UNITED STATES
NUCLEAR REGULATORY COMMISSION
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March 24, 2000

MEMORANDUM TO: Richard Corriea, Chief
Section 2
Project Directorate 2
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

FROM: George Hubbard, Chief **/RA/**
Balance of Plant and Containment Systems Section
Plant Systems Branch
Division of Systems Safety and Analysis
Office of Nuclear Reactor Regulation

SUBJECT: SAFETY EVALUATION INPUT FOR THE PROPOSED AMENDMENT TO SUPPORT ACTIVATION OF THE SHEARON HARRIS NUCLEAR POWER PLANT SPENT FUEL POOLS C AND D (TAC NO. MA4432)

In a letter dated December 23, 1998, Carolina Power and Light Company requested an amendment to the license for the Shearon Harris Nuclear Power Plant (SHNPP) to support their planned expansion of spent fuel storage to spent fuel pools (SFPs) C and D The proposed Technical Specification change would allow spent fuel to be stored in SFPs C and D, increasing the storage capacity at SHNPP to 8384 spent fuel assemblies from it current capacity of 3669 fuel assemblies. The proposed amendment also requests that the staff evaluate an unreviewed safety question identified by the licensee during the course of their review, and to review and approve an alternative plan to demonstrate the quality and safety of Component Cooling Water and Fuel Pool Cooling and Cleanup System piping installed or activated as part of this amendment request.

The Plant Systems Branch has completed its review of this amendment request. Our branch has primary review responsibility for two areas of the Technical Specifications change, the thermal-hydraulic aspects of the plant modification, and the heavy loads evaluation. Attached is our safety evaluation for thermal-hydraulics, plus a safety evaluation input prepared by Reactor Systems Branch addressing the unreviewed safety question. The evaluation of heavy loads will be forwarded to you in a separate memorandum. An evaluation of the licensee's alternative plan is not included in this safety evaluation, and is the responsibility of the Division of Engineering.

Docket No.: 50-400

Attachment: As stated

CONTACT: C. Gratton, SPLB/DSSA/NRR
301-415-1055

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SAFETY EVALUATION BY THE PLANT SYSTEMS BRANCH
TO ACTIVATE SPENT FUEL POOLS C AND D AT THE
HARRIS NUCLEAR PLANT
DOCKET NO. 50-400
(TAC MA4432)

1.0 INTRODUCTION

1.01 Background

In a letter dated December 23, 1998, Carolina Power and Light Company (hereafter CP&L, or the licensee) requested a change to Technical Specification 5.6, "Fuel Storage," to increase the spent fuel storage capacity by adding rack modules to spent fuel pools "C" and "D." The design of the spent fuel storage system at Harris (fuel pools A, B, C, and D, the cooling and cleanup system for pools A and B, the cooling and cleanup system for pools C and D, and the fuel handling building), was originally reviewed by the NRC in NUREG-1038, "Safety Evaluation Report Related to the Operation of Shearon Harris Nuclear Power Plant Units 1 and 2," dated November 1983. At the time the staff completed the safety evaluation report, Unit 2 was still under construction. In December 1983, the licensee decided to cancel the Unit 2 project and discontinue the final completion of the cooling and cleanup system for spent fuel pools C and D.

With the need for additional spent fuel assembly storage capacity, the licensee has now decided to complete the installation of the cooling and cleanup system supporting spent fuel pools C and D and plans to begin using the pools to store spent fuel.

1.2 Proposed Changes

The licensee requested that the NRC review and approve changes associated with the activation of spent fuel pools C and D. First, Technical Specification (TS) 5.6 is being modified to identify pressurized water reactor (PWR) fuel assembly (FA) burn up restrictions, boiling water reactor (BWR) FA enrichment limits, total FA storage capacity limits, heat load limitations for pools C and D, and the nominal center-to-center distances between fuel assemblies in pools C and D. Second, the licensee has prepared an alternative plan to demonstrate the acceptable level of quality and safety in the completion of the component cooling water system (CCW) and the fuel pool cooling and cleanup water system (FPCCS) piping. Finally, the proposed change addresses an unreviewed safety question identified by the licensee during their analysis of this change request. As a result of the modifications to the CCW system, the licensee is proposing a reduction in the minimum CCW flow to the residual heat removal (RHR) heat exchangers under certain operation conditions for the reactor at Harris.

This safety evaluation addresses the following aspects of the proposed changes noted above: the heat load limitations associated with the expanded capacity for pools C and D and the resolution of the unreviewed safety question regarding changes in CCW flow. Other portions of the proposed amendment, including our section's evaluation of heavy loads, are being reviewed and will be evaluated in a separate safety evaluation.

1.3 Systems Descriptions

The Harris plant was originally planned as a four unit site. A single fuel handling building (FHB) was designed and constructed with four separate pools capable of storing spent fuel for all planned units. The two pools at the south end of the FHB were designated A and B and were designed to store fuel for Units 1 and 4. Pool A, the smaller of the two pools, would stored new and spent fuel, while pool B stored spent fuel. The two pools at the north end of the FHB are designated C and D and were designed to support Units 2 and 3. The multi-unit design of the FHB includes a spent fuel pool cooling and cleanup system for pools A and B, and a separate cooling and cleanup system for pools C and D.

Upon cancellation of Units 2, 3, and 4, the licencee decided not to complete the fuel pool cooling system for pools C and D (the cooling and cleanup system for SFPs C and D was approximately 80% complete when construction on the system was halted upon the cancellation of Unit 2). However, the FHB and SFPs A, B, C, and D, including the pool liners, were constructed and turned over to the operating staff as part of the construction and licensing of Harris Unit 1. The licensee decided not to complete the cooling system for SFPs C and D until these pools were needed for spent fuel storage. The pools have been filled with coolant, but have not stored spent fuel assemblies since they were constructed.

SFP A contains six flux trap style pressurized water reactor (PWR) racks and three boiling water reactor (BWR) racks for a total storage capacity of 723 FAs. SFP B contains 12 PWR racks and 17 BWR racks, and it licensed to hold one additional BWR rack for a total capacity of 2946 fuel assemblies. The licensee proposed the following fuel storage capacities for the four pools (note: the authorized capacity of SFPs A and B will not change):

Pool Designation	Capacity		
A	PWR FA:360	BWR FA: 363	Total: 723
B	PWR FA:768	BWR FA: 2178	Total: 2946
C	PWR FA:927	BWR FA: 2763	Total: 3690
D	PWR FA:1025	BWR FA: 0	Total 1025

Each fuel pool cooling and cleanup system, north and south, is designed with two 100% capacity cooling trains, and a cleanup loop to remove dissolved fission and corrosion products. Each cooling system is comprised of two shell and straight tube heat exchangers, two horizontal centrifugal pumps, a demineralizer, two filters, skimmers, fuel pool and refueling water purification pumps, isolation gates for each pool and transfer canal, and the requisite piping, valves, and system instrumentation. Electrical power for the FPCCS pumps can be aligned to independent emergency supplies. Although originally designed to be cooled by separate cooling water systems, the south and north FPCCS heat exchangers will be cooled by the Unit 1 CCW system. Each pool is outfitted with direct reading temperature and level instruments that provide operators with indication and alarm at local and remote (i.e., the control room) stations.

The CCW system serves as an intermediate closed cooling water system between the radioactive and potentially radioactive systems and the non-radioactive service water system. The FPCCS rejects its heat to the CCW system, which in turn rejects its heat via the service water system to the ultimate heat sink. In addition to the FPCCS, the CCW system provides cooling to various safety-related and non safety-related heat loads supporting the operation of the reactor. Although the Unit 1 CCW system was originally designed to remove the heat rejected from the spent fuel stored in pools A and B, the system is being modified to remove decay heat from pools C and D as well. The CCW system contains two separate trains, each train containing a CCW heat exchanger. Three CCW pumps are shared by the two trains. During normal and accident operation, including refueling operations, only one CCW pump is required to be operated to remove the required heat loads from the plant. During plant cool down when heat removal demands on the CCW system are unusually high, two CCW pumps are operated.

2.0 EVALUATION

The focus of this review is to evaluate the licensee's plans to expand the storage capacity of fuel onsite and the effect the expanded capacity has on the heat removal capabilities of the spent fuel pool cooling and clean up systems to ensure they continue to meet staff guidelines on fuel storage. The staff organized the review into four sections:

- A review of the changes proposed to the FPCCS since the original design of the plant was accepted by the staff in NUREG-1038.
- A review of the effects of the increase decay heat loads on the cooling water systems supporting the storage of spent fuel.
- A review of the heavy loads aspects of this amendment.
- A review of an unreviewed safety question associated with a proposed reduction of CCW flow to the RHR heat exchangers under certain operating conditions.

The staff based our findings on information contained in the Harris Final Safety Analysis Report, NUREG-1038, and on information contained in letters from the licensee dated December 23, 1998, and September 5, 1999.

2.1 System Design Changes

The staff reviewed and accepted the design of the spent fuel storage system for Harris Units 1 and 2 in NUREG-1038 (November1983). Although the system was never completed, the design of the system was reviewed by the staff in accordance with NUREG-0800, "Standard Review Plan." The licensee's amendment dated December 23, 1998, requested the activation of pools C and D, but also made fundamental changes in the design of the system, for example, changing the system that supplies cooling water to the FPCCS for Unit 2 from Unit 2 CCW to Unit 1 CCW. As a result, the staff requested in a letter dated August 5, 1999, that the licensee address the differences between the system design that was accepted by the staff in NUREG-1038 and the "as-built" system.

In a letter dated September 3, 1999, the licensee provided a matrix which reconciles the differences between the "as-built" fuel storage system and the conclusions drawn by the staff in NUREG-1038 concerning the original design of the spent fuel storage system. In general, most of the FPCCS supporting pools C and D was built to the design reviewed by the staff in NUREG-1038. However, some portions of the system design underwent significant design changes. Those portions have been re-evaluated by the staff and the results are summarized in the following paragraphs.

The staff compared the conclusions drawn by the NRC in Section 9.1.2 of NUREG-1038 about the original fuel storage system design to the changes to the fuel storage system proposed by the licensee in their December 23, 1998, amendment request. The staff performed this review to ensure the proposed changes did not impact on the staff's previous conclusions concerning the acceptability of design of the fuel storage facility.

In NUREG-1038, the staff documented the acceptability of the spent fuel storage facility and the spent fuel pool cooling systems for both Units 1 and 2 in Sections 9.1.2 and 9.1.3. These sections frequently refer to both Unit 1 and Unit 2. Since Unit 2 was not completed, these references are inaccurate. However, the references are editorial in nature and do not affect the staff's previous conclusions about the acceptability of the fuel storage system.

For those portions of the system covered by Section 9.1.2 of NUREG-0800, specifically, the fuel handing building, the spent fuel storage racks, the spent fuel pool area ventilation system, and other portions of the fuel storage system described in Section 9.1.2 of NUREG-1038, the staff concluded based on our review that the proposed changes do not impact the NRC's previous conclusions and are still acceptable in accordance with the guidance in NUREG-0800, Section 9.1.2, and Regulatory Guide 1.13.

The staff also compared the conclusions drawn by the NRC in Section 9.1.3 of NUREG-1038 concerning the original FPCCS design to the changes to the FPCCS proposed by the licensee in their December 23, 1998, amendment request. The staff performed this review to ensure the proposed changes did not impact on the staff's previous conclusions concerning the acceptability of design of the fuel pool cooling and cleanup system.

The licensee called out the following differences between the original spent fuel pool cooling and cleanup system design accepted by the staff in NUREG-1038 and the "as-built" system described in the proposed license amendment:

a. A single Refueling Water Storage Tank (RWST) to provide system makeup water to both FPCCSs versus an RWST for each cooling system.

b. Emergency makeup for pools C and D provided from the Unit 1 ESW system, not the Unit 2 ESW system. Flanged connection described in NUREG-1038 for ESW hookup from Unit 2 will not be installed in the FPCCS system supporting pools C and D. Unit 1 ESW system is sized to accommodate the emergency fill requirements and can be cross-connected to all pools.

c. The current design limits the temperature of SFPs A and B to 137 °F, assuming a single active failure, which is lower than the temperature stated in NUREG-1038.

d. Spent fuel pool chemistry limits are currently maintained consistent with guidelines established by the NSSS vendor, fuel manufacturer, and EPRI guidelines. NUREG-1038 assumed a weekly sampling protocol.

e. NUREG-1038 contains many references to Unit 2. Due to the cancellation of Unit 2, references to GDC 5, sharing of structures, systems and components, are no longer applicable.

Items c, d, and e, above were reviewed by the staff and found to be editorial in nature, or approved by the staff in previous licensing actions and part of the current system design basis, and are, therefore, acceptable.

For items a and b above, the staff previously accepted a design for the fuel storage system whereby separate Refueling Water Storage Tanks (RWSTs) would be available to provide makeup water to pairs of spent fuel pools (spent fuel pools A and B from Unit 1 RWST, spent fuel pools C and D from Unit 2 RWST). Similarly, the staff accepted a backup method of makeup to the fuel storage system from the Unit 1 and Unit 2 Emergency Service Water (ESW) systems through valved and flanged connections. Since Unit 2 was never constructed, Unit 2 RWST and the Unit 2 ESW system are not available. Makeup from the RWST is used to compensate for coolant losses due to evaporation and cooling system leakage. The proposed change recognizes the Unit 1 RWST as the seismic Category 1 makeup water source for both FPCCSs, supplying makeup for all four spent fuel pools. Similarly, the Unit 1 ESW system is available to provide a seismic Category 1 backup makeup water source through a cross-tie to all four fuel storage pools in the event of an emergency. The licensee has evaluated this configuration and determined that the Unit 1 RWST and the Unit 1 ESW system have sufficient to supply makeup for all four pools. The staff reviewed the proposed changes to the seismic Category 1 makeup supplies for the FPCCS for pools C and D and finds that the Unit 1 RWST and the Unit 1 ESW system have sufficient capacity to provide makeup to the four fuel storage pools and is, therefore, acceptable.

In addition to the changes made to the systems that directly support spent fuel pools C and D, the Unit 1 CCW system was also modified to account for the absence of the Unit 2 CCW system. Valves, piping and other components were added to the Unit 1 CCW system provide heat removal capability for the Unit 2 FPCCS heat exchangers. The staff evaluated the effects of adding and additional heat load to the Unit 1 CCW system in Section 2.4 of this safety evaluation.

2.2 Changes in Decay Heat Load

The licensee provided a summary of methods, models, analyses and numerical results to demonstrate the compliance of the Harris spent fuel storage systems with the provisions of Section III of the USNRC "OT Position Paper for Review and Acceptance of Spent Fuel Storage and Handling Applications." The licensee provided the following analyses as justification for the acceptability of the proposed changes to the spent fuel storage system:

- Evaluation of the long term decay heat load in spent spent fuel pools C and D
- Evaluation of the steady state bulk pool temperature with forced cooling available (fuel pool bulk temperature is limited to 137 °F with the FPCCS in operation).
- Determination the maximum pool local temperature.
- Evaluation the potential for flow bypass from the pool inlet to the pool outlet with the sparger removed.
- Evaluation of the time-to-boil assuming all forced cooling is lost.

Holtec International, a contractor of the licensee, performed decay heat load calculations in accordance with USNRC Branch Technical Position ASB 9-2, "Residual Decay Energy for Light Water Reactors for Long Term Cooling." The calculations assumed that the spent fuel stored in spent fuel pools C and D had cooled a minimum of 5 years before being placed in spent fuel pools C or D. Holtec determined the bounding decay heat load in spent fuel pools C and D based on fuel characteristics documented on Tables 5.2.1. and 5.2.2 of Enclosure 6 to the letter dated December 23, 1998. Although the bounding calculations determined that the maximum decay heat load in spent fuel pools C and D could reach 15.63 Mbtu/hr, the licensee has decided to limit the maximum decay heat load in spent fuel pools C and D to 1 Mbtu/hr using administrative controls.

In a letter requesting additional information dated August 5, 1999, the staff asked the licensee to provide an analysis showing the maximum bulk temperature for SFPs C and D will not be exceeded assuming an increase in the decay heat load of 1 Mbtu/hr. In a letter dated September 3, 1999, the licensee provided and analysis that shows the maximum bulk temperature of all four spent fuel pools remains below the pool design temperature of 137 °F under a variety of operational conditions, including those that conform to the guideline in NUREG-0800 for partial and full core offloads. Where appropriate, the licensee assumed a single active failure and design temperatures (e.g., 95 °F for the ESW system) in the systems providing cooling water to the FPCCS heat exchangers.

The staff reviewed the documentation and agrees with the licensee that there is sufficient thermal margin in the CCW and ESW systems to maintain the bulk fuel pool coolant temperature in all spent fuel pools within their design limits assuming an additional decay heat load of 1 Mbtu/hr in spent fuel pools C and D, and assuming a single active failure.

The licensee's contractor, Holtec, also performed an analysis of the temperatures at various locations in the fuel pool to ensure localized boiling does not occur, especially in the fuel storage racks. Bounding assumptions for fuel storage location and cooling times were assumed, as well as for bulk coolant temperature and cooling flow to the spent fuel pools. A computational fluid dynamics model was used to determine the difference between peak local and bulk coolant temperatures. The results indicate that peak local temperature in the pool will be 6.8 °F higher than the maximum bulk coolant temperature of 137 °F. Based on a review of the licensee's methods and findings, the staff agrees that sufficient thermal margin exists to preclude localized boiling.

The licensee also provided the results of heat up calculations to determine the time-to-boil should a loss of all forced cooling occur. Section 5.4.1 of Enclosure 6 of the letter dated December 23, 1999, discusses the results of time to boil calculations performed by Holtec. The results indicate that with a heat load of 15.63 Mbtu/hr in spent fuel pools C and D, and an initial bulk coolant starting temperature of 140 °F, more than 13 hours are available take mitigating action. The staff considered this evaluation very conservative, given the heat load in spent fuel pools C and D will be limited to 1 Mbtu/hr, and requested that licensee evaluate the pool under its expected operating conditions. The licensee performed additional calculations that indicate several hundred hours are available to mitigate a total loss of cooling event in spent fuel pools C and D assuming a 1 Mbtu/hr heat load limit. These calculations are documented in a letter dated September 3, 1999.

The staff performed an independent heat up evaluation to ensure the licensee's results were conservative. For added conservatism, the staff assumed the spent fuel pools were isolated from each other when cooling was lost and that the entire decay heat load was located in a single pool. The staff's evaluation confirmed that more than one hundred hours are available to identify and address a loss of all forced cooling event if the heat load were limited to SFP C, and more than 50 hours are available if the decay heat load were limited to SFP D.

Given the decay load in spent fuel pools C and D will be limited to 1 Mbtu/hr, the staff agrees that sufficient time is available for plant operators to take mitigating actions prior to pool boiling.

2.3 Unreviewed Safety Question

The CCW system provides cooling to the residual heat removal (RHR) system heat exchangers, RHR pumps, the SFP heat exchangers, and other non safety-related systems. Two RHR trains provide long-term cooling during the containment sump recirculation phase of a LOCA by circulating the reactor coolant from the containment sump, through the heat exchangers, and returning it to the reactor coolant system cold legs. Each RHR train is capable of removing up to 111.1 Mbtu/hr in the post-LOCA scenario. In the USQ thermal-hydraulic analysis, the licensee demonstrates that adequate excess thermal capacity existed in the CCW system to accommodate the additional heat loads of 1.0 MBTU/hr (which is a limitation specified in
TS 5.6.3) from SFPs C and D during all normal and accident modes of system operation, i.e., the required RHR heat removal capability can be met with reduced CCW flow through the RHR heat exchanger due to the tie-in of the C and D FPCCS.

The USQ thermal-hydraulic calculations did not change any assumptions regarding maximum sump temperatures or RHR heat removal requirements under post-LOCA containment conditions. However, the licensee identified that fluid properties at the higher RHR temperatures associated with the post-LOCA scenario would result in an increase in the heat exchanger heat transfer coefficient values over the fixed value assumed in the existing analysis. The analyses used a "dynamic" RHR heat exchanger performance model in which the tube side inlet temperature is postulated to rise to 244.1 °F during the initial phase of containment sump recirculation, rather than a fixed 139 °F currently assumed. This increased tube side fluid temperature increases the overall RHR heat exchanger heat transfer coefficient (HTC) by approximately 10% due to the change in tube side fluid viscosity. Based on this increase heat exchanger HTC, the calculations showed that a minimum CCW system flow rate through the RHR heat exchanger of 4874 gpm at 120 °F is required at the beginning of the sump recirculation phase. Assuming a 6% model uncertainty, the required CCW system flow to the RHR heat exchanger would be 5166 gpm, which is less than 5600 gpm required by the existing analysis.

The licensee also provided, In response to a staff question (Question 6, September 3, 1999, letter), the results of analyses based on a time-dependent heat rejection load of the RHR heat exchanger, and the containment sump water temperature during a LOCA. The staff has performed an audit calculation of these results, and found that the analyses were conservatively based on a lower density and mass flow of the CCW volumetric flow rate of 4874 gpm. The staff concurs with the licensee's analysis conclusion that the required RHR heat removal capability can be met with the reduced CCW flow of approximately 5200 gpm.

3.0 Conclusions

The licensee proposed to modify Section 5.6.3, "Capacity," of Technical Specification to define the maximum capacity of the four spent fuel pools. In addition, the licensee included a section to limit the total decay heat load in spent fuel pools C and D to 1 Mbtu/hr. The licensee also identified an unreviewed safety question and provided a justification why the changes to the design of the CCW system were acceptable. Information provided by the licensee in the amendment request dated December 23, 1998, and letter dated September 3, 1999, documented the licensee's justification for requesting the staff's approval of this amendment.

The staff has completed their review of the of the unreviewed safety question justification and the decay heat load aspects of increasing capacity of the fuel storage system at Harris. Based on the evaluation documented in Section 2.0 of this evaluation, the staff finds the licensee proposed changes acceptable.

The staff is preparing an evaluation of the heavy loads and the alternate plan to demonstrate the acceptable level of quality and safety in the completion of the component cooling water system (CCW) and the fuel pool cooling and cleanup water system (FPCCS) piping and will transmit that evaluation to you in a separate memorandum.

Lead Reviewer(s):

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