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

SUBJECT: BRUNSWICK STEAM ELECTRIC PLANT, UNIT 2 – APPROVAL OF A REGULATORY COMMITMENT CHANGE REGARDING REPLACEMENT OF UNIT 2 CORE PLATE PLUGS (TAC NO. ME7702)

Dear Mr. Annacone:

By letter dated December 8, 2011, as supplemented by letters dated November 5 and December 18, 2012, Carolina Power & Light Company, the licensee for Brunswick Steam Electric Plant, Unit 2, submitted “Revision of Regulatory Commitment Regarding Replacement of Unit 2 Core Plate Plugs” requesting U.S. Nuclear Regulatory Commission (NRC) approval of a revision to a commitment for license renewal, to replace the Unit 2 core plate plugs prior to the period of extended operation, which for Unit 2 begins on December 28, 2014. The revised commitment states:

Replacement of the spring-loaded core plate plugs installed in Unit 2 will be completed during the refueling outage currently scheduled for 2013. However, if installation problems preclude completion of the core plate plug replacements during the 2013 refueling outage, replacement of the Unit 2 spring-loaded core plate plugs may be deferred for completion during the refueling outage currently scheduled for 2015.

The NRC staff reviewed the information in the licensee's request and found that the justification for modifying the license renewal-related commitment acceptable. The NRC staff's safety evaluation is enclosed. Therefore, Technical Assignment Control No. ME7702 associated with this review will be closed.
M. Annacone

If you have any questions regarding this letter, please contact me at (301) 415-1055.

Sincerely,

Christopher Gratton, Senior Project Manager
Plant Licensing Branch II-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-324

Enclosure: As stated

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

BRUNSWICK STEAM ELECTRIC PLANT, UNIT 2

REGULATORY COMMITMENT REVISION REGARDING

REPLACEMENT OF CORE PLATE PLUGS

DOCKET NO. 50-324

1.0 INTRODUCTION

By letter dated December 8, 2011 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML11348A115) as supplemented by letters dated November 5 and December 18, 2012 (ADAMS Accession Nos. ML12321A318 and ML12362A108, respectively), Carolina Power & Light Company (the licensee) submitted for U.S. Nuclear Regulatory Commission (NRC) staff review a request to revise a Brunswick Steam Electric Plant (BSEP), Unit 2 license renewal-related commitment. This commitment requires the licensee to replace the existing Unit 2 core plate plugs prior to entering the period of extended operation, and more specifically, during the BSEP, Unit 2, 2011 refueling outage. The BSEP, Unit 2 period of extended operation begins December 28, 2014.

The licensee's attempt to replace the core plate plugs during the 2011 Unit 2 outage was unsuccessful. The licensee subsequently received permission from the NRC staff to delay the replacement until the 2013 Unit 2 outage. The licensee proposes to alter the commitment such that if problems occur during the 2013 refueling outage core plate plug replacement, the licensee would delay the replacement of the core plate plugs until the 2015 refueling outage, which is beyond the commencement of the period of extended operation.

2.0 REGULATORY EVALUATION

The Atomic Energy Act of 1954 and NRC regulations limit commercial power reactor licenses to an initial 40-year term, but also permits such licenses to be renewed. Nuclear power plants seeking an extension of their operating licenses may submit License Renewal Applications (LRAs) that are reviewed pursuant Title 10 of the Code of Federal Regulations (10 CFR), Parts 51 and 54.

License renewal requires the identification and updating of the time-limited aging analyses (TLAAs). During the design phase for a plant, certain assumptions are made about the length of time the plant can operate. These assumptions are incorporated into design calculations for
several of the plant's structures, systems, and components (SSCs). In accordance with 10 CFR 54.21(c)(1), the applicant must either show that these calculations will remain valid for the period of extended operation, project the analyses to the end of the period of extended operation, or demonstrate that the effects of aging on these SSCs can be adequately managed for the period of extended operation.

Section 4.2.8 of the BSEP, Unit 2 LRA provided a TLAA analyzing stress relaxation of the Unit 2 spring-loaded core plate plugs. During the review of the application, the NRC staff requested, and the licensee agreed, to add a commitment to manage the loss of preload stress due to stress relaxation in the core plate plugs by replacing the core plate plugs. This commitment, as reflected in the final safety evaluation (SE) report (ADAMS Accession No. ML053550324), states:

The applicant's two responses to RAI [request for additional information] B.2.28-5 clarify that the applicant's basis for managing stress relaxation in the Unit 2 spring-loaded core plate plugs will be to replace them with a welded configuration [...] and that the replacement of the plugs is scheduled to be performed in the Unit 2 2011 refueling outage. The applicant included its program to replace the Unit 2 spring-loaded core plate welds for the RV & ISIP [Reactor Vessel and Internals Structural Integrity Program] in Commitment Item #22.

License Renewal Commitment Item #22 specified that the core plate plugs would be managed by replacement of the plugs and that any evaluation to extend the service life of the core plate plugs would be submitted to the NRC for review and approval.

3.0 TECHNICAL EVALUATION

3.1 Licensee Evaluation

The licensee stated that the core plate plugs were installed in 1977 in order to limit flow through the bypass flow holes of the core support plate. This reduction in flow serves to protect the core neutron monitors and start-up sources against flow induced vibration. The plugs were designed such that an Alloy X-750 spring within each plug would regulate the plug behavior. The mechanical life of the core plate plugs was originally estimated to be 12 effective full-power years (EFPY) based upon radiation effects on the Type 304 stainless steel plug latches, relaxation of the X-750 springs, and intergranular stress corrosion cracking (IGSCC) of the spring and stainless steel structural members.

The licensee committed via their license renewal to replace the core plate plugs prior to the period of extended operation, however, due to difficulties encountered removing the plugs; the replacement was delayed until the following refueling outage in 2013. The licensee argued that their analysis justified potentially replacing the plugs in 2015 if difficulties were again encountered. Specifically they stated that the plugs could be safely left installed until 30 EFPY (calculation assumed a 120-percent power uprate), which would not be exceeded until approximately 2016. In the evaluation, the licensee assumed the unit would operate at a 100 percent capacity factor after 2011, when the plant was at 25.09 EFPY.
To justify potentially leaving the plugs in place the licensee addressed six topic areas: spring relaxation, IGSCC of the spring, IGSCC of the stainless steel components, embrittlement of the stainless steel components, flow past the plugs, and loose parts considerations.

The licensee concluded from its evaluation of the six topic areas that the plugs would remain sufficiently functional through 2015 to justify returning to power operation if the core plate plug replacement activity fails during the 2013 refueling outage.

3.2 NRC Staff's Evaluation

The NRC staff reviewed the submittal with an emphasis on the six topics noted in Section 3.1 of this SE. Operation with degraded core plate plugs is not recommended based upon the licensee's initial reason for installing the plugs, namely that flow induced vibration may damage sensitive equipment near the core plate. Replacing the core plate plugs so close to the period of extended operation would present an increased likelihood for plug failure prior to the replacement. This is counterbalanced by the desire to avoid producing loose parts or otherwise damaging other components while replacing the core plate plugs. The BSEP, Unit 2 core plate plugs were previously analyzed for 24 EFPY and were, thus, slated for replacement in 2011. Due to installation issues, the 2011 replacement process was unsuccessful and a second attempt is scheduled for the BSEP, Unit 2 2013 refueling outage.

The licensee-provided analysis began with a discussion of plug testing and operating experience. A number of core plate plugs were removed at other facilities having absorbed 1, 1.8, 5, 10, approximately 12, and 17.4 EFPY. No degradation due to IGSCC was observed in the spring, latch, pin, shaft, or body of plugs through the 11.7 EFPY specimens. Hardness measurements conducted indicated only moderate irradiation induced hardening of the metal. A small amount of spring relaxation was noted. Plugs recovered during a 2002 core plate plug replacement were analyzed. This analysis concluded that all metallic surfaces were free from flaws (i.e., no evidence of cracking, wear, or corrosion), that latch damage was primarily due to the removal process (as designed), and that the spring relaxation was more than predicted while previous plugs had exhibited less relaxation than forecast. Plugs tested prior to 2002 indicated that the original design plug lifespan estimates were very conservative and were not clearly consistent with the 2002 plug data.

The first of the six topics evaluated was spring relaxation. The licensee provided several calculations and General Electric (GE) conclusions from previous evaluations. The spring relaxation results from the 17.4 EFPY specimens exceeded the relaxation predicted by the previous GE evaluations. The NRC staff verified licensee calculations of spring relaxation and concurred that even including the 17.4 EFPY results, the BSEP, Unit 2 plugs would fulfill at least some of their intended function. This conclusion is supported by the evaluation presented below for flow past the plugs.

The second topic was IGSCC of the spring. The springs were produced from spring temper Alloy X-750. This material has been used in lantern and finger springs in GE fuel bundles as well as other nuclear applications. The specific temper used for the core plate plug springs is known to be more susceptible to IGSCC than milder heat treatments. Helpfully, the spring relaxation behavior is beneficial to spring resistance to IGSCC. The licensee calculated a cumulative usage factor per the Stress Rule Index (SRI) method for the spring and found that with and without considering the 17.4 EFPY results, the springs should remain free of IGSCC.
damage through 30 EFPY. The NRC staff requested that the licensee provide an associated GE report detailing the previous plug examinations and the SRI method. The licensee provided the requested information in a letter dated December 18, 2012 (ADAMS Accession No. ML12362A108). The staff reviewed the GE report, using it to help verify the licensee’s calculations and methods. Based on the lack of IGSCC damage in analyzed plugs and the discussion below regarding loose parts, the NRC staff concludes that IGSCC is unlikely to seriously challenge the springs through 30 EFPY.

The third topic the licensee evaluated was the potential for IGSCC in the stainless steel components of the plugs. It is generally understood that IGSCC occurs when components have been exposed to fluences of $5 \times 10^{20}$ neutrons/centimeter squared (n/cm$^2$) ($E > 1$ MeV) or greater. The greatest expected fluence of any of the plug components is for the top of the plug shaft, which is predicted not to reach $5 \times 10^{20}$ n/cm$^2$ ($E > 1$ MeV) until after 30 EFPY. In addition, most of the components in the plug are under minimal stresses and thus do not have the driving force necessary to induce IGSCC. The licensee further enumerated the details of heat treatments applied to plug components, noting that these precluded unusual sensitivity to IGSCC. The NRC staff reviewed the information provided and concluded that IGSCC is unlikely to challenge the stainless steel portions of the plugs before 30 EFPY.

The fourth topic was the embrittlement of stainless steel. Neutron radiation is known to cause metals to lose ductility and become embrittled. For the purposes of removing the plug, the embrittlement of the latch is related to the likelihood of producing lose parts. Due to the shielding effect of the core plate and upper core plate plug, the latch receives relatively little radiation and the licensee stated, and the staff concurs, that embrittlement of the stainless steel would not present an obstacle to delaying plug replacement.

The fifth topic concerns the potential flow past the plugs. The licensee calculated leakage past the plug for normal and faulted conditions for four different cases of plug movement. The licensee concluded that even for severely upset plugs, the flow through the plug would be 27 gallons per minute (gpm), a value not significantly different than the flow past a barely upset plug. Without any plug, the flow would be approximately 151-157 gpm. This result was noted to be consistent with GE testing. The GE testing had also indicated that ejection of a single plug would not produce unacceptable instrument vibration levels, while this ejection should be detectable via the nearby local power range monitor (LPRM). Based on the NRC staff’s review of the licensee’s calculations and GE testing results, the NRC staff concludes that there is margin to the point where plug degradation would affect its flow characteristics, and therefore, there is reasonable assurance that plant operations will not be challenged by degradation of the plugs.

The final topic was loose parts considerations. If a plug was left in place, loose parts could be generated through complete ejection of the plug due to spring relaxation or IGSCC. The licensee stated that a complete failure of the latch, pin, or core plate plug body would be required for the plug to be ejected. A double failure of the spring would be required to generate loose parts from the spring. As all of these cases are very unlikely to occur before increased flow through a core plate plug may be detected through vibration of an LPRM, the NRC staff concludes that it is unlikely that loose parts will be generated without ample warning.

Based on the review detailed above, the NRC staff concludes that the core plate plugs will remain operational and will not challenge safety systems without sufficient warning until the
damage through 30 EFPY. The NRC staff requested that the licensee provide an associated GE report detailing the previous plug examinations and the SRI method. The licensee provided the requested information in a letter dated December 18, 2012 (ADAMS Accession No. ML12362A108). The staff reviewed the GE report, using it to help verify the licensee's calculations and methods. Based on the lack of IGSCC damage in analyzed plugs and the discussion below regarding loose parts, the NRC staff concludes that IGSCC is unlikely to seriously challenge the springs through 30 EFPY.

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Based on the review detailed above, the NRC staff concludes that the core plate plugs will remain operational and will not challenge safety systems without sufficient warning until the
2015 refueling outage. The staff concludes operation beyond 2015 with the original core plate plugs is not justified.

4.0 CONCLUSION

Based on its review of the basis for the proposed change, the NRC staff concludes that the licensee’s revised commitment to complete core plate plug replacement during the 2015 outage should replacement not be completed during the 2013 outage is acceptable. This conclusion is reached in part due to consideration of the risks associated with replacement and is not a generic endorsement of extending core plate plug life. Operation with the current core plate plugs beyond 2015 is not approved.
M. Annacone

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If you have any questions regarding this letter, please contact me at (301) 415-1055.

Sincerely,

/RA/

Christopher Gratton, Senior Project Manager
Plant Licensing Branch II-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-324

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