Progress Energy

Serial: RNP-RA/06-0021

JUL 06 2006

United States Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

H. B. ROBINSON STEAM ELECTRIC PLANT, UNIT NO. 2
DOCKET NO. 50-261/LICENSE NO. DPR-23

RESPONSE TO NRC REQUEST FOR ADDITIONAL INFORMATION
REGARDING PROPOSED TECHNICAL SPECIFICATIONS CHANGE TO SECTION 5.6.5

Ladies and Gentlemen:

In a letter dated March 3, 2005, Carolina Power and Light Company, also known as Progress Energy Carolinas, Inc. (PEC), requested NRC review and approval of a change to the Technical Specifications (TS) Section 5.6.5, "Core Operating Limits Report (COLR)," for H. B. Robinson Steam Electric Plant (HBRSEP), Unit No. 2. The proposed change would add topical report EMF-2103(P)(A), "Realistic Large Break LOCA Methodology for Pressurized Water Reactors," to the list of documents specified in TS 5.6.5. In an electronic mail transmission dated January 17, 2006, the NRC provided a request for additional information (RAI) related to the proposed TS submittal.

The RAI was provided to AREVA for response because the questions were related to the modeling and analyses as performed by AREVA NP, Inc. The AREVA response is enclosed.

The Attachment provides an Affirmation in accordance with the provisions of Section 182a of the Atomic Energy Act of 1954, as amended, and 10 CFR 50.54(f).

If you have any questions concerning this matter, please contact Mr. C. T. Baucom at (843) 857-1253.

Sincerely,

Jan F. Lucas
Manager – Support Services – Nuclear

Progress Energy Carolinas, Inc.
Robinson Nuclear Plant
3581 West Entrance Road
Hartsville, SC 29550

A001

RAC/rac

Attachment: Affirmation
Enclosure: AREVA letter dated June 16, 2006, "AREVA Responses to NRC's Comment on the Robinson RLBLOCA Report"

c: Dr. W. D. Travers, NRC, Region II
Mr. C. P. Patel, NRC, NRR
NRC Resident Inspector

AFFIRMATION

The information contained in letter RNP-RA/06-0021 is true and correct to the best of my information, knowledge, and belief; and the sources of my information are officers, employees, contractors, and agents of Carolina Power and Light Company, also known as Progress Energy Carolinas, Inc. I declare under penalty of perjury that the foregoing is true and correct.

Executed On: 7/6/06

Ernest J. Kapopoulos, Jr.
Plant General Manager
H. B. Robinson Steam Electric Plant, Unit No. 2

AREVA

June 16, 2006
FAB06-410 Rev.01

Mr. Bruce Morgen (PEB 6)
Lead Engineer, PWR Fuel
Progress Energy
410 South Wilmington Street
Raleigh, NC 27601

Subject: AREVA Responses to NRC's Comment on the Robinson RLBLOCA Analysis Report

Dear Bruce,

Progress Energy provided NRC's comments (reference 1) on the Robinson RLBLOCA analysis reports. The attachment A to this letter provides AREVA's responses (from reference 2).

If you have any questions or comments, feel free to call at (434) 832-2773, or you can e-mail me at Larry.Creasy@areva.com.

Sincerely,

J.L. Creasy
Technical Project Manager

References:

1. 38-9022811-000, NRC Questions to Progress Energy on Realistic LBLOCA.
2. 51-99022760-000, Responses to NRC RAIs for Roninson Cycle 23 RLBLOCA Submittal (AREVA Document EMF 3030(P) Rev.0).

cc: Randy Saas Contract File 4564
Ann Smith, Records Center, Contract 4564 T1.2
File IV-12B

AREVA NP INC.
An AREVA and Siemens company

3315 Old Forest Road, P.O. Box 10935, Lynchburg, Va. 24506-0935
Tel.: (434) 832-3000 – Fax: (434) 832-3840

ATTACHMENT A

NRC REQUEST: A. OVERALL APPLICABILITY TO ROBINSON-2

The H. B. Robinson Unit No. 2 (Robinson-2) Realistic Large Break Loss of Coolant Accident (RLBLOCA) Analysis report, EMF-3030 (P), Revision 0, provides a plant description and a summary of analysis parameters. This report also contains Tables 3.1 - 3.7, and Figures 3.6 - 3.20, which provide information specific to the LBLOCA analyses performed to define the licensing basis for Robinson-2 LBLOCA. The submittal also provides Figures 3.1 - 3.5, which show the Robinson-2 Realistic LBLOCA methodology (RLBLOCA using the S-RELAP5 computer code) Loop and Reactor Vessel noding diagrams used for the analyses. The staff requests further information to address the programmatic requirements of 10 CFR 50.46(c).

NRC Question 1

To show that the referenced generically approved LOCA analysis methodologies apply specifically to the Robinson-2 plant, provide a statement that Progress Energy and its vendor have ongoing processes which assure that the ranges and values of the input parameters for the Robinson-2 LOCA analysis conservatively bound the ranges and values of the as-operated plant parameters. Furthermore, if the Robinson-2 plant-specific analyses are based on the model and/or analyses of any other plant, then justify that the model or analyses apply to Robinson-2 (e.g., if the other design has a different vessel internals design the model wouldn't apply to Robinson-2.)

Response to Question 1

Carolina Power and Light Company, also known as Progress Energy Carolinas, Inc. (PEC), and its vendor, AREVA NP Inc, have in place processes to assure that the input parameters for H. B. Robinson Steam Electric Plant (HBRSEP), Unit No. 2, plant-specific LOCA analyses bound the ranges and values of the as-operated plant parameters. For each operating cycle, a Plant Parameters Document is created to provide the vendor with a current plant description, which is used to assure that the analyses and plant-specific parameters are consistent.

The HBRSEP, Unit No. 2, LOCA analysis is based only on the HBRSEP, Unit No. 2, plant design and does not rely on analyses for any other plant.

NRC REQUEST: B. APPLICABILITY OF ANALYTICAL MODELS

Many of the analytical models in the Robinson-2 best estimate large break (LB) LOCA methodology (used to perform calculations in EMF-3030) are supported by empirical data taken at temperatures less than 1700°F and by sensitivity studies performed at temperatures less than 1700°F. The LOCA peak cladding temperature (PCT) spectrum calculated for Robinson-2 using this methodology extends above 1950°F. At temperatures above 1700°F many of the principal phenomena which influence PCT change or increase in their influence (e.g., cladding oxidation rate), such that the data and sensitivity studies identified for cladding temperatures lower than 1700°F may not apply.

General Response to Part B

A number of the tests that support the evaluation model were performed above 1700°F. Therefore, the model is supported by test data above 1700°F.

The use of the RLBLOCA evaluation model for PCT predictions described in EMF-2103, Revision 0, was approved by the NRC in a Safety Evaluation Report dated April 9, 2003. This Safety Evaluation Report did not indicate that PCT predictions above 1700°F should be subject to any special conditions. Additionally, one of the demonstration plants for topical report EMF-2103, Revision 0, was HBRSEP, Unit No. 2, with a predicted PCT in excess of 1700°F.

NRC Question 2

Prominent among the phenomena of concern is heat transfer from the rod to the coolant during the dispersed flow film boiling regime. S-RELAP5 uses the Forslund-Rohsenow model which was developed using data from a test with geometry and thermal-hydraulic conditions that are non-prototypic of the Robinson-2 core. While this model was shown to have only a small effect below 1700°F, this has not been demonstrated for the higher temperatures predicted for the Robinson-2 calculation which exceed 1950°F. Justify the applicability of the Forslund-Rohsenow model as it is used in the proposed Robinson-2 plant licensing basis methodology. (The S-RELAP5 topical report presented a sensitivity study of the Forslund-Rohsenow model to PCT and quench time to address this concern. However, the analyses for this study were at low temperatures which are not prototypic of Robinson-2.)

Response to Question 2

The sensitivity study of the impact of the Forslund-Rohsenow heat transfer correlation was performed at temperatures up to and above 2200°F. The sensitivity study is documented in a letter from Framatome ANP to the NRC, NRC:02:062, dated December 20, 2002, Responses to a Request for Additional Information on EMF-2103(P), Revision 0, "Realistic Large Break LOCA Methodology for Pressurized Water Reactors," in response to Questions 21 and 22.

Additional justification is provided in Appendix F, "Applicability of the Forslund-Rohsenow Correlation," of EMF-2103(P), Revision 1, which is currently under NRC review.

NRC Question 3

The S-RELAP5 approval was based, in part, on assessment against separate and integral effects data. This assessment focused on those phenomena that would govern the PCT response during a LBLOCA transient. The correlations in the S-RELAP5 methodology that predict the evolution of these phenomena depend on a variety of thermal hydraulic parameters, such as temperature, pressure, mass flux, etc. Demonstrate that the range of these parameters covered by the assessment data bounds the range encountered in the Robinson-2 LBLOCA analyses.

Response to Question 3

Table 3.7 of EMF-3030(P) (Attachment VI of the HBRSEP, Unit No. 2, March 3, 2005 submittal) compares the range of parameters covered by the assessments with the range of parameters encountered in the HBRSEP, Unit No. 2, plant-specific LBLOCA analysis.

NRC Question 4

The convective heat transfer coefficient used in the AREVA NP Inc. RLBLOCA methodology does not extract the effect of radiation heat transfer. Experimental test cases exist for which it can be shown that inclusion of radiation heat transfer in the convective heat transfer coefficient results in non-conservative reflood heat transfer. Confirm that the Robinson-2 fuel and core configuration will not result in reflood heat transfer that takes undue credit for the inclusion of radiation heat transfer in the convective heat transfer coefficient.

Response to Question 4

The NRC Safety Evaluation Report for topical report EMF-2103, Revision 0, approves the topical report without an explicit accounting for the effect of radiation heat transfer between fuel rods. This question was discussed and resolved as part of the review of EMF-2103, Revision 0. Also, EMF-2103(P), Revision 1, provides additional information to support the approved model with respect to radiation heat transfer.

An approach to confirm that the effects of radiation are treated conservatively is described in a Framatome ANP letter to the NRC, NRC:05:025, dated April 14, 2005, Request for Additional Information - EMF-2103(P), Revision 1, "Realistic Large Break LOCA Methodology for Pressurized Water Reactors." The approach consists of confirming that the separation of hot rod and assembly power is equal to or greater than that used in the sensitivity evaluations contained in EMF-2103(P), Revision 1, which demonstrated that the effect of radiation is treated conservatively in the RLBLOCA evaluation model. The HBRSEP, Unit No. 2, fuel and core configuration is such that the separation of hot rod and assembly power is greater than or equal to the 4% assumed in the sensitivity study. Therefore, the effects of radiation are treated conservatively in the HBRSEP, Unit No. 2, analysis.

NRC Question 5

The methodology does not consider pellet fragmentation and relocation (including relocation to the ruptured zone). By ignoring both of these effects and using a fixed value of gap conductance at the higher PCTs calculated in the Robinson-2 analyses, the Robinson-2 model may underestimate the LBLOCA limiting PCT and oxidation values. Sensitivity studies supporting the absence of these phenomena from the S-RELAP5 methodology were performed at PCTs not prototypic of the Robinson-2 analyses. Address this issue within the Robinson-2 LBLOCA methodology.

Response to Question 5

The NRC Safety Evaluation Report for topical report EMF-2103(P), Revision 0, approves the topical report without the need to explicitly model the effect of fuel relocation. Additional justification was provided in the response to Question 131 in the previously referenced December 20, 2002, letter from Framatome ANP to the NRC. The response to Question 131 demonstrates that the combined effect of the treatment of fuel relocation and cladding rupture cooling (no explicit treatment of either) results in a lower PCT than if rupture and relocation had not occurred. It was concluded that not including rupture and relocation in the model would be slightly conservative.

NRC Question 6

The Robinson-2 LBLOCA calculations were ranged to ~ 0.25 ft^2 which is below the minimum size in the current Robinson-2 LBLOCA. This size for Robinson-2 falls in the current SBLOCA range. The supporting demonstration plant analyses for the AREVA NP Inc. LBLOCA were accepted to this small size because for the demonstration plant the phenomena that were predicted to occur were indicative of a LBLOCA rather than a SBLOCA. Robinson-2 must justify that the ranging of break size for application of the AREVA NP Inc. RLBLOCA methodology does not result in phenomena occurring that are atypical of a SBLOCA.

Response to Question 6

The NRC Safety Evaluation Report for topical report EMF-2103(P), Revision 0, approves the topical report for use with the break sizes analyzed for HBRSEP, Unit No. 2. The smallest break size that the methodology is qualified for is 10% of the cold leg area. The HBRSEP, Unit No. 2, cold leg area is approximately 4.1 ft^2. The range of break sizes is specified in the topical report in Section 3. The smallest break size in the 59 sampled cases for HBRSEP, Unit No. 2, is approximately 0.41 ft^2 as shown in Figure 3.8, not 0.25 ft^2. Therefore, the analyzed breaks fall within the LBLOCA approved methodology break size.

NRC Question 7

Has a counter current flow limitation (CCFL) violation warning been implemented in the Robinson-2 LBLOCA methodology consistent with the Framatome ANP commitment dated December 20, 2002?

Response to Question 7

The NRC Safety Evaluation Report conditions and limitations are addressed in Table 3.4 of EMF-3030(P). The issue of the counter current flow limitation is Item 1 in the table.

A CCFL warning was added to the code to comply with the NRC SER. As stated in Table 3.4, there was no significant occurrence of CCFL violation for the HBRSEP, Unit No. 2, analysis. Occurrences of CCFL violation were noted in a statistically insignificant number of time steps.

NRC Question 8

The LBLOCA submittal did not address slot breaks at the top and side of the pipe. Please justify why these breaks are not considered for the Robinson-2 LBLOCA response.

Response to Question 8

The NRC SER for the RLBLOCA topical report requires that one "evaluate the effect of the deep loop seal on the slot breaks." The SER also states that the evaluation of slot breaks may be based on relevant engineering experience and may be documented in either the RLBLOCA guideline or plant-specific calculation file. Slot 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 RLBLOCA analysis guidelines; therefore, slot breaks at the top and side of the pipe have been considered for HBRSEP, Unit No. 2.

The generic evaluation in the analysis guidelines concluded that due to the loop steam velocities, the Reactor Coolant System loop seals cannot accumulate significant liquid inventory for several hours following a LBLOCA. As decay heat continues to decrease, the steam velocities decrease below that required to maintain the loop seal clear of water. Once all of the loop seals are filled with water, the core liquid level will be suppressed and cladding temperatures will begin to increase. HBRSEP, Unit No. 2, was explicitly considered in this evaluation. 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.

Although the generic evaluation showed acceptable results for HBRSEP, Unit No. 2, without any credit for operator action, the evaluation also acknowledged that normal Emergency Operating Procedure (EOP) actions taken at HBRSEP, Unit No. 2, following a LBLOCA, such as aligning the emergency core cooling system (ECCS) for hot leg recirculation, 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.

NRC Question 9

The qualitative discussion in the Robinson-2 submittal (EMF-3030) is not sufficient to demonstrate that the mixed core has been fully assessed. The Robinson-2 licensing basis LBLOCA methodology must be shown to be able to analyze all fuel in the Robinson-2 core, not just the hot assembly. Provide values for PCT and total oxidation (including pre-LOCA, LOCA cladding outside, and cladding post-rupture inside oxidation) for the non-Framatome fuel in the core, and indicate how these values were determined.

Response to Question 9

The fuel in the HBRSEP, Unit No. 2, reactor core is AREVA NP Inc.-supplied fuel. AREVA NP Inc. fuel was first used at HBRSEP, Unit No. 2, in 1975. There is no mixed core.

NRC Question 10

Table 7.2-2, 3.0, "Accident Boundary Conditions," lists the Refueling Water Storage Tank (RWST) temperature as less than/equal to 100°F. The Robinson-2 Technical Specifications, page 3.3.14, mentions a temperature of 263°F. It appears that this is used as a bounding value assumption for the

ECCS recirculation cooling mode net positive suction head and ECCS flow evaluation. Please confirm this conclusion or explain the relevance of the cited temperature.

Response to Question 10

RWST temperature is set to a conservative value as stated on page 3-5 of EMF-3030(P). The conservative value is specified in Table 3.2 on page 3-9 and in Table 3.3 on page 3-10. EMF-3030(P) does not contain a Table 7.2-2.

A value of 100°F is used in the analysis for the RWST temperature. This value is found in the HBRSEP, Unit No. 2, Technical Specifications, Section 3.5.4

RWST temperature is entered in the model in two locations: the temperature of safety injection (SI) flow and the containment spray temperature. While not physical, the analysis values are set differently to conservatively bound the uncertainty associated with each condition. It is set at the TS high limit for SI flow to reduce SI coolability, and is set at the TS low limit to minimize containment pressure. The range of RWST temperatures in the TS are 45°F to 100°F.

NRC Question 11

Downcomer Boiling - The containment pressure in Figure 3.20 indicates that the containment pressure is at about 30 psia and continues to decline at 200 seconds into the limiting LBLOCA. Figures 3.17, 3.18, and 3.19 seem to indicate that downcomer boiling occurs at about 375 seconds into the transient. The containment plot ends at 200 seconds and it appears from Figures 3.17, 3.18, and 3.19 that the calculation was terminated at ~450 seconds. At ~310 seconds the PCT drops to ~212°F (Figure 3.10). At this time the (extrapolated) containment pressure is ~32 psia and declining. The saturation temperature at 32 psia is ~250°F or less, but collapsed liquid level in the core downcomer and lower plenum are declining at about 400 seconds. 10 CFR 50.46 requires analyses to be run until the core is quenched (to establish the acceptably low value that must be maintained during long term cooling).

NRC Question 11-a

Extend the analysis results tables and graphs, particularly Table 7.2-11 and Figure 7.2-33, to the time that stable and sustained quench is established.

Response to Question 11-a

EMF-3030(P), Revision 0, Figure 3.10, shows the peak cladding temperature versus time for the limiting break. The temperature drops to less than 300°F at about 310 seconds and remains there until the plot is terminated at about 420 seconds.

Quench is the condition in which a heated surface is no longer in a film boiling mode. When quench occurs, the surface temperature will drop significantly in a very short period of time because the insulating steam layer that existed prior to quench has been collapsed by liquid in the region. The liquid next to the heated surface will then contact the surface and cool it quickly. The quench phenomenon is demonstrated in the analysis when the temperature drops sharply at 310 seconds.

Investigation of the plots for the limiting case shows that a drop in downcomer collapsed liquid level does occur in the time frame for the analysis. The collapsed liquid level in the core does not show a significant change in inventory, nor is there a trend in core temperature indicating that a change in the downcomer phenomena appears to affect the ability to maintain the core at the quenched temperature. Therefore, the calculation has been executed to quench and beyond.

EMF-3030(P) does not contain a Table 7.2-11 or a Figure 7.2-33.

NRC Question 11 (continued)

NRC staff studies using RELAP5 indicate that a downcomer lateral crossflow resistance coefficient value of 0.2 to 0.3 is appropriate for PWRs.

NRC Question 11-b

Identify and justify the crossflow resistance coefficient value used for the Robinson-2 LBLOCA calculation (including during downcomer boiling).

Response to Question 11-b

EMF-2103(P)(A), Revision 0, uses the lateral crossflow modeling as approved for the evaluation model. The approved model uses a crossflow resistance in the downcomer with a form loss of 0.0. This value is conservative since it allows more bypass flow from the intact loops to the broken loop. The approach was demonstrated to be conservative versus the full scale Upper Plenum Test Facility (UPTF) test as shown in Figures 4.106 through 4.111 of EMF-2103(P)(A), where the calculated lower plenum liquid level is shown to be lower than the test measurements. It was also demonstrated to be conservative in the response to Question 27 in the December 20, 2002 letter from Framatome ANP to the NRC (NRC:02:062) where the crossflow form loss of 0.0 was replaced with a value of 0.1167. The analysis most appropriate to HBRSEP, Unit No. 2, demonstrated that the PCT dropped approximately 100°F when the higher form loss resistance was used.

NRC Question 12

The upper core plate and associated upper plenum modeling assumptions for Robinson-2 can significantly affect the characteristic LOCA transient and/or LOCA results. A variety of upper core plate designs are available for NA-2.

NRC Question 12-a

It is not clear from Figure 3.3 what specific upper core plate configuration is used for Robinson-2. Identify the specific upper plenum and core plate configuration used in Robinson-2.

Response to Question 12-a

The upper internals assembly consists of the following major components: upper support plate, upper core plate, upper support columns, and control rod guide tube assemblies. The upper core plate is located at the bottom of the upper internals assembly and provides the interface between the upper internals and the fuel assemblies. The upper core plate has one flow hole for each fuel assembly for a total of 157 flow holes. There are 61 square flow holes for possible RCCA locations, 23 flow holes with stand-alone flow mixers, 19 flow holes with flow mixers and short support columns, four flow holes with flow mixers and tall support columns, 37 open flow holes, and 13 flow holes associated with support columns without flow mixers.

Design drawings of the upper internals components for HBRSEP, Unit No. 2, were provided to AREVA NP Inc. These drawings, which provided the number, types, and configurations of the support columns and guide tubes; the number, types, and configurations of the flow holes; material thicknesses and weights; and, various other dimensions (heights, diameters, etc.), were used to model the upper internals assembly, including the upper core plate.

NRC Question 12-b

Identify in LBLOCA Figure 3.3 how the upper core assembly is represented in the Robinson-2 LBLOCA and SBLOCA models.

Response to Question 12-b

The upper core plate was modeled in accordance with the approved methodology, which, for the upper plenum region, is shown in Figures 4.8 and 4.9 of EMF-2103(P)(A).

It should be noted that the license amendment request does not involve the SBLOCA model.

NRC Question 12 (continued)

Location of the hot assembly/hot rod with respect to the upper core plate (and related structures) in the Robinson-2 LOCA models can significantly affect the calculated LOCA results for Robinson-2.

NRC Question 12-c

Discuss where the hot assembly/hot rod is located in relation to the Robinson-2 upper core plate and its design features. Show that the Robinson-2 modeling assumption is not non-conservative.

Response to Question 12-c

The upper plenum region, as shown in Figure 4.8 of EMF-2103(P)(A), shows the modeling of the hot assembly relative to the features of the upper core plate. The upper plenum/upper head modeling is also discussed in Section 4.2.4.4 of EMF-2103(P)(A). In that discussion it is indicated that sensitivity studies were performed showing the modeling of the hot assembly under the flow mixer or support column is conservative. Consequently, plant analyses are performed with the hot assembly under a flow mixer or support column. This is shown in EMF-3030(P), Figure 3.5, where the hot assembly is connected to a flow mixer or support column on the upper core plate.

NRC Question 13

It appears from Figure 3.3 that Robinson-2 has a baffle/barrel downflow design. Please confirm this impression.

Response to Question 13

The HBRSEP, Unit No. 2, baffle/barrel is a downflow design.