



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

March 23, 2012

Mr. Michael J. Annacone, Vice President
Brunswick Steam Electric Plant
Carolina Power & Light Company
Post Office Box 10429
Southport, North Carolina 28461

SUBJECT: BRUNSWICK STEAM ELECTRIC PLANT, UNIT 2 – REVIEW AND APPROVAL
OF A FLAW EVALUATION REGARDING AN INDICATION IN THE REACTOR
PRESSURE VESSEL SHELL-TO-FLANGE WELD (TAC NO. ME6033)

Dear Mr. Annacone:

By letter dated April 13, 2011, as supplemented by letter dated September 29, 2011, Carolina Power & Light Company (the licensee) submitted for the Nuclear Regulatory Commission (NRC) NRC staff's review a flaw evaluation report for Brunswick Steam Electric Plant (BSEP), Unit 2, regarding an indication found in the circumferential shell-to-flange weld joining the reactor pressure vessel (RPV) closure flange forging to the adjacent shell. Small reportable indications were originally found near the site of the flaw of interest during preoperational examinations conducted on June 13, 1972. The licensee intended to demonstrate through a flaw evaluation that the RPV shell-to-flange weld is acceptable for continued service.

The NRC staff has completed the review and determined that the flaw evaluation is in accordance with the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," and meets the ASME Code, Subarticle IWB-3000 acceptance criteria. Hence, the NRC staff concludes that BSEP, Unit 2 can be operated without repair of the subject shell-to-flange weld for the operating period and conditions analyzed. The safety evaluation of the flaw indication is enclosed.

If you have any questions regarding this matter, please contact me at (301) 415-1447.

Sincerely,

A handwritten signature in black ink that reads "Farideh E. Saba".

Farideh E. Saba, Senior Project Manager
Plant Licensing Branch II-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. 50-324

Enclosure: Safety Evaluation

cc w/enclosure: Distribution via ListServ



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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

REACTOR PRESSURE VESSEL FLAW EVALUATION

BRUNSWICK STEAM ELECTRIC PLANT, UNIT 2

CAROLINA POWER & LIGHT COMPANY

DOCKET NO. 50-324

1.0 INTRODUCTION

By letter dated April 13, 2011, as supplemented by letter dated September 29, 2011 (Agencywide Documents Access and Management System Accession Nos. ML11110A022 and ML11286A011, respectively), Carolina Power & Light Company (the licensee) submitted for the Nuclear Regulatory Commission (NRC) staff's review a flaw evaluation report for Brunswick Steam Electric Plant (BSEP), Unit 2, regarding an indication found in the circumferential shell-to-flange weld joining the reactor pressure vessel (RPV) closure flange forging to the adjacent shell. Small reportable indications were originally found near the site of the flaw of interest during pre-operational examinations conducted on June 13, 1972. In accordance with the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, IWB-3610(e), the licensee requested the NRC's approval of the analytical flaw evaluation to demonstrate that the reactor pressure vessel (RPV) shell-to-flange weld is acceptable for continued service.

2.0 REGULATORY REQUIREMENTS

The inservice inspection (ISI) of the ASME Code, Class 1, 2, and 3 components shall be performed in accordance with Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," of the ASME Code and applicable editions and addenda as required by Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.55a(g), except where specific written relief has been granted by the Commission pursuant to 10 CFR 50.55a(g)(6)(i).

Pursuant to 10 CFR 50.55a(g)(4), ASME Code, Class 1, 2, and 3 components (including supports) shall meet the requirements, except the design and access provisions and the preservice examination requirements, set forth in Section XI of the ASME Code to the extent practical within the limitations of design, geometry, and materials of construction of the components.

When flaws are detected by volumetric examinations, acceptance of the flaws by supplemental examination, repairs, replacement, or analytical evaluation shall be in accordance with ASME Code, Section XI, IWB-3130, "Inservice Volumetric and Surface Examinations." In this application, IWB-3600, "Analytical Evaluation of Flaws," as required in IWB-3132.3, "Acceptance by Analytical Evaluation," was applied by the licensee to demonstrate that the RPV shell-to-flange weld is acceptable for continued service.

Enclosure

The ASME Code of record for the fourth 10-year ISI interval at BSEP, Unit 2 is the 2001 Edition of the ASME Code, Section IX, through 2003 Addenda.

3.0 TECHNICAL EVALUATION

The circumferential flaw indication was recorded on March 8, 2011, during an ultrasonic inspection complying with ASME Code, Section XI, Appendix VIII as required and modified by 10 CFR 50.55a(b)(2)(xv). This examination indicated that the flaw length was 6.4 inches and the flaw was 0.45 inches in depth. The flaw was located nearer to the inside surface of the RPV.

The licensee flaw evaluation, in its submittal dated April 13, 2011, considers only fatigue crack growth-rate (FCG), as this is a subsurface flaw and is based on the following conservative assumptions, inputs, and criteria:

1. The indication was assumed to be located at the location of highest stress reported in the BSEP Main Closure Flange stress analysis;
2. The applied loading assumed was a superposition of the maximum individual membrane, bending, and residual stresses taken from all load cases considered;
3. All load cycles are assumed to have the applied loading specified above;
4. The number of stress cycles was estimated by dividing the difference between the number of year until end of life and the number of years already operated by 40 and multiplying this by the number of cycles estimated to have occurred to date;
5. The R ratio, as defined in ASME Code, Section XI, Appendix A, Paragraph A-4300, was chosen to be 1, since this value maximizes FCG;
6. Weld residual stress was modeled assuming a 8 kilo-pounds per square inch (ksi) cosine distribution consistent with industry evaluations;
7. All stresses were scaled by the ratio of the largest power uprate to pre-uprate pressures identified in the power uprate design specification.

The NRC staff considers these assumptions to be appropriately conservative. In particular, the stress assumptions were made conservative through picking the highest loads from different loading conditions, and then multiplying them by the highest ratio of power uprate to pre-uprate pressures and applying them to every load cycle.

The licensee, in the Enclosure to April 13, 2011, submittal, calculated stress intensity factor, K_I (defined in ASME Code, Section XI, IWA-9000), considering membrane, bending, and residual stresses. However, the NRC staff questioned a number of results in this submittal. The licensee, in its response dated September 29, 2011, revised its original analysis by considering all the previous assumptions, except item 2 of the above list. The licensee recalculated the

FCG to be 7.5×10^{-9} -inch per cycle for the analyzed flaw for 275 stress cycles using the crack growth law given in ASME Code, Section XI, Appendix A, paragraph A-4300 and a realistic but less conservative stress state. The assumed 275 cycles is an estimate based on the total past history of operation, and is, therefore, likely to be conservative under current operating conditions.

The NRC staff independently completed the analysis using all the above-listed assumptions with the licensee's revised approach and found an FCG of 3.5×10^{-6} -inch per cycle. Over the 275 estimated cycles, this would increase the crack size by 1.92×10^{-3} inches in depth and twice that in length, a negligible increase. The NRC staff-calculated FCG was in fact less than that determined by the licensee's original calculations, an FCG that would still have been acceptable. The FCG results in both the NRC staff and licensee analyses are so low that even after 275 cycles the crack dimensions would be nearly identical to the current dimensions. The significant layers of conservatism throughout the calculation support the likelihood that the FCG bounds reality.

Finally, Subarticle IWB-3612 of the ASME Code 2001 Edition with 2003 Addenda, Section XI, requires that the analysis confirm that $K_I < K_{Ia}/10^{0.5}$ for normal conditions, where K_{Ia} is crack arrest toughness. The licensee, in its letter dated April 13, 2011, verified that $K_I < K_{Ic}/10^{0.5}$ after 275 cycles, where K_{Ic} is plane stress toughness. The NRC staff noted that this discrepancy was due to the licensee using the 2007 Edition of the ASME Code requirements instead of the appropriate 2001 Edition with 2003 Addenda version of the ASME Code. In response to the NRC staff question regarding the justification for using the K_{Ic} criterion, the licensee recalculated and confirmed the K_{Ia} criterion in the September 29, 2011 submittal. The NRC staff also calculated the appropriate K_I to be 15.7 ksi, and confirmed that it was lower than the K_{Ia} criterion for all necessary conditions (the lowest of which was 17.7 ksi).

Based on the review detailed above, the NRC staff finds that the subject flaw will meet the ASME Code, Section XI, IWB-3613 requirements through the remainder of the plant's licensed life barring change in loading conditions or other circumstances not currently considered. Adherence to ASME Code, Section XI, IWB-2420(b), requiring that the area containing the analyzed flaw be reexamined during the "next three inspection periods listed in the schedule" provides further assurance.

4.0 CONCLUSION

The NRC staff has completed the review of the licensee's submittals dated April 13 and September 29, 2011, and found that the licensee's flaw evaluation meets the rules in the 2001 Edition with 2003 Addenda of Section XI of the ASME Code. As the projected flaw growth is predicted to be negligible and to pose no challenge to the integrity of the component, the NRC staff concludes that the RPV shell-to-flange weld is acceptable for continued service provided that the subsequent examinations required by ASME Code, Section XI are performed as described above.

Principal Contributor: Daniel S. Widrevitz, NRR/DE

Date: March 23, 2012

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/RA/

Farideh E. Saba, Senior Project Manager
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