January 29, 1979

SAFETY EVALUATION BY THE OFFICE OF

NUCLEAR REACTOR REGULATION

RELATING TO MODIFICATION OF THE

SPENT FUEL STORAGE RACKS

FACILITY OPERATING LICENSE NO. NPF-4

VIRGINIA ELECTRIC AND POWER COMPANY

NORTH ANNA POWER STATION, UNITS 1 AND 2

DOCKET NOS. 50-338 AND 50-339

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1.0 INTRODUCTION

In a letter dated May 1, 1978, the Virginia Electric and Power Company requested an amendment to Facility Operating License No. NPF-4 to increase the spent fuel storage capacity of the fuel pool for the North Anna Power Station, Units 1 and 2, from the present capacity of 400 fuel assemblies (approximately 2-1/2 cores) to 966 fuel assemblies (approximately 6 cores). The expanded storage capacity would allow the storage of all spent fuel to be generated by the operation of North Anna Power Station, Units 1 and 2, from the present until about 1987 and still provide storage space for the discharge of a full core loading.

2.0 EVALUATION

2.1 Criticality

The present spent fuel storage racks, which utilize a center-to-center spacing of 21 inches, would be removed and replaced with new stainless steel racks utilizing a center-to-center spacing of 14 inches between individual storage cans (cells). The licensee has provided a criticality analysis utilizing these revised spent fuel storage rack dimensions for normal, abnormal, and accident conditions. A fresh fuel enrichment of 3.5 weight percent uranium 235 was assumed and the water in the pool was assumed to be at 68 degrees Fahrenheit and to be free of soluble boron. Credit was taken for the neutron poisoning effect of the stainless steel cans, but for no other poisons in the racks. The fuel rack array was assumed to be infinite in all three dimensions.

The licensee performed calculations using the NUS Corporation version of the LEOPARD Code, which has been verified by comparison with critical experiments. Further verification was done by comparison of selected cases with results of KENO calculations. From these comparisons, a calculational uncertainty was obtained. Sensitivity studies were performed which investigated the effect of lattice pitch uncertainties, uncertainties in thickness and composition of the stainless steel cans, variations in pool temperature, and uncertainties in the fuel enrichment. The Leopard Code and KENO Code are industry standards which have been verified by experiment and, therefore, we find these calculational methods to be acceptable.

The calculations resulted in a nominal effective multiplication factor (k effective)* of 0.889 for the racks and a value of 0.924 when all uncertainties were algebraically combined. This value is more conservative than our acceptance criterion of 0.95, as specified in Section 9.1.2 of the Standard Review Plan, and is, therefore, acceptable. Additionally, there is an existing technical specification in the North Anna operating license which limits k effective in the spent fuel pool to 0.95.

The limiting accident condition is that in which an assembly (without stainless steel can) is placed next to the storage rack array at the closest point (5 inch water gap) permitted by a mechanical restriction on the rack. This resulted in an increase of the effective multiplication factor (k effective) of less than 0.1 percent (to 0.925) which meets our acceptance criterion of 0.95 and is, therefore, acceptable.

2.2 Design

The spent fuel pool is a reinforced concrete seismic Category I structure with a 1/4 inch thick stainless steel liner. The spent fuel pool is located in the fuel building which is supported by a reinforced concrete mat on bedrock.

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The modified storage rack design will preclude storage of fuel assemblies in other than their prescribed locations as did the racks being replaced. The new storage racks are classified as seismic Category I and the design is in accordance with the applicable portions of Sections 3.7 and 3.8 of the Standard Review Plan considering loads, load combinations and structural acceptance criteria. The proposed storage rack design is also in accord with the recommendations of Regulatory Guide 1.29, "Seismic Design Classification". Design codes are based on Part 1 of the American Institute of Steel Construction "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings," dated February 12, 1969 and its Supplements 1, 2 and 3 for their elastic design methodology and allowable stress criteria. Yield strengths were obtained from appropriate American Society of Mechanical Engineers Boiler and Pressure Vessel Code, Section III tables for stainless steel structures and the American Institute of Steel Construction "Manual of Steel Construction" was used for guidance to determine the allowable design stresses. We find the codes and standards used in the design of the new storage racks to be in compliance with the Standard Review Plan and, therefore, acceptable.

The modeling and analytical methods for seismic analysis of the spent fuel storage racks are in compliance with the recommendations of Sections 3.7 and 3.8 of the Standard Review Plan. Racks are modeled in detail using beam and

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*k effective is the ratio of neutrons from fissions in each generation to the total number lost by absorption and leakage in the preceeding generations. To achieve criticality in finite system, k effective must equal 1.0.

plate finite elements with consideration of gaps between assemblies and submergence in liquid. A response spectrum modal dynamic analysis is employed for seismic design and the response spectra used for the operating basis earthquake and safe shutdown earthquake are the same as those used in other North Anna Power Station, Units 1 and 2, seismic Category I structures. The fuel racks could slide under seismic conditions, but will be designed against tipping and overturning. The proposed modification does not change the physical configuration of the spent fuel pool. However, two additional floor pads to accommodate seismic loads from the proposed fuel storage racks are presently installed in the fuel pool. This installation was performed before the issuance of the operating license for Unit 1. The additional embedments or pads, which are anchored to the concrete via use of rock anchor bolts, have been seismically designed and analyzed, and would not impair the structural integrity of the pool structure nor cause any leakage problem.

We have determined that, although the load in the fuel pool will be more than twice the original load, no significant settlement of the fuel building is expected because the fuel building is supported by a reinforced concrete mat on bedrock as stated above.

We conclude that the proposed spent fuel storage racks do not involve any significant change in design methods and criteria of structures, nor cause any potential problem in structural integrity and are, therefore, acceptable.

2.3 Materials

The materials to be used for construction of the spent fuel storage racks have been identified by specification and found to be in conformance with the requirements of Section III of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code. The mechanical properties of the selected material satisfy Appendix I of Section III of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code and Parts A, B and C of Section II of the Code.

The revised spent fuel storage rack material is Type 304 austenitic stainless steel as was the previous material. Type 304 is compatible with the expected environment, as proven by testing and satisfactory past service performance. Therefore, general corrosion of the material will be negligible. Galvanic corrosion is avoided since stainless steel Type 304 material is also used in the construction of the base structure angle plates, embedment plates and the spent pool liner.

The controls to be imposed upon the fabrication of the austenitic stainless steel material used in the construction of the spent fuel storage racks satisfy the requirements of Regulatory Guide 1.31, "Control of Ferrite Content of Stainless Steel Weld Metal" and American National Standard Institute (ANSI) Standard N45.2.1, "Cleaning of Fluid Systems and Associated

Components During the Construction Phase of Nuclear Power Plants." The welding procedures and the welders are qualified in accordance with the requirements of Section IX of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code.

Since materials selection, fabrication practices and cleaning procedures will be performed in accordance with the requirements of the ASME Code, the ANSI standard and the regulatory guide referenced above, we conclude that there is reasonable assurance that the spent fuel storage racks will perform satisfactorily in service.

2.4 Safety Analysis

In Section 9.1.. of the North Anna Power Station, Units 1 and 2 Safety Evaluation Rerort, we concluded that the fuel handling system and facilities design was not in conformance with paragraph C.5 of Regulatory Guide 1.13, "Fuel Storage Facility Design Basis", regarding prevention of moving cranes carrying heavy loads into the vicinity of the pool and was not acceptable. Subsequent to the issuance of the Safety Evaluation Report, the licensee modified the design of the spent fuel pool to provide a wall between the spent fuel storage area and the fuel cask loading pit to preclude damage to stored fuel in the event of a cask drop. Our evaluation of this modification is contained in Section 9.0 of Supplement 8 to the Safety Evaluation Report, dated December 1977. We determined that the licensee's modification to prevent the potential damage from a cask drop was acceptable. The proposed increased spent fuel storage rack design will not affect this conclusion since there will be no structural modifications made to the spent fuel pool or the separating wall.

We have underway a generic review of load handling operations in the vicinity of spent fuel pools to determine the likelihood of a heavy load impacting fuel in the pool and, if necessary, the radiological consequences of such a event. However to minimize the dropping of heavy loads on the spent fuel pool, Section 3.9.7 of the Technical Specifications for the North Anna Power Station Unit 1 operating license limits loads over the irradiated assemblies in the pool to 3250 pounds. This is the approximate weight of a single assembly which was used in the design basis fuel element drop analysis discussed below. Therefore, we conclude that the likelihood of a heavy load handling accident is sufficiently small so that the acceptability of the proposed modification is not affected, and that no additional restrictions on load handling operations in the vicinity of the spent fuel pool are necessary while our generic review is underway.

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In Section 15.4 of the Safety Evaluation Report for the North Anna Power Station, Units 1 and 2, dated June 4, 1976, we evaluated the radiological consequences of a postulated fuel handling accident (design basis event) in the spent fuel storage area, and determined that the resultant offsite doses are well within the guidelines of 10 CFR Part 100. The analysis for this evaluation conservatively assumed that an element that had operated in the maximum power region of the core and had decayed for a minimum cooling time, is dropped the full height to the bottom of the spent fuel pool and all of the cladding is damaged. The consequences of an element dropped onto the storage racks would be less severe since the first rack supports extend above the stored fuel assemblies themselves and the drop height would be significantly less. The proposed doubling of the storage capacity of the spent fuel pool will not change the results of the above evaluation since the same underlying assumptions are still valid. Therefore, we conclude that the proposed modifications will not increase the radiological consequences of the postulated design basis fuel handling accident.

The flood design criteria for the North Anna Power Station, Units 1 and 2, was evaluated in Section 3.4 of the Safety Evaluation Report, and found acceptable to preserve the structural integrity of seismic Category I structures and seismic Category I systems and components within these structures. The design criterion for the tornado missile protection for the facility was such that tornado-generated missiles would not cause damage to more than one spent fuel assembly within the spent fuel pool. This matter was evaluated in Sections 3.5 and 9.1.2 of the Safety Evaluation Report and our basis for accepting the design of the fuel building and spent fuel pool, with regard to missile protection, was that there is a low probability that a tornado-generated missile would damage sufficient fuel assemblies to cause offsite doses in excess of 10 CFR Part 100. The design provisions for protection from flood and tornado missiles are unaffected by the proposed modification and are, therefore, acceptable.

On the basis of the above, we conclude that the increase in the number of assemblies in the fuel storage pool of the North Anna Power Station, Units 1 and 2, will not increase the offsite radiological consequences beyond the design basis fuel handling accident.

2.5 Thermal Analysis

We had previously found the design for the spent fuel pool cooling and purification system to be acceptable, as discussed in Section 9.1.3 of the Safety Evaluation Report.

The licensee has performed a design heat load calculation for the existing spent fuel pool cooling system assuming 966 spent fuel assemblies in the pool and that the plant had operated at a power stretch rating of 2990 megawatts thermal. We have performed an independent evaluation of the capability of the spent fuel pool cooling and purification system to handle the increased cooling requirements resulting from the additional spent fuel storage without modification to the system. For this evaluation, we conservatively assumed that the decay heat load for the pool based on back to back annual refuelings of each unit would include the heat load from a third of a core from one unit at equilibrium conditions which is placed in the pool 150 hours after reactor shutdown plus the heat load from a third of a core from the other unit placed in the pool 150 hours after reactor shutdown, 45 days previously and 16 previous one-third core annual cyclic refueling discharges.

Each spent fuel pooling cooling system is designed for a heat removal capability of 56.8 million British thermal units (BTU) per hour. Our evaluation verifies that the revised normal spent fuel heat load will be 19.4 million British thermal units per hour which is an incremental increase of 5.6 million British thermal units per hour (40 percent increase) attributable to the proposed modifications. The present system is adequate for removing this incremental increase in heat load, and it results in an increase in the heat load to the service water system of approximately five percent.

Our evaluation of the spent fuel pool cooling system for the original fuel storage configuration, as presented in Section 9.1.3 of the Safety Evaluation Report, disclosed that the spent fuel pool cooling system will maintain the pool water temperature below 140 degrees Fahrenheit assuming a total spent fuel inventory of one third of a core and below 170 degrees Fahrenheit for emergency conditions where total spent fuel inventory of one plus one third core at equilibrium conditions is stored. Our evaluation of the proposed spent fuel pool modification has verified that the existing spent fuel pool cooling system can also maintain these specified temperatures for the proposed modification. Therefore, we find that the existing spent fuel pool cooling system is acceptable for the proposed modifications.

The maximum load on the fuel pool purification portion of the system occurs during refueling operations when fuel is being moved or when larger than normal amounts of defective fuel are stored in the racks. The purification portion of the system has the design capability of accommodating any anticipated increase in the amount of stored defective fuel resulting from the increase in the storage capacity.

On the basis of our review, we conclude that the present cooling and purification capacity of the spent fuel pool will be sufficient to handle the incremental heat load and potential water quality degradation in the pool that would be added by the modification and that the spent fuel pool cooling and purification system is acceptable for the proposed modification.

2.6 Radiation Protection

The licensee plans to perform the modification to the spent fuel pool storage capacity prior to any contact with radioactivly contaminated spent fuel pool storage coolant and shielding water. If this takes place, there will be no personnel radiation exposure associated with the modification. In the event that the modification takes place after spent fuel is stored in the spent fuel storage pool, then there will be some radiation exposure to the plant personnel who replace the racks that have been exposed to radioactively contaminated coolant. Based on information that we have on exposures to personnel from pressurized water reactors which already have modified their spent fuel storage pools, we would expect the exposure at the North Anna Power Station, Units 1 and 2, to be less than 20 man-rem. This installation is expected to be performed only once during the lifetime of the station and, therefore, any resultant exposure would represent only a small fraction of the total man-rem burden from expected occupational exposure. This small increase in radiation exposure will not affect the licensee's ability to maintain individual occupational doses as low as is reasonably achievable and within the limits of 10 CFR 20.

We have evaluated the radiation protection design features to assure that occupational radiation exposures to plant personnel due to the proposed modification will not significantly increase.

Although it is expected that the additional spent fuel in the pool will increase the amount of corrosion and fission products introduced into the cooling water to some extent, as noted above in Section 2.5, the existing purification system will provide adequate removal of those nuclides to assure that the radiation fields will not exceed 1.5 to 3.0 millirem per hour at waist level at the edge of the pool. We consider these radiation fields and resultant exposures during fuel handling operations to be acceptable. Additionally, the licensee provided actual radiation field data and radiation exposure data from their Surry Power Station, Units 1 and 2 (Docket Nos. 50-280 and 50-281) which has a spent fuel storage capacity and design similar to that proposed for the North Anna Power Station, Units 1 and 2. The radiation shield water in the storage pool will provide adequate shielding for the additional fuel elements. Based on operating experience at the Surry Power Station, Units 1 and 2, the exposure of personnel to airborne radioactivity will be within the limits of 10 CFR Part 20.

Accordingly, we conclude that storing additional fuel in the spent fuel pool will not result in any significant increase in doses received by occupational workers and that the radiation protection design is acceptable without change for the proposed modification.

2.7 Industrial Security

We have reviewed the proposed modification with respect to industrial sabotage. We consider the fuel array compaction in the spent fuel pool to have no effect or relevance to the security plan for the North Anna Power Station, Units 1 and 2. Our conclusion is based on the fact that the spent fuel pool is designated as a vital area. As a vital area, it is afforded the protection required by 10 CFR Section 73.55 to provide high assurance against successful industrial sabotage by both of the following:

(1) A determined violent external assault, attack by stealth, or deceptive actions, of several persons with the following attributes, assistance and equipment: (i) well-trained (including military training and skills) and dedicated individuals, (ii) inside assistance which may include a knowledgeable individual who attempts to participate in both a passive role (e.g., provide information) and an active role (e.g., facilitate entrance and exit, disable alarms and communications, participate in violent attack), (iii) suitable weapons, up to and including hand-held automatic weapons, equipped with silencers and having effective long range [illegible], (iv) hand-carried equipment, including incapacitating age[illegible] and explosives for use as tools of entry or otherwise destroyi[illegible] the reactor integrity, and

(2) An internal threat of an insider, including an employee (in any position).

In light of the above, compaction of the fuel array in the spent fuel storage pool does not change the required level of protection nor the structural design of the external barriers of the pool against the threat of industrial sabotage.

3.0 SUMMARY

Our evaluation supports the conclusion that the proposed modification to the spent fuel pool for the North Anna Power Station, Units 1 and 2 is acceptable because:

(1) The physical design of the new storage racks will preclude criticality for any moderating condition with the limits imposed.

(2) The spent fuel pool cooling system has adequate cooling capacity.

(3) The increase in occupational radiation exposure to individuals due to the storage of additional fuel in the spent fuel pool would be negligible.

(4) The installation and use of the new fuel racks can be accomplished safely.

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(5) The likelihood of an accident involving heavy loads in the vicinity of the spent fuel pool is not affected by the proposed modification and is sufficiently small that no additional restrictions on load handling operations in the vicinity of the spent fuel pool are necessary while our generic review is underway.

(6) The structural design and the materials of construction are adequate and meet the applicable design criteria.

4.0 CONCLUSION

Based on the considerations discussed above we conclude that: (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the propo ed manner, and (2) such activities will be conducted in compliance with the Co ission's regulations and the issuance of this amendment will not be inimical to the common defense and security or the health and safety of the public.