QUAD-CITIES NUCLEAR POWER STATION

UNIT 2 CYCLE 12

STARTUP TEST RESULTS

STMGR\U2STRTUP

TABLE OF CONTENTS

1. 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margin of 0.333% ΔK (=0.25% + R + B_4C settling penalty) cannot be demonstrated with the strongest control rod fully withdrawn, the core loading must be altered to achieve this margin.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 4000 MWd/ST into the cycle and R is given as 0.033% ΔK. The control rod B_4C settling penalty for Unit Two is 0.05% ΔK.

Results and Discussion

On April 11, 1992, control rod H-9 was fully withdrawn to demonstrate that the reactor would remain subcritical with the strongest rod out. This rod was calculated by GE to have the highest worth with the core fully loaded at the beginning of the cycle. The strongest rod out maneuver was performed to allow single control rod withdrawals for CRD testing.

Control Rod functional subcritical checks were performed as part of 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 No unexpected reactivity insertions were observed when any of the 177 control rods were withdrawn.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Electric provided rod worth information for the two strongest diagonally adjacent rods G-10 and J-10 with rod H-9 fully withdrawn. This method provided an adequate reactivity insertion to demonstrate the desired shutdown margin. On April 11, 1992, a diagonally adjacent shutdown margin demonstration was successfully performed. Using the G.E. supplied rod worth for H-9 (the strongest rod) and diagonally adjacent rod G-10, it was determined that with H-9 at position 48, and G-10 at position 24, a moderator temperature of 137°F, and the reactor subcritical, a shutdown margin of 0.592% ΔK was demonstrated. The G.E. calculated shutdown margin with H-9 withdrawn and 68°F reactor water temperature was 3.001% ΔK at the beginning of Cycle 12.

At approximately 4000 MWd/ST into Cycle 12 a minimum calculated shutdown margin of 2.968% ΔK will occur with E-4 fully withdrawn.

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 0.1154% ΔK after correcting for temperature and period. This initial critical demonstrated that the actual shutdown margin at the beginning of cycle 12 was 3.1164% ΔK and 3.0834% ΔK at 4000 MWd/ST into cycle 12.

2. Core Verification

Purpose

The purpose of this test is to verify proper core location and orientation for each core fuel assembly.

Criteria

Prior to reactor startup, the actual core configuration shall be verified to be identical to the planned core configuration.

Results and Discussion

The Unit Two Cycle 12 core was verified on March 17, 1992. Fuel assembly orientation, seating, and ID serial number were verified for each assembly. Two inspection passes were made over each assembly. The first pass was made to verify orientation and seating of assemblies. The second pass was made to verify bundle ID numbers. A video camera was used during the inspection. All assemblies were found to be properly seated and orientated in their designated locations.

On March 21, 1992, 24 fuel assemblies were reverified due to the unload and reload of 4 fuel assemblies for control rod J-14 drive replacement. Two passes were again made for orientation, seating and ID verification. All 24 assemblies were found to be properly seated and orientated in their designated location. Similarly, on March 23, 1992, 22 fuel assemblies were reverified due to the unload and reload of eight fuel assemblies to allow drive replacement for control rods P-10 and P-11. Two passes were again made for orientation, seating and ID verification. All 22 fuel assemblies were found to be properly seated and orientated in the designated locations.

The bundle ID numbers are shown in Figure 1.

3. 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 will be cause for an On-Site Review and investigation by Nuclear Fuel Services.

Results and Discussion

On May 8, 1992, at 2041 hours the reactor was brought critical with reactor water temperature at the time of criticality of 165°F. The ΔK difference between the expected critical rod pattern at 68°F and the actual critical rod pattern at 165°F was 0.002894 from rod worth tables supplied by General Electric. The temperature effect was -0.00145 ΔK from General Electric supplied corrections. The excess reactivity yielding the 215 second positive period was 0.00029 ΔK. These reactivities resulted in a 0.001154 ΔK difference (0.1154% 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 worth is, therefore, successfully demonstrated.

4. 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 CMC 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 May 20 at 1303 and 2045 hours, both at 99.2.% and 98.9%, power respectively. The average total TIP uncertainty from the two TIP sets was 3.230%. The random noise uncertainty was 1.150%. This yields a geometrical uncertainty of 3.018%. The total TIP uncertainty was well within the 9% limit.

Table 1 lists the symmetrical TIP pairs and their respective average deviations. Figure 1 shows the core location of the TIP pairs and the average TIP readings. The maximum deviation between symmetrical TIP pairs was 8.51% for pair 5-33. 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:

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

where Rij is the ratio for the ith node of TIP pair j, there being n such pairs, where n=18.

Next the standard deviation of the ratios is calculated by:

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

σ_R is multiplied by 100 to express σ_R as a percentage of the ideal value of σ_R of 1.0.

$$\% \sigma_R = \sigma_R \times 100$$

The total TIP uncertainty is calculated by dividing % σ_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:

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

where NT = number of runs per machine = 5
MT = number of machines = 5
$\overline{BASE}$ (K) = average reading at nodal level K,
K = 5 through 22

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

$$\%s\ noise = \left[\frac{\sum_{K=5}^{22} \sum_{M=1}^{MT} \sum_{N=1}^{NT} \left[\frac{BASE\ (N, M, K) - \overline{BASE}\ (K)}{BASE\ (K)} \right]^2}{18\ (NT \times MT - 1)} \right]^{1/2} \times 100$$

Finally the TIP geometric uncertainty can be calculated by:

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

Table 1

CORE SYMMETRY
Based on OD-1's From
05-20-92 at 1303 Hours and 2045 Hours
(99.2% and 98.9% Power Respectively)

SYMMETRICAL TIP PAIR NUMBERS	ABSOLUTE DIFFERENCE	AVERAGE % DEVIATION
a-b	$T = T_a - T_b$	$\% = 100 \times T/((T_a + T_b)/2)$
1-6	0.48	0.71
2-12	5.06	5.48
3-19	3.32	3.33
4-26	2.66	3.07
5-33	3.15	8.51
8-13	1.43	1.28
9-20	1.87	1.86
10-27	1.38	1.33
11-34	5.51	6.07
15-21	2.18	2.02
16-28	3.54	3.53
17-35	2.60	2.52
18-39	2.11	3.59
23-29	1.14	1.07
24-36	5.57	5.56
25-40	3.65	5.32
31-37	6.95	7.06
32-41	0.46	1.13

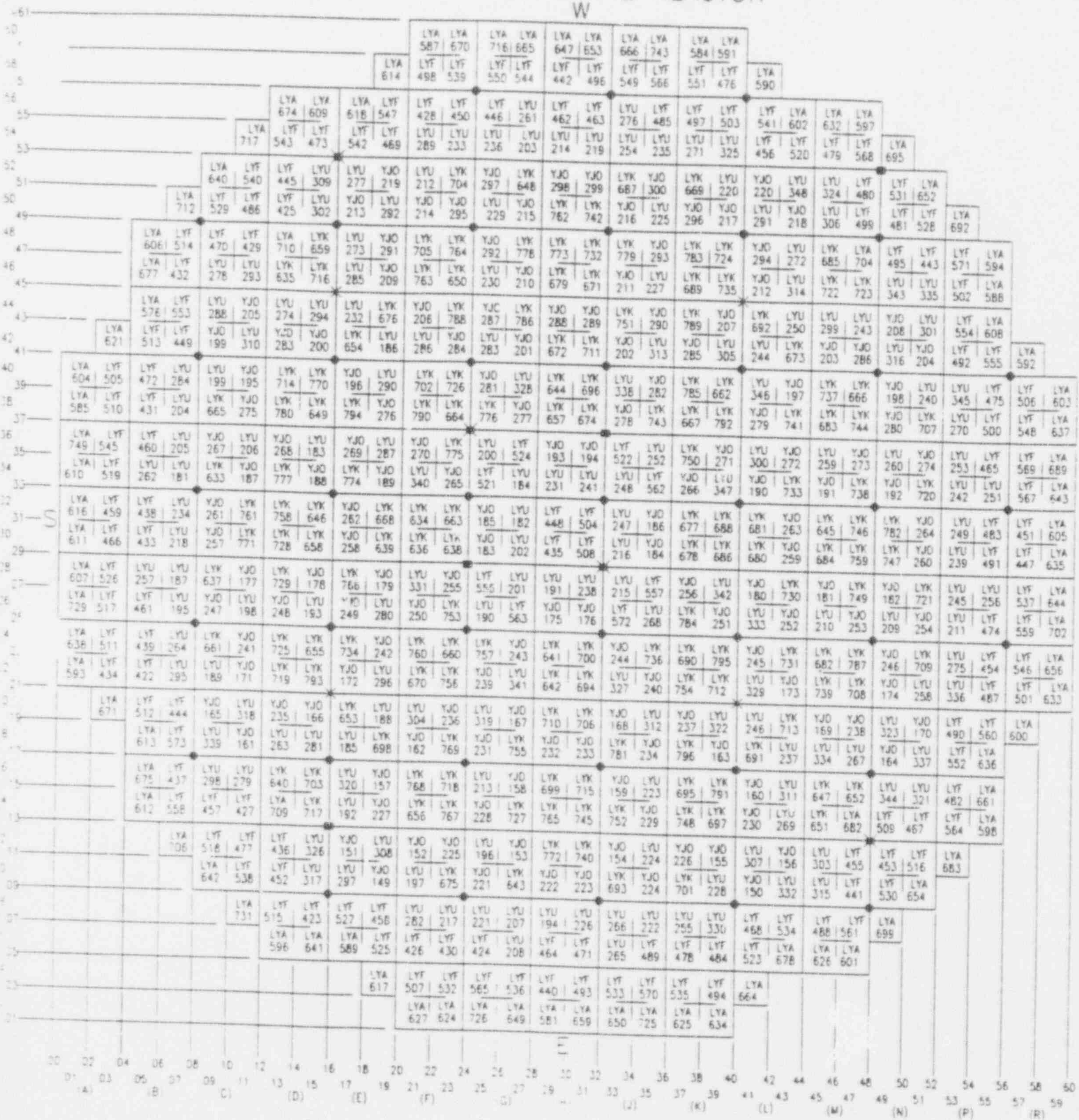
$$T_t = \sum_{i=5}^{22} T_t(K) \quad /18$$

Average Deviation = 3.52

FIGURE 1

CYCLE 12

QUAD CITIES UNIT 2 REACTOR



SOURCE RANGE MONITORS

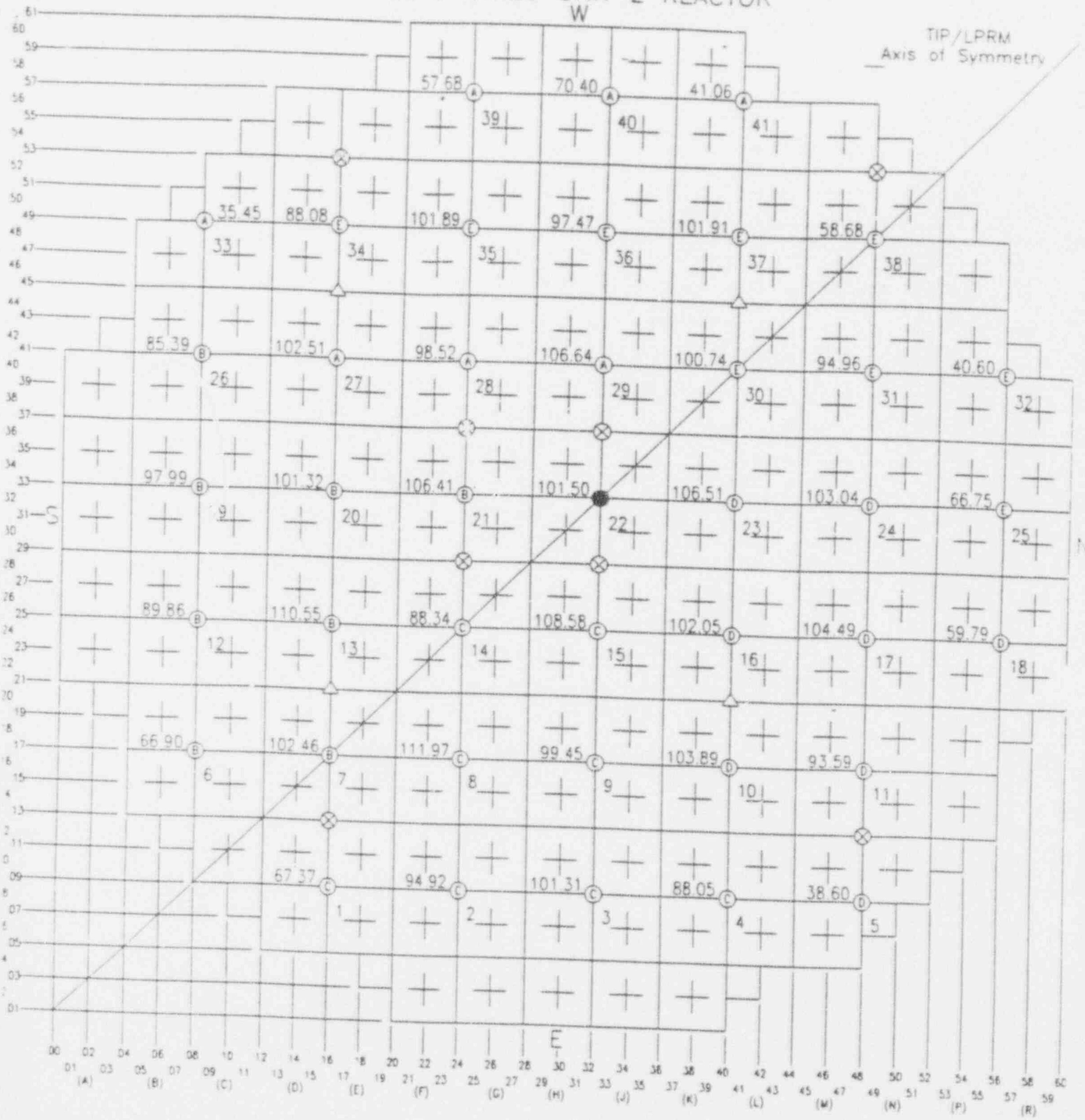
INTERMEDIATE RANGE MONITORS - BUS "A"

INTERMEDIATE RANGE MONITORS - BUS "B"

LOCAL POWER RANGE MONITORS

FIGURE 2

QUAD CITIES UNIT 2 REACTOR



Ⓐ LPRM Location (Letter indicates TIP machine)

● LPRM Location (Common location for all TIP machines)

⊗ IRM Locations

△ SRM Locations

✳ Source Locations

UNIT TWO POWER SYMMETRY
AVERAGE BASE READINGS
(NODES 5-22)
BASED ON OD-1's from
May 20, 1992 at 1303 Hours (99.2% Power)
May 20, 1992 at 2045 Hours (98.92% Power)

BASE AVERAGE — STRING NUMBER