XN-NF-86-90
SUPPLEMENT 1

SUSQUEHANNA UNIT 2 CYCLE 2
STABILITY TEST RESULTS

JANUARY 1987

RICHLAND, WA 99352

EXXON NUCLEAR COMPANY, INC.

XN-NF-86-90
Supplement 1
Issue Date: 1/28/87

SUSQUEHANNA UNIT 2 CYCLE 2

STABILITY TEST RESULTS

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1.0 INTRODUCTION

As part of the reload licensing process in support of Susquehanna SES Unit 2 Cycle 2 operation, PP&L committed to perform startup testing designed to demonstrate stable reactor operation with Exxon Nuclear Company (ENC) 9x9 fuel. This commitment was required by the NRC since the reload constituted the first reload (42% of the core) of 9x9 fuel into a U.S. BWR-4 reactor.

The test program involved the independent collection of neutron noise measurements by PP&L and Oak Ridge National Laboratory (ORNL), the latter under contract with the NRC. Two operating state points were chosen for the data collection: one at a point close to the operating condition at which the baseline noise level is measured per the Technical Specifications, and one within the "detect and suppress" region of the power/flow map during single loop operation. The actual test conditions were utilized by ENC to perform post-test stability calculations using COTRAN (References 1,2) and COTRANSA-2 (Reference 3). ENC also used the acquired noise data to determine decay ratios using the ORNL algorithm (Reference 4).

The following results are presented in this report:

- o ENC COTRAN stability calculations
- o ENC COTRANSA-2 stability calculations
- o Measured decay ratio determinations by ENC using the ORNL algorithm

2.0 SUMMARY

Results from Susquehanna SES Unit 2 reactor APRM noise monitoring, COTRAN and COTRANSA-2 calculations, and measured decay ratios based on noise analysis confirm that the Unit 2 core, which contains 324 ENC 9x9 reload fuel assemblies (42% of core; balance 8x8 fuel), is stable for two-loop and single loop operation. Results from the COTRAN and COTRANSA-2 decay ratio calculations indicate core decay ratios less than or equal to 0.33 for both two-loop and single loop operation at the test conditions. These results are consistent with the measured decay ratios determined by a noise analysis of the APRM signals.

3.0 TEST DESCRIPTION AND RESULTS

The two-loop stability test at Susquehanna SES Unit 2 was performed during Cycle 2 startup on November 2, 1986. The single loop stability test was performed a week later on November 8, 1986. Prior to the tests, the plant was maneuvered to the power/flow conditions required for the test (see Figure 3.2). At the start of the test, the APRMs and LPRMs were monitored to assure unusual oscillations (compared to Cycle 1 operation) did not exist. The stability test procedure consisted of data collection during steady state operation. The ENC POWERPLEX® CMSS was used to record plant parameters that were necessary to perform post-test stability calculations. APRM and LPRM data were recorded at both test conditions with the PP&L GETARS system. Each GETARS signal was collected at a frequency of 30 samples per second. ORNL recording equipment was used during the two-loop stability test but was not set up for the single loop test. All LPRM signals monitored and recorded during the tests were adjacent to two 9x9 fuel assemblies. The Cycle 2 core loading map, which shows the location of the LPRMs and 9x9 assemblies, is presented in Figure 3.1.

3.1 Two-Loop Stability Test

The plant was maneuvered to the 59.7% power/46.7% core flow condition, which is very close to the 100% equilibrium xenon rod line at the SIL 380 (Reference 5) boundary (45% flow) for the two-loop stability test. Figure 3.2 shows the test locations on the Susquehanna power flow map. By the end of the 2-1/2 hour data recording period, power decreased approximately

2% due to a xenon increase. No unusual APRM or LPRM oscillations, as compared to Cycle 1 operation, were observed.

Data was recorded on three different devices during the two-loop test; the ORNL FM recorder, the PP&L GETARS computer, and the ORNL portable computer. Table 3.1 shows which signals were recorded by these devices. In addition to the recorded noise data, the ENC POWERPLEX® CMSS was used to record plant parameters that were necessary to perform post-test stability calculations.

The APRM-A signal data were processed by the ORNL portable computer at the time of the test. The data were recorded by the portable computer at the rate of 5 samples/sec (each sample contained the average of 20 signals) and blocked into 50 second increments. The Power Spectral Density (PSD) was determined for each data increment as the computer continued to sample data. The Power Spectral Densities for each data block were averaged together for the test period. The final Power Spectral Density was then saved for the actual determination of the decay ratio. This final PSD was a composite of all the data acquired during the first 47 minutes of the test (12:09 to 12:56 p.m.). The "measured" decay ratio recorded by the ORNL portable computer was 0.396.

Subsequent to the test, PP&L supplied the GETARS data to ENC for determination of a "measured" decay ratio. Analysis of the GETARS recorded APRM noise signals for the two-loop stability test was performed at ENC using the ORNL decay ratio algorithm. Results of the analysis indicate a "measured" decay ratio of 0.33 with a standard deviation of 0.064.

3.2 Single Loop Stability Test

The single loop stability test at Susquehanna Unit 2 was performed at a flow of 44% and power of 55%, within the boundary of the "detect and suppress" operating region (Figure 3.2). The methodology and data recorded were similar to the data recorded for the two-loop stability test except that equipment from ORNL was not installed for this test. The LPRM and APRM signals recorded during the test on the GETARS computer are shown in Table 3.2.

Subsequent to the test, PP&L supplied the GETARS data to ENC for determination of a "measured" decay ratio. The noise analysis of the single loop GETARS recorded data was performed at ENC using the ORNL decay ratio algorithm (Reference 4). Results of the analysis indicate a decay ratio of 0.30 with a 0.064 standard deviation for the single loop stability test.

TABLE 3.1 RECORDED SIGNALS TWO-LOOP TEST

Signal	FM Recorder	GETARs Computer	Portable Computer
APRM-A	x	x	x
B		x	
C		x	
D		x	
E		x	
F		x	
LPRM 40-25 C		x	
24-49 D		x	
48-17 A		x	
24-49 A		x	
16-17 B		x	
24-49 B	x	x	x
48-17 C		x	
24-49 C		x	
Narrow Range Pressure	x	x	
Total Core Flow	x	x	

TABLE 3.2 RECORDED SIGNALS SINGLE LOOP TEST

Signal	GETARs Computer
APRM-A	x
B	x
C	x
D	x
E	x
F	x
LPRM 32-49 B	x
32-09 C	x
16-49 A	x
32-09 D	x
32-49 D	x
32-09 A	x
16-49 C	x
32-09 B	x
Narrow Range Pressure	x
Total Core Flow	x

SSES UNIT 2, CYCLE 2
CORE LOADING PATTERN

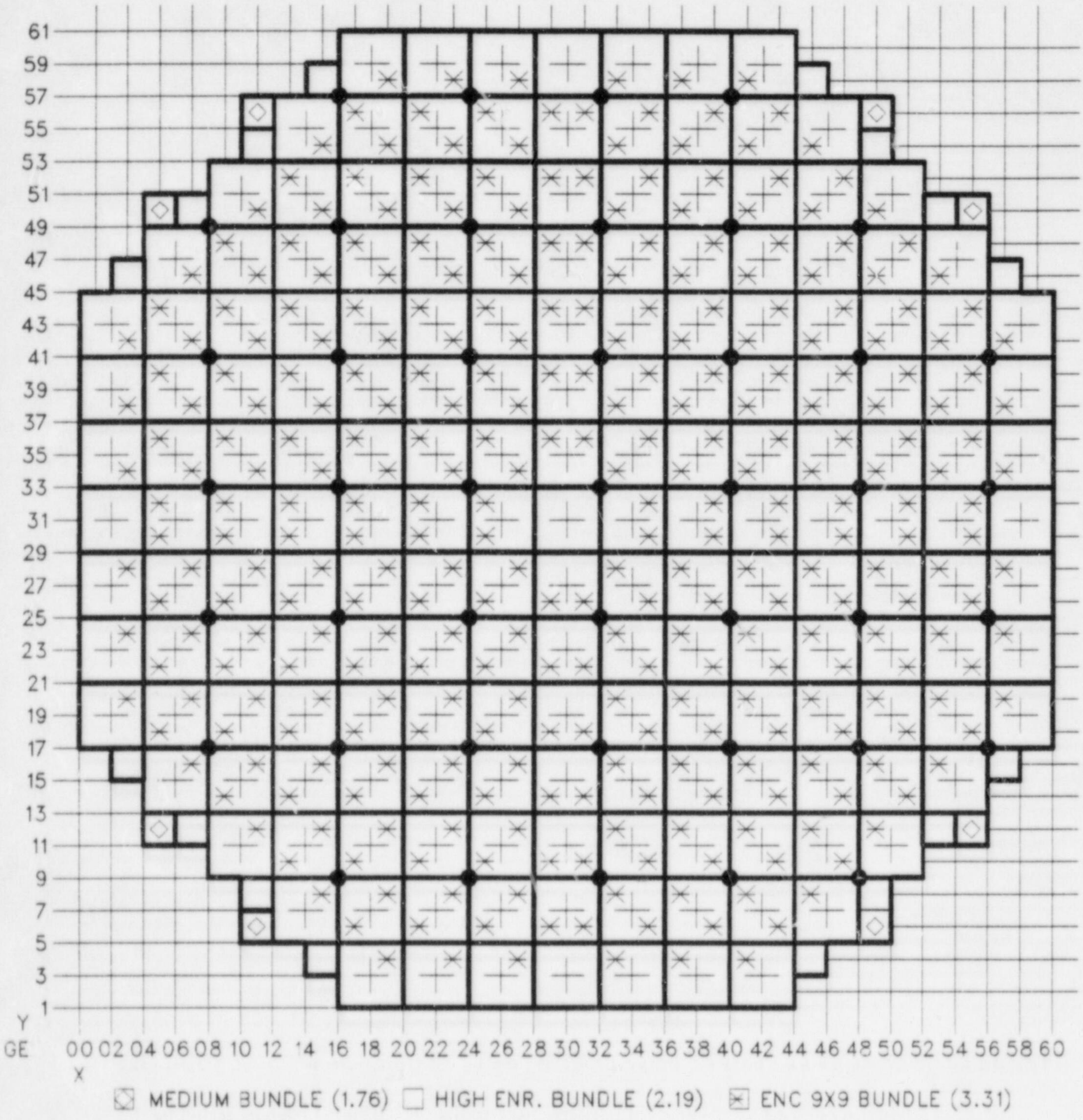
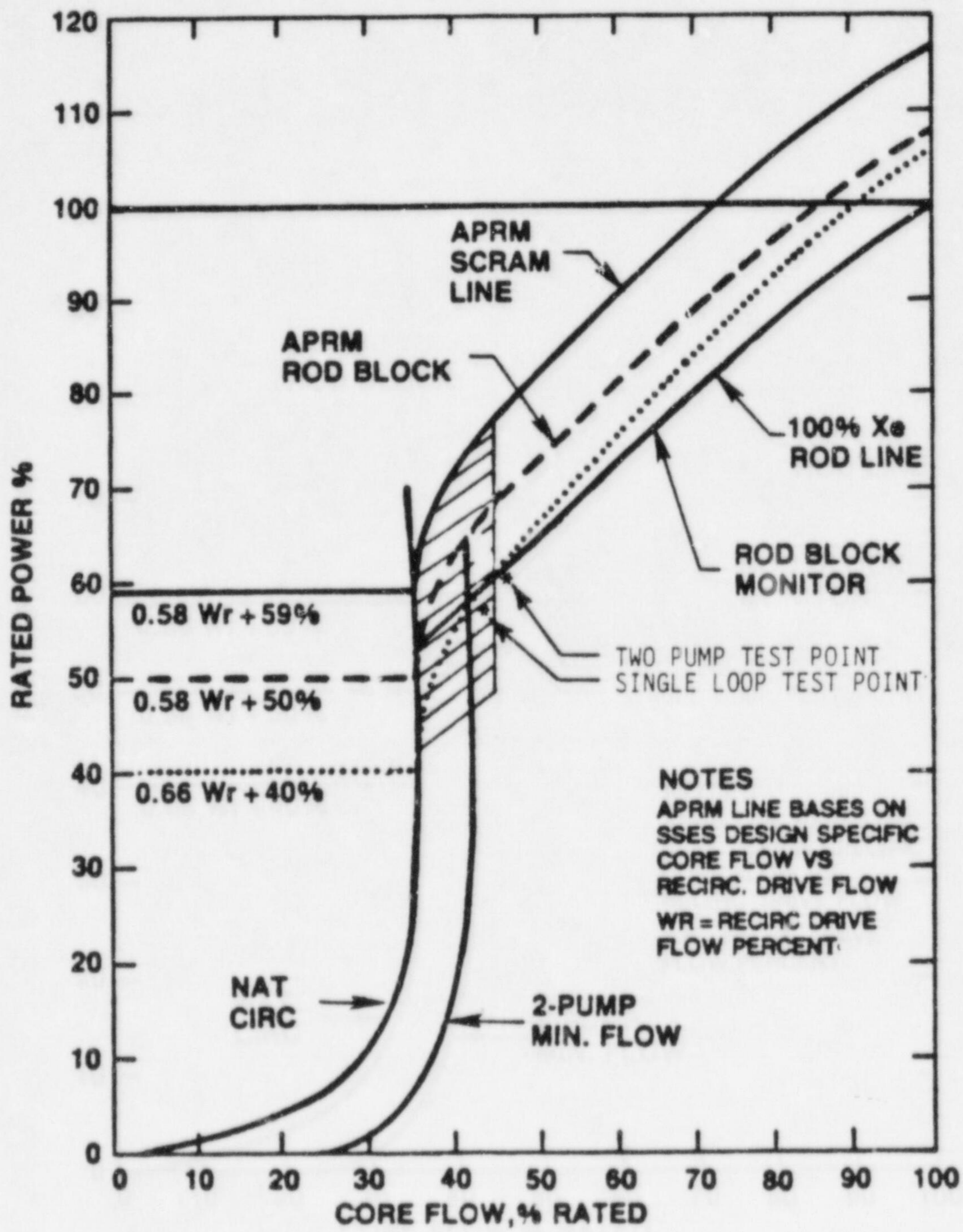


FIGURE 3.1

FIGURE 3.2

CORE POWER VS. CORE FLOW



4.0 COTRAN AND COTRANSA-2 ANALYSES

Core decay ratios for the two test conditions were calculated with COTRAN[1,2], a two dimensional reactor kinetics program with reactivity feedbacks for BWR core analysis and COTRANSA-2[3], a two-dimensional reactor kinetics program which consists of the core coupled with the recirculation loops. These analyses and results are discussed below.

4.1 COTRAN Stability Analyses

The approved ENC COTRAN methodology, described in References 1 and 2 to analytically calculate core decay ratios, was used to calculate the core decay ratios at the Susquehanna SES Unit 2 test conditions. The cross-sections for the core simulator model XTGBWR were generated with the assembly depletion model XFYRE[6]. The reactor core at the reported test conditions was modeled explicitly with the core simulator model XTGBWR[6] using data obtained from the POWERPLEX® Core Monitoring Software System. Included in this data were the control rod density, core pressure, total core flow, and core thermal power. Data calculated with XTGBWR and used in the COTRAN core stability calculation included the axial average cross sections, bypass flow, power distribution, xenon distribution, and the core axial pressure drop.

The decay ratio calculations performed with the COTRAN model are performed in the time domain which allows for an easy computation of the core decay ratio. The change in power is calculated by COTRAN as a function of time following a simulated step perturbation in the core pressure.

Decay Ratios calculated by COTRAN for the two-loop test and single loop test are DR = 0.33 and DR = 0.29, respectively. Table 4.1 shows that these calculated decay ratios are consistent with decay ratios determined by ENC using the APRM data recorded by GETARS and the ORNL algorithm.

4.2 COTRANSA-2 Stability Analyses

COTRANSA-2 (Reference 3), a reactor system stability model which couples core neutronics, core thermal hydraulics, and the recirculation loop was developed to determine BWR system stability with two-loop and single loop forced convection in addition to natural circulation. This system is a dynamic code that accounts for feedback between components of a system.

Conditions from both Susquehanna Unit 2 Cycle 2 stability tests were simulated with the COTRANSA-2 model. A decay ratio of 0.32 was calculated for the two-loop test and 0.24 was calculated for the single loop test. Table 4.1 shows that these calculated decay ratios are consistent with the "measured" decay ratios determined by ENC using the APRM data recorded by GETARS and the ORNL algorithm.

TABLE 4.1 COTRAN AND COTRANSA-2 CALCULATED DECAY RATIOS

	Two-Loop Decay Ratio	Single Loop Decay Ratio
COTRAN	.33	.29
COTRANSA-2	.32	.24
Measured	.33 (σ = 0.064)	.30 (σ = 0.064)

5.0 CONCLUSION

Stability tests performed at Susquehanna SES Unit 2 during the first several weeks of Cycle 2 operation show that the Cycle 2 core containing the 9x9 reload fuel is very stable. Noise monitoring, COTRAN calculations (Table 4.1), COTRANSA-2 calculations (Table 4.1), and ENC decay ratios based on noise analyses confirm consistent and very low decay ratios for the core. When comparing the single loop decay ratio to the two-loop decay ratio, no significant changes in stability margin are observed that clearly stand out beyond the inherent accuracy of the results. Consistency of results from these tests and calculations also adds to the confidence in the reliability of the ENC stability methodology to predict core stability for cores containing 9x9 reload fuel.

6.0 REFERENCES

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