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YANKEE ATOMIC ELECTRIC COMPANY

Regulatory File Cy.

20 Turnpike Road Westborough, Massachusetts 01581

WYR 74-47

December 5, 1974

United States Atomic Energy Commission
Washington, D.C. 20545

Attention: Directorate of Licensing

50-29

References: (a) License No. DPR-3 (Docket No. 50-59)
(b) YAEC letter to USAEC dated 9/18/74

Dear Sir:

Yankee Atomic Electric Company submits the attached supplement to Reference 1. This supplement is an evaluation of the cause of the discrepancy as promised in the original Unusual Occurrence Report.

As stated in the original report, the plant operation below 400 ppm all-rods-out critical boron will be addressed in a separate submittal. The present all-rods-out critical boron concentration is 950 ppm.

We trust you will find this information satisfactory; however, should you desire additional information, feel free to contact us.

Very truly yours,

YANKEE ATOMIC ELECTRIC COMPANY

L. H. Heider

L. H. Heider
Manager of Operations

dm

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Regulatory File Cy.

Received w/Ltr Dated 12-5-74

1. Chronology

8/13 (Tues)-8/17 (Sat)-Measurements of control rod worth in Core XI.

8/14 (Wed)-8/19 (Mon)-Preliminary reduction of data from worth measurements

8/19 (Mon)-Notification of AEC by phone call to F. Burger.

8/19 (Mon)-Internal non-conformance report filled out by plant and reviewed by PORC, recommending that "power operation [be] based on a satisfactory safety evaluation being performed by NSD [Yankee Nuclear Services Division] justifying operation with the measured rod worths."

8/19 (Mon)-NSAR Committee approves operation at 100 percent power based on NSD safety analysis review.

8/19 (Mon)-Investigation of discrepancy begun.

9/19 (Wed)-Unusual occurrence report filed with AEC.

2. Core Description

The configuration of Core XI is described in the Yankee Rowe FHSR, as modified by Amendment No. 9. A brief description is included here to facilitate understanding the explanation which follows:

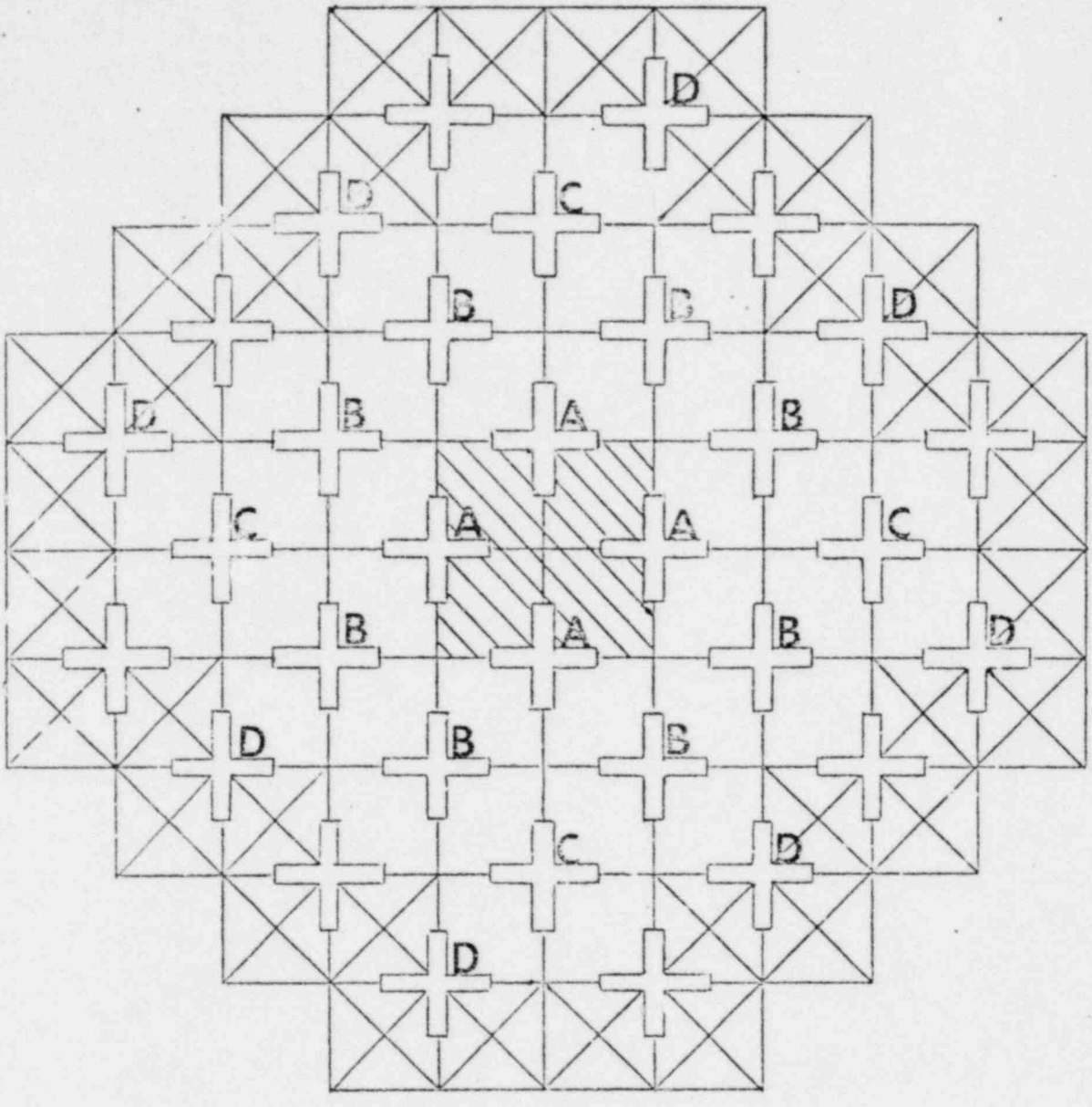
The core consists of:

- 36 fresh, 4 w/o zirc clad assemblies;
- 36 once burned, zirc-clad assemblies of 4 w/o initial enrichment;
- 4 twice-burned, stainless steel clad assemblies of 4.94 w/o initial enrichment.

Each zirc assembly is surrounded by an integral perforated stainless steel shroud for structural support. As shown in Figure 1, the core was loaded in an annular fashion, with the burned fuel preferentially toward the center. The same kind of loading pattern had been used in previous Yankee cores. Figure 1 also displays the placement of the various control rod groups relative to the fuel loading pattern.

3. Summary of Discrepancy

Table 1 compares the measured control rod worths with the original calculated values.



4 ASSEMBLIES
Stainless Steel Clad, Twice Recycled

36 ASSEMBLIES
Zircaloy Clad, Once Recycled

36 ASSEMBLIES
Zircaloy Clad, Fresh

YANKEE NUCLEAR POWER STATION	Figure 1 YANKEE CORE XI FUEL LOADING AND CONTROL ROD BANK LOCATIONS	

Table 1

Control Rod Bank Worths
Measured vs. Original Calculated Values

Rod Bank Designation	Temperature Condition	Original Calculated Worth (%Δρ)	Measured Worth (% Δρ)
A	Cold	0.56	0.52
B	Cold	2.04	1.77
C	Cold	1.54	1.35
A	Hot	0.91	0.70
B	Hot	2.66	2.21

4. Cause of Discrepancy

It has been determined that incorrect burnups were used for the shuffled fuel in the calculation of control rod worths. Because of a numerical error, these burnups were approximately eight (8) percent lower than the true values, as shown in Table 2. The relative locations of the shuffled fuel and of the control rod banks are shown in Figure 1. The increased burnup of the shuffled fuel in the center of the core represents a decrease in the reactivity of this region, which causes the decrease in the worth of control rods located here.

5. Supporting Evidence

This explanation is supported by the following observations:

1. Calculations using the corrected burnups in a slightly revised model show much better agreement with the measured control rod worths. Table 3 shows the comparison of new and revised calculations withthe measured values.

2. The increased burnup (lower reactivity) in the shuffled fuel manifests itself in a small but observable discrepancy between measured and calculated assembly powers. Again, revised calculations with the corrected burnups show much better agreement, as indicated in Table 4.

3. The percentage discrepancy in control rod worth is greatest for the bank located in the midst of the shuffled fuel (Bank A) and least for those banks (B and C) located nearer the interface between fresh and shuffled fuel. In addition, Banks B and C, which are about equally distant from the interface, exhibit equal discrepancies.

Measures taken to insure that no other factors contributed to the discrepancy included the following:

1. The reactor engineer verified that the core had actually been loaded as intended.

2. The measurements of control rod worth were repeated by Westinghouse Nuclear Services Division, using their own reactivity computer.

Table 2

Batch Burnup Comparison - Corrected vs. Uncorrected

Fuel Batch	Uncorrected Burnup (MWD/MTU)	Percent Increase in Batch Average Burnup*
Fresh	0	0
Once Burned	11300	8
Twice Burned	19600	10

*(Corrected burnup-uncorrected burnup)/uncorrected burnup

Table 3

Control Rod Bank Worths
Measured vs. Revised Calculated Values

Rod Bank Designation	Temperature Condition	Revised Calculated Worth (% Δρ)	Measured Worth (% Δρ)
A	Cold	0.53	0.52
B	Cold	1.74	1.77
C	Cold	1.41	1.35
A	Hot	0.73	0.70
B	Hot	2.34	2.21

Table 4

Batch Power Comparison-Measured vs. Calculated

Fuel Batch	Percent Difference in Batch Power*	
	Original Calculation	Revised Calculation
Fresh	+5.4	-1.8
Once Burned	-1.6	+0.6
Twice Burned	-5.6	+0.2

*(Measured-calculated)/measured

3. The reactor engineer verified (by noting that a period resulted from incremental conrol rod motion) that each individual control rod was indeed latched.

4. The model used to calculate control rod worths was checked independently.

5. Calculations were performed to show that control rod worth could not be affected by lateral movement of the stainless steel shroud surrounding the zirc assemblies.

6. Monte Carlo calculations of relative control rod worth were conducted by an outside party (NUS Corporation) to verify that control rod worth was not significantly affected by whether the fuel was clad with zirc or stainless steel.

6. Safety Implications

A. A review of the FHSR, including all amendments has established that the difference between measured and calculated control rod worths does not present any unreviewed safety questions except for a Steam Line Rupture at end-of-core life. For this accident, it has been determined that operation at full power will not violate the assumptions used in the accident analysis as long as the full power, all-rods-out, critical boron concentration is greater than 400 ppm. Plant operation below 400 ppm all-rods-out critical boron will be addressed in a later submittal. The present all-rods-out critical boron concentration is about ~~1000~~ 950 ppm.

B. The effect of the radial tilt in core power (discussed in Section 5) has been to increase the peak fuel rod power by less than 4 percent above the nominal predicted value. Since the nominal predicted value was 10 percent below the design value used in the accident analysis, (see Table 102-3 of Reference 1), this does not present any unreviewed safety question.

7. Summary

The discrepancy in control rod worths was due to the incorrect burnups used for shuffled fuel in the original calculation. This explanation is supported by all available evidence. The only unreviewed safety question which may occur is related to a Steam Line Rupture at end-of-life, which will be addressed in a later submittal.

AEC DISTRIBUTION FOR PART 50 DOCKET MATERIAL
(TEMPORARY FORM)

CONTROL NO: 12376

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FROM: Yankee Atomic Elec. Co. Westborough, Mass. 01581 L.H. Heider	DATE OF DOC 12-5-74	DATE REC'D 12-9-74	LTR X	TWX	RPT	OTHER
TO: DRL	ORIG 3 signed	CC 37	OTHER	SENT AEC PDR XX SENT LOCAL PDR [redacted]		
CLASS	UNCLASS XXX	PROP INFO	INPUT	NO CYS REC'D 40	DOCKET NO: 50-29	

DESCRIPTION: Ltr trans the following:

ENCLOSURES: Supplemental Info re YAEC ltr to USAEC dated 9-18-74 re Unusual Occurrenc re plant operation below 400 ppm all-rods-out critical boron.....:

(40 cys encl rec'd)

ACKNOWLEDGED

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PLANT NAME: YAEC

FOR ACTION/INFORMATION DHL 12-9-74

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