March 10, 2006

Mr. Cornelius J. Gannon, Vice President
Shearon Harris Nuclear Power Plant
Carolina Power & Light Company
Post Office Box 165, Mail Code: Zone 1
New Hill, North Carolina 27562-0165

SUBJECT: SHEARON HARRIS NUCLEAR POWER PLANT, UNIT 1 - ISSUANCE OF AMENDMENT REGARDING SOLUBLE BORON CREDIT FOR FUEL STORAGE POOLS (TAC NO. MC8267)

Dear Mr. Gannon:

The Nuclear Regulatory Commission has issued Amendment No.121 to Facility Operating License No. NPF-63 for the Shearon Harris Nuclear Power Plant, Unit 1. This amendment changes the Technical Specifications (TS) in response to your application dated September 1, 2005, as supplemented by letters dated December 22, 2005, and January 23, 2006.

The amendment revises the TS requirements for pressurized-water reactor Boraflex fuel storage racks and adds TS requirements for fuel storage pool boron concentration. Specifically, the amendment (1) adds a new TS 3/4.7.14, “Fuel Storage Pool Boron Concentration,” with a Limiting Condition for Operation that requires a fuel pool boron concentration of at least 2000 parts per million at all times, (2) revises and reformats TS 5.6.1 to specify the design features and fuel storage limitations in accordance with the categorization of spent fuel storage racks in various spent fuel pools, and (3) revises TS 5.3.1 to remove the cross-reference to TS 5.6.1.1.b.

A copy of the related Safety Evaluation is enclosed. Notice of Issuance will be included in the Commission's regular biweekly *Federal Register* notice.

Sincerely,

/RA/

Chandu P. Patel, Project Manager
Plant Licensing Branch II-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-400

Enclosures:
1. Amendment No. 121 to NPF-63
2. Safety Evaluation
cc w/encls: See next page

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Carolina Power & Light Company

Shearon Harris Nuclear Power Plant
Unit 1

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CAROLINA POWER & LIGHT COMPANY, et al.

DOCKET NO. 50-400

SHEARON HARRIS NUCLEAR POWER PLANT, UNIT 1

AMENDMENT TO FACILITY OPERATING LICENSE

Amendment No. 121
License No. NPF-63

1. The Nuclear Regulatory Commission (the Commission) has found that:

   A. The application for amendment by Carolina Power & Light Company (the licensee), dated September 1, 2005, as supplemented by letters dated December 22, 2005, and January 23, 2006, complies with the standards and requirements of the Atomic Energy Act of 1954, as amended (the Act), and the Commission's rules and regulations set forth in 10 CFR Chapter I;

   B. The facility will operate in conformity with the application, the provisions of the Act, and the rules and regulations of the Commission;

   C. There is reasonable assurance (i) that the activities authorized by this amendment can be conducted without endangering the health and safety of the public, and (ii) that such activities will be conducted in compliance with the Commission's regulations;

   D. The issuance of this amendment will not be inimical to the common defense and security or to the health and safety of the public; and

   E. The issuance of this amendment is in accordance with 10 CFR Part 51 of the Commission's regulations and all applicable requirements have been satisfied.

2. Accordingly, the license is amended by changes to the Technical Specifications, as indicated in the attachment to this license amendment; and paragraph 2.C.(2) of Facility Operating License No. NPF-63 is hereby amended to read as follows:

   (2) Technical Specifications and Environmental Protection Plan

   The Technical Specifications contained in Appendix A, and the Environmental Protection Plan contained in Appendix B, both of which are attached hereto, as revised through Amendment No. 121, are hereby incorporated into this license. Carolina Power & Light Company shall operate the facility in accordance with the Technical Specifications and the Environmental Protection Plan.

3. This license amendment is effective as of the date of its issuance and shall be implemented within 60 days of issuance.

FOR THE NUCLEAR REGULATORY COMMISSION

/RA/

Michael L. Marshall, Jr., Branch Chief
Plant Licensing Branch II-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Attachment:
Changes to the Technical
Specifications

Date of Issuance: March 10, 2006

ATTACHMENT TO LICENSE AMENDMENT NO. 121

FACILITY OPERATING LICENSE NO. NPF-63

DOCKET NO. 50-400

Replace the following pages of the Appendix A Technical Specifications with the attached revised pages. The revised pages are identified by amendment number and contain marginal lines indicating the areas of change.

Remove Pages	Insert Pages
x	x
xvii	xvii
5-6	3/4 7-31
5-7	5-6
5-7a	5-7
5-7b	5-7a
	5-7b
	5-7c
	5-7d

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO AMENDMENT NO. 121 TO FACILITY OPERATING LICENSE NO. NPF-63

CAROLINA POWER & LIGHT COMPANY

SHEARON HARRIS NUCLEAR POWER PLANT, UNIT 1

DOCKET NO. 50-400

1.0 INTRODUCTION

By letter dated September 1, 2005, as supplemented by letters dated December 22, 2005, and January 23, 2006, the Carolina Power & Light Company (the licensee) submitted a request for changes to the Shearon Harris Nuclear Power Plant, Unit 1 (HNP), Technical Specifications (TS). The requested changes would modify the TS requirements for pressurized-water reactor (PWR) Boraflex fuel storage racks and add TS requirements for fuel storage pool boron concentration. Specifically, the amendment would (1) add a new TS 3/4.7.14, "Fuel Storage Pool Boron Concentration," with a Limiting Condition for Operation (LCO) that requires a fuel pool boron concentration of at least 2000 parts per million (ppm) at all times, (2) revise and reformat TS 5.6.1 to specify the design features and fuel storage limitations in accordance with the categorization of spent fuel storage racks in various spent fuel pools (SFP), and (3) revise TS 5.3.1 to remove the cross-reference to TS 5.6.1.1.b.

The HNP fuel storage facilities consist of a New Fuel Inspection Pit (NFIP) and four SFPs, referred to as Pools A, B, C, and D. New fuel is stored in the NFIP that is maintained in dry condition for new fuel dry storage, and can also be stored in SFP Pool A fuel racks under flooded condition. The SFPs contain both PWR and boiling water reactor (BWR) fuel racks designed for the storage of both PWR and BWR spent fuel. The fuel racks use a neutron absorber in the rack design for reactivity control. Two types of neutron absorbers, Boral and Boraflex, are used. The storage racks in Pools A and B were designed to be "low density" racks with "Flux Traps" containing Boraflex panels to ensure criticality safety. Fuel is stored in cells that have a center-to-center spacing of 10.5 inches. These racks are used in Pools A and B, as well as for dry storage of new fuel. Because of the concerns with Boraflex dissolution in the PWR racks that are contained in Pools A and B, the HNP SFP storage rack criticality design basis is being changed to reflect a zero Boraflex credit, becoming an unpoisoned storage rack system. The removal of the Boraflex rack poison credit needs to be counterbalanced with the use of both burnup credit (BUC) and soluble boron credit in order to comply with the regulatory reactivity acceptance criteria for loading the storage racks.

This amendment, as well as the corresponding criticality analysis, addresses the PWR racks that have a Boraflex absorber, and does not impact the racks that use Boral or the BWR racks that have a Boraflex absorber.

The December 22, 2005, and January 23, 2006, supplemental letters provided additional information that did not change the initial proposed no significant hazards consideration determination or expand the scope of the original *Federal Register* notice.

2.0 REGULATORY EVALUATION

General Design Criterion (GDC) 62, “Prevention of criticality in fuel storage and handling,” in Appendix A to Title 10, Code of Federal Regulations (10 CFR) Part 50, specifies that the licensee must limit the potential for criticality in the fuel handling and storage system by physical systems or process.

The regulatory requirements and acceptance criteria established by the Nuclear Regulatory Commission (NRC) for maintaining subcritical conditions in SFPs are specified in 10 CFR 50.68, “Criticality accident requirements.” The following acceptance criteria are specified in 10 CFR 50.68(b)(2) and (3) for fresh fuel storage:

- The effective neutron multiplication factor, or k-effective (k_{eff}), of the fresh fuel in the fresh fuel rack shall be calculated assuming the racks are loaded with fuel of maximum fuel assembly reactivity and flooded with unborated water and must be less than or equal to 0.95, at a 95 percent probability, 95 percent confidence (95/95) level; and

- The k_{eff} of the fresh fuel in the [dry] fresh fuel racks shall be calculated assuming the racks are loaded with the maximum fuel assembly reactivity and filled with a low-density hydrogenous fluid, resulting in optimum moderation conditions, and must be less than or equal to (#) 0.98 at a 95/95 level.

The following acceptance criteria are specified in 10 CFR 50.68(b)(4) for criticality prevention in the SFPs:

- The k_{eff} shall be # 0.95 if fully flooded with borated water at a 95/95 level; and

- The k_{eff} shall be < 1.0 if fully flooded with unborated water at a 95/95 level.

The staff used the guidance contained in the following documents to assist its review of the amendment request to ensure compliance with GDC 62 and 10 CFR 50.68:

1. NUREG-0800, Standard Review Plan, Section 9.1.2, “Spent Fuel Storage,” Draft Revision 4.

2. Proposed Revision 2 to Regulatory Guide 1.13, “Spent Fuel Storage Facility Design Basis.”

3.0 TECHNICAL EVALUATION

3.1 Description of Proposed Technical Specification Changes

The amendment would (1) add TS 3/4.7.14, “Fuel Storage Pool Boron Concentration,” to include LCO 3.7.14 and Surveillance Requirement (SR) 4.7.14, and (2) Revise TS 5.6.1 regarding Fuel Storage Criticality design features.

3.1.1 Addition of TS 3/4.7.14

A new TS 3/4.7.14, "Fuel Storage Pool Boron Concentration," is added with the following LCO and SR.

LCO 3.7.14 The boron concentration of spent fuel pools shall be more than or equal to 2000 ppm.

Applicability: At all times for pools that contain nuclear fuel

Action:

1. With the spent fuel pool boron concentration not within the limits, immediately suspend movement of fuel assemblies.

2. Immediately initiate action to restore pool boron concentration within the limit.

SR 4.7.14 At least once every 7 days verify spent fuel pool boron concentration is within the limit by:

1. Sampling the water volume connected to or in applicable pools.

2. In addition to 4.7.14.1, sampling an individual pool containing nuclear fuel if the pool is isolated from other pools.

The proposed addition of TS 3/4.7.14 applies a restriction that is not contained in the existing TS. LCO 3.7.14 requires a fuel pool boron concentration of at least 2000 ppm at all times. Additionally, actions must be initiated immediately to return the boron concentration to within limits if determined to be below the limit. The proposed SR 4.7.14 to determine the pool boron concentration must be performed once per 7 days.

The HNP fuel storage boron concentration has typically been maintained above 2000 ppm. Therefore, there will be no change in actual plant practices regarding pool boron concentration. However, including this requirement in the TS provides assurance that the required minimum boron concentration will be maintained. The acceptability of the SFP boron concentration of 2000 ppm is demonstrated by the criticality analysis as discussed in Section 3.2 of this safety evaluation.

3.1.2 Revision to TS 5.6.1

The licensee proposes to revise TS 5.6.1, Fuel Storage Design Features, by reformatting TS 5.6.1 to specify the fuel storage racks design features and limitations in accordance with the following categories: (1) PWR storage racks in pools "A" and "B," (2) dry new fuel PWR storage racks, (3) BWR storage racks in Pools "A" and "B," and (4) PWR and BWR racks in pools "C" and "D," respectively.

TS 5.6.1.1 PWR storage racks in pools “A” and “B” [are designed and shall be maintained with:]

a. k_{eff} # 0.95 if fully flooded with water borated to 2000 ppm.

b. k_{eff} < 1.0 if flooded with unborated water.

c. A nominal 10.5-inch center-to-center distance between fuel assemblies.

d. Assemblies must be within the “acceptable range” of the burnup restrictions shown in Figure 5.6-2 prior to storage in unrestricted storage.

e. Assemblies that do not meet the requirements of 5.6.1.1.d shall be stored in a 2-of-4 checkerboard within and across rack module boundaries. Less dense storage patterns (e.g., 1-of-4 or 1-of-5) are acceptable in place of 2-of-4.

f. The empty spaces (water holes) in the 5.6.1.1.e checkerboard may be occupied by nonfuel items (e.g., containment specimen and trash baskets, mock fuel assemblies, etc.) up to a limit of one per every six storage spaces.

g. If fuel that meets the requirement of 5.6.1.1.d and fuel that does not meet 5.6.1.1.d are stored in the same rack module, an interface region must exist between the two regions. The interface region shall be either an empty row/column or a row/column of fuel that meets the requirements of 5.6.1.1.d in a checkerboard pattern with the restricted (5.6.1.1.e) region.

It should be noted that the term “k_{eff}” in TS 5.6.1 is the effective neutron multiplication factor (k-effective) calculated that includes an allowance for all uncertainties evaluated at a 95-percent probability and 95-percent confidence level (i.e., $K_{95/95}$). It should also be noted that the proposed TS 5.6.1.1.a and 5.6.1.1.b for the PWR storage racks in pools “A” and “B” are less restrictive than the existing TS 5.6.1, which requires that the spent fuel storage racks are designed and maintained with a k_{eff} # 0.95 when flooded with unborated water. However, they are consistent with the requirements specified in 10 CFR 50.68(b)(4). This revised TS 5.6.1 takes credit of the proposed addition of LCO 3.7.14 with soluble boron in excess of 2000 ppm to maintain k_{eff} below 0.95. Should a low probability boron dilution event occur, k_{eff} would still remain less than 1.0 and, hence, a criticality accident is not credible. This will be demonstrated by the criticality evaluation that shows that for appropriate limiting conditions the $K_{95/95}$ of the racks remain below 1.0 for the deboration accident and below 0.95 for normal conditions with the required amount of boron credit.

TS 5.6.1.1.c simply specifies the PWR rack modules located in Pools “A” and “B” have a center-to-center spacing (pitch) of 10.5 inches between cells, as specified in Table 9.1.2-2 of the HNP Updated Final Safety Analysis Report (UFSAR).

TS 5.6.1.1.d restricts assemblies to be loaded in pools A and B to be within the “acceptable range” of the burnup restrictions (i.e., BUC curve) shown in Figure 5.6-2 prior to storage in the unrestricted storage. TS 5.6.1.1.e and 5.6.1.1.f restrict assemblies not meeting the BUC loading curve to be stored in a 2-of-4 checkerboard or less-dense patterns, with the empty spaces in the checkerboard occupied by nonfuel items up to a limit of one per six storage

spaces. TS 5.6.1.1.g requires that, if fuel that meets the requirement of 5.6.1.1.d and fuel that does not meet 5.6.1.1.d are stored in the same rack module, an interface region must exist between the two regions. These limitations are to assure that TS 5.6.1.1.a and b are complied with as demonstrated by the criticality evaluation.

The existing TS 5.6.1.1.b specifies that the reactivity margin is assured for pools "A" and "B" by maintaining the maximum core geometry k_4 for PWR fuel assemblies less than or equal to 1.470 at 68^{o}F. The licensee has requested to remove this specification. In response to an NRC staff request for additional information, the licensee stated that the core geometry equivalencing was used to apply gadolinium credit in the existing criticality analysis and, therefore, a cold core geometry k_4 limit was specified to limit the reactivity of the gadolinium loaded assemblies stored in the pool. Since the revised analyses assume an assembly with the maximum enrichment of 5.0 weight percent (wt%) that bounds any enrichment and gadolinium combination in the fuel, there is no need for equivalencing to limit the reactivity of the assemblies of the same design that are stored in the pools. As such, the existing TS 5.6.1.1.b could be removed. The licensee further requested that the last sentence of TS 5.3.1 that cross references the existing TS 5.6.1.1.b be removed. Since the new criticality analyses do not take credit for gadolinium, the staff finds the removal of existing TS 5.6.1.1.b, as well as the removal of the last sentence of TS 5.3.1, to be acceptable.

TS 5.6.1.2 Dry new fuel PWR storage racks [are designed and shall be maintained with:]

a. Fuel assemblies having a maximum U-235 enrichment of 5.0 wt%.

b. k_{eff} # 0.95 if fully flooded with unborated water without credit for Boraflex in the rack module.

c. k_{eff} # 0.98 in an optimum moderation event.

d. A nominal 10.5-inch center-to-center distance between storage cells with alternating rows and columns blocked such that fuel is stored in a 1-of-4 pattern.

TS 5.6.1.2 is a new entry added for the design features and restrictions for the dry new fuel PWR storage racks. TS 5.6.1.2.b and c, are consistent with 50.68(b)(2) and (3) respectively. TS 5.6.1.2.a specifies the maximum U-235 enrichment of the new fuel assemblies, and TS 5.6.1.2.d specifies the PWR rack cell pitch and restricts the storage of these assemblies in a 1-of-4 pattern to satisfy the k_{eff} limitation of TS 5.6.1.2.b and c. The reactivity compliance is demonstrated in the criticality evaluation addressed in Section 3.2 of this safety evaluation.

TS 5.6.1.3 BWR Storage Racks in Pools A and B

Except for the editorial and format changes, no change is made to the design features and limitations for the BWR storage racks in pools A and B.

TS 5.6.1.4 PWR and BWR racks in pools C and D

Except for the editorial and format changes, no change is made to the design features and limitations for the PWR and BWR racks in pools C and D.

TS 5.6.1.5

Except for editorial change, TS 5.6.1.5 maintains that "in each case, k_{eff} includes allowances for uncertainties as described in Section 4.3.2.6 of the FSAR" in existing TS 5.6.1.

TS Figure 5.6.1

Figure 5.6-1 is revised to include a linear equation to describe the locus of the burnup versus enrichment restriction line, and revise the title of the figure from "Burnup Versus Enrichment for PWR Fuel" to "Pools 'C' and 'D' Burnup Versus Enrichment for PWR Fuel." This change is necessary because of the change in the format of TS 5.6.1 that separates the spent PWR fuel in pools "A" and "B" and pools "C" and "D," and because the figure is only applicable to pools "C" and "D." The actual burnup-enrichment restriction line is not changed because no change has been made to the design basis of pools "C" and "D."

TS Figure 5.6.2

Figure 5.6-2, "Pools 'A' and 'B' Burnup Versus Enrichment for PWR Fuel," is added as the burnup loading restriction to be applied to Pools "A" and "B" fuel racks. The derivation of this figure is addressed in Section 3.2.3.1 of this safety evaluation.

3.2 Criticality Analysis

In determining the acceptability of the amendment request, the staff reviewed three aspects of the licensee's analyses: (1) the computer codes employed for the analyses, (2) the methodology used to calculate the maximum k_{eff}, and (3) the criticality analyses to demonstrate compliance with the regulatory reactivity limits. For each part of the review, the staff evaluated whether the licensee's analyses and methodologies provided reasonable assurance that adequate safety margins in accordance with NRC regulations were developed and could be maintained in the HNP SFPs.

This safety evaluation addresses only the PWR storage racks in Pools "A" and "B" and the dry new fuel storage racks, since these are the only storage racks affected by the proposed changes in TS 5.6.1.1 and 5.6.1.2, respectively.

3.2.1 Computer Codes

The licensee performed the HNP criticality analyses of the SFP racks and the dry storage NFIP with the KENO V.a code and the CASMO-3 code. KENO V.a, a part of the SCALE 4.4a package, is a three-dimensional Monte Carlo criticality code used to calculate the k_{eff}. The KENO V.a code was benchmarked against critical experiments under conditions that are appropriate for the expected range of parameters in the HNP spent fuel rack analyses. Appendix A of the Criticality Evaluation Report (CER) describes the benchmark of the KENO V.a code. One hundred critical configurations were selected from various sources.

These benchmarks include configurations performed with lattices of UO_2 fuel rods in water having various enrichments and moderating ratios, and also include some experiments with mixed oxide fuel rods. The experimental data is sufficiently diverse to establish that the method bias and uncertainty will apply to HNP storage rack conditions. By applying the appropriate steps of the statistical methodology presented in NUREG-6698 taking into account the possible trending of k_{eff} with various spectral and/or physical parameters, the licensee determined the KENO V.a code calculation (methodology) bias and the 95/95 level bias uncertainty (σ_{bias}). The resulting values of the method bias and uncertainty, as shown in Appendix A and Section 2.5.4 of the CER, are used to support the HNP SFP criticality analyses.

In addition to using the KENO V.a code to perform the criticality analyses, the licensee employed the CASMO-3 code set to perform the fuel depletion analyses and to determine the isotopic composition of the spent fuel. CASMO-3 is a multigroup, two-dimensional transport theory program for burnup calculations on light-water reactor (LWR) assemblies or simple pin geometries. The code handles a geometry consisting of cylindrical fuel rods of varying composition in a square pitch array. It is typically used to generate cross-sections for the fuel cycle codes, and is used for reactivity studies and to provide depletion data for burnup credit. The neutron data is provided from ENDF/B-4, although some data comes from other sources. Microscopic cross-sections are tabulated in 70 energy groups. CASMO-3 also uses a 40-group library (used in this analysis) which is a condensation from the 70-group library using typical LWR spectra from various nuclides. The 40-group library is the production library for both BWR and PWR analyses.

The staff reviewed the licensee's application of the codes to determine whether each could reasonably calculate the appropriate parameters necessary to support the maximum k_{eff} analyses. In an NRC memorandum (Ref. 1), the staff stated that KENO V.a and CASMO-3 were acceptable computer codes for the analysis of fuel assemblies stored in the SFP. The staff also stated that the Babcock & Wilcox series of criticality experiments provided an acceptable basis for benchmarking storage racks with thin strong absorber panels for reactivity control and closed-packed arrays of fuel. Therefore, the staff concludes that the licensee's use of KENO V.a code for the calculation of the nominal k_{eff} was appropriate since it was benchmarked against experimental data which reflect the proposed assembly and rack conditions for the HNP SFPs. Additionally, the staff finds that the licensee's use of the CASMO-3 code set was acceptable for determining the Δk for each manufacturing tolerance, performing the fuel depletion analyses, and calculating the nominal k_{eff}.

3.2.2 Methodology

The licensee performed criticality analysis of its SFP that combines a worst-case analysis based on the bounding fuel and rack conditions, with a sensitivity study using 95/95 analysis techniques. The major components in this analysis were the k_{eff} calculated using either the KENO V.a or CASMO-3 code based on the limiting fuel assembly, SFP temperature and code biases, and a statistical sum of 95/95 uncertainties and worst-case delta-k manufacturing tolerances. The effective neutron multiplication factor at 95/95 probability/confidence level, $K_{95/95}$, is calculated using the following formulation:

$$K_{95/95} = k_{eff} + bias_{method} + \Delta k_{sys} + [C^2 (\sigma_k{}^2 + \sigma_{bias}{}^2 + \sigma_{sys}{}^2) + \Delta k_{tol}{}^2]^{1/2}$$

Where,

k_{eff} = the KENO V.a calculated result;

$bias_{method}$ = the bias associated with the calculation methodology;

Δk_{sys} = summation of Δk values associated with the variation of system and base case modeling parameters, e.g., moderator temperature and off-centered assembly in cell;

C = confidence multiplier based on the number of benchmark cases;

σ_k, σ_{bias}, σ_{sys} = standard deviation of k_{eff}, methodology bias, and system Δk_{sys}, respectively;

Δk_{tol} = statistical combination of statistically independent Δk values due to manufacturing tolerances (e.g., fuel enrichment, cell pitch, etc.).

The licensee determined the calculation methodology biases and uncertainties, the system Δk and uncertainty, the base k_{eff} and uncertainty, and the manufacturing tolerance.

The methodology bias ($bias_{method}$) is related to the computer code (i.e., KENO V.a used for the criticality calculation). The KENO V.a methodology bias and uncertainty on the bias (σ_{bias}) are determined based on comparison to measured critical fuel configurations (i.e., critical benchmark). The bias is not assembly-specific but can be dependent on the type of fuel involved or on intervening absorber materials. Typically, a bias is determined using critical benchmark calculations that are appropriate for the type of rack and fuel being analyzed. There is an uncertainty component on the bias that is the result of both measured and calculated uncertainties associated with the critical configurations analyzed. Appendix A of the CER provides a detailed calculation of the methodology bias and bias uncertainty. One hundred critical configurations from various sources, such as the International Handbook of Evaluated Criticality Safety Benchmark Experiments, were selected to cover the range of values of key parameters in the HNP SFPs. The calculation of the bias and uncertainty are performed according to the appropriate steps of the statistical methodology described in NUREG/CR-6698, "Guide for Validation of Nuclear Criticality Safety Methodology." The results of the evaluation arrived at the specific bias and bias uncertainty values (identified by licensee as Proprietary and summarized in Section 2.5.4 of the Criticality Evaluation Report) that were applied as a positive penalty in the equation for computation of $K_{95/95}$.

Section B.1 in Appendix B of the CER describes, in detail, the calculation of the rack manufacturing and assembly tolerances (Δk_{tol}) that apply to the dry new fuel storage racks and Pools "A" and "B" racks that are used in the determination of $K_{95/95}$. The CASMO-3 code is used to determine the reactivity effects of dimensional tolerances for the design basis fuel assembly and the PWR storage rack. The evaluation is based upon the dimensional tolerances for the Boraflex storage rack and the Framatome Advanced High Thermal Performance (HTP) 17x17 design basis fuel assembly, provided in Table 2.3.2-1 and 2.3.1-2, respectively, in the CER. These tolerances are statistically combined since they are independent. Table 2.5.2-1 provides the total manufacturing tolerances for the spent fuel 4of 4 loading and fresh fuel 2-of-4 loading.

There are five system parameters that have significant reactivity impact and contribute to the system bias effects on $K_{95/95}$ (Δk_{sys}), including moderator temperature variation from the base case model, off-centered assembly placement in the rack cell, rack interface effects, fuel assembly type and irradiation history, and insertion of nonfuel bearing component (NFBC) containers. Section B.2 of the CER provides a detailed description of the calculation of the system bias and uncertainty ($\Delta k_{sys} \pm \sigma_{sys}$) for each of these parameters. The results of the calculations are summarized in Table 2.5.3-1 of the CER for the spent PWR fuel rack, fresh racks, and BWR racks.

The confidence multiplier, C, in equation 1 is the single-sided tolerance limit factor. The value of C (proprietary) is obtained based on the 100 experiments included in the evaluation.

To summarize, the numeric values of all parameters in Equation 1 have been determined for the Advanced HTP fuel design, except for k_{eff} and σ_k which will be calculated with the KENO V.a code. Table 2.5.5-1 (and Table B.3-1) of the CER summarizes, for spent PWR racks, fresh racks, and BWR racks, the numeric values of these parameters, including an assumed value of σ_k that covers a sufficient number of histories in the k_{eff} calculation. The overall critical evaluation is to show that $K_{95/95}$ is # 0.95 for fresh and spent PWR fuel in Pools “A” and “B” without credit for Boraflex in the PWR racks, and $K_{95/95}$ is # 0.98 for fresh fuel in the dry storage racks in the NFIP.

3.2.3 Analysis of PWR Storage Racks in Pool A and B

The HNP SFP Pools “A” and “B” contain both spent PWR and BWR fuel racks. In addition, Pool “A” also contains fresh PWR fuel racks to be used for storage with fresh fuel receipt and reload fuel handling activities. Irradiated fuel assemblies with sufficient burnup above the acceptable burnup loading restrictions are stored in the BUC spent fuel racks without restrictions. Fuel assemblies with insufficient burnup to be stored in the spent fuel racks are treated as fresh, zero burnup assemblies, subject to restrictions imposed on the storage of fresh fuel.

Table 9.1.2-2 of the HNP UFSAR provides the basic dimensional parameters for the HNP spent fuel racks. The PWR rack modules located in Pools “A” and “B” have a center-to-center spacing (pitch) of 10.5 inches between cells. (The PWR rack modules in Pools “C” and “D” have a center-to-center spacing of 9.0 inches between cells. The BWR rack modules have a pitch of 6.25 inches.)

The HNP SFP storage rack criticality design basis is being changed to reflect a zero Boraflex credit and will become an unpoisoned storage rack system. Removal of Boraflex needs to be counterbalanced with the use of both fuel BUC and pool soluble boron credit to provide safe storage of the discharged fuel assemblies and to comply with the regulatory reactivity limits. There are many combinations of BUC and soluble boron credits possible to offset the reactivity increase due to the Boraflex removal. The soluble boron credit should be limited to avoid deboration time requirements and to maintain the $K_{95/95}$ below 1.00 for an unborated SFP, whereas the BUC loading restriction should not be excessively demanding (i.e., requiring very high assembly burnup) in order to remain useful and applicable to the expected fuel assembly discharge burnups. The licensee performed the analyses to determine the BUC loading restrictions and the pool boron concentration requirement to meet the reactivity limits for both normal loading and accident or upset conditions.

3.2.3.1 Burnup Loading Curve and Usage Requirements

Section 3.1 and Appendix D of the CER describe in detail the BUC analysis for Pools "A" and "B." The BUC analysis developed a BUC loading curve that allows the discharged assemblies with acceptable burnup-enrichment combination to be stored in the BUC racks without storage restrictions. To reasonably bound the existing fuel being stored in the HNP SFP, and to alleviate the need for frequent calculation of $K_{95/95}$ in the iterative process for determining the BUC loading curve, the BUC analysis was performed first without boron credit and based on the selected BUC "design condition" that the BUC design reactivity (K_{design}) is less than or equal to a "target design value" (proprietary). The BUC conditions were then evaluated to set the pool soluble boron concentration requirements such that regulatory criterion of $K_{95/95}$ # 0.95 is met for both storage and fuel handling, as well as accident/upset conditions. K_{design} includes k_{eff} and σ_k to be calculated by KENO V.a and all other components (i.e., the allowances for bias and uncertainties for codes, methods, and manufacturing tolerances) in Equation (1) except for Δk_{sys} and σ_{sys} that are accounted for in the soluble boron concentration calculation. The numeric values of these components are listed in Table 2.5.5-1 of the CER.

The spent fuel rack BUC calculation was performed using the KENO V.a code. The KENO V.a calculations used a rack geometry model that has a 2x2 array of storage cells with a periodic boundary condition conservatively applied. This rack geometry model represents an infinite x-y array of fully loaded storage cells with 12 inches of water at the top and bottom of the active fuel length. The in-core fuel depletion isotopic densities for the selected burnups that were input to KENO V.a were calculated with the CASMO-3 code. The evaluation used the Advanced HTP fuel design as design basis assembly. To allow flexibility in fuel cycle designs, the evaluation assumed that the fuel assemblies contain only rods with a nominal, uniform axial and planar enrichment of 4.95 wt% with 0.05% tolerance. This assumption bounds assembly designs with integral absorber rods, axial cut-back regions, or axial blankets of varying enrichments that are typical of current assembly designs.

The BUC loading curve calculations were performed for a discrete number of initial assembly enrichments up to a maximum of 5.0 wt%. The calculation determined the allowable minimum assembly average burnup for each of the initial assembly enrichments, as well as a determination of the allowable initial assembly enrichment with the zero burnup. For each fuel initial enrichment, an iterative process was performed until the selected assembly burnup results in K_{design} slightly below the target value.

The results of the BUC analyses were provided in Tables D.6-1 through D.6-9 of the CER. Table D.6-1 lists the results that show that a limiting initial enrichment of 1.76 wt% U235 is required for a zero burnup fuel assembly to meet the design acceptance criteria. The maximum assembly initial U-235 enrichment allowed at the HNP plant is 5.0 wt% U-235. Table D.6-2 lists the results that show that the required assembly average burnup is 42.35 GWD/MTU to meet the design acceptance criteria. Tables D.6-3 through D.6-9 list the results of various initial enrichments showing the required burnup associated with each enrichment to meet the design acceptance criteria. These results are combined to form the BUC loading curve for PWR fuel in HNP SFP pools "A" and "B." Table D.7-1 and Figure D.7-1 (also identified as Table 3.1-1 and Figure 3.1-1, respectively) of the CER summarize the BUC loading equation and BUC loading curve for PWR fuel in SFP pools "A" and "B." Figure D.7-1 is referred to as Figure 5.6-2 specified in TS 5.6.1.1.d for burnup restriction. It should be noted that, as shown in Table D.8-1

of the CER, the maximum value of the $K_{95/95}$ for the burnup-initial enrichment conditions on the BUC loading curve with zero boron credit is less than 1.0, consistent with TS 5.6.1.1.b.

3.2.3.2 Pool Soluble Boron Requirements

Section D.8 of the CER describes the evaluation of the soluble boron requirements based on the BUC credit to satisfy the regulatory acceptance criteria of $K_{95/95}$ # 0.95. Based on the KENO V.a calculated unborated results of k_{eff} and σ_k values for the burnup-enrichment pairs of the BUC loading curve calculated in section D.6 of the CER, the licensee calculates the soluble boron concentration requirement (proprietary value) to bring the $K_{95/95}$ to be # 0.95 for the BUC rack normal condition. The results show that the required soluble boron concentration for the BUC rack normal condition is far less than the 2000 ppm limit specified in the proposed LCO 3.7.14.

3.2.3.3 Accident and Upset Conditions Evaluation

The licensee also evaluated the reactivity accident and operator induced upset conditions to demonstrate compliance with the “double contingency” principle that at least two unlikely, independent accidents or upsets have to occur concurrently for a criticality event to be possible. The bounding reactivity accidents and upset conditions studied include:

(1) abnormal positioning of a fuel assembly outside the BUC storage rack,
(2) misloading of a fresh 5.0 wt%-enrichment PWR assembly in a storage cell of the BUC storage rack,
(3) loss of cooling resulting in SFP water temperature rising to 212 ^{o}F, and
(4) lateral motion of a fuel rack module causing the rack-rack water gap to close.

Section D.9 of the CER provides KENO V.a calculations used to determine the additional soluble boron credit needed to counter balance the increased reactivity to maintain and satisfy the regulatory acceptance criteria of $K_{95/95}$ # 0.95 for each of these upset conditions. Among these accident/upset conditions, the abnormal positioning of a fuel assembly outside the BUC rack requires the most boron credit approximately 800 ppm.

The results of the evaluation of the limiting accident and upset conditions show that the proposed LCO 3.7.14 SFP boron concentration limit of at least 2000 ppm provides a large margin to assure compliance with the regulatory reactivity limits for both normal and upset conditions.

3.2.3.4 Fresh Fuel Rack Calculations

Section E.1 in Appendix E of the CER provides the evaluation of the various rack configurations for the fresh fuel region in Pool “A.” Sensitivity studies were performed that demonstrated that the 2-of-4 arrangement bounds any less dense loading arrangement and loading patterns with assembly densities of one assembly in four cells, or less, essentially represent an isolated assembly in the rack. The analysis determined the value of the soluble boron credit required to provide $K_{95/95}$ # 0.95 with various configurations with water cells and with NFBCs placed in the water cells. The calculations also determined the soluble boron needed to mitigate upset conditions resulting from seismic movement. A total boron credit value of approximately 100 ppm is needed.

The calculations also evaluated the interaction effects between the fresh fuel rack and the PWR or BWR spent fuel racks. Various arrangements of the two modules in infinite arrays were examined. Since the fresh fuel rack is more reactive than the spent fuel rack, it controls the system reactivity. The results show that the bounding case of a checkerboard arrangement of two fresh fuel racks adjacent to two PWR spent fuel racks requires a total boron credit of approximately 500 ppm to cover both the normal and seismic upset event. The licensee also evaluated the arrangement with the fresh fuel and irradiated fuel placed in the same rack module. The results indicate that as long as there is an interface region between the fresh and spent assemblies, the k_{eff} of the mixed system is within the statistical uncertainty of the single module. The interface can either be a row of water holes or a row of spent assemblies in a checkerboard pattern with the fresh assemblies. This conclusion is consistent with TS 5.6.1.1.g.

Section E.2 of the CER also cited a fresh fuel rack calculation for accident conditions, including a misload of a fresh assembly in a water hole in the fresh rack or into a location in the spent rack, an assembly dropped adjacent to the outside of the rack during fresh fuel movement. The results show the limiting upset condition to be the dropped fresh assembly that requires a boron credit of approximately 1000 ppm to assure $K_{95/95}$ # 0.95. Therefore, the proposed LCO 3.7.14 SFP boron concentration limit of at least 2000 ppm provides a large margin to assure compliance with the regulatory reactivity limits for both normal and upset conditions.

3.2.3.5 Deboration Accident Evaluation

Since the licensee's application relies on soluble boron to maintain subcritical conditions within the SFP for certain accident conditions, the NRC staff reviewed the licensee's boron dilution analysis to determine whether appropriate controls, alarms, and procedures are available to identify and terminate a boron dilution event.

By letter dated October 25, 1996, the NRC staff issued a safety evaluation on licensing topical report WCAP-14416, "Westinghouse Spent Fuel Rack Criticality Analysis Methodology." This safety evaluation specified that the following issues be evaluated for applications involving soluble boron credit: the events that could cause boron dilution, the time available to detect and mitigate each dilution event, the potential for incomplete boron mixing, and the adequacy of the boron concentration surveillance interval.

The Fuel Handling Building (FHB) consists of five main pools. The south end of the FHB consists of New Fuel Pool "A" and SFP "B." The north end of the FHB consists of SFP "C," SFP "D," and the Cask Loading Pool. The five pools are tied to each other by the main transfer canal and the South and North Transfer Canals. The spent fuel is placed in either the "A" or "B" fuel pool during refueling and stored until further disposition. Gates are provided to isolate the five pools and the transfer canals.

The criticality analyses performed by licensee determined that the fuel stored in the PWR racks would remain subcritical (k_{eff} < 1.0) if stored in unborated water and the minimum soluble boron concentration required to maintain k_{eff} < 0.95 for normal and accident conditions in the SFP. The results of these calculations indicate that the specified k_{eff} is maintained with a boron concentration of 500 ppm under normal conditions and 1000 ppm for the most serious credible accident scenario. To provide margin to these values for undetected boron dilution conditions,

proposed TS 3.7.14 specifies that the boron concentration of the SFPs be greater than or equal to 2000 ppm.

Draining or siphoning of the SFPs via piping or hose connections to these pools and transfer canals is precluded by the location of the penetrations, limitations on hose length and termination of piping penetrations flush with the liner. Control Room and local alarms are provided to alert the operator of abnormal pool level and high temperature. Local water level indication is provided at SFPs "A," "B," "C," and "D."

Thermal gradients generated by stored fuel and operation of the SFP cooling system will cause significant mixing within the pool. The licensee assumed that all unborated water introduced from any uncontrolled dilution source instantaneously mixes with the water in the SFP (i.e., no unborated water is lost prior to its mixing with borated water). The configuration of the pool and the mixing of the coolant provide reasonable assurance that this assumption is valid for low to moderate dilution flow rates.

The volume of water in the SFP A is 127,888 gallons. SFP A is the smallest pool used for fuel storage. Four examples of potential dilution sources were identified by the licensee: a 2-gallon per minute (gpm) flowrate from small failures or misaligned valves that could occur in the normal soluble boron control system or related systems, the failure of the moderate energy pipe in demineralized water system (DWS) or the fire protection system (FPS), a spent fuel pool heat exchanger tube rupture, and mixing of unborated SFP D with SFP A.

To demonstrate that sufficient time exists for plant personnel to identify and terminate a boron dilution event, the licensee provided a description of all alarms available to alert operators, and potential response to an alarm. There is no automatic level control system for the SFP; therefore, any large, uncontrolled water addition would cause the SFP to overflow. However, a high level alarm in the control room would alert personnel of a potential boron dilution event when the water level reaches the high level setpoint.

Under certain accident conditions, it is calculated that a high flow rate of unborated water could flow onto the top of a pool. Such an accident scenario could result from a moderate energy pipe crack in the DWS or the FPS. Both of these events potentially allow unborated water to spray onto a pool.

A crack in the fire protection pipe could cause a dilution flow of approximately 178 gpm. However, upon the initial break, the fire protection system header pressure would drop to the auto start setpoint of the motor driven fire pump. The start is accompanied with an alarm in the main control room. The annunciator response is to dispatch an operator to find the source of the pump start. Approximately 16 minutes into the event (in the case of SFP A) a SFP high level alarm would be received in the main control room, assuming that the pool level started at the low alarm level. Each SFP has redundant high and low-level alarms that are safety-related. The annunciator response for this SFP level is to investigate the cause. The coincidence of the two alarms would quickly lead to the discovery of the failure of the pipe and sufficient time to isolate the failure. The time to reach a boron concentration of 500 ppm, as provided by licensee, is estimated to be 16.8 hours.

The flow rate for a failure of the DWS header would provide approximately 52 gpm into a fuel pool. Failure of the demineralized water header is not accompanied with a DWS alarm;

however, the time to dilute a SFP is very large. For the SFP A, the time to reach 500 ppm is approximately 2.4 days. An alarm on SFP A level would occur within 53 minutes into the event in the main control room, assuming that the SFP A level started at the low alarm. In this scenario, there is sufficient time to isolate the failure and to prevent the spilling of water.

The flow rate for a tube failure in the spent fuel heat exchanger would provide approximately 238 gpm. Failure of the tube would quickly cause a low level alarm on the Component Cooling Water (CCW) system surge tank. The CCW system is a closed system and makeup to the system is performed manually. The surge tank has a normal level of about 500 gallons so the tube break would quickly cause low level alarms in the main control room. The operator's response would be to investigate the source of the leak and isolate the affected component. The CCW system pumps would be stopped if the CCW surge tank emptied and this would reduce the differential pressure between CCW and FPCCS. The time required to reach a boron concentration of 500 ppm is 12.6 hours. There is a reasonable assurance that the failure will be isolated during this time.

An event where SFP D is mixed with the contents of SFP A was also evaluated by licensee. SFP D is currently not used for spent fuel storage and is gated from the balance of the SFPs. The boron concentration of SFP D is not monitored. Under the worst conditions, the failure of SFP D's gate would result in no noticeable level change in the balance of the pools. The failure of this gate was evaluated assuming the instantaneous mixing of SFP D and SFP A along with the interconnecting canals. SFP A is smaller than SFP B and SFP C and thus would be more limiting. The result of the calculation is that the SFP A boron concentration would be 1431 ppm. This is greater than the 500 ppm required during normal operation or the 1000 ppm required during an accident.

Small dilution flows may not be readily identified by level changes in the SFP due to evaporation and potential operational leakage through the pool liner and the SFP cooling system. The licensee determined that a dilution flow of 2 gpm would require approximately 30.7 days to dilute the boron concentration of the SFP near to that calculated as the boron concentration required for most severe fuel-handling accidents. The proposed TS surveillance requirement 4.7.14 requires that the boron concentration be verified to be greater than or equal to 2000 ppm at least once every 7 days. The reduction in boron concentration due to a dilution flowrate of 2 gpm would be detected by the required boron concentration surveillance well before a significant dilution occurs. Therefore, the proposed boron surveillance requirement is acceptable.

Based on the NRC staff's review of the licensee's boron dilution analysis, the NRC staff finds the licensee has provided sufficient information to demonstrate that the proposed TS 3.7.14 and proposed TS surveillance requirement 4.7.14 are acceptable and satisfy the requirements of 10 CFR 50.68(b)(4).

3.2.4 Dry Fuel Storage Analysis

Section 4.0 of the CER describes the criticality analysis of the dry fuel storage racks in the NFIP with the Advanced HTP-17 fuel assembly design with a maximum enrichment of 5.0 wt%. Although the normal condition for the NFIP is dry with no substantial amount of moderation present, low-density water, fog, or mist conditions can occur (e.g., when fire fighting equipment is used). Therefore, it is possible for a secondary reactivity spike to occur at low-density

moderator conditions that range from approximately 3 percent to 10 percent of fully dense water conditions. Under interspersed moderator conditions the separate new fuel storage racks can be neutronically coupled. Therefore, the licensee performed the analysis to determine the reactivity effect caused by the addition of various densities of moderation into the pit. Two sets of KENO V.a calculations were performed to determine reactivity at normal and upset conditions. Each set of calculations varied the interspersed moderation from dry to 100 percent density water at 68°F both inside and outside the fuel assemblies to account for upset conditions. The results showed that the maximum calculated k-effective occurred for the condition of fuel against the wall under fully flooded conditions. The resulting $K_{95/95}$ is less than 0.95. For credible upset conditions, the licensee evaluated a fuel assembly dropped outside the rack but adjacent to one in the rack during the dry condition. (This upset condition will not occur during a flooded condition because all fuel dandling is suspended if there is water in the NFIP.) The calculated k-effective was far below 0.95. In all, the calculations show that the criticality criteria are met for both the fully flooded and interspersed moderator (misted or fog) cases, including upset conditions.

4.0 SUMMARY

The staff reviewed the effects of the proposed changes using the appropriate requirements of 10 CFR 50.68 and GDC 62. The staff found that the licensee's amendment request provided reasonable assurance that under both normal and accident/upset conditions, the licensee would be able to safely operate the plant and comply with the NRC regulations. Therefore, the staff finds the proposed amendment acceptable.

5.0 STATE CONSULTATION

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

6.0 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 and changes the Surveillance Requirements. 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 67745). 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.

7.0 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.

8.0 REFERENCE

1. NRC Memorandum from L. Kopp to T. Collins, “Guidance on the Regulatory Requirements for Criticality Analysis of Fuel Storage at Light-Water reactor Power Plants,” August 19, 1998.

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