MAINE YANKEE CYCLE 6
STARTUP TEST REPORT

TABLE OF CONTENTS

MAINE YANKEE CYCLE 6

Startup Test Report

Maine Yankee initiated system heatup for Cycle 6 on July 9, 1981 after reloading the core in basic accordance with the loading pattern documented in Proposed Change No. 84 (Reference 1) and its supplements. The startup tests (acceptance criteria outlined in Reference 2) were performed from July 12 to July 25, 1981, the latter the completion date for 50% power testing. The plant is currently restricted to approximately 97% power due to a back end loading problem with the low pressure turbine. The startup tests performed were subject to the acceptance criteria in Reference 2, as given in Table 1. Each of the following tests is detailed below with the results compared to those predicted in Table 2. In these comparisons the nominal measured value is compared to the calculated value, the latter corrected for any difference between the measurement and calculational conditions.

1. Critical Boron Concentration

The approach to criticality began on July 9, 1981 by withdrawal of all CEA's except Bank 5. A dilution was initiated with Bank 5 partially inserted until the reactor was critical. A final ARO critical boron concentration of 1153 ppm was established, compared to the predicted value of 1197 ppm. The deviation of 44 ppm was within the acceptance criteria of $\pm$ 1%$\Delta\rho$ (approximately $\pm$ 95 ppm). A rodded critical condition was established with Banks 5 through 1 (the regulating banks) inserted. A final critical boron concentration of 881 ppm was achieved, compared to a predicted value of 908 ppm. The deviation for the rodded case between measurement and prediction was 27 ppm.

2. CEA Bank Worths

The CEA worth of all the regulating Banks 5 through 1 in the non-overlap conditions were measured via a reactivity computer. The individual bank worths are given in Table 2. The total worth of Banks 5-1 was measured as 3.050%$\Delta\rho$ compared to a predicted worth of 3.076%$\Delta\rho$. The difference from the predicted, which is +0.9% of the total measured worth, is within the acceptance criteria of $\pm$10.0% nominal in total worth.

3. Ejected CEA Worth

The worth of the most limiting near full power ejected CEA was measured at the zero power condition. The ejected CEA is a Bank 5 (2 full strength finger) CEA measured from the Banks 5+4 inserted configuration. The single CEA had a measured worth of 0.072%$\Delta\rho$ compared to a predicted worth of 0.083%$\Delta\rho$, which is within the acceptance criteria of measured worth no more than 15% nominal greater than predicted worth.

4. Isothermal Temperature Coefficient at HZP

The ITC was measured at the ARO and Banks 5-1 inserted conditions at zero power. As given in Table 2, a measured ARO ITC of +0.31($10^{-4}\Delta\rho/^{o}F$) was obtained, compared to a predicted value of +0.07($10^{-4}\Delta\rho/^{o}F$). The difference of -0.24($10^{-4}\Delta\rho/^{o}F$) was within the acceptance criteria of $\pm$0.50($10^{-4}\Delta\rho/^{o}F$) for the ARO case.

5. CEA Drop Times

The measured drop times for 90% insertion for each individual CEA was performed from the hot zero power condition. The values were compared to the Technical Specification limit of 2.70 seconds. All CEA's achieved 90% insertion within 2.66 seconds. The average time of insertion was 2.13 seconds with a standard deviation of 0.14 seconds.

6. INCA Tilt Monitoring

INCA incore (as well as excore) tilt was monitored at least each 5% in core power during power escalation up to 30% power. Due to computer problems, INCA tilt monitoring data was unavailable for power levels from 33%-49%. As a result of discussions with the NRC (Reference 3), tilt behavior was monitored by observing changes in the RPS excore detector indications for the 33%-49% power level range. Excore readings were recorded at least every 3% power interval and deviation in readings remained less than 1% between any two quadrants from 33% to 49% power. The INCA tilt near 50% power was 2.2%, within the acceptance criteria of 3.0%.

7. Isothermal Temperature Coefficient at 50% Power

The ITC was measured at the near 50% power condition. A measured value of $-0.18(10^{-4}\Delta\rho/^{\circ}F)$ was obtained. The predicted value of $-0.45(10^{-4}\Delta\rho/^{\circ}F)$ was in deviation from the measured value by $-0.27(10^{-4}\Delta\rho/^{\circ}F)$. The measured and calculated ITC values reflect an ARO equilibrium boron concentration of 961 ppm.

8. Power Distribution Measurements

Power distribution measurements via INCA were performed during power escalation. The equilibrium power distribution measured near 50% power is compared to the predicted power distribution in Figure 1. The comparison shows excellent agreement, well within the acceptance criteria of ±10% for each individual assembly. The maximum deviation which occurs is 5.6% with a deviation of 2.3% in the limiting assembly.

A near full power comparison of power distributions at approximately 500 MWD/MTU is presented in Figure 2. Excellent agreement is witnessed again with a deviation of 2.9% in the limiting assembly.

9. CEA Guide Tube Wear

Twenty Combustion Engineering (three cycle resident) and four Exxon Nuclear Company (one cycle residence) fuel assemblies were examined for CEA guide tube sleeve wear using eddy current test equipment. No detectable CEA guide tube sleeve wear was found during the examination. The approximate threshold of wear detectability in sleeves is 3 mils distributed over 90 degrees in the expanded region of the sleeve, and 3 mils over 180 degrees in the unexpanded region of the sleeve. These results are formally documented in Reference 4.

10. CEA Wear

Nineteen Control Element Assemblies (CEA's) were measured for wear using a profilometer device at the end of Cycle 5 (Reference 5). CEA wear occurs due to vibrations in the upper region of the fuel assembly guide post. Sixteen (16) CEA's examined were from suspected high wear locations based on previous guide tube wear measurement results. The remaining three (3) CEA's examined were from Control Bank 5, the lead power maneuvering bank.

Based on the profilometry measurement results and assuming a linear relationship between wear depth and cycle operating time, fourteen (14) of the nineteen (19) CEA's have remaining lifetimes in excess of four (4) operating cycles. Of the remaining five (5) CEA's, the most worn CEA has a minimum lifetime of approximately two (2) operating cycles. The three (3) CEA's from Control Bank 5 exhibited negligible wear. These results are documented in Reference 5.

References

1) R. H. Groce letter to NRC, "Maine Yankee Proposed Change No. 84", April 28, 1981.

2) MYAPC letter to USNRC, FMY 81-93, June 19, 1981, Subject: Cycle 6 Startup Physics Testing.

3) W. J. Metevia letter to USNRC, FMY 81-110, July 24, 1981.

4) R. C. Jacques letter to E. C. Wood, MYC-81-102, October 14, 1981, Subject: CEA Guide Tube Sleeve Wear.

5) Combustion Engineering report NPSD-162-P, CEA Profilometry Measurements from the Maine Yankee EOC-5 Refueling Outage, August 1981 (Proprietary).

Table 1

Maine Yankee Cycle 6

Startup Test Acceptance Criteria

	Measurement	Conditions	Criteria
1.	Critical Boron Concentration	Hot zero power, near all rods out	Measurement within $\pm 1\%\Delta\rho$ of predicted value
2.	CEA Bank Worths	Hot zero power, CEA Banks 1+2+3+4+5 in the non-overlap condition	Total worth within $\pm 10\%$ of the predicted value
3.	CEA Bank Worths	Hot zero power, CEA Banks A+B+C+1+2+3+4+5 in the non-overlap condition	If the criteria in Measurement (2) is not met, the total worth of all CEA banks must be within $\pm$ 10% of the predicted value.
4.	Ejected CEA Worth	Hot zero power, pre-ejection CEA banks inserted for measurement of the most limiting near full power ejected CEA.	Ejected CEA worth no more than 15% greater than the predicted value.
5.	Isothermal Temperature Coefficient	Hot zero power, near all rods out	Measurement within $\pm$ 0.5 x $10^{-4}\Delta\rho/^{o}F$ of predicted value
6.	Control Rod Drop	Operating temperature, insertion to 90%	Drop times no greater than 2.70 seconds.
7.	Radial Power Distribution	At or slightly below 50% power, near all rods out	Each assembly average power within $\pm 10\%$ of predicted value.
8.	INCA Tilt Monitoring for Symmetry Verification	5-48% rated power, near all rods out, tilt is monitored at 5% power intervals	Tilt trends to less than 3.0% for greater than 50% power operation.

Table 2

Maine Yankee Cycle 6
Startup Test Measurements and Predictions

	Item	Units	Measurement	Prediction	Deviation	Criteria
1.	Critical boron concentration	ppm				
	ARO		1153	1197	+44	±1%Δρ (±95ppm)
	Banks 5-1		881	908	+27	
2.	CEA Bank Worths	%Δρ				
	5		0.448	0.446	-0.5%	-
	4		0.259	0.257	-0.8%	-
	3		0.769	0.766	-0.4%	-
	2		0.864	0.890	+3.0%	-
	1		0.710	0.717	+1.0%	-
	Total 5-1		3.050	3.076	+0.9%	±10%
3.	Ejected CEA Worth					
	5+4+Ejected 5 (2 finger)	%Δρ	0.07[illegible]	0.083	-15.3%	<+15%
4.	Isothermal Temperature Coefficient at HZP	$10^{-4}\Delta\rho/^{o}$				
	ARO		+0.31	+0.07	-0.24	±0.50
	Banks 5-1		-0.71	-0.83	-0.22	
5.	CEA Drop Times	seconds	2.13 average 2.6[illegible] worst		-	less than 2.70 seconds

Table 2
(Continued)

Maine Yankee Cycle 6
Startup Test Measurements and Predictions

Item	Units	Measurement	Prediction	Deviation	Criteria
6. INCA Tilt Monitoring Percent Rated Power	% Incore Tilt				
3.0	5.8	-	-	-	-
5.6	5.3	-	-	-	-
10.6	3.8	-	-	-	-
13.4	3.0	-	-	-	-
0.4	7.4	-	-	-	-
7.5	3.9	-	-	-	-
17.0	2.9	-	-	-	-
21.6	3.0	-	-	-	-
23.0	2.6	-	-	-	-
26.2	2.6	-	-	-	-
28.8	2.5	-	-	-	-
32.8	2.5	-	-	-	-
*33-49	-	-	-	-	-
49.2	2.2	-	-	-	<3.0
7. Isothermal Temperature Coefficient Near 50% Power	$10^{-4}\Delta\rho/^{o}F$				
ARO		-0.18	-0.45	-0.27	-

* See discussion in Section 6

Figure 1

Maine Yankee Cycle 6
Cycle Burnup Distribution by Assembly
INCA versus Predicted BOC, ARO,
Equilibrium Conditions near 50% Power

Assembly Type and INCA Location	K-0 8	K-0 21
INCA at 47% Power, 48 MWD/MTU	0.592	0.752
Predicted at 50% Power, 50 MWD/MTU	0.577	0.734
Percent Difference	-2.5	-2.4

	K-0 15 0.593 0.603 1.7	K-0 31 0.848 0.875 3.2	K-0 11 1.033 1.045 1.2	I-0 25 0.842 0.815 -3.2	K-8 4 1.017 0.984 -3.2
K-0 16 0.703 0.712 1.3	K-8 33 0.956 0.982 2.7	I-0 13 0.911 0.945 3.7	J-8 28 1.139 1.148 0.8	K-8 7 1.146 1.124 -2.0	I-0 20 0.915 0.884 -3.4
K-4 34 1.081 1.108 2.5	J-8 14 1.068 1.085 1.6	I-0 30 1.031 1.055 2.3	J-0 10 1.227 1.279 4.2	I-4 24 0.991 0.972 -1.9	J-8 3 1.001 1.006 0.5
	I-0 32 1.094 1.109 -1.4	J-0 12 1.258* 1.287* 2.3	I-0 27 1.125 1.133 0.7	J-0 6 1.172 1.166 -0.5	I-0 19 0.974 0.959 -1.5
		J-4 29 1.240 1.245 0.4	J-0 9 1.161 1.146 -1.3	I-4 23 0.977 0.938 -4.0	J-0 2 1.153 1.137 -1.4
			I-4 26 1.007 0.967 -4.0	J-0 5 1.110 1.104 -0.5	I-4 18 0.988 0.946 -4.3
				I-0 22 1.052 1.031 -2.0	J-0 1 1.218 1.199 -1.6
					E-16 17 1.092 1.031 -5.6

* Maximum 1-pin

Octant Location 12
Measured 1.405
Predicted 1.434
Difference 2.1%

Percent Difference: $\frac{\text{Pred - INCA}}{\text{INCA}} \times 100$

Figure 2

Maine Yankee Cycle 6
Assembly Relative Power Densities
INCA versus Predicted
BOC, ARO, Equilibrium Conditions near HFP

Assembly Type and INCA Location	K-0 8	K-0 21
INCA at 95% Power, 504 MWD/MT	0.591	0.751
Predicted at 100% Power, 500 MWD/MT	0.554	0.701
Percent Difference	-6.3	-6.7

	K-0 15 0.595 0.575 -3.4	K-0 31 0.846 0.831 -1.8	K-0 11 1.021 0.996 -2.4	I-0 25 0.841 0.796 -5.4	K-8 4 1.018 0.958 -5.9
K-0 16 0.699 0.680 -2.7	K-8 33 0.957 0.948 -0.9	I-0 13 0.915 0.922 0.8	J-8 28 1.134 1.128 -0.5	K-8 7 1.151 1.114 -3.2	I-0 20 0.923 0.892 -3.4
K-4 34 1.079 1.064 -1.4	J-8 14 1.069 1.070 0.1	I-0 30 1.026 1.046 1.9	J-0 10 1.215 1.265 4.1	I-4 24 0.996 0.990 -0.6	J-8 3 1.024 1.038 1.4
	I-0 32 1.086 1.103 1.6	J-0 12 1.240 1.280* 3.2	I-0 27 1.117 1.115 -0.2	J-0 6 1.177 1.192 1.3	I-0 19 0.986 0.998 1.2
		J-4 29 1.227 1.263 2.9	J-0 9 1.153 1.178 2.2	I-4 23 0.983 0.986 0.3	J-0 2 1.164 1.185 1.8
			I-4 26 1.010 1.018 0.8	J-0 5 1.125 1.162 3.3	I-4 18 0.999 1.009 1.0
				I-0 22 1.064 1.094 2.8	J-0 1 1.231* 1.267 2.9
					E-16 17 1.103 1.113 0.9

Maximum 1-pin		
Octant Location	1	12
Measured	1.398	1.384
Predicted	1.397	1.426
Difference	-0.1%	3.0%

Percent Difference: $\frac{\text{Pred} - \text{INCA}}{\text{INCA}} \times 100$