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MARTIN,T.T. Region 1 (Post 820201)

SUBJECT: Forwards Unit 2 startup rept for Cycle 5 startup,submitted in accordance w/Tech Specs 6.9.1.1 through 6.9.1.3.Rept addresses startup tests described in 910307 application for reload.

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AUG 0 1 1991

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SUSQUEHANNA STEAM ELECTRIC STATION
UNIT 2 CYCLE 5 STARTUP REPORT
PLA-3583 FILE R41-2A **Docket No. 50-388**

Dear Mr. Martin:

Attached is a copy of the Susquehanna SES Unit 2 Startup Report for the Unit 2 Cycle 5 startup. This report is submitted in accordance with Technical Specifications Section 6.9.1.1 through 6.9.1.3. The report addresses those startup tests described in our application for reload dated March 7, 1991.

Very truly yours,

H. W. Keiser

Attachment

cc: NRC Document Control Desk (original)
Mr. J. J. Raleigh, NRC Project Manager (OWFN)
Mr. G. S. Barber, NRC Sr. Resident Inspector (SSES)

SUSQUEHANNA SES UNIT 2 CYCLE 5

STARTUP TEST SUMMARY

Prepared by: J Brian Forgie

Approved by: James R. Doxsey
Reactor Engineering Supervisor

Approved by: Howard J Palmer
Manager Nuclear Operations

ABSTRACT

Susquehanna Unit 2

Cycle 5

Startup Test Summary

Susquehanna Unit 2 resumed commercial operation for Cycle 5 on May 8, 1991 following a 61 day refueling and maintenance outage. Susquehanna Unit 2 Cycle 5, hereafter referred to as S2C5 reload included:

85	ANF	9x9	thrice burned assemblies
7	ANF	9x9	twice burned reinserted assemblies
236	ANF	9x9	twice burned assemblies
204	ANF	9x9	once burned assemblies
232	ANF	9x9	unirradiated fuel assemblies

The following startup tests, identified in the S2C5 Reload Licensing Submittal, are discussed in this report:

1. Core Loading Verification
2. POWERPLEX Input deck validation
3. Control Rod Functional (Insert and Withdrawal Checks)
4. Subcritical Shutdown Margin Demonstration
5. In-Sequence Critical and Shutdown Margin Demonstration
6. Control Rod Scram Time Testing
7. Tip Asymmetry

In addition, the startup program included core flow and LPRM calibrations, thermal limits monitoring and baseline recirculation data acquision. A summary of these activities is also included in this report.

Susquehanna Unit 2

Cycle 5

Startup Test No. 1

Core Verification and Audit

Purpose

The purpose of this test is to visually verify that the core is loaded per the analyzed designs.

Criteria

Upon completion of core alterations during the refueling outage, the core must be verified to conform with the reference core design used in the various licensing analyses. The verifications to be performed include fuel bundle location, fuel bundle orientation, and proper seating of the fuel bundles within the core. The verifications will be performed by the Reactor Engineering Group utilizing an underwater television camera. The verification will be videotaped so that an independent verification may be performed. Any discrepancies discovered in the loading will be promptly corrected and the affected bundles shall be reverified prior to unit startup.

Results

Susquehanna took the following precautions to prevent a misloaded fuel bundle. During the total core offload, bundles to be used next cycle were placed in the pool in the order in which they were to be reloaded. This facilitated an orderly stripping of bundles during the reload. After the offload was complete, a serial number verification of these bundles was performed on 4/5/91 prior to the core reload. The core reload was performed in two parts. First, the irradiated bundles were loaded and a partial core verification (serial number, location, orientation and height check) was performed on 4/15/91. Control rod motion was permitted on the fully loaded and verified cells after this verification. Secondly the new fuel (3.43 wt % U-235) was loaded.

The Cycle 5 final core verification consisted of two videotaped passes over the core. During the first pass, the fuel bundle serial numbers were recorded on the videotape to verify proper location. The second pass was performed to verify proper fuel assembly seating (assembly height check) and correct orientation.

The core tapes were independently verified to be correct by the Reactor Engineering Supervisor designee and a representative of Quality Control on 4/17/91. Therefore, the as-loaded core configuration is consistent with the core design Advanced Nuclear Fuels and PP&L used in the evaluation of the S2C5 Reload Licensing Analyses. The S2C5 core map is included as Figure 1.

C R E A T E M O D E S S E S U N I T - 2 / C Y C L E - 5

CYCLE(5) CALCULATED FULL CORE LOADING PATTERN

PREPARED BY/DATE: [signature] 1/7/91 REVIEWED BY/DATE: [signature] 1/10/91

APPROVED BY/DATE: [signature] 1/10/91

RECEIVED BY/DATE (SUPV REACT ENGRG): [signature] 1/17/91

GE-Y/GE-X:	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29
60									X21007	X21048	X21068	X21026	X21152	X21081	X21046
58								X21113	X23681	X23573	X23565	X23753	X23693	X23613	X23581
56						X21047	X21124	X23697	X22479	X23729	X24993	X23593	X24989	X22356	X22367
54						X21035	X23589	X24985	X23653	X24981	X22361	X24977	X23713	X24973	X23605
52					X21098	X22368	X22350	X23629	X24969	X23633	X24965	X22344	X24961	X22334	X24957
50			X21016	X21058	X22343	X22483	X23649	X24953	X22370	X24949	X22492	X24945	X23689	X24941	X22389
48			X21083	X23601	X22327	X23617	X24937	X22325	X24933	X23621	X24929	X23685	X24925	X23705	X22362
46		X21097	X23665	X24921	X23661	X24917	X22341	X24913	X22491	X24909	X22355	X22333	X22393	X24905	X22503
44	X21085	X23761	X22499	X23597	X24901	X22349	X24897	X22465	X24893	X22480	X24889	X23677	X24885	X22484	X22467
42	X21151	X23645	X23673	X24881	X23609	X24877	X23561	X24873	X22474	X23733	X22371	X24869	X23669	X24865	X22378
40	X21096	X23641	X24861	X22328	X24857	X22468	X24853	X22359	X24849	X22388	X24845	X22488	X24841	X23577	X22505
38	X21036	X23745	X23657	X24837	X22387	X24833	X23721	X22360	X23737	X24829	X22495	X24825	X22507	X24821	X22335
36	X21060	X23757	X24817	X23725	X24813	X23709	X24809	X22336	X24805	X23741	X24801	X22496	X22473	X23717	X24797
34	X21001	X23625	X22377	X24793	X22342	X24789	X23749	X24785	X22511	X24781	X23569	X24777	X23701	X24773	X22475
32	X21126	X23637	X22369	X23585	X24769	X22331	X22381	X22487	X22509	X22351	X22500	X22379	X24765	X22466	X22380
30	X21192	X23640	X22415	X23588	X24772	X22457	X22407	X22535	X22515	X22437	X22524	X22405	X24768	X22554	X22406
28	X21319	X23628	X22403	X24796	X22442	X24792	X23752	X24788	X22513	X24784	X23572	X24780	X23704	X24776	X22549
26	X21264	X23760	X24820	X23728	X24816	X23712	X24812	X22452	X24808	X23744	X24804	X22528	X22547	X23720	X24800
24	X21286	X23748	X23660	X24840	X22397	X24836	X23724	X22424	X23740	X24832	X22527	X24828	X22517	X24824	X22451
22	X21218	X23644	X24864	X22460	X24860	X22556	X24856	X22423	X24852	X22398	X24848	X22536	X24844	X23580	X22519
20	X21163	X23648	X23676	X24884	X23612	X24880	X23564	X24876	X22548	X23736	X22417	X24872	X23672	X24868	X22404
18	X21235	X23764	X22523	X23600	X24904	X22435	X24900	X22553	X24896	X22544	X24892	X23680	X24888	X22540	X22555
16		X21219	X23668	X24924	X23664	X24920	X22441	X24916	X22531	X24912	X22431	X22449	X22395	X24908	X22521
14			X21233	X23604	X22459	X23620	X24940	X22463	X24936	X23624	X24932	X23688	X24928	X23708	X22426
12			X21304	X21262	X22443	X22539	X23652	X24956	X22416	X24952	X22532	X24948	X23692	X24944	X22399
10					X21220	X22414	X22436	X23632	X24972	X23636	X24968	X22444	X24964	X22450	X24960
8						X21285	X23592	X24988	X23656	X24984	X22425	X24980	X23716	X24976	X23608
6						X21050	X21190	X23700	X22543	X23732	X24996	X23596	X24992	X22432	X22413
4								X21207	X23684	X23576	X23568	X23756	X23696	X23616	X23584
2									X?1311	X21276	X21246	X21296	X21164	X21231	X21274

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Figure 1, Susquehanna Unit 2 Cycle 5 Core Loading Map

C R E A T E   M O D E   S S E S   U N I T - 2 / C Y C L E - 5

CYCLE(5) CALCULATED FULL CORE LOADING PATTERN

APPROVED BY/DATE: [signature] 1/10/91

RECEIVED BY/DATE (SUPV REACT ENGRG): [signature] 1/17/91

PREPARED BY/DATE: [signature] 1/7/91 REVIEWED BY/DATE: [signature] 1/10/91

GE-Y/GE-X:	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59
60	X21051	X21094	X21161	X21029	X21079	X21049	X21014								
58	X23582	X23614	X23694	X23754	X23566	X23574	X23682	X21118							
56	X22376	X22357	X24990	X23594	X24994	X23730	X22482	X23698	X21135	X21291					
54	X23606	X24974	X23714	X24978	X22364	X24982	X23654	X24986	X23590	X21040					
52	X24958	X22339	X24962	X22345	X24966	X23634	X24970	X23630	X22353	X22375	X21105				
50	X22390	X24942	X23690	X24946	X22493	X24950	X22373	X24954	X23650	X22486	X22346	X21063	X21021		
48	X22363	X23706	X24926	X23686	X24930	X23622	X24934	X22326	X24938	X23618	X22330	X23602	X21092		
46	X22504	X24906	X22394	X22340	X22358	X24910	X22494	X24914	X22348	X24918	X23662	X24922	X23666	X21106	
44	X22470	X22485	X24886	X23678	X24890	X22481	X24894	X22472	X24898	X22354	X24902	X23598	X22502	X23762	X21090
42	X22385	X24866	X23670	X24870	X22372	X23734	X22477	X24874	X23562	X24878	X23610	X24882	X23674	X23646	X21162
40	X22506	X23578	X24842	X22489	X24846	X22391	X24850	X22366	X24854	X22469	X24858	X22329	X24862	X23642	X21107
38	X22338	X24822	X22508	X24826	X22498	X24830	X23738	X22365	X23722	X24834	X22392	X24838	X23658	X23746	X21039
36	X24798	X23718	X22478	X22497	X24802	X23742	X24806	X22337	X24810	X23710	X24814	X23726	X24818	X23758	X21061
34	X22476	X24774	X23702	X24778	X23570	X24782	X22512	X24786	X23750	X24790	X22347	X24794	X22386	X23626	X21006
32	X22383	X22471	X24766	X22384	X22501	X22352	X22510	X22490	X22382	X22332	X24770	X23586	X22374	X23638	X21133
30	X22409	X22559	X24767	X22410	X22525	X22438	X22516	X22538	X22408	X22458	X24771	X23587	X22420	X23639	X21199
28	X22550	X24775	X23703	X24779	X23571	X24783	X22514	X24787	X23751	X24791	X22447	X24795	X22412	X23627	X21324
26	X24799	X23719	X22552	X22529	X24803	X23743	X24807	X22453	X24811	X23711	X24815	X23727	X24819	X23759	X21265
24	X22454	X24823	X22518	X24827	X22530	X24831	X23739	X22429	X23723	X24835	X22402	X24839	X23659	X23747	X21289
22	X22520	X23579	X24843	X22537	X24847	X22401	X24851	X22430	X24855	X22557	X24859	X22461	X24863	X23643	X21229
20	X22411	X24867	X23671	X24871	X22418	X23735	X22551	X24875	X23563	X24879	X23611	X24883	X23675	X23647	X21174
18	X22558	X22541	X24887	X23679	X24891	X22545	X24895	X22560	X24899	X22440	X24903	X23599	X22526	X23763	X21240
16	X22522	X24907	X22396	X22456	X22434	X24911	X22534	X24915	X22448	X24919	X23663	X24923	X23667	X21228	
14	X22427	X23707	X24927	X23687	X24931	X23623	X24935	X22464	X24939	X23619	X22462	X23603	X21242		
12	X22400	X24943	X23691	X24947	X22533	X24951	X22419	X24955	X23651	X22542	X22446	X21267	X21309		
10	X24959	X22455	X24963	X22445	X24967	X23635	X24971	X23631	X22439	X22421	X21227				
8	X23607	X24975	X23715	X24979	X22428	X24983	X23655	X24987	X23591	X21290					
6	X22422	X22433	X24991	X23595	X24995	X23731	X22546	X23699	X21201	X21278					
4	X23583	X23615	X23695	X23755	X23567	X23575	X23683	X21212							
2	X21279	X21244	X21173	X21299	X21257	X21277	X21318								

Figure 1, Susquehanna Unit 2 Cycle 5 Core Loading Map

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Susquehanna Unit 2

Cycle 5

Startup Test No. 2

POWERPLEX Input Deck Validation

Purpose

To ensure the POWERPLEX input deck is updated correctly before the start of every new fuel cycle.

Criteria

POWERPLEX is the ANF software system designed to perform in-core monitoring of BWR cores. Core monitoring is performed by the module, XTGBWR, a three-dimensional reactor simulation code which calculates bundle nodal powers. The POWERPLEX input deck consists of all data needed for the execution of this code and subsequent calculation of the margin to thermal limits. This data must be updated prior to the start of every new fuel cycle in order to ensure satisfactory core monitoring of the new core configuration. The deck is updated by an ANF core management engineer and validated jointly by members of the Reactor Engineering Group at Susquehanna and the Nuclear Fuels Engineering Group in Allentown.

Results

The POWERPLEX input deck was completely reviewed, all comments resolved, verified to be correct and successfully loaded into the POWERPLEX system prior to S2C5 startup.

Susquehanna Unit 2

Cycle 5

Startup Test No. 3

Control Rod Functional (Insert and Withdrawal Checks)

Purpose

The purpose of this startup test is to assure proper control rod function and demonstrate that criticality will not occur due to the withdrawal of a single rod.

Criteria

Control Rod Functionals include mobility, overtravel and subcritical checks. These may be performed as each control cell is loaded in its final configuration.

Each control rod will be cycled individually to ensure mobility. As each rod is fully withdrawn, it will be checked for overtravel by continually applying a withdrawal signal. Subcriticality will also be verified with the rod withdrawn.

Results

Due to Shutdown Margin considerations, no control rod functionals were permitted on fully loaded control cells until the partial core verification was completed on 4/15/91. No control rods overtraveled and subcriticality was maintained as each rod was individually fully withdrawn and reinserted.

Susquehanna Unit 2

Cycle 5

Startup Test No. 4

Subcritical Shutdown Margin Demonstration

Purpose

The purpose of this startup test is to assure at least the minimum required shutdown margin exists with the strongest worth control rod fully withdrawn.

Criteria

The minimum required shutdown margin at BOC for Susquehanna Unit 2 Cycle 5 is 0.38% Δ K/K. This test will verify at least this amount by performance of a subcritical shutdown margin demonstration. The highest (strongest) worth control rod is fully withdrawn, then a diagonally adjacent rod is slowly notched out verifying subcriticality at each step until the analytically determined reactivity worth of the control rods at their respective notch position equals or slightly exceeds the required amount of SDM.

Results

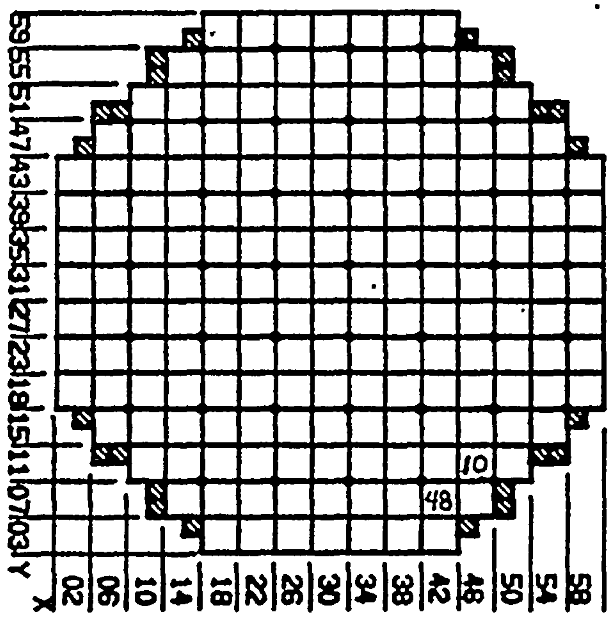
The reactor remained subcritical with the highest worth control rod fully withdrawn and an additional diagonally adjacent rod pulled to a notch position with a calculated worth of 1.034% Δ K/K. The required shutdown margin to be demonstrated was calculated to be 0.50% Δ K/K. This is 0.38% Δ K/K plus a correction factor for the recirculation loop temperature (100.0 degrees F) at the time of the test. Using data supplied by PP&L it was determined that the following rods pulled to the indicated position would demonstrate a shutdown margin of 0.914% Δ K/K.

ROD	POSITION	TOTAL WORTH %ΔK/K
42-07*	48	-
46-11	10	1.034

*analytically determined strongest rod.

As rods were pulled, subcriticality was verified after each notch. Subcriticality was also verified with the rods at the above indicated positions, thus satisfying the purpose of this startup test. Figure 2 is a core map showing the test rod positions.

FIGURE 2. CORE MAP SHOWING TEST ROD POSITIONS FOR SUBCRITICAL SHUTDOWN MARGIN DEMONSTRATION



BLANKS INDICATE RODS AT 00.

Susquehanna Unit 2

Cycle 5

Startup Test No. 5

In-Sequence Critical and SDM Determination

Purpose

The purpose of this startup test is to calculate the actual shutdown margin of the cycle 5 core and to demonstrate that no reactivity anomaly exists.

Criteria

1) Shutdown Margin

Technical Specification 3.1.1 requires an adequate shutdown margin to ensure the reactor can be made subcritical from all operating conditions. This value, .38% Δ K/K has been determined to be the minimum required SDM to bring a reactor subcritical under the worst case conditions - a cold, xenon-free core at the most reactive point in the cycle with the highest worth control rod unavailable for reactivity control. At beginning of cycle, the required SDM value must be increased by a factor, R, if it is determined that core shutdown margin is less at another point in the cycle than the initial shutdown margin (for Cycle 5, R=0). The required beginning-of-cycle SDM for Susquehanna Unit 2 Cycle 5 is 0.38% Δ K/K; the actual SDM will be calculated from data obtained during the initial startup criticality.

2) Reactivity Anomaly

Core reactivity is monitored to prevent excessive reactivity additions due to unforeseen reactivity changes or reactivity anomalies. At BOC, a 1% Δ K/K difference between predicted and actual critical control rod positions might indicate improper core loading or a computer code that is unreliable. Data gathered during the in-sequence critical, specifically the Keff at the notch position of the control rod at which criticality occurs, is compared to predicted critical control rod position Keff and a % reactivity difference is calculated.

Results

The calculated SDM was 1.3659% Δ K/K and the difference between actual Keff and predicted Keff at criticality was -0.086% Δ K/K.

Control rods were withdrawn in the B sequence until the reactor was on a stable, positive period. The notch position at which criticality occurred was rod 30-55, notch 24, step 31. A special log was initiated to record SRM count rates and recirculation loop temperatures. The average period was 205.25 seconds and the average loop temperature 111.95 degrees F which yield period and temperature corrections of $.318361 \times 10^{-3}$ Δ K/K and 1.78×10^{-3} Δ K/K, respectively.

1) Shutdown Margin

The equation used to calculate SDM

$$SDM = \frac{Kcrit - Ksro}{Kcrit * Ksro} - \Delta p\,(period) - \Delta p\,(temp)$$

Kcrit is Keff at the actual critical control rod position (1.00124) and Ksro is Keff predicted with the strongest rod out (0.985689).

The minimum required SDM for Unit 2 Cycle 5 at beginning of cycle was 0.38% Δ K/K; the calculated shutdown margin based on this test was 1.3659% Δ K/K, thus satisfying the acceptance criteria.

2) Reactivity Anomaly

The reactor went critical at step 31 with Kcrit of 1.00124. The equation used to calculate reactivity difference was

$$\text{Reactivity difference} = \frac{Kcrit - 1}{Kcrit} - \Delta p\,(period) - \Delta p\,(temp)$$

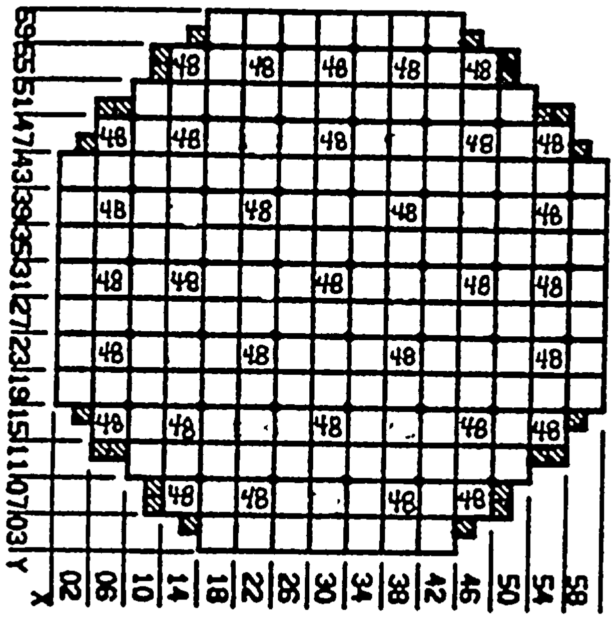
The calculated reactivity difference was -0.086% Δ K/K.

This satisfies ± 1% Δ K/K acceptance criteria.

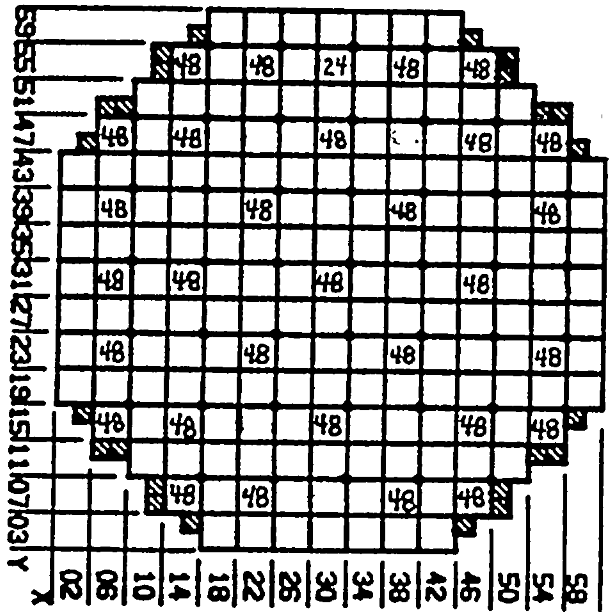
A comparison of the predicted versus actual critical control rod patterns is included as Figure 3.

FIGURE 3. COMPARISON OF PREDICTED VS ACTUAL CRITICAL ROD PATTERNS

PREDICTED CRITICAL PATTERN



ACTUAL CRITICAL PATTERN



BLANKS INDICATE RODS AT 00

Susquehanna Unit 2

Cycle 5

Test No. 6

Control Rod Scram Time Testing

Purpose

To demonstrate the maximum scram insertion times of all rods following core alterations.

Criteria

Susquehanna Technical Specification 4.1.3.2 states that scram insertion times of all control rods shall be demonstrated through measurement with reactor coolant pressure greater than 950 psig prior to exceeding 40% thermal power after core alterations. For Unit 2 cycle 5, one-half of all control rod scram times were to be determined by performing a black-and-white scram from the B sequence and using GETARS scram data. The remaining rods were to be individually scram time tested.

Results

Control rod scram times for 96 rods were obtained through GETARS from the black-and-white scram performed 5/6/91. (B sequence). The remaining 89 rods were individually scram timed on 5/10/91. All scram times were within the acceptance criteria, as shown in Table 1.

	ROD	ROD POSITION	TIME AS FOUND	T.S. LIMIT
MAXIMUM INDIVIDUAL SCRAM INSERTION TIME T.S. 3.1.3.2	38-27	5	3.26	7.0
AVERAGE SCRAM INSERTION TIME OF OPERABLE RODS T.S. 3.1.3.3		45 39 25 05	0.29 0.60 1.32 2.41	0.43 0.86 1.93 3.49
AVERAGE SCRAM INSERTION TIME OF SLOWEST 2X2 ARRAY T.S. 3.1.3.4		45 39 25 05	0.31 0.64 1.44 2.65	0.45 0.92 2.05 3.70

TABLE 1: Results of Scram Time Testing of All Control Rods S2C5.

Susquehanna Unit 2

Cycle 5

Startup Test No. 7

Tip Asymmetry

Purpose

The purpose of this test is to check core symmetry by performing a statistical uncertainty analysis on the Traversing In-Core Probe (TIP) System. Also, by the performance of this test, the proper operation of the TIP system will be assured.

Criteria

The X^2 test of significance will be performed with the significance level fixed at 1%. The test will be performed utilizing an octant symmetric rod pattern at a power level greater than 75% of rated power. The startup test criteria for symmetric TIP differences is that the X^2 value calculated shall be less than the critical X^2 value. Since Susquehanna has 19 symmetric TIP pairs, the calculated X^2 value must be less than a critical X^2 value of 36.19 (as determined by ANF). If the calculated X^2 value exceeds the critical value, the instrumentation and data processing system should be reviewed for any problems which may contribute to abnormal TIP asymmetries. A second determination of X^2 should be then made. If the new measured value of X^2 exceeds the critical value, the fuel vendor shall be consulted and appropriate action taken to assure that a larger than anticipated TIP asymmetry does not adversely affect the safe operation of the reactor.

Results

A complete set of TIP data was obtained at the completion of the Susquehanna Unit 2 BOC5 Startup Testing Program at rated thermal power. The nodal TIP values (Nodes 3 through 22) were summed up for each symmetric TIP pair using equation 5.1 with the results summarized in Table 2. Using Equations 5.2 and 5.3, the variance and X^2 were calculated to be 6.08 and 3.21 respectively. The X^2 value of 3.21 is well within the 36.19 limit established by ANF and comparable to past values.

Table 2

Absolute Relative Difference

Symmetric TIP Pair	Absolute Relative Difference dm (equation 5.1)
1	2.60
2	- 0.18
3	- 2.92
4	4.02
5	4.21
6	1.42
7	- 5.91
8	5.16
9	-2.81
10	2.65
11	- 5.87
12	- 1.55
13	- 1.18
14	- 4.64
15	3.98
16	1.46
17	- 1.90
18	- 4.31
19	- 1.85

Equation 5.1

$$dm = \frac{100\,(Tml - Tm2)}{\frac{Tml + Tm2}{2}}$$

Note: $Tml = \sum_{K=3}^{22} T(k)$ for TIP1 and $Tm2 = \sum_{K=3}^{22} t(k)$ for TIP2

where TIP1 and TIP2 are symmetric TIP pairs

Equation 5.2 (Variance)

$$S^2TIPij = \frac{\sum_{M=1}^{19} dm^2}{38} = 6.08$$

Equation 5.3

$$X^2 = \frac{19\, S^2\, TIPij}{36} = 3.21$$

Susquehanna Unit 2

Cycle 5

Startup Program Summary

The following is a short summary of additional Reactor Engineering activities performed during the Startup Testing Program.

Thermal Limit Monitoring

Thermal Limits were checked throughout the startup period through review of the POWERPLEX core monitoring program, MONITOR, output. At no time did thermal limits exceed Technical Specification limits.

TIP System - OD-1 Performance

A full set of TIPS was run at 37% power to update the core power distribution before the first core performance calculation, MONITOR, was initiated. Subsequent TIP sets were performed at 60 and 100% power in conjunction with two LPRM calibrations. The LPRM currents were updated and the LPRM GAFS found to be within the acceptable range.

Power Distribution Comparison with Offline Monitoring

PP&L Nuclear Fuels Engineering (NFE) has been comparing its offline SIMULATE-E/PPL results (core power distribution, reactivity, TIP response calculations, thermal limits calculations, etc.) with the on-line POWERPLEX results for many cycles of both SSES Unit 1 and Unit 2 operation. Documented observed biases (magnitudes and trends) between the methodologies permit our confident use of the offline methods for bundle and core design, core follow documentation, and cycle behavior predictions. The Unit 2 Cycle 5 comparisons are consistent with those previous comparisons and shown in Figures 4 through 7.

Differences between the U2C5 SIMULATE-E cycle management predicted results and the actual SIMULATE-E core follow calculations reflect the differences between assumed operating conditions and actual operating conditions. These differences result primarily from target k-effective uncertainties and the shallow control blade notch position achieved in the cycle's first operating sequence. Using the beginning of U2C5 information provided, it can be seen that moving shallow control blades from notch position 40 to the predicted 42 would have provided considerably closer agreement to the cycle management results for the MAPRAT and FDLRX thermal limits. During the startup, xenon transient effects and fuel preconditioning (PCI) restraints impeded attainment of notch position 42.

POWERPLEX is the on-line core monitoring system. It calculates thermal limits using the Advanced Nuclear Fuels (ANF) XTG calculated power distribution as modified by information from the in-core neutron monitoring system. The differences between POWERPLEX and SIMULATE-E calculated thermal limits have been characterized and documented during the Unit 1 and Unit 2 Susquehanna operation. The U2C5 comparisons are typical of what was expected.

Core Flow Calibration

A core flow calibration was performed at 99% core flow. No adjustments to the jet pump and recirculation loop flow instrumentation were required.

Recirculation Loop Baseline Data Acquisition

Recirculation loop data was collected throughout the startup program to provide baseline data for plant performance monitoring in two loop and single loop operation. This data is used throughout the cycle during the performance of the Technical Specification Jet Pump Operability Surveillance.

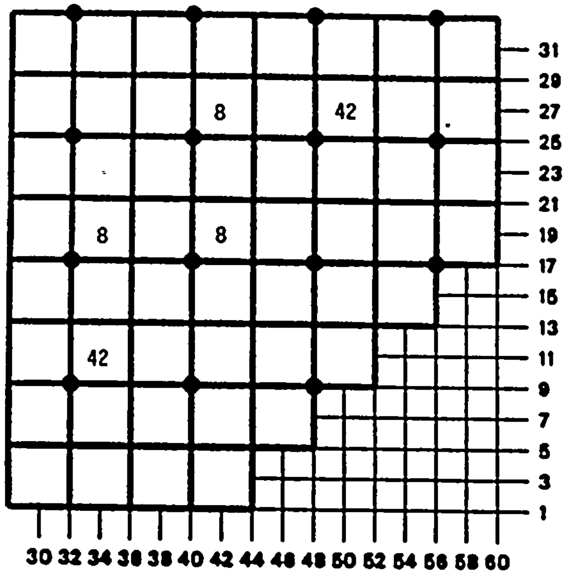
Figure 4

SUSQUEHANNA SES UNIT 2 CYCLE 5
CONTROL ROD PATTERN

** CYCLE MANAGEMENT DESIGN OPERATING CONDITIONS **

CONTROL ROD SEQUENCE: A1

CRITICAL EXPOSURE: 0.500 GWD/MTU



CORE POWER LEVEL 3293 MWth
TOTAL CORE FLOW 96.0 Mlb/hr

THERMAL MARGIN:

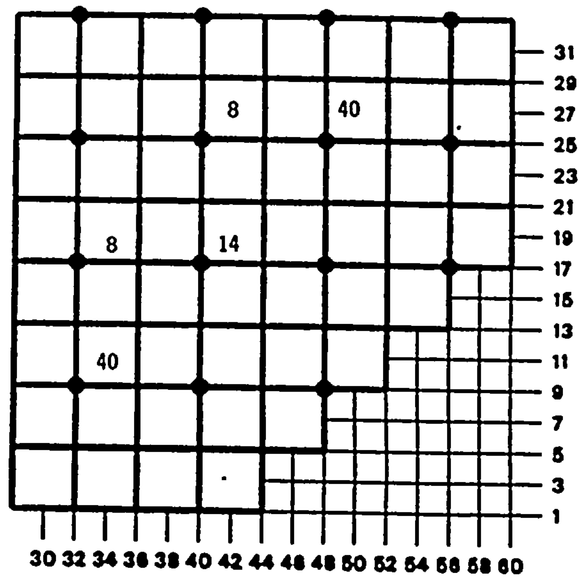
	MFLCPR	LOC	MAPRAT	LOC	FDLRX	LOC
SIM-E CM EXPECTED	.914	33-28	.916	51-26-5	.919	51-26-5

SUSQUEHANNA SES UNIT 2 CYCLE 5
CONTROL ROD PATTERN

** ACTUAL CORE FOLLOW OPERATING CONDITIONS **

CONTROL ROD SEQUENCE: A1

CRITICAL EXPOSURE: 0.513 GWD/MTU



CORE POWER LEVEL 3293 MWth
TOTAL CORE FLOW 98.0 Mlb/hr

THERMAL MARGIN:

	MFLCPR	LOC	MAPRAT	LOC	FDLRX	LOC
SIM-E CF EXPECTED	.909	33-28	.860	51-26-6	.863	51-26-6
POWERPLEX ACTUAL	.861	49-38	.876	51-36-6	.874	51-36-6

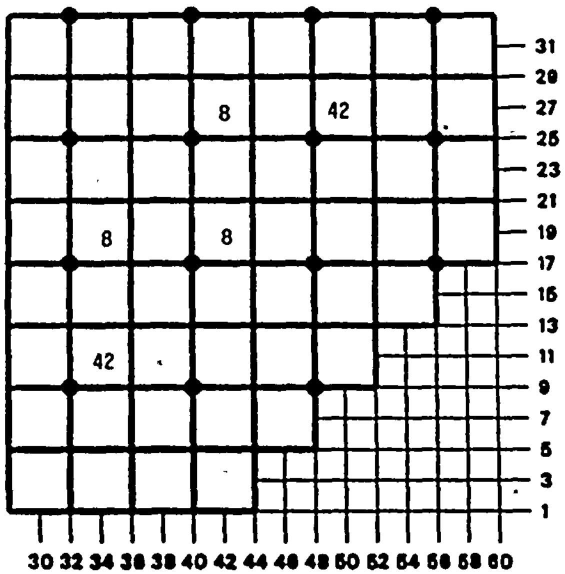
Figure 5

SUSQUEHANNA SES UNIT 2 CYCLE 5
CONTROL ROD PATTERN

** CYCLE MANAGEMENT DESIGN OPERATING CONDITIONS **

CONTROL ROD SEQUENCE: A1

CRITICAL EXPOSURE: 1.000 GWD/MTU



CORE POWER LEVEL 3293 MWth
TOTAL CORE FLOW 96.0 Mlb/hr

THERMAL MARGIN:

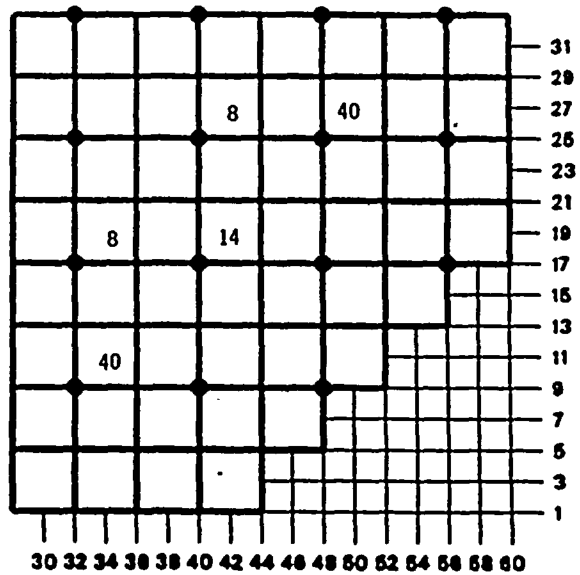
	MFLCPR	LOC	MAPRAT	LOC	FDLRX	LOC
SIM-E CM EXPECTED	.909	33-28	.910	51-26-6	.904	51-26-6

SUSQUEHANNA SES UNIT 2 CYCLE 5
CONTROL ROD PATTERN

** ACTUAL CORE FOLLOW OPERATING CONDITIONS **

CONTROL ROD SEQUENCE: A1

CRITICAL EXPOSURE: 0.962 GWD/MTU



CORE POWER LEVEL 3293 MWth
TOTAL CORE FLOW 98.2 Mlb/hr

THERMAL MARGIN:

	MFLCPR	LOC	MAPRAT	LOC	FDLRX	LOC
SIM-E CF EXPECTED	.904	33-28	.861	51-26-6	.854	51-26-6
POWERPLEX ACTUAL	.876	49-38	.897	51-36-6	.887	51-36-6

Figure 6

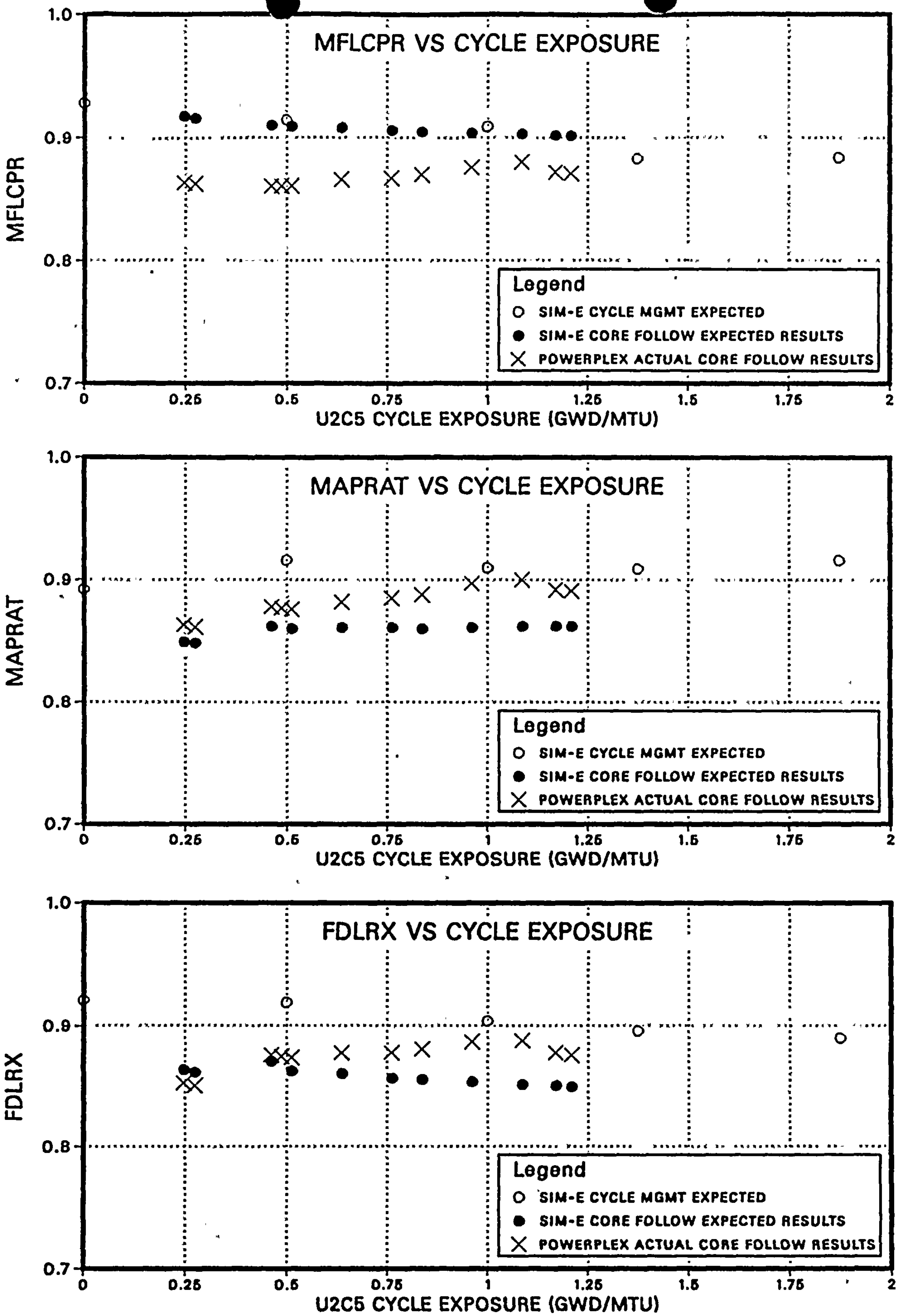
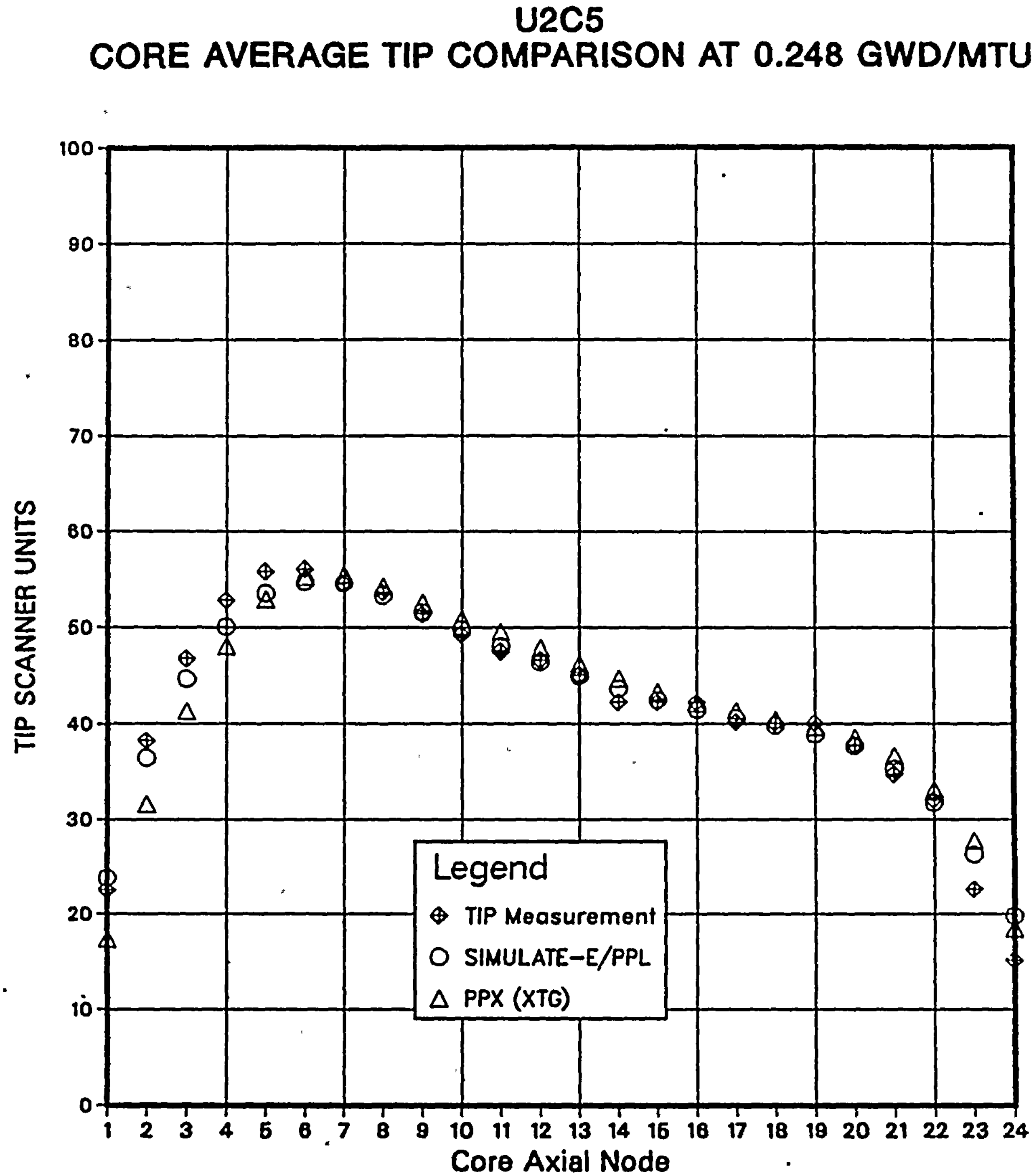

MFLCPR VS CYCLE EXPOSURE
MFLCPR
1.0
0.9
0.8
0.7
0
0.25
0.5
0.75
1
1.25
1.5
1.75
2
U2C5 CYCLE EXPOSURE (GWD/MTU)
Legend
SIM-E CYCLE MGMT EXPECTED
SIM-E CORE FOLLOW EXPECTED RESULTS
POWERPLEX ACTUAL CORE FOLLOW RESULTS
MAPRAT VS CYCLE EXPOSURE
MAPRAT
FDLRX VS CYCLE EXPOSURE
FDLRX

Figure 7


U2C5
CORE AVERAGE TIP COMPARISON AT 0.248 GWD/MTU
TIP SCANNER UNITS
100
90
80
70
60
50
40
30
20
10
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Core Axial Node
Legend
TIP Measurement
SIMULATE-E/PPL
PPX (XTG)