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

May 29, 2013

Mr. George H. Gellrich, Vice President
Calvert Cliffs Nuclear Power Plant, LLC
Calvert Cliffs Nuclear Power Plant
1650 Calvert Cliffs Parkway
Lusby, MD 20657-4702

SUBJECT: CALVERT CLIFFS NUCLEAR POWER PLANT, UNIT NO. 2 – RELIEF REQUEST RR-ISI-04-07A FOR DISSIMILAR METAL BUTT WELDS BASELINE EXAMINATIONS (TAC NO. ME8871)

Dear Mr. Gellrich:

By letter dated June 7, 2012, as supplemented by letter dated as supplemented by letters dated January 10 and February 18, 2013, Calvert Cliffs Nuclear Power Plant, LLC, the licensee, submitted a request for authorization of a proposed alternative to the requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code Case N-770-1, as conditioned by Title 10 of the *Code of Federal Regulations* (10 CFR) 55a(g)(6)(ii)(F)(3) for Calvert Cliffs Nuclear Power Plant, Unit No. 2 (Calvert Cliffs). Specifically, the licensee proposed to credit the ultrasonic examinations of the reactor coolant pump (RCP) suction and discharge dissimilar metal butt welds performed at Calvert Cliffs in spring 2011 to fulfill the baseline examination requirement of ASME Code Case N-770-1. Pursuant to 10 CFR 50.55a(a)(3)(ii), the licensee requested to use an alternative on the basis that complying with the specified requirement would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Due to unforeseen circumstances during the Calvert Cliffs refueling outage, the Nuclear Regulatory Commission (NRC) staff expedited its review and granted verbal authorization on March 12, 2013, for the proposed alternative, as described in Relief Request RR-ISI-04-07A, on the basis that the proposed alternative provides reasonable assurance of structural integrity and leak tightness of the subject RCP welds and that complying with the specified requirement would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety. Accordingly, the NRC staff concluded that the regulatory requirements of 10 CFR 50.55a(a)(3)(ii) has been fulfilled and authorized acceptance of the spring 2011 examination of the subject welds at Calvert Cliffs, as the baseline examination until the scheduled spring 2017 refueling outage. The NRC staff final written authorization, including the results of its review, is provided in the enclosed safety evaluation.

All other ASME Code, Section XI requirements for which relief was not specifically requested and authorized in the subject proposed alternative remain applicable, including third-party review by the Authorized Nuclear Inservice Inspector.

If you have any questions, please contact the Calvert Cliffs Project Manager, Nadiyah Morgan at (301) 415-1016.

Sincerely,

Sean Meighan, Acting Branch Chief
Plant Licensing Branch I-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-318

Enclosure:
As stated

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

REGARDING RELIEF REQUEST RR-ISI-04-07A

DISSIMILAR METAL BUTT WELDS BASELINE EXAMINATIONS

CALVERT CLIFFS NUCLEAR POWER PLANT, LLC.

CALVERT CLIFFS NUCLEAR POWER PLANT, UNIT NO. 2

DOCKET NO. 50-318

1.0 INTRODUCTION

By letter dated June 7, 2012 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12164A372), as supplemented by letter dated as supplemented by letters dated January 10 (ADAMS Accession No. ML13015A007) and February 18, 2013 (ADAMS Accession No. ML13051A740), Calvert Cliffs Nuclear Power Plant, LLC, the licensee, submitted a request for authorization of a proposed alternative to the requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code Case N-770-1, as conditioned by Title 10 of the *Code of Federal Regulations* (10 CFR) 55a(g)(6)(ii)(F)(3) for Calvert Cliffs Nuclear Power Plant, Unit No. 2 (Calvert Cliffs). Specifically, the licensee proposed to credit the ultrasonic (UT) examinations of the reactor coolant pump (RCP) suction and discharge dissimilar metal butt welds (DMBWs) performed at Calvert Cliffs in spring 2011 to fulfill the baseline examination requirement of ASME Code Case N 770-1. The licensee stated that the previous UT examinations could not obtain essentially 100 percent coverage of the required examination volume due to weld taper, insulation support obstruction, and the presence of the cast austenitic stainless steel (CASS) safe-ends. Pursuant to 10 CFR 50.55a(a)(3)(ii), the licensee requested to use an alternative on the basis that complying with the specified requirement would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Due to unforeseen circumstances during the Calvert Cliffs refueling outage, the Nuclear Regulatory Commission (NRC) staff expedited its review and granted verbal authorization on March 12, 2013, for the proposed alternative.

2.0 REGULATORY EVALUATION

Paragraph 55a(g)(6)(ii)(F) of 10 CFR 50 requires that licensees of existing operating pressurized water reactors (PWRs) implement the requirements of ASME Code Case N 770-1, "Alternative Examination Requirements and Acceptance Standards for Class 1 PWR Piping and Vessel Nozzle Butt Welds Fabricated With UNS N06082 or UNS W86182 Weld Filler Material With or Without Application of Listed Mitigation Activities," subject to the conditions specified in paragraphs (g)(6)(ii)(F)(2) through (g)(6)(ii)(F)(10), by the first refueling outage after August 22, 2011. Paragraph 55a(g)(6)(ii)(F)(3) of 10 CFR 50 states, "Baseline examinations for welds in Table 1, Inspection Items A–1, A–2, and B, shall be completed by the end of the next refueling outage after January 20, 2012. Previous examinations of these welds can be credited for baseline examinations if they were performed within the re-inspection period for the weld item in Table 1 using Section XI, Appendix VIII requirements and met the Code required examination volume of essentially 100 percent. Other previous examinations that do not meet these requirements can be used to meet the baseline examination requirement, provided NRC approval of alternative inspection requirements in accordance with paragraphs (a)(3)(i) or (a)(3)(ii) of this section is granted prior to the end of the next refueling outage after January 20, 2012."

Paragraph 10 CFR 50.55a(a)(3) states, in part, that alternatives to the requirements of 10 CFR 50.55a(g) may be used when authorized by the NRC if the applicant demonstrates that: (i) the proposed alternatives would provide an acceptable level of quality and safety, or (ii) compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

3.0 TECHNICAL EVALUATION

3.1 Licensee's Relief Request

3.1.1 Affected Components

- ASME Code Class 1 dissimilar metal piping welds containing Alloy 82/182, ASME Code Case N-770-1 Inspection Item B, unmitigated butt weld at cold leg operating temperature

- RCP inlet weld numbers: 30-RC-21A-7; and 30-RC-22A-7

- RCP outlet weld numbers: 30-RC-21A-10; 30-RC-21B-10; and 30-RC-22A-10

3.1.2 Code Requirements

- The Calvert Cliffs code of record for the fourth 10-year inservice inspection interval that started on October 10, 2009 and is scheduled to end on June 30, 2019 is the 2004 Edition, no Addenda, of the ASME Code, Section XI.

- 10 CFR 55a(g)(6)(ii)(F)(3)

- The subject welds are classified as Inspection Item B, "Unmitigated butt weld at Cold Leg operating temperature ≥ 525° F and < 580° F" for which visual and essentially 100 percent volumetric examinations are required.

3.1.3 Licensee's Proposed Alternative

The licensee is proposing to credit the ultrasonic UT examinations of the RCP DMBWs performed at Calvert in spring 2011 to fulfill the baseline examination requirement of ASME Code Case N-770-1, as conditioned by 10 CFR 50.55a(g)(6)(ii)(F)(3).

3.1.4 Licensee's Basis for Requesting Relief (as stated)

> All of the unmitigated welds are found in lower temperature regions of the reactor coolant system (at temperatures near T_{cold}). Therefore, there is a lower probability of crack initiation and a slower crack growth rate. These welds are also highly flaw tolerant, as demonstrated in MRP-109. As shown in this reference, continued operation without repair can be demonstrated for substantial flaw sizes.
>
> Where appropriate, contouring has already been completed on the examination surface. Further actions are limited by the design minimum wall calculations for the piping. Additional axial flaw coverage would require a weld build up of the DM weld followed by additional contouring and a Construction Code required radiography examination. These additional steps to improve axial coverage constitute a hardship that does not result in an increase to health and safety of the public.
>
> Additionally, bare metal visual examinations in accordance with ASME Code Case N-722 were performed on the subject components of the reactor coolant pressure boundary during the 2011 refueling outage. Those examinations identified no evidence of leakage for these components.
>
> Therefore, the UT examination coverages, which include a large percentage of the susceptible material for the circumferential and axial flaws, combined with the periodic system pressure tests and outage walk downs, provide an acceptable level of quality and safety for identifying degradation from PWSCC [primary water stress corrosion cracking] prior to the development of a safety significant flaw.

3.2 NRC Staff Evaluation

PWSCC of nickel-based pressure boundary materials is a safety concern. Operational experience has shown that PWSCC can occur as the result of the combination of susceptible material, corrosive environment, and tensile stresses, resulting in leakage and the potential for loss of structural integrity. The subject DMBWs meet these conditions, and therefore, may be susceptible to PWSCC. The examination requirements of ASME Code Case N-770-1, as conditioned by 10 CFR 50.55a(g)(6)(ii)(F), are intended to ensure the structural integrity and leak tightness, thus an acceptable level of quality and safety, of DMBWs through nondestructive examination.

The subject DMBWs are located on the 30 inch inside diameter (ID) piping at the safe-ends of either the inlet or outlet of the RCPs. The weld filler material is PWSCC-susceptible Alloy 82/182 joining mill-clad carbon steel (SA-516, Grade 70, with SA-240-304L cladding) to CASS, SA-351, Grade CF8M, safe-ends.

Paragraph 55a(g)(6)(ii)(F)(3) of 10 CFR 50 states that previous examinations of DMBWs may be credited for baseline examinations if they were performed within the re-inspection period for the inspection item in Table 1 of ASME Code Case N-770-1 using Section XI, Appendix VIII requirements and meet the Code required examination volume of essentially 100 percent. The licensee stated that the UT examination performed in spring 2011 was a manually-delivered, non-encoded, phased-array, single-sided UT examination performed in both the circumferential and axial directions from the outside diameter in accordance with Electric Power Research Institute (EPRI) Materials Reliability Program (MRP)-139 Rev. 1 (Reference 5). The personnel and UT procedure, SI UT-130, "Procedure for the Phased Array Ultrasonic Examination of Dissimilar Metal Welds" (Reference 2), were qualified to the requirements of ASME Code Section XI Appendix VIII, Supplement 10, and the previous UT examination was performed within the re-inspection period for Inspection Item B, but could not obtain essentially 100 percent coverage of the required examination volume due to weld taper, insulation support obstruction, and the presence of the CASS safe-ends.

The licensee states that contouring has already been completed on the examination surface and further actions are limited by the design minimum wall calculations for the piping; obtaining additional circumferential scan coverage would require a weld build up of the DMBW, followed by contouring and an ASME Code, Section III, required radiographic examination. Where axial scan coverage is limited by the presence of a spray nozzle, modification or replacement of the piping would be required in order to remove the spray nozzle examination limitation. The NRC staff has examined the drawings submitted by the licensee and finds that fulfilling the essentially 100 percent examination coverage requirement is not possible using currently available UT technology and procedures. The NRC staff finds that the lack of ASME Code Section XI, Appendix VIII-compliant examination of the CASS and carbon steel materials is not a structural integrity concern since they are not known to be susceptible to PWSCC or other service-related cracking in the reactor coolant system environment; thus, the NRC staff accepts the UT examination achieved for these materials. The NRC staff further finds that the efforts needed to obtain essentially 100 percent scan coverage of the susceptible material would present a hardship.

In response to the NRC staff's request for additional information (RAI, Reference 3), the licensee provided flaw tolerance curves. These curves allow the determination of the time required for a hypothetical flaw in the susceptible material to grow by PWSCC and fatigue to the ASME Code, Section XI acceptance limit of 75 percent through wall. In order to confirm the licensee's analysis, the NRC staff needed values for the initial hypothetical flaw size, operational stress, and weld residual stresses as inputs. The largest hypothetical flaw size is determined by the missed coverage of the UT examination, the operational stresses are given by plant design, and the weld residual stresses are dependent on the weld geometry and depth of any weld repairs.

The UT scan coverage maps submitted by the licensee show the unexamined volume of the susceptible material that could contain a hypothetical flaw. The NRC staff has examined the licensee's drawings and, based on the maximum size of a hypothetical flaw that could exist in the unexamined volume of the susceptible material, has selected weld 30-RC-21B-10 as bounding for axial scan coverage and weld 30-RC-22A-10 as bounding for circumferential scan coverage. In response to the NRC staff's RAI, the licensee proposed that the largest undetected hypothetical circumferential flaw in the susceptible material of weld 30-RC-21B-10 would have a depth of 1.2 inches and a length of 10 inches, and the largest undetected hypothetical axial flaw in the susceptible material of weld 30-RC-22A-10 would have a depth of 0.2 inches and a length of 0.4 inches (Reference 2).

Due to the significance of the initial hypothetical flaw size in the flaw growth analysis, the NRC contracted Pacific Northwest National Laboratory (PNNL) to independently estimate the maximum size of an undetected flaw based on the actual configuration of the welds, and the UT examination procedures and equipment used. The PNNL modeled the UT response in the susceptible weld material (Reference 6) using the weld geometry and the phased-array design parameters specified by the licensee (Reference 2) in response to the NRC staff's RAI. PNNL based their evaluation of UT scan coverage on the direction and intensity of UT sound field. It was assumed that adequate volumetric coverage exists for sound field intensity greater than or equal to -6 decibels (dB).

Modeling the UT coverage of weld 30-RC-21B-10 in the axial scan direction has shown that −6 dB beam coverage exists at the weld ID region for the lowest qualified scan angle of 30 degrees. However, PNNL results show that the ID surface cannot be examined for 10 inches in length due to geometric coverage limitations when the spray nozzle insulation support is present, thus the NRC staff accepts the value of 10 inches for the maximum hypothetical crack length. When inspection access is limited by the insulation support, the PNNL model determined that a low amplitude "top-of-flaw" response is observed; indicating that the licensee's postulated 1.2 inches flaw depth could possibly be detected at 30 degrees, given the axial scanning limitation. The PNNL UT simulations for this case show that the top-of-flaw signal response increases as the flaw depth increases until a maximum response is reached at a 1.4-inch flaw depth, somewhat deeper than the 1.2 inches proposed by the licensee. Based on the results of the PNNL modeling, the NRC staff finds that the likely maximum hypothetical circumferential flaw size which would remain undetected when the insulation support obstruction is present is 1.4 inches in depth and 10 inches in length.

PNNL also modeled the circumferential UT scan coverage for hypothetical axial flaws in weld 30-RC-22A-10. The models show that potential flaws of the size proposed by the licensee, 0.2 inches in depth and 0.4 inches in length, may go undetected during an inspection due to the lack of sufficient beam intensity at the ID surface region. Based on the PNNL modeling results, a flaw approximately 0.49 inches in depth is the minimum depth needed to place the upper region of the flaw into the −6dB UT sound field. The NRC staff used a flaw depth of 0.49 inches and a length of 0.98 inches in confirmatory flaw tolerance analyses.

In order to perform a flaw tolerance calculation, the weld residual stress (WRS) is needed. The WRS depends on the depth of any weld repair. The NRC staff generally assumes that undocumented weld repairs of 50 percent in depth have been performed unless sufficient documentation is submitted. In response to the NRC staff's RAI concerning undocumented weld repairs (Reference 3), the licensee submitted a review of the Shop Traveler, Report of Inspections and Weld Inspection Records, associated with the fabrication of weld 30-RC-21B-10, shop weld #15-504, and that of a second weld that had a documented weld repair, safe-end weld #12-507. The NRC staff has reviewed the Shop Traveler timelines for the two welds and finds that the licensee has demonstrated that weld repairs in excess of 10 percent of the wall thickness would have been recorded during fabrication, thus, accepts a 10 percent weld repair, corresponding to the depth of backchipping of the weld, for WRS calculations.

In response to the NRC staff's RAI, the licensee submitted the WRS calculation results for a weld with a 10 percent repair depth that did not have a subsequent post-weld heat treatment (Reference 3). The NRC staff finds that the absence of subsequent post-weld heat treatment reflects the condition of the weld, thus, finds it acceptable. The NRC staff has compared the licensee's WRS values to reference WRS values for a 10 percent weld repair and finds that the licensee's WRS values are reasonable. Therefore, the NRC staff accepts the licensee's WRS values for use in PWSCC flaw growth analysis.

In response to the NRC staff's RAI, the licensee submitted a flaw tolerance calculation (Reference 3) for a hypothetical circumferential flaw growing by PWSCC in response to operational loading (References 3 and 7) and WRS. The licensee's plot showed that a hypothetical 1.4-inch deep by 10-inch long circumferential flaw would require in excess of 72 months to grow to the ASME Code allowable 75 percent through wall size. The NRC staff has performed an independent flaw growth analyses using the WRS provided by the licensee and reference WRS values, and has confirmed the licensee's calculation. Therefore, the NRC staff finds it to be acceptable. The NRC staff has also analyzed PWSCC growth of the hypothetical 0.49-inch deep axial crack and confirmed that the 72 month lifetime of the circumferential crack bounds the lifetime of the hypothetical axial crack.

In summary, the NRC staff finds that performing the actions needed to achieve the UT examination coverage required by 10 CFR 50.55a(g)(6)(ii)(F)(3) would constitute a hardship. The NRC staff also finds that there is reasonable assurance of structural integrity and leak tightness of the subject welds for a period of at least 72 months from the time of the spring 2011 UT examination.

4.0 CONCLUSION

As set forth above, the NRC staff has concluded that proposed alternative RR ISI-04-07A, "Dissimilar Metal Butt Welds Baseline Examinations," provides reasonable assurance of structural integrity and leak tightness of the subject RCP welds and that complying with the specified requirement would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety. Accordingly, the NRC staff concludes that the regulatory requirements of 10 CFR 50.55a(a)(3)(ii) have been fulfilled and authorizes acceptance of the spring 2011 examination of the subject welds at Calvert Cliffs, as the baseline examination until the scheduled spring 2017 refueling outage.

All other ASME Code, Section XI requirements for which relief was not specifically requested and authorized in the subject proposed alternative remain applicable, including third-party review by the Authorized Nuclear Inservice Inspector.

5.0 REFERENCES

1. Letter dated June 7, 2012, "Relief Request for Unit 2 Dissimilar Metal Butt Welds Baseline Examinations (RR-ISI-04-07A)," Agencywide Documents Access and Management System (ADAMS) Accession No. ML12164A372.

3. Letter dated February 18, 2013, "Response to Request for Additional Information – Relief Request RR-ISI-04-07A. Dissimilar Metal Butt Welds Baseline Examinations," ADAMS Accession No. ML13051A740.

4. Teleconference Summary dated March 14, 2013 between the NRC staff and the licensee's representatives, "NRC Verbal Approval of Calvert Cliffs RR-ISI-04-07A, TAC No. ME8871," ADAMS Accession No. ML13073A175.

5. EPRI, Materials Reliability Program Technical Report MRP-139, Rev. 1, "Materials Reliability Program: Primary System Piping Butt Weld Inspection and Evaluation Guideline," ADAMS Accession No. ML100970671.

6. Pacific Northwest National Laboratory, Technical Letter Report, "Evaluation of Licensee's Alternative to 10 CFR 50.55A(G)(6)(II)(F) for Limitations to Volumetric Examinations of Dissimilar Metal Welds," ADAMS Accession No. ML13113A233.

7. Westinghouse Topical Report WCAP-17128-NP, Rev. 1, May 2010, "Flaw Evaluation of CE Design RCP Suction and Discharge Nozzle Dissimilar Metal Welds, Phase III Study," ADAMS Accession No. ML12306A291.

Principal Contributor: Jay Wallace, NRR/DE/EPNB

Date: May 29, 2013

If you have any questions, please contact the Calvert Cliffs Project Manager, Nadiyah Morgan at (301) 415-1016.

Sincerely,

/ra/

Sean Meighan, Acting Branch Chief
Plant Licensing Branch I-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-318

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JWallace, NRR

ADAMS Accession No: ML13141A647 *See dated memo May 16, 2013

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