

ID/TS2-B

QUAD-CITIES NUCLEAR POWER STATION

UNIT 1 CYCLE 7

STARTUP TEST RESULTS

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I. Control Rod Scram Timing

Purpose

The purpose of this test is to demonstrate the scram capability of all of the operable control rods in compliance with Technical Specifications 4.3.C.1 and 4.3.C.2.

Criteria

- A. The average scram insertion time, based on the de-energization of the scram pilot valve solenoids as time zero, of all operable control rods during reactor power operation shall be no greater than:

<u>% INSERTED FROM FULLY WITHDRAWN</u>	<u>AVG. SCRAM INSERTION TIMES (sec)</u>
5	0.375
20	0.900
50	2.000
90	3.500

The average of the scram insertion times for the three fastest control rods of all groups of four rods in a two by two array shall be no greater than:

<u>% INSERTED FROM FULLY WITHDRAWN</u>	<u>AVG. SCRAM INSERTION TIMES (sec)</u>
5	0.398
20	0.954
50	2.120
90	3.800

If these times cannot be met, the reactor shall not be made supercritical; if operating, the reactor shall be shutdown immediately upon determination that average scram time is deficient.

- B. The maximum insertion time for 90% insertion of any operable control rod shall not exceed 7.00 seconds. If this requirement cannot be met, the deficient control rods shall be considered inoperable, fully inserted into the core, and electrically disarmed.

Results and Discussion

All 177 control rods were scram tested. The results are presented in Table 1.1. The maximum 90% insertion time was 3.02 seconds for control rod J-10 (34-39). Both criteria A and B were met.

Table 1.1

Control Rod Scram Results

<u>NUMBER OF RODS</u>	<u>REACTOR CONDITIONS</u>	<u>AVERAGE TIMES FOR % INSERTED, SEC</u>			
		<u>5%</u>	<u>20%</u>	<u>50%</u>	<u>90%</u>
177	Cold	0.22	0.46	0.95	1.69
177	Hot	0.27	0.65	1.43	2.52

II. Shutdown Margin Demonstration and Control Rod Functional Checks

Purpose

The purpose of this test is to demonstrate for this core loading in the most reactive condition during the operating cycle, that the reactor is subcritical with the strongest control rod full out and all other rods fully inserted.

Criteria

If a shutdown margin of 0.977% ΔK ($=0.25\% + R + B_4C$ settling penalty) cannot be demonstrated with the strongest control rod fully withdrawn, the core loading must be altered to achieve this margin. The core reactivity has been calculated to be at a maximum 5000 MWD/T into the cycle and R is given as 0.687%. The control rod B_4C settling penalty for Unit One is 0.04%.

Results and Discussion

On December 4, 1982, control rod N-7 (the rod which was calculated by General Electric to be of the highest worth) was fully withdrawn to demonstrate that the reactor would remain subcritical with the strongest rod full out. This maneuver was performed to allow cold control rod testing prior to the shutdown margin demonstration.

Control Rod functional subcritical checks were performed as part of the cold scram timing and control rod friction testing. No unexpected reactivity insertions were observed when any of the 177 control rods were withdrawn.

General Electric provided rod worth information for the two strongest diagonally adjacent rods P-6 and M-8 with rod N-7 full out. This method provided an adequate reactivity insertion to demonstrate the desired shutdown margin. On December 20, 1982, a diagonally adjacent shutdown margin demonstration was successfully performed. Using the G.E. supplied rod worth for N-7 (the strongest rod) and diagonally adjacent rods P-6 and M-8, it was determined that with N-7 and P-6 at position 48, and M-8 at position 16, a moderator temperature of 128°F, and the reactor subcritical, a shutdown margin of 1.466% ΔK was demonstrated. The G.E. calculated shutdown margin with N-7 withdrawn and 68°F reactor water temperature was 2.656% ΔK at the beginning of cycle 7.

At approximately 5000 MWd/t into cycle 7 a minimum calculated shutdown margin of 1.969% ΔK will occur with N-5 fully withdrawn. Note that the minimum shutdown margin shifts from rod N-7 at beginning of cycle to rod N-5 at 5000 MWd/T.

G.E.'s ability to determine rod worth was demonstrated by the accuracy of their in-sequence criticality prediction. The ΔK difference between the expected critical rod pattern and the actual critical rod pattern was determined to be 0.326% ΔK . This initial critical demonstrated that the actual shutdown margin at the beginning of cycle 7 was 2.982% ΔK and that the predicted SDM will be approximately 2.295% ΔK at 5000 MWd/t into cycle 7.

III. Initial Critical Prediction

Purpose

The purpose of this test is to demonstrate General Electric's ability to calculate control rod worths and shutdown margin by predicting the insequence critical.

Criteria

General Electric's prediction for the critical rod pattern must agree within 1% ΔK to actual rod pattern. A discrepancy greater than 1% ΔK in the non-conservative direction will be cause for an On-Site Review and investigation by Nuclear Fuel Services.

Results and Discussion

On December 21, 1982, at 0610 hours the reactor was brought critical with a reactor water temperature at the time of criticality of 150°F. The ΔK difference between the expected critical rod pattern at 68°F and the actual critical rod pattern at 150°F was 0.0050 from rod worth tables supplied by General Electric. The temperature effect was -0.0011 ΔK from General Electric-supplied corrections. The excess reactivity yielding the 86 second positive period was 0.0006439 ΔK . These reactivities result in a 0.00326 ΔK difference (0.326% ΔK) between the expected critical rod pattern and the actual rod pattern. This is within the 1% ΔK required in the criteria of this test, and General Electric's ability to predict control rod worths is, therefore, successfully demonstrated.

IV. Core Power Distribution Symmetry Analysis

Purpose

The purpose of this test was to determine the magnitude of indicated core power distribution asymmetries using data (TIP traces and OD-1) collected in conjunction with the P-1 update.

Criteria

- A. The total TIP uncertainty (including random noise and geometric uncertainties obtained by averaging the uncertainties for all data sets) must be less than 9%.
- B. The gross check of TIP signal symmetry should yield a maximum deviation between symmetrically located pairs of less than 25%.

Results and Discussion

Core power symmetry calculations were performed based upon computer program OD-1 data runs on January 3, 1983, at 97% power, and January 4, 1983, at 97% power. The average total TIP uncertainty from the two TIP sets was 5.086%. The random noise uncertainty was 1.481%. This yields a geometrical uncertainty of 4.849%. The total TIP uncertainty was well within the 9% limit.

Table 2 lists the symmetrical TIP pairs and their respective deviations. Figure 1 shows the core location of the TIP pair, and the average TIP readings. The maximum deviation between symmetrical TIP pairs was 13.37% for pair 23-29. Thus, the second criterion, mentioned above, was also met.

The method used to obtain the uncertainties consisted of calculating the average of the nodal ratio of TIP pairs by:

$$\bar{R} = \frac{1}{18n} \left[\sum_{j=1}^n \sum_{i=5}^{22} R_{ij} \right]$$

where R_{ij} is the ratio for the i th node of TIP pair j , there being n such pairs, where $n=18$.

Next the standard deviation of the ratios is calculated by:

$$\sigma_{\bar{R}} = \left[\frac{\sum_{j=1}^n \sum_{i=5}^{22} (R_{ij} - \bar{R})^2}{(18n - 1)} \right]^{1/2}$$

$\sigma_{\bar{R}}$ is multiplied by 100 to express $\sigma_{\bar{R}}$ as a percentage of the ideal value of \bar{R} of 1.0.

$$\% \sigma_{\bar{R}} = \sigma_{\bar{R}} \times 100$$

The total TIP uncertainty is calculated by dividing $\% \sigma_R$ by $\sqrt{2}$ in order to account for data being taken at 3 inch intervals and analyzed on a 6 inch nodal basis.

In order to calculate random noise uncertainty the average reading at each node for nodes 5 through 22 is calculated by:

$$\overline{\text{BASE}}(K) = \frac{1}{NT \cdot MT} \left[\sum_{M=1}^{MT} \sum_{N=1}^{NT} \text{BASE}(N, M, K) \right]$$

where NT = number of runs per machine = 4

MT = number of machines = 5

$\overline{\text{BASE}}(K)$ = average reading at nodal level K,
K = 5 through 22

The random noise is derived from the average of the nodal variances by:

$$\% \sigma \text{ noise} = \left[\frac{\sum_{K=5}^{22} \sum_{M=1}^{MT} \sum_{N=1}^{NT} \left[\frac{\text{BASE}(N, M, K) - \overline{\text{BASE}}(K)}{\overline{\text{BASE}}(K)} \right]^2}{16 (NT \times MT - 1)} \right]^{\frac{1}{2}} \times 100$$

Finally the TIP geometric uncertainty can be calculated by:

$$\% \sigma \text{ geometric} = (\% \sigma \text{ total}^2 - \% \sigma \text{ noise}^2)^{\frac{1}{2}}$$

Table 2

CORE SYMMETRY
Based on OD-1's From
1-3-83 (97% power), and 1-4-83 (97% power)

SYMMETRICAL TIP
PAIR NUMBERS

$T = T_a - T_b$
ABSOLUTE DIFFERENCE

$\% = 100 \times T / \frac{T_a + T_b}{2}$
% DEVIATION

a b

1	6	7.436	8.310
2	12	2.769	2.632
3	19	9.376	9.130
4	26	11.275	11.410
5	33	2.147	4.184
8	13	1.330	1.191
9	20	3.880	3.317
10	27	0.471	0.463
11	34	10.534	10.305
15	21	9.036	8.478
16	28	4.263	4.166
17	35	7.547	6.608
18	39	2.100	3.079
23	29	16.080	13.373
24	36	5.083	4.418
25	40	2.183	3.116
31	37	6.423	2.747
32	41	4.544	7.448

$$T_i = \sum_{i=5}^{22} T_i (K) / 18$$

Average Deviation=
5.737%

Figure 1

UNIT ONE POWER SYMMETRY
Average BASE Readings
(nodes 5 through 22)
From OD-1's on 1-03-83, and 1-04-83

