UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

SUPPORTING AMENDMENT NO. 75 TO FACILITY OPERATING LICENSE NO. DPR-3

(MODIFICATION OF THE SPENT FUEL STORAGE POOL)

YANKEE ATOMIC ELECTRIC COMPANY

YANKEE NUCLEAR POWER STATION (YANKEE)

DOCKET NO. 50-29

1.0 INTRODUCTION

By letter dated July 13, 1978, Yankee Atomic Electric Company (YAEC) (the licensee) set forth a proposed program for modifications and improvements to the spent fuel pool (SFP) at the Yankee Nuclear Power Station (Yankee). The modifications would include the installation of a stainless steel liner for the pool walls, additional decay heat removal capacity, provisions for the installation of a divider gate to allow the modifications to be made, and provisions for additional spent fuel storage capacity in the pool.

The licensee provided additional information regarding the proposals by letters dated July 13, 1978 (two supplements to the original letter), September 15, 1978, September 25, 1978, October 18, 1978, February 7, 1979, March 5, 1979, August 18, 1980, September 17, 1981, and July 28, 1982.

By letters dated October 6, 1978 (License Amendment No. 51), April 3, 1979 (License Amendment No. 57), and January 22, 1981, the NRC staff approved the initial phases of the program dealing with the installation of the stainless steel liner, the divider gate installation, and the spent fuel pool cooling system modifications. The purpose of this Safety Evaluation is to address the issue of increased spent fuel pool storage capacity.

2.0 DISCUSSION

The proposed increase in spent fuel pool capacity from the currently authorized level of 391 fuel elements to 721 elements would be accomplished by the addition of new racks to the bottom level and the addition of a second tier of fuel racks above the currently installed set of racks. The new racks would consist of individual, five-element, welded aluminum modules, with the same center-to-center spacing (eleven inches), poison material (B_4C plates), and cavity channels at the existing racks. However, the racks will not be bolted together to form assemblies, but rather will be inserted directly into a supporting framework consisting of a network of beams supported by intermediate columns attached to the pit floor. The general arrangement and details of the proposed new spent fuel storage racks are presented in the licensee's submittals of August 18, 1980 and September 17, 1981.

The modifica ons to the pool would extend the spent fuel storage capability Yankee through 1997, when the operating license for the faci... expires.

The major safety considerations associated with the proposed expansion of the spent fuel pool storage capacity for Yankee are discussed below.

3.0 EVALUATION

3.1 Criticality Considerations

The criticality aspects of the existing fuel racks were evaluated by the staff in 1976, when the spent fuel pool capacity was first increased. The increased capacity of the current racks, compared to the original ones, was achieved by reducing the center-to-center spacing of the stored fuel assemblies to eleven inches. The reactivity increase caused by the closer spacing was compensated for by surrounding the assemblies with neutron poison in the form of Boral sheets.

The K_{eff} value for the arrays was calculated by a 4-group diffusion theory code (PDQ) and a transport correction determined by the Monte-Carlo KENO code. A calculational uncertainty of 3% $\Delta k/k$ was used. Conservatisms used in the calculations included: fresh 4.5 w/o U^{235} fuel; minimum center-to-center spacing; minimum boron content and thickness in the Boral sheets; unpoisoned water at 68°F; and infinite pool extent. The calculated value of K_{eff} for the existing racks is 0.80, which is far below the acceptance criterion of 0.95.

The licensee considered the inadvertent omission of 1/4 of the Boral sheets, one being missing in each fuel assembly position. For this case the K_{eff} was calculated to increase from 0.80 to 0.83 which is still well below the 0.95 acceptance criterion. Measures to be taken by the licensee to preclude such abnormalities included thorough QA at the time of fabrication and actual onsite measurements to verify the presence of the Boral at each fuel assembly position.

The new rack modules to be installed are identical (with respect to criticality) to the present ones which were previously reviewed and approved. Additional modules are to be installed in the lower tier.

However, the criticality analysis of the existing racks assumed an infinite array of racks so the earlier analysis is not affected by expansion. The second tier of racks is separated from the lower tier by thirty-three inches of water. Twelve inches of water is sufficient to permit the assumption of no neutronic interaction between arrays. Since the new racks are identical in design to the existing ones the previous criticality analysis is still valid. Furthermore, dropping a fuel assembly from above the top of the racks will not result in deformation of the racks and the fuel will be sufficiently above that stored in the racks so that the reactivity increase due to an assembly lying across the racks will be negligible.

The previous analysis concluded that the effective multiplication factor for the racks, including uncertainties, was 0.80. This provides ample margin to our acceptance criterion of 0.95 for this quantity. We, therefore, conclude that the proposed new fuel storage scheme is acceptable from a criticality point of view.

3.2 Material Considerations

The current and proposed additional spent fuel storage racks consist of an anodized aluminum support structure to which are attached, by welding, sheets of poison curtain material. The aluminum shapes and sheets form cavities into which Boral poison plates are placed and sealed by welding of aluminum cap sheets. The seal welding prevents direct contact of the Boral with the SFP water. Each Boral plate consists of a 0.084 inch thick core of B_4C (35% by weight) dispersed in a matrix of type 1100 aluminum alloy enclosed in a skin of 0.050 inch nominal thickness type 1100 aluminum alloy sheet.

A quality control program is carried out during fabrication of the racks to assure uniform minimum B_4C. The program includes random sampling of the Boral plates during production and destructive examination of these sample sections for proper material density.

Boral sheet in the configuration described above has similar corrosive resistant properties to standard aluminum clad sheet. Corrosion data and industrial experience with standard aluminum clad sheet confirm that Boral has acceptable corrosive resistant properties for the proposed application.

In addition to the quality control measures during fabrication to verify and document that the required Boral plates are installed in the spent fuel storage rack, the licensee conducts a measurement program at Yankee to demonstrate that the racks actually contain the B_4C material.

Furthermore, since 1976, the licensee has had underway a materials compatability monitoring program consisting of aluminum to stainless steel couples. These couples and the existing racks have shown minimal signs of attack after this prolonged exposure to the spent fuel pool environment.

Based on our review of the proposed spent fuel storage rack material selection, material stability, and corrosion resistance in the spent fuel pool environment, and based on the excellent experience to date with the existing racks, we conclude that the proposed new spent fuel racks are acceptable from the point of materials of construction and corrosion.

3.3 Structural Considerations

The licensee has stated that the structural framework and supports for the proposed second tier of spent fuel racks has been designed, fabricated, installed, and inspected in accordance with the requirements of ASME Section III, Subsection NF, "Components Support." The supports are designed to carry dead load plus seismic loads, which consist of 0.5g in the two horizontal directions and 0.2g in the vertical direction. The licensee has committed to perform a more rigorous analysis in accordance with the requirements of Standard Review Plan Section 3.7 as part of the Systematic Evaluation Program.

Until the results of that analysis have been submitted, reviewed and accepted by the staff, we can only provide conditional approval of the proposed spent fuel storage plan. Although the technical specification limit regarding the maximum number of fuel elements permitted in the pool has been changed from 391 to 721, License Condition No. 2.C(6) has been added to the license to limit the maximum capacity of the pool to 391 elements until the structural analysis has been reviewed and accepted by the NRC staff.

3.4 Spent Fuel Pool Cleanup System

The spent fuel pool cleanup system is designed to remove corrosion products, fission products, and impurities from the pool water. Pool water purity is monitored by monthly chemical and radiochemical analysis. Demineralizer resin is replaced when pool water samples show reduced decontamination effectiveness. The licensee indicated that no change or equipment addition to the spent fuel pool cleanup system would be necessary to maintain pool water quality for the additional fuel storage capacity.

Past experience has shown that the greatest increase in radioactivity and impurities in spent fuel pool water occurs during refueling and spent fuel handling. The refueling frequency, the amount of core to be replaced for each fuel cycle, and frequency of operating the spent fuel pool cleanup system are not expected to increase as a result of the increase in pool storage capacity. The chemical and radionuclide composition of the spent fuel pool water is not expected to change either. Past experience has also shown that no significant leakage of fission products occurs from spent fuel stored in pools after the fuel has cooled for several months. To maintain water quality, the licensee has established an acceptable frequency for chemical and radiological analyses to monitor the water quality and to determine when the spent fuel pool cleanup system demineralizer resin and filter should be replaced. In addition, the licensee has also set acceptable chemical and radiochemical limits to be used in monitoring the spent fuel pool water quality and initiating corrective action.

We find that the proposed expansion of the spent fuel pool will not appreciably affect the capability of the existing spent fuel pool cleanup system. More frequent replacements of filter or demineralizer resin, required when the differential pressure exceeds a predetermined limit or demineralization effectiveness is reduced as indicated by the analyses, can offset any potential increase in radioactivity and impurities in the pool water as a result of the expansion of the pool capacity. Thus, we have determined that the existing fuel pool cleanup system with the proposed increase in storage capacity (1) provides the capability and capacity of removing radioactive materials, corrosion products, and impurities from the pool and, thus, meets the requirements of General Design Criterion 61 in Appendix A of 10 CFR Part 50 as it relates to appropriate systems to fuel storage; (2) is capable of reducing occupational exposures to radiation by removing products from the pool water, and, therefore, meets the requirements of Section 20.1(c) of 10 CFR Part 20 as it relates to maintaining radiation exposures as low as is reasonably achievable; (3) confines radioactive materials in the pool water to the filters and demineralizers, and thus meets Regulatory Position C.2.f(2) of Regulatory Guide 8.8, as it relates to reducing the spread of contaminants from the source; and (4) removes suspended impurities from the pool water by filters, which is consistent with Regulatory Position C.2.f(3) of Regulatory Guide 8.8, as it relates to removing crud from fluids through physical action.

We, therefore, conclude that the proposed spent fuel storage plan is acceptable with regard to the spent fuel pool cleanup system.

3.5 Occupational Exposure

The occupational dose for the installation of the double-tier storage rack system was estimated by the licensee to be approximately 1.25 person-rem. This estimate is based on the licensee's detailed breakdown of occupational exposure for each phase of the pool modification. The licensee considered the number of individuals performing a specific job, their occupancy time while performing this job and the average dose rate in the area where the job will be performed.

No additional underwater work is necessary that would require the use of divers. Throughout the spent fuel pool modification operation, the personnel exposure controls will be administered in accordance with the licensee's radiological control procedures to assure as low as is reasonable achievable exposures (ALARA) to workers. Based on the manner in which the licensee will perform the modifications, and relevant experience from other operating reactors that have performed similar SFP modifications, the staff concludes that the Yankee SFP modification can be performed in a manner that will ensure exposure to the workers will be ALARA.

We have estimated the increment in onsite occupational doses resulting from the proposed increase in stored fuel assemblies on the basis of information supplied by the licensee and by utilizing relevant assumptions for occupancy times and for dose rates in the spent fuel pool area from radionuclide concentrations in the SFP water. The spent fuel assemblies themselves contribute a negligible amount to the dose rates in the pool area because of the depth of water shielding the fuel. The occupational radiation exposure resulting from the proposed actions represents a negligible burden. Based on present and projected operations in the spent fuel pool area, we estimate that the proposed modifications should add less than one percent to the total annual occupational radiation exposure burden. Thus, we conclude that storing additional fuel in the pool will not result in any significant increase in doses received by occupational workers.

3.6 Spent Fuel Pool Cooling

The Yankee spent fuel pool is currently licensed to hold a maximum of 391 spent fuel elements. Because the proposed increase in capacity to 721 elements will also increase the heat input to the pool water, it is necessary to assure that the spent fuel pool cooling system has the capacity to remove this additional heat.

The spent fuel pool cooling system consists of a 500 gpm pump and a 600 gpm pump, connected in parallel, which circulate water from the pool through a single heat exchanger. Heat is removed from the heat exchanger by the plant component cooling water (CCW), which is a closed system. The CCW system has its own set of heat exchangers which are ultimately cooled by service water drawn from Sherman Pond. The Reactor Shutdown Cooling System may also be lined up to provide a backup cooling system for the spent fuel pool.

Makeup water to the pool is normally supplied from the demineralized water storage tank, with backup water available from the primary water storage tank and the firewater system. The makeup water pumps can each provide 100 gpm of water to the pool.

The spent fuel pool water level and temperature indications are provided locally at both ends of the pool. Also, local pressure indication on the discharge header of the pumps is available. High and low level alarms for both ends of the pool will be provided in the control room along with a low discharge header pressure alarm in the waste disposal building. The normal pool operating water temperature is 85-90°F with a maximum allowable temperature of 150°F.

Because of the piping arrangement and location, a break in the cooling system piping will not result in the water level dropping below the top of the fuel elements. The water level is maintained by manual operations. Should the pool liner be penetrated, no loss of water would occur that could not be made up because the spent fuel pool floor is a 36-inch concrete slab. (See Section 3.7)

The staff calculated a decay heat generation rate using ASB TP 9-2 for 721 elements in the pool of 6.62 X 10^6 Btu/hr. This compares favorably with the licensee's value of 6.33 X 10^6 Btu/hr at 120 hours after full core discharge. With this assumed heat load and the maximum permissible pool water temperature of 150°F, the spent fuel pool heat exchanger CCW outlet temperature will be approximately 86°F, which is well below the design inlet temperature of 96°F for CCW heat exchangers.

If spent fuel pool cooling were to be lost, with the pool at rated storage capacity, 7.5 hours would elapse before the water in the pool would begin to boil, and then the evaporation rate would be 14 gpm. This quantity of water can be readily made up from the three different water supplies. We also consider that 7.5 hours is a sufficient time period to either make repairs to the cooling system or to establish an alternate source of cooling water.

We, therefore, conclude that the proposed spent fuel storage plan is acceptable with regard to the spent fuel pool cooling system.

3.7 Accidents

3.7.1 Heavy Load Drop Accidents

Technical Specification Limiting Condition for Operations (LCO) 3.9.7 prohibits loads in excess of 900 pounds from travel over the spent fuel pool (SFP), with the following exceptions: (a) spent fuel pool building roof hatches, (b) spent fuel inspection stand, (c) fuel handling equipment, (d) spent fuel racks, (e) temporary gate, and (f) shielding panels. Of these loads, (a) spent fuel pool building roof hatches and (d) spent fuel racks, may be transported under administrative control, over spent fuel assemblies stored in the pool. No spent fuel cask may be transported over the spent fuel pool. Therefore, a cask drop accident is not considered herein.

In support of Amendment No. 57 to the Yankee license, the licensee evaluated the consequences of an accidental drop of the temporary gate sections and shielding panels while suspended from the crane above the spent fuel pit. The licensee used the Modified National Defense Research Committee Formula to calculate the penetration of these objects into the pit slab. Because the roof hatches are much lighter (1.5 tons each) than either the shield panels (9 tons each) or the temporary gate sections (14.5 tons per section), a specific analysis of the roof hatches is not necessary. The licensee concluded that the 36 inch spent fuel pit slab would not be perforated from such a postulated accident and that the water would be retained in the spent fuel pit.

The staff has found these calculations to be reasonable and have concluded that even in the unlikely event that such an accident were to occur, the safety consequences would be acceptable. The use of redundant slings and lifting eyes provides additional assurance that a construction handling accident will not occur. Nevertheless, we have considered the potential radiological consequences of the temporary gate and shielding panels falling or tipping into the part of the pit containing spent fuel.

Postulated drops of roof hatches or temporary gates onto racks holding stored fuel could result in immediate release of gap radionuclide inventory of struck stored spent fuel. If it is assumed that all of the struck fuel assemblies have undergone cooldown for at least 90 days, even if the gap activity of all 721 assemblies is released to the pool water, offsite 0-2 hr radiological consequences of 18 Rem to thyroid and <1 Rem whole body at the exclusion area boundary (EAB) would result. These doses conservatively assume an overall pool decontamination factor of 60 for iodines, corresponding to 14 feet of water covering fuel in the upper tier, and an atmospheric diffusion air transport relative concentration value of 2.8×10^{-4} sec/m^3. These doses are well within the guideline values of 10 CFR Part 100.

In order to ensure that this evaluation remains valid, a Technical Specification limit has been established which requires that all fuel elements in the pool must have decayed for at least 90 days prior to allowing movement of the roof hatches, the temporary gates, or the shield panels over the spent fuel pit.

3.7.2 Fuel Handling Accidents

The licensee has proposed to expand the storage capacity of the spent fuel pool (SFP) from 225 assemblies to 721 assemblies by means of a two-tiered configuration of storage racks. During the activity, as well as normally, the maximum weight of loads which may be transported over the spent fuel pool is 900 pounds (LCO 3.9.7). Since a strong protective grating, which will not be penetrated by a fuel assembly drop, is being installed between the two tiers of racks, the fuel handling accident will still result in release of the equivalent gap radioactivity inventory of one fuel assembly. An iodine decontamination factor of 60 is assumed, corresponding to a water cover depth of 14 feet for fuel in the upper tier. No fuel is assumed to be moved into the pool storage array having less than 5 days of cooldown time. Assuming a 0-2 hr atmospheric diffusion and transport relative concentration of 2.8×10^{-4} sec/m^3, the 0-2 hr exclusion area boundary thyroid dose is 51 Rem; the whole body dose is <0.2 Rem. Thus, the offsite radiological consequences of the fuel handling accident are well within the guidelines values of 10 CFR Part 100.

3.7.3 Conclusions

The staff concludes that a postulated gate drop or SFP building roof hatch drop accidents would result in radio-nuclide releases leading to offsite consequences well within the guidelines of 10 CFR Part 100, namely 18 Rem to the thyroid and <1 Rem whole body at the exclusion area boundary (EAB).

The results of our analysis of the fuel handling accident indicate radiological consequences of 51 Rem to the thyroid and <1 Rem whole body, well within the guideline values of 10 CFR Part 100. We, therefore, conclude that the proposed spent fuel pool storage modifications are acceptable with regard to the consequences of postulated accidents.

4.0 SUMMARY

In summary, we have determined that the concept of the proposed modifications to the Yankee SFP are acceptable because: (1) the design precludes criticality for any moderating condition, (2) the existing SFP cooling system has been analyzed to have sufficient capacity to provide adequate cooling for the increased heat load, and (3) the increased radiation doses both onsite and offsite would be negligible. Final approval on the increase in spent fuel pool capacity is contingent upon the submittal of the structural analyses described in Section 3.3 of this evaluation.

5.0 CONCLUSION

We have 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, and (2) such activities will be conducted in compliance with the Commission's regulations and the issuance of the amendment will not be inimical to the common defense and security or to the health and safety of the public.

6.0 ACKNOWLEDGMENTS

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