QUAD-CITIES NUCLEAR POWER STATION

UNIT 2 CYCLE 13

STARTUP TEST RESULTS

SUPPLEMENT ONE

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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 carried out based upon computer program OD-1 data run on August 19, 1993 and again on October 9, 1993. The average total TIP uncertainty from the two symmetry calculations was 2.985%. The random noise uncertainty was 1.427%. This yields a geometrical uncertainty of 2.621%. The total TIP uncertainty was well within the 9% limit.

The above results were performed without using LPRM strings 5 and 33. String 5 is a Hydrogen Water Chemistry (HWC) probe in which the "D" level LPRM detector has been replaced by HWC detectors. A safety evaluation (93-27) was performed for this change and no unreviewed safety questions were indicated. The effect on the OD-79 program will be that 1 symmetric pair of LPRMs will be unavailable for the core symmetry calculation, namely pairs 48-09 and 08-49 (strings 5 and 33, respectively). These are peripheral strings and will have the effect of decreasing the core symmetry calculation total uncertainty. This effect occurs because the power magnitude on the periphery is smaller than the power magnitude in the center of the core. Thus, a differential change between the peripheral pair power levels will result in a greater percent uncertainty than a differential change in the power level of center core symmetric pairs. Data was taken in order to support this from a Unit 2 tip set done in December 1992 with only 39 strings run. With no other failures present, the core symmetry calculation will meet its acceptability requirements.

Table 1 lists the symmetrical TIP pairs and their respective deviations. Figure 2 shows the core location of the TIP pairs and their TIP readings. The maximum deviation between symmetrically located TIP pairs occurred during the October 9, 1993 run and was 9.611% for pair 9-20. This is well within the 25% limit.

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:

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

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

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

The total TIP uncertainty is calculated by dividing $\% \sigma_{\bar{R}}$ 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:

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

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:

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

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 From
The Average Between the 8-19-93 Case
and the 10-9-93 Case

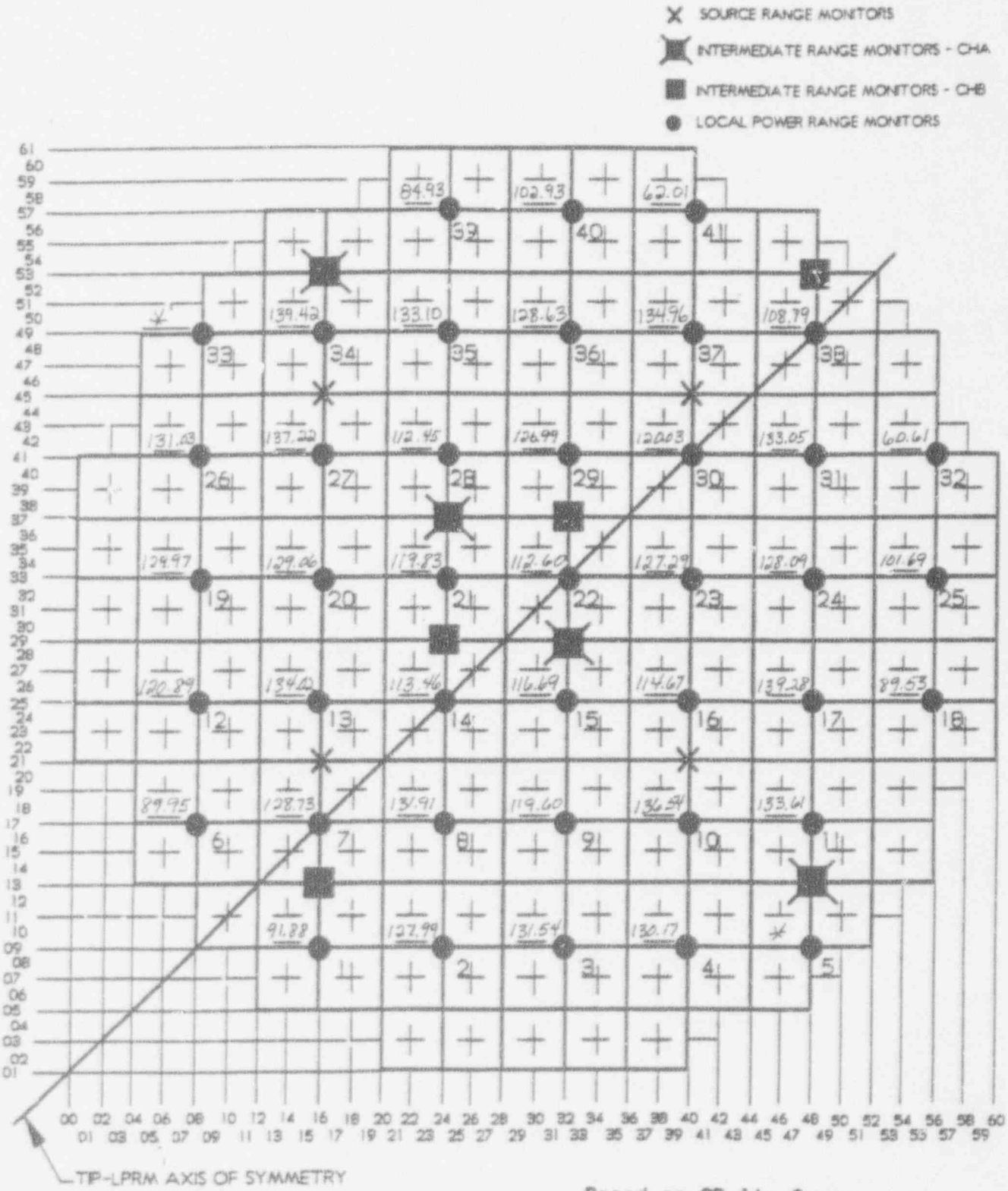
SYMMETRICAL TIP PAIR NUMBERS a-b	ABSOLUTE DIFFERENCE $T = T_a - T_b$	$\% = 100 \times T/((T_a + T_b)/2)$	AVERAGE % DEVIATION
1-6	1.93		2.12
2-12	7.16		5.71
3-19	1.57		1.20
4-26	0.86		0.66
* 5-33	–		–
8-13	2.11		1.59
9-20	9.46		7.61
10-27	0.68		0.50
11-34	5.81		4.26
15-21	3.14		2.66
16-28	2.22		1.95
17-35	6.18		4.54
18-39	4.60		5.27
23-29	0.30		0.24
24-36	0.54		0.42
25-40	1.24		1.21
31-37	1.91		1.43
32-41	1.40		2.28

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

Average Deviation = 3.0029

* Not used due to Hydrogen Water Chemistry Probe in-core location 48-09 (string 5). The "D" level detector does not exist, so the TIP could not be run in index. Thus OD-79 core symmetry could not be calculated.

FIGURE 2
CYCLE 13
QUAD CITIES UNIT 2 REACTOR
POWER SYMMETRY
AVERAGE BASE READINGS



Based on OD-1's from
Date 6/19/93 Power 99%
Date 10/9/93 Power NORMALIZED TO 99%

* TIP pairs were not used due to the Hydrogen Water Chemistry (HWC) test (Temp Alt 92-2-126). The "D" level detector in string 5 was replaced by HWC probes.

(final)