October 11, 2006

Mr. Thomas D. Walt, Vice President
Carolina Power & Light Company
H. B. Robinson Steam Electric Plant
Unit No. 2
3581 West Entrance Road
Hartsville, South Carolina 29550

SUBJECT: H. B. ROBINSON STEAM ELECTRIC PLANT, UNIT NO. 2 — CORRECTION LETTER FOR AMENDMENT NO. 209 ON METHODOLOGY FOR LARGE BREAK LOSS-OF-COOLANT ACCIDENT ANALYSES (TAC NO. MC6630)

Dear Mr. Walt:

This letter provides a correction to the Safety Evaluation (SE) for Amendment No. 209, which was issued by the Nuclear Regulatory Commission (NRC) on September 20, 2006, to Renewed Facility Operating License No. DPR-23 for the H. B. Robinson Steam Electric Plant, Unit No. 2 (HBRSEP2). The amendment approved changes to the HBRSEP2 Operating License and Technical Specifications to change the methodology for large break loss-of-coolant accident analyses.

The NRC staff had inadvertently referred to the use of “Zircaloy” cladding as “M5" cladding in Section 1.0 on page 1 and Table 1 on page 2 of the SE. Consequently, the footnote on Table 1 referring to an exemption for M5 cladding was also removed. A copy of the corrected Safety Evaluation is enclosed for your convenience.

Sincerely,

/RA/

Brenda L. Mozafari, Senior Project Manager
Plant Licensing Branch II-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-261

Enclosure: Safety Evaluation

cc w/encl: See next page

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Carolina Power & Light Company

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Unit No. 2

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO AMENDMENT NO. 209 TO

RENEWED FACILITY OPERATING LICENSE NO. DPR-23

CAROLINA POWER & LIGHT COMPANY

H. B. ROBINSON STEAM ELECTRIC PLANT, UNIT NO. 2

DOCKET NO. 50-261

1.0 INTRODUCTION

By letter dated March 3, 2005, as supplemented by letter dated July 6, 2006, the Carolina Power & Light Company (CP&L, licensee) requested changes to the H. B. Robinson Steam Electric Plant, Unit No. 2 (HBRSEP2) Operating License and Technical Specifications (TS), specifically, changes to the HBRSEP2 methodology for large break (LB) loss-of-coolant accident (LOCA) analyses. The licensee requested approval to apply the Nuclear Regulatory Commission (NRC)-approved Framatome best estimate (BE) LBLOCA methodology described in EMF-2103(P)(A) "Realistic Large Break Loss-of-Coolant Accident Methodology for Pressurized Water Reactors", Revision 0, April 2003, for HBRSEP2.

The July 6, 2006, letter provided clarifying information that did not change or expand the scope of the initial proposed no significant hazards consideration determination.

The NRC staff reviewed the licensee's evaluations of the emergency core cooling system (ECCS) performance analyses for HBRSEP2 that were done in accordance with the EMF-2103(P)(A) methodology, operating at about 102 percent of the licensed core power of 2339 mega-watts thermal (MWt). For HBRSEP2 the LOCA analyses were conducted assuming the plant uses Framatome Zircaloy fuel assemblies.

HBRSEP2 is a 3-loop pressurized water reactor (PWR) of Westinghouse design, enclosed within a large, dry containment. The ECCS consists of low pressure safety injection (LPSI) flow and high head safety injection (HHSI) flow delivered to the cold legs, and three accumulators with a cover gas pressure of about 600 psia, also injecting into the cold legs. The shut-off head of the HHSI pumps is about 1500 psia. The analyzed core power was the current licensed power level of 2339 MWt plus uncertainties.

2.0 REGULATORY ANALYSIS

The LBLOCA analyses were performed to demonstrate that the system design would provide sufficient ECCS flow to transfer the heat from the reactor core following a LOCA at a rate such that (1) fuel and clad damage that could interfere with continued effective core cooling would be

prevented, and (2) the clad metal-water reaction would be limited to less than enough to compromise cladding ductility and would not result in excessive hydrogen generation. The NRC staff reviewed the analyses to ensure that it reflected suitable redundancy in components and features; and suitable availability of interconnections, leak detection, isolation, and containment capabilities such that the safety functions would be accomplished assuming a single failure or for LOCAs considering the availability of onsite power (assuming offsite electric power is not available with onsite electric power available or onsite electric power is not available with offsite electric power available). The acceptance criteria for ECCS performance are provided in Section 50.46 of Title 10 of the *Code of Federal Regulations* (10 CFR 50.46), and were used by the NRC staff in assessing the acceptability of the EMF-2103(P)(A) methodology for HBRSEP2.

The NRC staff also reviewed the limitations and conditions stated in its safety evaluation report supporting approval of the methodology and the range of parameters described in the EMF-2103 topical report in its assessment of the acceptability of the methodology for HBRSEP2.

3.0 LBLOCA ANALYSIS

In the July 6, 2006, submittal, the licensee stated, "Carolina Power and Light Company, also known as Progress Energy Carolinas, Inc. (PEC) and its vendor, AREVA NP Inc. have ongoing processes which assure that the input parameters for the HBRSEP2 LOCA analyses conservatively bound the ranges and values of the as-operated plant parameters." The NRC staff finds that this statement, along with the generic acceptance of the EMF-2103(P)(A) methodology, provides assurance that EMF-2103(P)(A) and LBLOCA analyses performed using that the methodology apply to HBRSEP2 operated at the current licensed power of 2339 MWt.

In its submittal, the licensee provided the results for the HBRSEP2 BE LBLOCA analyses at 2339 MWt (plus uncertainties) performed in accordance with the EMF-2103(P)(A) methodology. The licensee's results for the limiting peak cladding temperature (PCT), the maximum cladding oxidation (local), and the maximum core-wide cladding oxidation are provided in the following table along with the acceptance criteria of 10 CFR 50.46(b).

TABLE 1: LARGE BREAK LOCA ANALYSIS RESULTS

Parameter	EMF-2103 HBRSEP2 Results	10 CFR 50.46 Limits
Limiting Break Size/Location	DEG/PD	N/A
Cladding Material	Zircaloy	(Cylindrical) Zircaloy or Zirlo
Peak Clad Temperature	1952 °F	2200 °F (10 CFR 50.46(b)(1))
Maximum Local Oxidation	1.82 percent	17.0 percent (10 CFR 50.46(b)(2))
Maximum Hydrogen Generation	0.04 percent	1.0 percent (10 CFR 50.46(b)(3))

DEG/PD is a double ended guillotine break at the pump discharge.

In assessing the analyses for HBRSEP2, the NRC staff considered the concern that present fuel may have pre-existing oxidation that must be considered in its LOCA analyses. The NRC staff notes that the fuel with the highest LOCA generated oxidation will likely not be the same fuel that has the highest pre-LOCA oxidation. It should be noted that the NRC staff is discussing a concern with the Framatome about the statistical approach used in the EMF-2103(P)(A) LBLOCA methodology for determining local oxidation and maximum hydrogen generation. Section 3.1.4 of this safety evaluation provides additional information on this concern. Even with the NRC staff's concern, the NRC staff considered that the calculated local oxidation is sufficiently low (1.82 percent) that the pre-accident oxidation would have to be incredibly high (greater than 15 percent) for any power-producing rod in the core to exceed the 10 CFR 50.46(b)(2) total oxidation limit of 17 percent. The NRC staff finds that this appropriately addresses the issue with pre-LOCA oxidation at HBRSEP2.

The concern with core-wide oxidation relates to the amount of hydrogen generated during a LOCA. Because hydrogen that may have been generated pre-LOCA (during normal operation) will be removed from the reactor coolant system throughout the operating cycle, the NRC staff notes that pre-existing oxidation does not contribute to the amount of hydrogen generated post-LOCA and therefore, it does not need to be addressed when determining whether the calculated total core-wide oxidation meets the 1.0 percent criterion of 10 CFR 50.46(b)(3).

As discussed previously, PEC requested Framatome to conduct the BE LBLOCA analyses for HBRSEP2 at the licensed power level of 2339 MWt (plus uncertainties) using the NRC approved EMF-2103(P)(A) methodology. The NRC staff concluded that the results of these analyses (see Table 1) demonstrated compliance with 10 CFR 50.46(b)(1) through (b)(3) for licensed power levels of up to 2339 MWt.

3.1 OTHER TECHNICAL ISSUES

3.1.1 Breaks at the Top and Side of Cold Leg Pump Discharge Piping

A LOCA scenario of concern to the NRC staff is a break of a size that could result in extended core uncovery requiring operator action to depressurize and establish low pressure recirculation cooling. The NRC staff's concern applies to plants with deep reactor coolant system pump (suction) loop seals (such as HBRSEP2). The size of break for this scenario falls within the range of breaks analyzed by both small break (SB) and LBLOCA methodologies. To the extent that the SBLOCA and LBLOCA analyses overlap on break size, the more conservative results are considered limiting by the NRC staff. A split break at the top or side of cold leg pump discharge piping could lead to this scenario.

In response to an NRC staff request for additional information on cold leg slot breaks, the licensee referred to EMF-3030(P) "Robinson Nuclear Plant Realistic Large Break LOCA Analysis", dated February 27, 2004, in its July 6, 2006, letter. The licensee stated that "[s]lot breaks at the top and side of the cold leg piping were evaluated generically, based on relevant engineering experience for 3-loop and 4-loop recirculating steam generator plants. As noted in Table 3.4 of EMF-3030(P), the evaluation is documented in the realistic LBLOCA analysis guidelines; therefore, slot breaks at the top and side of the pipe have been considered for HBRSEP, Unit No. 2." The licensee also indicated that HBRSEP2 was explicitly considered in the generic evaluation and that "the high loop seal elevations at HBRSEP, Unit No. 2, resulted

in a minor amount of core uncovering, with a minimum collapsed liquid level of 9.45 feet and minor cladding heatup to approximately 600 °F." Further, the licensee indicated that the HBRSEP2 emergency operating procedures direct operator actions, "such as aligning ECCS for hot leg recirculation, that will mitigate the consequences of the core uncovering by suppressing core boiling and/or minimizing the amount of time that the core is partially uncovered."

Based on the relatively low PCTs associated with slot breaks based on the EMF-2103(P)(A) methodology, and the existing emergency operating procedure guidance, the NRC staff concludes that the issue related to compliance with 10 CFR 50.46(b)(1)-(4) has been adequately addressed for HBRSEP2.

3.1.2 Post-LOCA Boron Precipitation

This issue was considered in the original licensing of HBRSEP2. The LBLOCA methodology described in EMF-2103(P)(A) does not affect this issue. Therefore, the NRC staff considers that the status of this issue is unchanged by the application of the EMF-2103(P)(A) LBLOCA methodology to HBRSEP2.

3.1.3 Downcomer Boiling

The NRC staff has raised concerns to the licensee with the modeling of downcomer boiling in LBLOCA analysis methodologies. These concerns are being discussed with the methodology vendors to develop solutions. The NRC staff's concerns are primarily associated with PWRs with subatmospheric or ice condenser containments, and to a lesser extent 3-loop Westinghouse PWRs. Consistent with the requirements of 10 CFR 50.46, HBRSEP2 is required to evaluate the effect of the generic resolution applicable to its class of plant and to revise its LBLOCA analyses as appropriate.

During the reflood stage of post-LOCA ECCS operation, latent heat from the reactor vessel, the core barrel, and other vessel internals is transferred to the water in the downcomer of the vessel. The head of water in the downcomer provides the driving force for reflooding the core. The heat transferred to the downcomer water would reduce the density of the water and boil away water. Both of these effects reduce the driving head for reflooding of the core. Depending on the magnitude and timing of this heat addition to the downcomer water, the core reflood rate could be adversely affected, with adverse consequences to the fuel in the core. If the LOCA analysis methodology does not correctly model heat conduction in the reactor vessel wall, the magnitude and timing of vessel wall heat deposition to the fluid in the downcomer could be non-conservatively timed, such that the PCT, oxidation, and hydrogen generation may be underestimated due to the downcomer boiling effect.

While this issue may ultimately result in higher limiting PCT, local oxidation, and maximum hydrogen generation at HBRSEP2, as shown in Table 1 of this safety evaluation, the licensee has demonstrated for the current licensed power level that there is substantial margin to the acceptance criteria of 10 CFR 50.46(b)(1), (2), and (3), respectively.

Based on the application of the NRC staff approved ECCS performance evaluation methodology described in EMF-2103(P)(A) and the substantial margin to the acceptance criteria of 10 CFR 50.46(b)(1), (2), and (3), the NRC staff determined that even with the

concerns related to downcomer boiling, the HBRSEP2 LBLOCA analyses was acceptable for the current licensed power level.

3.1.4 Oxidation and Hydrogen Generation

The staff is discussing with Framatome a generic concern with the BELOCA methodology described in EMF-2103(P)(A) used to determine the limiting LBLOCA oxidation and hydrogen generation. The concern is that the method used to determine the limiting LBLOCA oxidation and hydrogen generation is not consistent with Regulatory Guide 1.157, “Best Estimate Calculations of Emergency Core Cooling Performance,” Section 4.4, that states, “The revised paragraph 10 CFR 50.46(a)(1)(i) requires that it be shown with high probability that none of the criteria of paragraph 10 CFR 50.46(b) will be exceeded, and is not limited to the peak cladding temperature criterion. However, since the other criteria are strongly dependent on peak cladding temperature, explicit consideration of the probability of exceeding the other criteria may not be required if it can be demonstrated that meeting the temperature criterion at the 95 percent probability level ensures with equal or greater probability that the other criteria will not be exceeded.” The fundamental issue the NRC staff raised in various calls with Framatome is whether the statistical approach used in the methodology provides the high level of probability that the oxidation and maximum hydrogen generation criteria of 10 CFR 50.46 (b)(2) and (b)(3), respectively, would not be exceeded.

In assessing whether the local oxidation and maximum hydrogen generation results of the HBRSEP2 BELOCA analysis provide the high level of probability that these criteria will not be exceeded, the NRC staff considered the margin between the results and the acceptance criteria, and the results of the previous 10 CFR 50, Appendix K, LBLOCA analyses. As noted in Table 1 of this safety evaluation, the BELBLOCA analyses are significantly below the limits of 10 CFR 50.46 (b)(2) and (b)(3). Even with the staff’s concern with the statistical approach used in the Framatome EMF-2103(P)(A) BELBLOCA methodology, given the margin, the NRC staff concluded that there is a high probability that at the current licensed power level for HBRSEP2, the oxidation and hydrogen generation acceptance criteria of 10 CFR 50.46(b)(2) and (b)(3) would not be exceeded. Further, the previous LBLOCA analysis results described in the Robinson Final Safety Analysis Report (FSAR) for oxidation (3.5 percent) and hydrogen generation (less than 1.0 percent) bound the results using the EMF-2103 (P)(A) methodology, for HBRSEP2, operating at its current licensed power level. Because the results in the HBRSEP2 FSAR bound the EMF-2103(P)(A), results and the significant margin to the acceptance criteria of 10 CFR 50.46(b)(2) and (b)(3), the NRC staff finds the submitted LBLOCA oxidation and hydrogen generation results acceptable for HBRSEP2 operating at its current licensed power level.

3.1.5 Long Term Cooling

One of the limitations specified in the NRC safety evaluation report approving EMF-2103 (P)(A) stated, "the model does not determine whether Criterion 5 of 10 CFR 50.46, long term cooling, has been satisfied. This will be determined by each applicant or licensee as part of its application of this methodology." The licensee stated “[f]or HBRSEP, Unit No. 2, this was evaluated previously in report EMF-2286, "H. B. Robinson Unit 2 Extended Transfer to Cold Leg Recirculation Following a LBLOCA," and was approved by the NRC in a letter dated July 12, 2001.”

For HBRSEP2, the NRC staff concluded that the existing licensing basis described in EMF-2286 was not affected by the adoption of EMF-2103(P)(A) and remains adequate as the licensing basis to demonstrate compliance with 10 CFR 50.46(b)(5) at its present power. Therefore, as it relates to long term cooling, the NRC staff concludes that EMF-2103(P)(A) is acceptable.

3.2 LBLOCA CONCLUSIONS

The NRC staff's review of the acceptability of the EMF-2103(P)(A) methodology for HBRSEP2 focused on assuring that the HBRSEP2 specific input parameters or bounding values and ranges (where appropriate) were used to conduct the analyses, that the analyses were conducted within the conditions and limitations of the NRC approved Framatome EMF-2103(P)(A) methodology, and that the results satisfied the requirement of 10 CFR 50.46(b) based on a licensed power level of up to 2339 MWt.

This Safety Evaluation documents the NRC staff review and the bases of acceptance of the EMF-2103(P)(A) BELBLOCA analysis methodology for application to HBRSEP2, and of the LBLOCA analyses discussed above, which were performed with the EMF-2103(P)(A) methodology for reference at HBRSEP2.

Based on its review as discussed above, the NRC staff concluded that the Framatome BELBLOCA methodology, as described in EMF-2103(P)(A), is acceptable for use at HBRSEP2. Further, the NRC staff concluded that the results demonstrate high probability that the acceptance criteria of 10 CFR 50.46(b)(1), (b)(2), and (b)(3) would not be exceeded during a LBLOCA.

4.0 TECHNICAL SPECIFICATIONS

4.1 TS 5.6.5 Core Operating Limits Report (COLR)

Add the following reference to TS 5.6.5.b:

> 24. EMF-2103(P)(A), "Realistic Large Break LOCA Methodology for Pressurized Water Reactors," approved version as specified in the COLR.

EMF-2103(P)(A) is an acceptable methodology to apply to HBRSEP2 for evaluation of ECCS performance in response to LBLOCAs as discussed in Section 3 of this safety evaluation, and therefore is an appropriate reference for the LBLOCA analyses for core power up to current licensed power level of 2339 MWt.

5.0 TECHNICAL CONCLUSION

The licensee has performed LBLOCA analyses for HBRSEP2 using an NRC approved Framatome methodology. The NRC staff concluded that the NRC approved Framatome methodology applies to HBRSEP2 for core power up to the current license power of 2339 MWt. The licensee's LBLOCA analyses demonstrated that the calculated LBLOCA values for PCT, local oxidation, and core-wide hydrogen generation were less than the acceptance criteria of 2200 °F, 17 percent, and 1.0 percent specified in 10 CFR 50.46(b)(1), (2), and (3),

respectively. The adoption of EMF-2103(P)(A) does not affect the current licensing basis for long term cooling.

Therefore, the NRC staff finds the licensee's LBLOCA analyses for HBRSEP2 acceptable for the current licensed power level of 2339 MWt.

6.0 STATE CONSULTATION

In accordance with the Commission's regulations, the State of South Carolina official was notified of the proposed issuance of the amendment. The State official had no comments.

7.0 ENVIRONMENTAL CONSIDERATION

The amendment changes a requirement with respect to installation or use of a facility component located within the restricted area as defined in 10 CFR Part 20. The NRC staff has determined that the amendment involves no significant increase in the amounts, and no significant change in the types, of any effluents that may be released offsite, and that there is no significant increase in individual or cumulative occupational radiation exposure. The Commission has previously issued a proposed finding that the amendment involves no significant hazards consideration, and there has been no public comment on such finding (70 FR 29787). Accordingly, the amendment meets the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9). Pursuant to 10 CFR 51.22(b) no environmental impact statement or environmental assessment need be prepared in connection with the issuance of the amendment.

8.0 CONCLUSION

The Commission has concluded, based on the considerations discussed above, that: (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, (2) such activities will be conducted in compliance with the Commission's regulations, and (3) the issuance of the amendment will not be inimical to the common defense and security or to the health and safety of the public.

Principal Contributor: Frank Orr, NRR

Date: