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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

SUPPORTING AMENDMENT NO. 44 TO FACILITY OPERATING LICENSE NO. DPR-3

YANKEE ATOMIC ELECTRIC COMPANY

YANKEE NUCLEAR POWER STATION (YANKEE-ROWE)

DOCKET NO. 50-29

Introduction

On August 25, 1977, the NRC issued Amendment No. 43 to Facility License No. DPR-3 for the Yankee Nuclear Power Station (Yankee-Rowe). That amendment incorporated provisions in the Technical Specifications required for operation with the refueled Core XIII, with an active ECCS accumulator subsystem, and with modified ECCS piping, based on an ECCS performance analyses using certain modeling changes. The licensee agreed to submit certain confirmatory LOCA analyses following Cycle XIII startup. These analyses, which have now been submitted and reviewed, are: (1) an accumulator delay sensitivity study; (2) a core inlet temperature sensitivity study; and (3) additional small break analyses.

The licensee also has submitted proposed Technical Specification changes specifying a new time delay setting for accumulator actuation, and specifying new linear heat generation rate (LHGR) curves taking into account the effects of fuel burnup. These proposed Technical Specification changes and analyses are contained in licensee submittals dated September 8, 21, 26, October 7, 11, 27 and November 14, 1977.

In addition to our action in the above matters, we have changed page 3/4 2-10 of the Technical Specifications by deleting a sentence which was inadvertently retained from the Core XII Technical Specifications. This sentence describes the Core XII fuel loading and is not applicable to the present Core XIII. Thus, this change is purely administrative.

Evaluation

A. Accumulator Time Delay Setting

The LOCA analysis on which Cycle XIII operation was based assumed accumulator pressurization in 7.4 $\pm$1.0 seconds following receipt of a safety injection actuation signal. The present Technical Specification

specifies the timer setting which was estimated to result in the desired delay (6.4 to 7.1 seconds). This timer setting allowed for the most accurate conservative estimate for component actuation times known at the time the Technical Specification was issued. During preoperational testing of the modified ECCS accumulator subsystem, the licensee determined the actual component actuation times associated with the subsystem response. The proposed Technical Specification change (a timer setting of 4.0 ± 0.75 seconds), is acceptable because it will give a timer setting which will result in the same delay in accumulator pressurization as was assumed in the approved Core XIII LOCA analysis, and as verified by system response testing.

B. Small Break Analysis

In Support of Cycle XIII startup, the licensee provided small break analysis for a break postulated to occur in a small length of ECCS piping (1 to 2 feet) immediately downstream of the check valve which is nearest one of the reactor coolant system (RCS) cold leg injection points. This break location results in RCS blowdown through a 2.25 in. I.D. thermal sleeve and ECCS spillage through a 3.438 in. I.D. ECCS line to containment. With the modified ECCS system the PCT was calculated to be 1124°F for this break. This break location was the worst small break previously analyzed for Core XII. The licensee committed to provide confirmatory analysis demonstrating the acceptability of other small breaks after startup assuming the flow characteristics of ECCS pumps and throttle valves as measured during Cycle XIII preoperational testing.

The licensee, using the approved model, reanalyzed the 2.25 inch I.D. break with the new assumptions, and also analyzed the 4.0, 5.0, 7.5, and 10 inch I.D. breaks. The results were as follows:

	Break Size Equivalent Internal Diameter, Inches				
Parameter	2.25	4.0	5.0	7.5	10.0
Peak Clad Temperature (PCT) °F	1133.5	1793.4	1522.4	1398.4	1625.3
Maximum Local Zr/H_2O Reaction, %	.13	0.70	.24	.17	.20
Percent of Total Core Zr/H_2O Reaction, %	<1	<1	<1	<1	<1

The maximum PCT of 1793°F for the 4.0 inch I.D. break is well below the 1983°F PCT for the limiting break for Cycle XIII (a 1.0 inch I.D. double ended cold leg guillotine break, or 1.0 DECLG) and is much less than the acceptable limit of 2200°F. We find the results of the small break analysis acceptable.

C. Accumulator Delay Sensitivity Study

Before commencing Cycle XIII operation the licensee made equipment changes related to the pressurization,depressurization and inventory of the accumulator portion of the ECCS. For the large break LOCA, the modifications reduced the time required to reflood the bottom of the core by: (1) increasing the accumulator flow rates by means of higher operating pressures; and (2) assuring adequate accumulator inventory by utilizing its full volume and by an increase in the delay time for its pressurization.

The increased delay period of about seven seconds for pressurization of the accumulator reduces the loss of inventory through the broken loop during the time that the reactor coolant system depressurizes to a pressure equal to the operating pressure of the accumulator for the large break LOCA. After a timed period of about seven seconds from actuation of the safety injection signal, nitrogen would be admitted to the accumulator to build its pressure up to 473 psig within two (2) seconds (compared with the 337 psig operating pressure in the system prior to Cycle XIII startup. The increased pressure in the modified system would provide a greater driving force for injecting water into the core at a faster rate following the postulated LOCA.

Before Cycle XIII operation began, the licensee agreed to submit a study to compare the effect of delayed accumulator injection with accumulator injection without delay. The study, which has been submitted and reviewed, assumes: (1) accumulator pressurization to 473 psig in both cases, (2) full accumulator pressurization prior to the LOCA for the case of accumulator injection without delay, and (3) a LHGR of 9.7 kw/ft for both cases. The limiting break (1.0 DECLG) was analyzed for both cases. The results show that without accumulator delay the clad would rupture and the PCT would be greater than 2200°F. This compares with a PCT of 1983°F for the case of the approved delay in accumulator pressurization (7.4 $\pm$ 1.0 seconds). We conclude that the licensee's study acceptably demonstrates that delaying accumulator injection significantly improves ECCS performance for the Yankee-Rowe reactor.

D. Core Inlet Temperature Sensitivity Study

In the past, it has been widely accepted that it was conservative to assume the highest possible initial coolant temperature for LOCA calculations (typically maximum full power operating temperature plus 4°F for measurement uncertainty).

Recently, the NRC staff has noted that in LOCA calculations for some PWRs, a decrease in reactor coolant inlet temperature has resulted in a predicted increase in PCT. In discussions with the PWR vendors we have learned that they have all observed this trend while performing LOCA calculations with their individual approved evaluation models. However, a reduction in coolant inlet temperature may not always result in an increase in PCT.

Based on the maximum sensitivity of PCT to inlet temperature seen to date, we have conservatively bounded the possible effect of inlet temperature variation as described in the Safety Evaluation accompanying Amendment No. 43 for Cycle XIII startup. In addition, the licensee agreed to submit an ECCS analysis of the worst break LOCA assuming coolant inlet temperature and steam conditions equal to their nominal values. Nominal inlet temperature and steam conditions as used here refer to the most probable values for the plant when it is operating at 103% power.

The licensee has submitted the inlet temperature sensitivity analysis and we have reviewed it.

Initial conditions assumed are:

	Base Case	Sensitivity Case
Core Power, MW_T	618	618
Core Inlet Temperature °F	519	510
Core Outlet Temperature °F	563.7	555.8
Steam Generator Secondary Temperature, °F	489.7	488.0
Steam Generator Secondary Pressure, PSIA	619.7	610.2
Steam Generator Secondary Inventory, lb_m	80,392	70,882

The analysis of the limiting break occurring at the above conditions gives the following results:

	Base Case	Sensitivity Case
Inlet Temperature	519°F	510°F
End of Bypass (EOBY)	23.50 sec	23.57 sec
Clad Surface Temperature @ EOBY		
Core	976°F	915°F
Assembly	1132°F	1111°F
Rod	1309°F	1291°F
Accumulator Injection	16.4 sec	16.43 sec
Beginning of Core Recovery (BOCREC)	76.9 sec	76.5 sec
Accumulator Empty	86.0 sec	85.8 sec

We conclude that for the Yankee-Rowe reactor a higher inlet temperature is, in fact, a conservative assumption.

E. Burnup Sensitivity Study

Amendment No. 43 which authorized reactor startup following Cycle XIII core loading specified an allowable peak LHGR for fresh fuel of 9.7 kw/ft which corresponds to approximately 90% of full core power at Beginning of Cycle (BOC) for Core XIII. The licensee intended to perform a burnup sensitivity study and based on this study propose a burnup dependent LHGR following Cycle XIII startup.

The licensee submitted the burnup sensitivity study and proposed Technical Specification changes by letters dated October 27 and November 14, 1977, and we have reviewed this material.

The fresh fuel is limiting due to the significant pellet to clad gap and resultant high stored energy at BOC of Core XIII. During the first several days of exposure, the fresh fuel pellet-to-clad gap decreases rapidly, which in turn reduces the stored energy. After this, the pellet-to-clad gap changes slowly and the fission gas inventory increases with burnup which tends to restrict allowable LHGR because of clad burst pressure considerations.

The analysis was performed using the same methods and assumptions previously used and approved for Cycle XIII operation. The limiting break (1.0 DECLG) was analyzed at various burnups for new fuel to construct a curve of the allowable LHGR throughout the life of Core XIII.

Recycled fuel was also analyzed and LHGR limits for this fuel were found to be less restrictive.

The allowable LGHR was found to be 9.4 kw/ft at BOC, peaking at 11.2 kw/ft after about 10 Effective Full Power Days (EFPD's), and reducing to 9.4 kw/ft at about the end of cycle. Because non-LOCA accident and transient analyses for Core XIII had been performed and reviewed assuming 12.5 kw/ft in connection with Amendment No. 43, analysis of non-LOCA accidents and transients remains valid.

The burnup dependent allowable LHGR behaves for Core XIII in a manner similar to its behavior for Core XII. We find the proposed Technical Specification change providing a burnup-dependent LHGR to be acceptable.

Summary of Findings

From our review of the material submitted by the licensee related to Cycle XIII post-startup considerations, including the ECCS cooling performance evaluation, we find:

A. The proposed Technical Specification changes dealing with burnup-dependent LHGR and accumulator actuation time delay setting are acceptable.

B. The ECCS cooling performance for Core XIII has been calculated with an approved evaluation model in conformity with Appendix K and meets the acceptance criteria in 10 CFR 50.46.

C. Sensitivity analyses of the effect of accumulator actuation delay and core inlet temperature variation, and additional small break analyses confirm the conservatism of Cycle XIII LOCA analyses on which approval of Amendment No. 43 was based.

Environmental Consideration

We have determined that the amendment does not authorize a change in effluent types or total amounts nor an increase in power level and will not result in any significant environmental impact. Having made this determination, we have further concluded that the amendment involves an action which is insignificant from the standpoint of environmental impact and pursuant to 10 CFR 51.5(d)(4) that an environmental impact statement or negative declaration and environmental impact appraisal need not be prepared in connection with the issuance of this amendment.

Conclusion

We have concluded, based on the considerations discussed above, that: (1) because the amendment does not involve a significant increase in the probability or consequences of accidents previously considered and does not involve a significant decrease in a safety margin, the amendment does not involve a significant hazards consideration, (2) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, and (3) such activities will be conducted in compliance with the Commission's regulations and the issuance of this amendment will not be inimical to the common defense and security or to the health and safety of the public.

Date: November 29, 1977