

DRESDEN UNIT 2
STARTUP TEST NO. 3
TIP SYSTEM SYMMETRY - UNCERTAINTY

PURPOSE

The purpose of this test is to perform a gross symmetry check and a detailed statistical uncertainty analysis on the Transversing In-Core Probe (TIP) System.

CRITERIA

- 1) TIP Symmetry - Gross Check
The maximum deviation between symmetrically located TIP pairs of LPRM strings should be less than 25%.
- 2) TIP Symmetry - Statistical Check
The calculated χ^2 of the integrated TIP responses should be less than 34.81.

NOTE: One data set may be used to meet the above criteria. If either criteria is not met, the instrumentation and data processing system should be checked for any problems that could lead to asymmetries. If the problem persists, the fuel vendor should determine if the larger than expected TIP asymmetries affect safe reactor operation.

RESULTS

One complete set of data set of data required for evaluating TIP uncertainty was obtained during the D2 BOC9 Startup Testing Program. Data was obtained at steady state power levels greater than 75% of rated power. The results for each method of analysis are summarized below.

- 1) TIP Symmetry - Gross Check
In order to determine the overall symmetry of the TIP system, full power adjusted TIP readings were obtained and averaged for each symmetric TIP pair (the symmetric locations are given in Table 3.1). The absolute percent deviation between each symmetric TIP pair was calculated and summarized in Table 3.2. The average absolute deviation overall symmetric TIP pairs was 2.49%, with a maximum absolute deviation of 8.03% which is well below the 25% criteria.
- 2) TIP Symmetry - Statistical Check
The TIP symmetry analysis was performed using a method recommended by Exxon Nuclear Company. TIP values obtained from a whole core LPRM calibration performed during the startup test program were summed

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(Nodes 5 through 44) for each TIP location. The absolute relative difference (Dm) for each symmetric TIP pair was then calculated using equation 3.1 - the results are summarized in table 3.3. From equations 3.2 and 3.3, the variance and χ^2 were calculated to be 5.29 and 2.65 respectively. Note that the value for χ^2 is well within the limit established by Exxon.

TABLE 3.1. Symmetric TIP Locations

TIP PAIR	LPRM	TIP PAIR	LPRM
1	08-17 16-09	10	24-33 32-25
2	08-25 24-09	11	24-41 40-25
3	08-33 32-09	12	24-49 48-25
4	08-41 40-09	13	24-57 56-24
5	08-49 48-09	14	32-41 40-33
6	16-25 24-17	15	32-49 48-33
7	16-33 32-17	16	32-57 56-33
8	16-41 40-17	17	40-49 48-41
9	16-49 48-17	18	40-57 56-41

TABLE 3.2. TIP Symmetry - Gross Check

Symmetric TIP Pair	Absolute Percent Deviation
1	.340
2	2.00
3	.140
4	4.81
5	1.84
6	1.13
7	1.15
8	.680
9	3.35
10	4.63
11	.250
12	2.39
13	5.23
14	3.62
15	8.03
16	3.11
17	.440
18	1.59

Average Absolute Percent Deviation: 2.49

Maximum Absolute Percent Deviation: 8.03

TABLE 3.3. TIP Symmetry - Statistical Check

Symmetric TIP Pair	Relative Difference Dm
1	.94
2	1.32
3	.660
4	4.58
5	2.65
6	2.38
7	.980
8	.660
9	3.06
10	4.62
11	.360
12	1.56
13	4.87
14	3.94
15	8.26
16	3.10
17	.640
18	1.18

Equation 3.1
$$D_m = \frac{100 (T_{m1} - T_{m2})}{\left(\frac{T_{m1} + T_{m2}}{2} \right)}$$

Note:
$$T_{m1} = \sum_{k=5}^{44} T(k) \text{ for TIP}_1 \text{ and } T_{m2} = \sum_{k=5}^{44} T(k)$$

for TIP₂ where TIP₁ and TIP₂ are symmetric TIP pairs.

Equation 3.2 (Variance)

$$S_{TIP_{ij}}^2 = \frac{\sum_{m=1}^{18} D_m^2}{36} = 5.29$$

Equation 3.3

$$\chi^2 = \frac{18 S_{TIP_{ij}}^2}{36} = 2.65$$