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SUSQUEHANNA STEAM ELECTRIC STATION
UNIT 1 CYCLE 11 STARTUP TEST SUMMARY
PLA-4979 FILE R41-2

Docket Nos. 50-387
and 50-388

The purpose of this letter is to submit the enclosed Startup Test Summary for Susquehanna SES Unit 1, Cycle 11. This report is submitted pursuant to Technical Specification 6.9.1.1.

If you have any questions, please contact Mr. J. M. Kenny at (610) 774-7535.

Sincerely,

R. G. Byram

Enclosure

copy: Regional Administrator, NRC Region I
Mr. K. M. Jenison, NRC Sr. Resident Inspector - SSES
Mr. V. Nerses, NRC Sr. Project Manager - OWFN

IE26 1/1

SUSQUEHANNA SES UNIT 1 CYCLE 11

STARTUP TEST SUMMARY

Prepared by: Paul J. Moran

Approved by: Robert N. Boesch

Approved by: K. V. Chambliss
Manager Nuclear Operations

ABSTRACT

Susquehanna Unit 1
Cycle11
Startup Test Summary

Susquehanna Unit 1 resumed commercial operation for Cycle 11 on June 5, 1998 following a refueling and maintenance outage. The Unit 1 Cycle 11 (hereafter referred to as S1C11) reload included:

4	ABB	10x10	once burned Lead Use Assemblies
16	SPC	9 x 9	thrice burned
200	SPC	9 x 9	twice burned
236	SPC	9 x 9	once burned
308	SPC	10 x 10	unirradiated fuel assemblies*

* First reload of SPC ATRIUM™-10 fuel at Susquehanna Unit 1

The following startup tests are discussed in this report:

1. Core Loading Verification
2. POWERPLEX®-II Input Deck Validation
3. Control Rod Testing (Insert and Withdrawal Checks)
4. In-Sequence Critical and Shutdown Margin Demonstration
5. Control Rod Scram Time Testing
6. TIP Asymmetry

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

Susquehanna Unit 1
Cycle 11
Startup Test No. 1
Core Loading Verification

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 (i.e. partial offload and core shuffle), 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.

Results:

Susquehanna took the following precautions to prevent a misloaded fuel bundle. During the partial core offload (to allow maintenance and subsequent core shuffle), 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 core shuffle. After the partial offload was complete, a serial number verification of these bundles was performed prior to commencing the core shuffle.

The Cycle 11 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 a member of the Reactor Engineering Group and a representative of Quality Control on 5/14/98. Subsequently cell 50-11 and some adjacent peripheral bundles had to be offloaded to facilitate in-vessel inspection of a shroud weld. The bundles that were removed were verified to have been properly reinserted (with respect to orientation, seating, and orientation) into the reactor core on 5/21/98.Therefore, the as-loaded core configuration is consistent with the core design Siemens Power Corporation and PP&L used in the evaluation of the S1C11 Reload Licensing Analyses. The S1C11 core map is included as Figure 1.

SSES UNIT-1/CYCLE-11 FULL CORE LOADING PATTERN.

PREPARED BY/DATE: [signature] 3/24/98 REVIEWED BY/DATE: R.M. Fox 3/24/98 APPROVED BY/DATE: [signature] 3/25/98
RECEIVED BY/DATE (SUPV REACT ENGRG) [signature]

CASE: 75 DATE STORED: 02/25/98 TITLE: SSES UNIT 1 CYCLE 11 REV 2 FULL CORE LOADING PATTERN

GE-Y/GE-X:	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29
60									S18670	S18662	S18686	S18690	S18750	S18650	S18814
58								S18778	S19035	S10379	S19978	S10375	S19854	S10371	S19930
56						A15162	S18806	S19946	S10367	S19886	S10363	S19842	S10359	S18710	S10355
54						S18638	S19003	S10351	S18678	S10347	S19023	S10343	S19039	S10339	S19974
52					A15074	S19071	S10335	S19998	S10331	S19878	S10327	S18834	S10323	S19027	S10319
50			A15126	S18654	S19067	S19910	S18802	S10315	S19015	S10311	S19906	S10307	S19838	S10303	S18770
48			A15102	S19011	S10299	S18786	ABBS01	S18674	S10295	S18706	S10291	S19850	S10287	S18642	S10283
46		S18790	S19962	S10279	S19954	S10275	S18726	S10271	S18766	S10267	S19926	S10263	S19882	S10259	S19051
44	S18698	S19043	S10255	S18798	S10251	S19047	S10247	S18762	S10243	S19862	S10239	S18782	S10235	S18746	S10231
42	S18666	S10227	S19970	S10223	S19914	S10219	S18794	S10215	S19902	S10211	S19942	S10207	S19031	S10203	S19846
40	S18714	S19866	S10199	S19019	S10195	S19894	S10191	S19870	S10187	S19938	S18718	S19958	S10183	S19934	S10179
38	S18742	S10175	S19858	S10171	S18738	S10167	S19898	S10163	S18730	S10159	S19922	S10155	S18754	S10151	S18830
36	S18694	S19918	S10147	S19055	S10143	S19966	S10139	S19994	S10135	S19007	S10131	S18734	S18818	S19982	S10127
34	S18646	S10123	S18758	S10119	S19063	S10115	S18658	S10111	S18722	S10107	S19950	S10103	S19890	S10099	S18774
32	S18682	S19990	S10095	S19986	S10091	S18810	S10087	S19059	S10083	S19874	S10079	S18702	S10075	S18822	S18826
30	S18685	S19993	S10098	S19989	S10094	S18813	S10090	S19062	S10086	S19877	S10082	S18705	S10078	S18825	S18829
28	S18649	S10126	S18761	S10122	S19066	S10118	S18661	S10114	S18725	S10110	S19953	S10106	S19893	S10102	S18777
26	S18697	S19921	S10150	S19058	S10146	S19969	S10142	S19997	S10138	S19010	S10134	S18737	S18821	S19985	S10130
24	S18745	S10178	S19861	S10174	S18741	S10170	S19901	S10166	S18733	S10162	S19925	S10158	S18757	S10154	S18833
22	S18717	S19869	S10202	S19022	S10198	S19897	S10194	S19873	S10190	S19941	S18721	S19961	S10186	S19937	S10182
20	S18669	S10230	S19973	S10226	S19917	S10222	S18797	S10218	S19905	S10214	S19945	S10210	S19034	S10206	S19849
18	S18701	S19046	S10258	S18801	S10254	S19050	S10250	S18765	S10246	S19865	S10242	S18785	S10238	S18749	S10234
16		S18793	S19965	S10282	S19957	S10278	S18729	S10274	S18769	S10270	S19929	S10266	S19885	S10262	S19054
14			A15105	S19014	S10302	S18789	ABBS04	S18677	S10298	S18709	S10294	S19853	S10290	S18645	S10286
12			A15129	S18657	S19070	S19913	S18805	S10318	S19018	S10314	S19909	S10310	S19841	S10306	S18773
10					A15077	S19074	S10338	S19002	S10334	S19881	S10330	S18837	S10326	S19030	S10322
8						S18641	S19006	S10354	S18681	S10350	S19026	S10346	S19042	S10342	S19977
6						A15165	S18809	S19949	S10370	S19889	S10366	S19845	S10362	S18713	S10358
4								S18781	S19038	S10382	S19981	S10378	S19857	S10374	S19933
2									S18673	S18665	S18689	S18693	S18753	S18653	S18817

FIGURE 1

** PENNSYLVA‥IA POWER & LIGHT - NUCLEAR FUELS & SYSTEMS ENGINEER
** CLASP - E LOADING AND SHUFFLE PROGRAM

RUN #98-8

PAGE 21.
02/25/98

SSES UNIT-1/CYCLE-11 FULL CORE LOADING PATTERN

PREPARED BY/DATE: [signature] 3/24/98 REVIEWED BY/DATE: R. M. Rose 3/24/98

APPROVED BY/DATE. [signature] 3/24/98
RECEIVED BY/DATE
(SUPV REACT ENGRG): Robert [signature]

CASE: 75 DATE STORED: 02/25/98 TITLE: SSES UNIT 1 CYCLE 11 REV 2 FULL CORE LOADING PATTERN

GE-Y/GE-X:	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59
60	S18815	S18651	S18751	S18691	S18687	S18663	S18671								
58	S19931	S10372	S19855	S10376	S19979	S10380	S19036	S18779							
56	S10356	S18711	S10360	S19843	S10364	S19887	S10368	S19947	S18807	A15163					
54	S19975	S10340	S19040	S10344	S19024	S10348	S18679	S10352	S19004	S18639					
52	S10320	S19028	S10324	S18835	S10328	S19879	S10332	S19999	S10336	S19072	A15075				
50	S18771	S10304	S19839	S10308	S19907	S10312	S19016	S10316	S18803	S19911	S19068	S18655	A15127		
48	S10284	S18643	S10288	S19851	S10292	S18707	S10296	S18675	ABBS02	S18787	S10300	S19012	A15103		
46	S19052	S10260	S19883	S10264	S19927	S10268	S18767	S10272	S18727	S10276	S19955	S10280	S19963	S18791	
44	S10232	S18747	S10236	S18783	S10240	S19863	S10244	S18763	S10248	S19048	S10252	S18799	S10256	S19044	S18699
42	S19847	S10204	S19032	S10208	S19943	S10212	S19903	S10216	S18795	S10220	S19915	S10224	S19971	S10228	S18667
40	S10180	S19935	S10184	S19959	S18719	S19939	S10188	S19871	S10192	S19895	S10196	S19020	S10200	S19867	S18715
38	S18831	S10152	S18755	S10156	S19923	S10160	S18731	S10164	S19899	S10168	S18739	S10172	S19859	S10176	S18743
36	S10128	S19983	S18819	S18735	S10132	S19008	S10136	S19995	S10140	S19967	S10144	S19056	S10148	S19919	S18695
34	S18775	S10100	S19891	S10104	S19951	S10108	S18723	S10112	S18659	S10116	S19064	S10120	S18759	S10124	S18647
32	S18827	S18823	S10076	S18703	S10080	S19875	S10084	S19060	S10088	S18811	S10092	S19987	S10096	S19991	S18683
30	S18828	S18824	S10077	S18704	S10081	S19876	S10085	S19061	S10089	S18812	S10093	S19988	S10097	S19992	S18684
28	S18776	S10101	S19892	S10105	S19952	S10109	S18724	S10113	S18660	S10117	S19065	S10121	S18760	S10125	S18648
26	S10129	S19984	S18820	S18736	S10133	S19009	S10137	S19996	S10141	S19968	S10145	S19057	S10149	S19920	S18696
24	S18832	S10153	S18756	S10157	S19924	S10161	S18732	S10165	S19900	S10169	S18740	S10173	S19860	S10177	S18744
22	S10181	S19936	S10185	S19960	S18720	S19940	S10189	S19872	S10193	S19896	S10197	S19021	S10201	S19868	S18716
20	S19848	S10205	S19033	S10209	S19944	S10213	S19904	S10217	S18796	S10221	S19916	S10225	S19972	S10229	S18668
18	S10233	S18748	S10237	S18784	S10241	S19864	S10245	S18764	S10249	S19049	S10253	S18800	S10257	S19045	S18700
16	S19053	S10261	S19884	S10265	S19928	S10269	S18768	S10273	S18728	S10277	S19956	S10281	S19964	S18792	
14	S10285	S18644	S10289	S19852	S10293	S18708	S10297	S18676	ABBS03	S18788	S10301	S19013	A15104		
12	S18772	S10305	S19840	S10309	S19908	S10313	S19017	S10317	S18804	S19912	S19069	S18656	A15128		
10	S10321	S19029	S10325	S18836	S10329	S19880	S10333	S19001	S10337	S19073	A15076				
8	S19976	S10341	S19041	S10345	S19025	S10349	S18680	S10353	S19005	S18640					
6	S10357	S18712	S10361	S19844	S10365	S19888	S10369	S19948	S18808	A15164					
4	S19932	S10373	S19856	S10377	S19980	S10381	S19037	S18780							
2	S18816	S18652	S18752	S18692	S18688	S18664	S18672								

FIGURE 1
(continued)

Susquehanna Unit 1
Cycle 11
Startup Test No. 2
POWERPLEX®-II Input Deck Validation

Purpose:

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

Criteria:

POWERPLEX®-II is the Siemens Power Corporation software system designed to perform in-core monitoring of BWR cores. Core monitoring is performed by the module, MICROBURN-B, a three-dimensional reactor simulation code which calculates bundle nodal powers. The POWERPLEX®-II input deck consists of all constants needed for the execution of this code and subsequent calculation of the margin to thermal limits. These constants 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 generated by Nuclear Fuels Engineering and validated/verified by members of the Reactor Engineering Group at Susquehanna.

Results:

The POWERPLEX®-II input deck was completely reviewed, verified to be correct and successfully loaded into the POWERPLEX®-II system prior to S1C11 startup.

Susquehanna Unit1
Cycle 11
Startup Test No. 3
Control Rod Testing (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 Testing includes mobility (friction and stroke time testing) and subcritical checks. Each control rod will be cycled individually to ensure mobility. As each rod is fully withdrawn, it also will be checked for overtravel by continually applying a withdrawal signal. Subcriticality will be verified with the rod withdrawn.

Results:

Control Rod Testing commenced after the core was fully loaded and verified. Subcriticality was maintained as each rod was individually fully withdrawn and reinserted. Stroke time and friction testing were successfully completed on all 185 rods.

Susquehanna Unit1
Cycle 11
Startup Test No. 4
In-Sequence Critical and SDM Determination

Purpose:

The purpose of this startup test is to calculate the actual shutdown margin of the Cycle 11 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, 0.38% 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 fully withdrawn from the reactor . 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 (for Cycle 11, R = 0% Δ K/K). The required beginning-of-cycle SDM for Susquehanna Unit 1 Cycle 11 is 0.38% Δ K/K; the actual SDM will be calculated from data obtained during the initial 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 1.4226% Δ K/K and the difference between actual Keff and predicted Keff at criticality was -0.0646% Δ K/K.

Control rods were withdrawn in the A sequence until the reactor was on a stable, positive period. Criticality occurred on rod 18-31 at notch 16, which was step 43 of the startup sequence. A special log was initiated to record SRM count rates and recirculation loop temperatures. The average period was 111 seconds and the average loop temperature was 128°F which yield period and temperature corrections of $0.5189 \times 10^{-3}\ \Delta$ K/K and $2.63 \times 10^{-3}\ \Delta$ K/K, respectively.

1. Shutdown Margin (SDM)

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 (1.00251) and Ksro is Keff predicted with the strongest rod out (0.985346).

The minimum required SDM for Unit 1 Cycle 11 at beginning-of-cycle was 0.38% Δ K/K; the calculated shutdown margin based on this test was 1.4226% Δ K/K, thus satisfying the acceptance criteria.

NOTE: The predicted shutdown margin provided by Nuclear Fuels Engineering was 1.488% Δ K/K

2. Reactivity Anomaly

The reactor went critical at step 43 with Kcrit of 1.00251. The equation used to calculate reactivity difference was

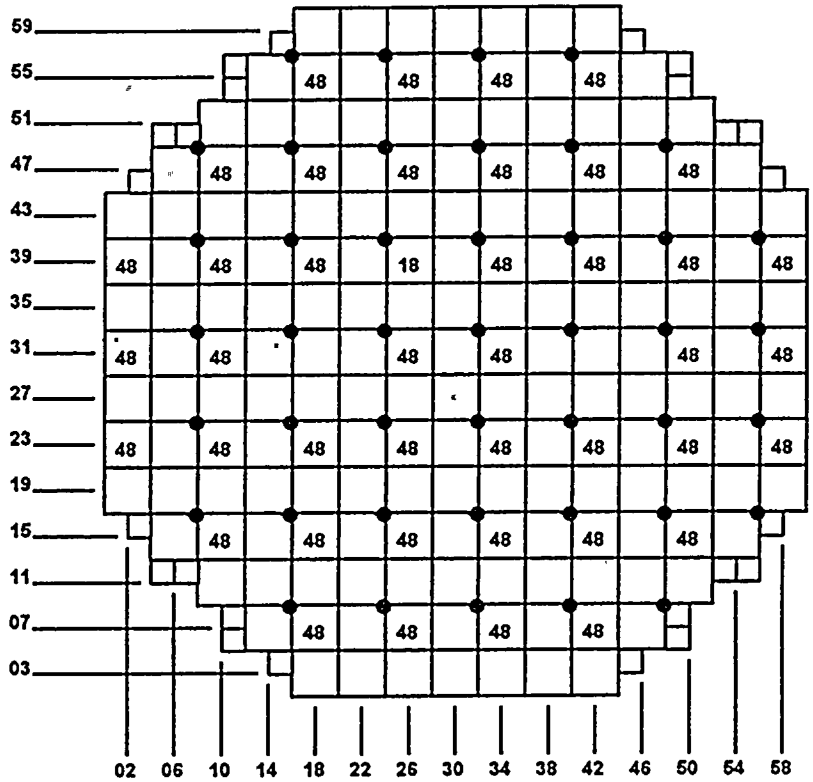
$$\text{Reactivity difference} = \frac{Kcrit - 1}{Kcrit} - \Delta\ p\ (period) - \Delta\ p\ (temp)$$

The calculated reactivity difference was -0.0646% Δ K/K. This satisfies ± 1% Δ K/K acceptance criteria.

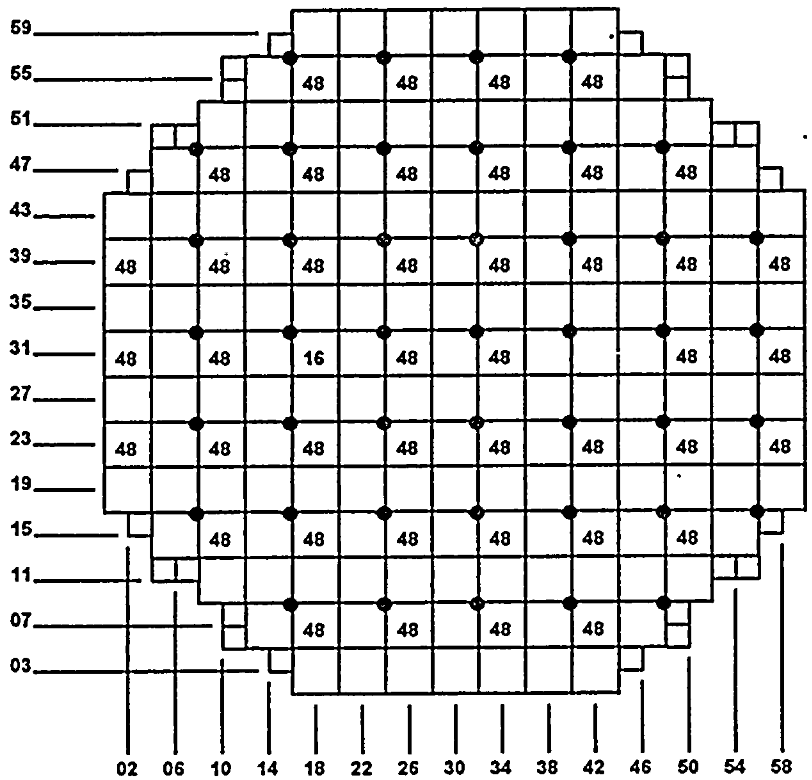
A comparison of the predicted versus actual critical control rod patterns is included as Figure 2.

FIGURE 2

COMPARISON OF PREDICTED VS ACTUAL CRITICAL ROD PATTERNS



PREDICTED CRITICAL PATTERN



ACTUAL CRITICAL PATTERN

BLANKS INDICATE RODS AT 00

Susquehanna Unit 1
Cycle 11
Startup Test No. 5
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.

Results:

Control rod scram times for 184 rods were obtained during the hydrostatic pressure test. Control rod 22-11 was not performed during the hydrostatic pressure test due to a leaky valve. Control rod 22-11 was scram timed prior to 40% thermal power as required by technical specifications. All scram times were within the acceptance criteria, as shown in Table 1.

	Rod	Rod Position	Time As Found	T.S. Limit
Maximum Individual Rod Scram Insertion Time T.S. 3.1.3.2	22-59	5	2.66	7.0
Average Scram Insertion Time Of Operable Rods T.S. 3.1.3.3		45 39 25 05	0.27 0.57 1.27 2.33	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	0.28 0.59 1.33 2.42	0.45 0.92 2.05 3.70

Table 1: Results of Scram Time Testing of All Control Rods BOC S1C11.

Susquehanna Unit 1
Cycle 11
Startup Test No. 6
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 Siemens Power Corporation). 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 then be made. If the new measured value of X^2 exceeds the critical value, Nuclear Fuels Engineering 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 Susquehanna Unit 1 BOC 11 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 6.21 and 3.3 respectively. The X^2 value of 3.3 is well within the 36.19 limit established by Siemens Power Corporation.

Table 2
Relative Difference

Symmetric TIP Pair	Relative Difference (dm)
1	-3.23
2	-5.46
3	2.99
4	0.56
5	-10.01
6	4.11
7	1.64
8	2.52
9	-2.32
10	0.45
11	-2.11
12	-2.00
13	3.67
14	1.06
15	-2.93
16	2.50
17	-2.58
18	-0.60
19	3.12

Equation 5.1

$$dm = \frac{100\,(Tm1 - Tm2)}{\frac{Tm1 + Tm2}{2}}$$

Note: $Tm1 = \sum_{K=3}^{22} T(k)$ for TIP1 and $Tm2 = \sum_{K=3}^{22} T(k)$ for TIP2

where TIP1 and TIP2 are symmetric TIP pairs

Equation 5.2 (Variance)

$$S^2TIPij = \sum_{M=1}^{19} \frac{dm^2}{38} = 6.21$$

Equation 5.3

$$X^2 = \frac{19\,S^2TIPij}{36} = 3.3$$

Susquehanna Unit 1
Cycle 11
Startup Program Summary

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

Reactivity and Thermal Limit Monitoring

Reactivity and thermal limits were monitored throughout the startup period. At no time were any Technical Specification limits exceeded.

TIP System - OD-1 Performance

A full set of TIPS was run at 38% power to update the core power distribution before the first core performance calculation, MONITOR, was initiated. Subsequent TIP sets were performed at 75% 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 Off-Line Monitoring

A comparison was performed between the off-line predictive method (SIMULATE-E/PPL) and actual TIP power distribution data (see Figure 3). As shown in Figure 3 the off-line core modeling data compared favorably with the actual core power distribution. No anomalies were observed for the new fuel/mixed core design.

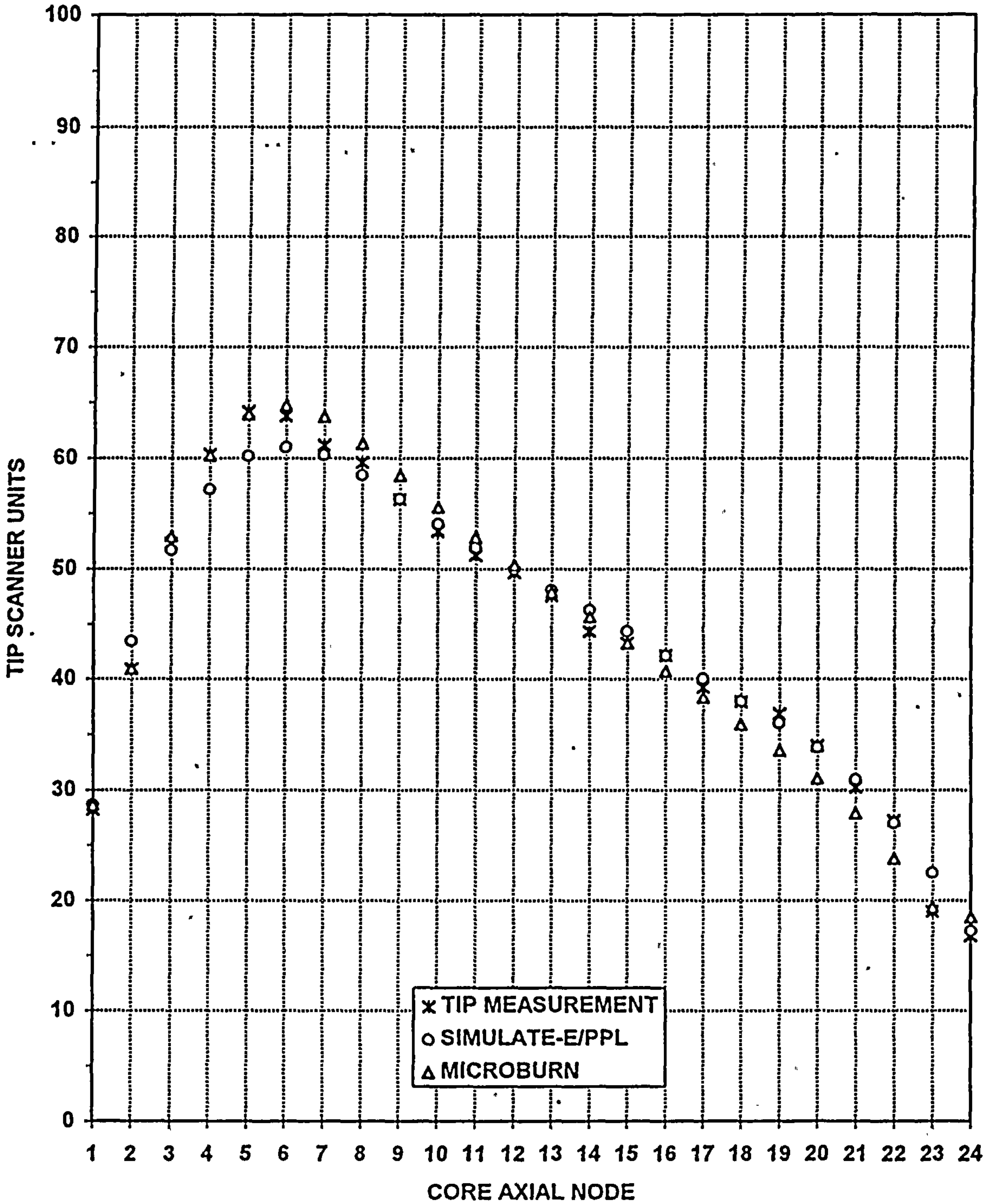
Core Flow Calibration

A core flow calibration was performed at ~100.0 Mlb/hr core flow. The Reference Drive Flow (WDr) for S1C11 was calculated to be 31.44 Mlb/hr.

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 operation. This data is used throughout the cycle during the performance of the Technical Specification Jet Pump Operability Surveillance.

FIGURE 3
U1C11
CORE AVERAGE TIP COMPARISON AT 00.426 GWD/MTU



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