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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

SUPPORTING AMENDMENT NO. 34 TO FACILITY OPERATING LICENSE NO. DPR-3

YANKEE ATOMIC ELECTRIC COMPANY

YANKEE NUCLEAR POWER STATION (YANKEE-ROWE)

DOCKET NO. 50-29

Introduction

By application dated October 8, 1976, Yankee Atomic Electric Company (the licensee) proposed changes to the Technical Specifications, appended to License No. DPR-3 for the Yankee-Rowe reactor. The proposal involves a revision of the "Core XII Allowable Peak Rod LHGR versus Exposure" specified in Figure 3.2-1 to reflect changes of the allowable LHGR values based on the revised ECCS performance analysis submitted with the October 8, 1976, application and the additional information provided in the licensee's letter dated December 27, 1976.

Discussion

Yankee-Rowe has been operated within the restrictions on the allowable peak rod LHGR imposed by the NRC's Order for Modification of License issued on August 27, 1976. Specifically, the Order modified the Technical Specification limit by reducing the allowable peak rod LHGR by 0.85 kw/ft. This provided assurance that ECCS performance at the facility conformed to all criteria set forth in 10 CFR §50.46(b), despite the assumption in the previous ECCS performance analyses that the reactor vessel upper head temperature is equal to the reactor inlet water temperature. The Order also required that the licensee provide as soon as possible revised calculations, using an approved evaluation model, with correct input for upper head water temperature, or assuming that the upper head water temperature equals reactor vessel outlet temperature. On October 8, 1976, the licensee submitted the revised ECCS analysis in compliance with the Order. On December 27, 1976, the licensee provided additional information as a result of discussions with the staff.

Evaluation

Previously, ECCS performance analyses for all Westinghouse reactors, including Yankee-Rowe, assumed that the reactor vessel upper head region was at the same temperature as the reactor inlet water (cold leg). This assumption was based on the existence of a bypass flow path with a small percentage of the flow routed directly to the upper head region. Recent

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operating data from another facility indicated that the upper head water temperature was higher than the reactor inlet water temperature by about 60% of the temperature difference between inlet and outlet. An increase in upper head region water temperature increases the calculated peak clad temperature in the event of a LOCA.

In lieu of actual plant measurements revised LOCA analyses were required with upper head temperature equal to reactor outlet temperature to establish new operating limits for Yankee-Rowe.

Complying with the NRC's Order for Modification of License, the licensee initially performed additional LOCA calculations consisting of:

(1) A reanalysis of the 0.6 DECLG (identified as the worst break in previous analysis at beginning-of-cycle (BOC) conditions;

(2) A reanalysis of the next worst break (1.0 DECLS) at BOC conditions;

(3) A reanalysis of the worst break (0.6 DECLG) at the current point in the operating cycle (180 EFPD).

The calculations were done with the Exxon ECCS evaluation model approved for Yankee-Rowe and used in previous ECCS performance analyses.

Tables 1 and 2 compare the important parameters for these breaks. Also compared in the tables are the results for the 0.6 DECLG and 1.0 DECLS breaks previously analyzed with a T_{cold} upper head temperature. It should be noted that the Peak Clad Temperature (PCT) for the 0.6 DECLG break increased at BOC by 70°F from 1896°F to 1966°F whereas the PCT for the next limiting break, the 1.0 DECLS, increased only 5°F from 1878°F to 1883°F.

Table 3 compares these results to the break spectrum analyzed previously for Core XII. Also shown in Table 3 are the temperature increases the remaining points in the break spectrum would have to experience in order to exceed the limiting case (0.6 DECLG). The licensee concluded that it is unlikely that any of the less limiting breaks would undergo the relatively large temperature increase (100°F-209°) required to become limiting and therefore contended that the most limiting break size (0.6 DECLG) does not change.

The limiting break size (0.6 DECLG) was reanalyzed at a LHGR of 10.15 kw/ft and a cycle burnup of 180 EFPD with the assumption of T_{hot} in the upper vessel head. The LHGR was lowered from the 10.50 kw/ft value used in the Core XII analysis because the Exxon Fuel in Core XII exhibits a rod burst threshold slightly above 2000°F and the analysis at a LHGR of 10.5 kw/ft resulted in a predicted PCT of 2034°F. At 10.15 kw/ft the PCT was calculated to be 1988°F.

The staff did not agree that the licensee had shown conclusively that the 0.6 DECLG break was still the limiting break for the changed assumption. The staff position was based in part on our experience with another plant where a reanalysis with the Exxon evaluation model did show that the limiting break size changed from 0.6 DECLG to 0.8 DECLG as a result of changing the upper head temperature from T_{cold} to T_{hot} with a substantial increase in PCT because for Yankee-Rowe the difference in break area between $C_D = 0.6$ and $C_D = 1.0$ is relatively small since the inlet pipe has a cross sectional area of only 1.42 square feet.

In addition, the variation of PCT was previously calculated to be small as C_D is varied from 0.4 to 1.0 so that a large variation in PCT between C_D of 0.6 and 1.0 would not be expected. However it was noted that the calculated peak clad temperature at $C_D = 0.6$ DECLG was 1988°F, just 12°F below the predicted rod burst threshold for the Exxon fuel.

Staff experience with the Exxon Evaluation Model indicates that guillotine type breaks result in a maximum PCT between $C_D = 0.4$ and $C_D = 1.0$ but that for split or slot type breaks the PCT increases with break size and $C_D = 1.0$ generally results in the maximum PCT. We therefore concluded that the reanalysis of the 1.0 DECLS break was sufficient to show that the slot breaks are not limiting.

The licensee was requested to perform additional analyses to verify that the limiting break size had been identified. These analyses were performed by the licensee and submitted on December 27, 1976. They consisted of three cases: C_D=0.4, C_D=0.6 and C_D=0.8 guillotine type breaks. The analyses were carried out to the beginning of the reflood period (BOCREC).

These analyses also included the POST-CHF return to nucleate boiling lockout heat transfer correlation model which is described in Exxon Nuclear Company's technical report XN-76-44, September 1976. This was done in response to a specific request in our letter to the licensee dated December 10, 1976.

The staff agreed to consider calculations made out to BOCREC as sufficient to indicate the limiting break size for Yankee-Rowe for the following reasons:

(1) The reflood transient for Yankee-Rowe is short compared to most other reactors, on the average of 15 seconds from BOCREC until PCT occurs.

(2) The containment backpressure which is a significant parameter during reflood is assumed to be constant and is selected to be conservative with respect to all blowdown cases considered.

TABLE 1

YANKEE ROWE CORE XII LOSS OF COOLANT ACCIDENT
UPPER VESSEL HEAD TEMPERATURE STUDY

SUMMARY OF RESULTS(1)

Parameter	1.0 DECLS		0.6 DECLG		0.6 DECLG	
Total Heat Generation Rate, kw/ft	8.7	8.7	8.7	8.7	10.5	10.15
Rod Linear Heat Generation Rate, kw/ft	8.47	8.47	8.47	8.47	10.22	9.88
Upper Head Temperature, ^{o}F	515	560	515	560	515	560
Peak Clad Temperature, ^{o}F	1878	1883	1896	1966	2034	1938
Peak Clad Temperature Location, Ft.	4.04	4.04	4.04	4.04	4.04	4.04
Maximum Local Z_R/H_2O Reaction, %	1.44	1.19	1.53	1.50	2.12	1.69
Maximum Local Z_R/H_2O Reaction Location, Ft.	4.04	4.04	4.04	4.04	4.04	4.04
Total Core Z_R/H_2O Reaction, %	<1	<1	<1	<1	<1	<1
Burnup, EFPD	0.0	0.0	0.0	0.0	180.	180.

(1) Calculations performed at the following conditions:

License Core Power Mwt	600
Power Used for analysis, Mwt	618
Accumulator Water Volume, Ft	700
Fuel Type	ENC

BEST ORIGINAL

TABLE 2

YANKEE ROWE CORE XII LOSS OF COOLANT ACCIDENT
UPPER HEAD TEMPERATURE STUDY

TIME SEQUENCE OF EVENTS

Event	Break Size:	1.0 DECLS		0.6 DECLG	
	Burnup/LHGR	BOC/8.7 kw/ft		BOC/8.7 kw/ft	
	Upper Head Temperature:	515°F	560°F	515°F	560°F
		Event Time, Seconds			
Pipe Rupture		0	0	0	0
Begin Accumulator Spillage		0	0	0	0
Loss of Offsite Power		0	0	0	0
Safety Injection Signal		7.54	7.58	7.54	7.58
Accumulator Injection, Intact Loops		19.10	18.28	19.88	19.42
Safety Injection Pump Flow Start		32.54	32.58	32.54	32.58
End of Blowdown (EOB)		32.50	30.95	34.73	33.70
End of Bypass (EOBY)		39.50	38.56	40.30	39.34
Bottom of Core Recovery (BOCREC)		102.0	100.65	102.49	101.60
Accumulator Empty		108.3	107.80	109.79	109.30
Peak Clad Temperature Reached		112.8	114.96	117.10	116.34

POOR ORIGINAL

Table 3

Yankee Rowe Core XII Loss of Coolant Accident
Upper Vessel Head Temperature Study

Comparison of Results With Previous LOCA Analysis

	Peak Clad Temperature °F		ΔT Required to Exceed Limiting Case, °F
LHGR kw/ft:	8.7	8.7	
Burnup, EFPD:	BOC	BOC	
Upper Head Temperature, °F:	515	560	
Break Size			
0.6 DECLG	1896	1966	--
1.0 DECLS	1878	1883	--
0.6 DECLS	1866	*	100
1.0 DECLG	1861	*	105
0.4 DECLG	1817	*	149
0.4 DECLS	1757	*	209

*Not re-analyzed

(3) Hot rod conditions, i.e. hot rod clad temperature and stored energy input to the reflood and fuel heatup calculations were calculated to beginning of reflood and were compared at that point to determine which case would result in the highest PCT.

The 0.6 DECLG case was clearly limiting with respect to both PCT and fuel pellet average temperature of the peak power rod at End of Bypass (EOBY).

Table 4 presents the results of the reanalyses. A comparison is also made of the previous analysis without the return to nucleate boiling lockout but with the upper head temperature at T_{hot}.

The staff concludes that the analyses described above adequately determine that the limiting break size remains C_D=0.6 DECLG.

The limiting break, C_D=0.6 DECLG was analyzed through the reflood and heatup period and the results are presented in Table 5. Table 5 also compares the results of the previous analysis without return to nucleate boiling lockout.

Revised curves showing allowable peak rod LHGR (Figure 3.2-1) as a function of burnup were submitted with the analyses. The curves for the Exxon fuel which is limiting and the Gulf fuel which had been previously burned in Cycle XI were both lowered proportionally based on the calculated reduction in LHGR for the Exxon fuel at 180 EFPD. The staff agrees that the proportional lowering of both curves based on the limiting analysis at 180 EFPD on the Exxon burnup curve is acceptable since the Exxon fuel is limiting, the LHGR curve is well predictable from 180 EFPD to end of cycle, and sufficient margin exists between limiting LHGR and clad damage threshold.

The staff finds that the licensee has provided acceptable revised ECCS calculations, using an approved evaluation model, with the assumption that the upper head water temperature equals the reactor vessel outlet temperature. The licensee has also included an acceptable correction in the evaluation model that precludes the use of a nucleate boiling heat transfer correlation during blowdown after CHF has been predicted. The staff also finds that the results of the revised ECCS calculations verify that ECCS performance at Yankee-Rowe will conform to the criteria set forth in 10 CFR §50.46(b) for operation with Core XII within the revised allowable peak rod LHGR as proposed in the licensee's October 8, 1976, application. Accordingly, the proposed revised Figure 3.2-1 is acceptable for incorporation in the Technical Specifications concurrent with the termination of NRC's August 27, 1976, Order for Modification of License.

Table 4

Yankee Rowe Core 12 LOCA Analysis
Results of Additional LOCA Analysis with Elevated Upper-Head Temperature (UHT)
and Post-CHF Return to Nucleate Boiling
Lockout (RNBLO)

	Analysis with Elevated UHT and RNBLO			Analysis with Elevated UHT Only
Break Size:	0.8	0.6	0.4	0.6
Break Type:	DECLG	DECLG	DECLG	DECLG
Cycle Conditions:	BOC	BOC	BOC	BOC
Total Max. LHGR, kw/ft:	8.7	8.7	8.7	8.7
EOBY, seconds:	38.30	39.54	43.54	39.54
PCT Rod Clad Temperature at EOBY, ^{o}F	1243.1	1317.1	1262.1	1314.90
BOCREC, seconds	100.46	101.64	105.14	101.64
PCT Rod Clad Temperature at BOCREC, ^{o}F	1751.0	1824.5	1765.4	1823.0
Pellet Average Temperature of Peak Power Rod at EOBY	1425	1492	1425	1490.2

Table 5

Yankee Rowe Core 12 Limiting LOCA Analysis
With Post-CHF Return-to-Nucleate Boiling Lockout (RNBLO)
And Upper Head Temperature T_{hot}

Break Size:	0.6 DECLG
Maximum Total LHGR:	10.15 kw/ft
Fuel Exposure:	18.0 EFPD
Fuel Type:	Exxon

Parameter	With RNBL	Without RNBLO
End-of-Bypass, seconds	39.54	39.54
PCT Rod Clad Temperature @ EOBY, ^{o}F	1280.7	1282.1
Bottom of Core Recovery, seconds	101.6	101.6
PCT Rod Clad Temperature @ BOCREC, ^{o}F	1872.0	1875.3
Time of Peak Clad Temperature, seconds	111.7	112.1
Peak Clad Temperature, ^{o}F	1985.1	1987.5

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: January 10, 1977