 12.
6. AREVA Document: 32-9126631-000, Material and Transient Data for Pressurizer Heater Sleeve Repair Stress Analysis.
7. AREVA Drawings:
    a) 02-9116243E-007, Calvert Cliffs Unit 1 – Pressurizer Heater Sleeve Modification.
    b) 02-1196370E-002, BG&E Calvert Cliffs – Pressurizer Bottom Head Dimensional & Mat'ls Design Information.
    c) 02-1196380E-002, BG&E Calvert Cliffs – Heater Sleeve Assembly & Welding – Specification Drawing.
    d) 02-9155725E-000, Calvert Cliffs Unit 2 – Pressurizer Penetration N3 Plug.
    e) 02-1209840E-02, Specification Drawing for Pressurizer Nozzle Nickel Plating, Sheets 1 & 2, BG&E Calvert Cliffs-Unit 1.