CATEGORY 1

REGULATORY INFORMATION DISTRIBUTION SYSTEM (RIDS)

ACCESSION NBR:9708200146 DOC.DATE: 97/08/08 NOTARIZED: NO DOCKET #
FACIL:50-387 Susquehanna Steam Electric Station, Unit 1, Pennsylva 05000387
50-388 Susquehanna Steam Electric Station, Unit 2, Pennsylva 05000388

AUTH.NAME	AUTHOR AFFILIATION
FORGIE,J.B.	Pennsylvania Power & Light Co.
EMMETT,J.H.	Pennsylvania Power & Light Co.
BYRAM,R.G.	Pennsylvania Power & Light Co.

RECIP.NAME RECIPIENT AFFILIATION

SUBJECT: "Susquehanna Steam Electric Station Unit 2 Cycle 9 Startup Test Summary."

DISTRIBUTION CODE: IE26D COPIES RECEIVED:LTR 1 ENCL 1 SIZE: 22
TITLE: Startup Report/Refueling Report (per Tech Specs)

NOTES: 05000387

	RECIPIENT ID CODE/NAME	COPIES LTTR	COPIES ENCL	RECIPIENT ID CODE/NAME	COPIES LTTR	COPIES ENCL
	PD1-2 PD	1	1	POSLUSNY,C	1	1
INTERNAL:	ACRS	1	1	FILE CENTER	1	1
	NRR/DSSA/SRXB/B	1	1	RGN1 FILE 01	1	1
EXTERNAL:	NOAC	1	1	NRC PDR	1	1
NOTES:		1	1			

C A T E G O R Y 1 D O C U M E N T

NOTE TO ALL "RIDS" RECIPIENTS:
PLEASE HELP US TO REDUCE WASTE! CONTACT THE DOCUMENT CONTROL DESK, ROOM OWFN 5D-5(EXT. 415-2083) TO ELIMINATE YOUR NAME FROM DISTRIBUTION LISTS FOR DOCUMENTS YOU DON'T NEED!

TOTAL NUMBER OF COPIES REQUIRED: LTTR 9 ENCL 9

PP&L Pennsylvania Power & Light Company
Two North Ninth Street • Allentown, PA 18101-1179 • 610/774-5151

Robert G. Byram
Senior Vice President
Generation and Chief Nuclear Officer
610/774-7502
Fax: 610/774-5019

AUG 0 8 1997

U. S. Nuclear Regulatory Commission
Attn.: Document Control Desk
Mail Station P1-137
Washington, D.C. 20555

SUSQUEHANNA STEAM ELECTRIC STATION
UNIT 2 CYCLE 9 STARTUP TEST SUMMARY
PLA-4655 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 2, Cycle 9. 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.

Very truly yours,

R. G. Byram

IE26 1/1

Enclosure

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

SUSQUEHANNA SES UNIT 2 CYCLE 9

STARTUP TEST SUMMARY

Prepared by: J. Brian Forgie

Approved by: John H. Emmett

Approved by: Karl V. Chamberlin
Manager Nuclear Operations

ABSTRACT

Susquehanna Unit 2
Cycle 9
Startup Test Summary

Susquehanna Unit 2 resumed commercial operation for Cycle 9 on May 10, 1997 following a refueling and maintenance outage. The Unit 2 Cycle 9 (hereafter referred to as S2C9) reload included:

4	GE	10 x 10	once burned Lead Use Assemblies
244	SPC	9 x 9	twice burned
204	SPC	9 x 9	once burned
312	SPC	10 x 10	unirradiated fuel assemblies*

* First reload of SPC ATRIUM™-10 fuel at Susquehanna Unit 2

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. Subcritical Shutdown Margin Demonstration
5. Local Criticality Test
6. In-Sequence Critical and Shutdown Margin Demonstration
7. Control Rod Scram Time Testing
8. 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, as well as impacts due to new fuel/mixed core design (ATRIUM™-10 and 9 x 9-2), are also included in this report.

Susquehanna Unit 2
Cycle 9
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 9 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 4/17/97. Therefore, the as-loaded core configuration is consistent with the core design Siemens Power Corporation and PP&L used in the evaluation of the S2C9 Reload Licensing Analyses. The S2C9 core map is included as Figure 1.

SSES UNIT-2/CYCLE-9 FULL CORE LOADING PATTERN

APPROVED BY/DATE: [signature] 12/5/96
RECEIVED BY/DATE
(SUPV REACT ENGRG) [signature] 12/?/96

PREPARED BY/DATE: [signature] 11/25/96 REVIEWED BY/DATE: [signature] 12/4/96

CASE: 41 DATE STORED: 11/25/96 TITLE: SSES UNIT 2 CYCLE 9 FULL CORE LOADING PATTERN

GE-Y/GE-X:	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29
60									S26429	S26273	S26433	S26265	S26437	S26285	S26425
58								S26353	S27677	S28998	S27517	S28994	S27641	S28990	S27661
56						S26269	S26461	S27569	S28986	S26309	S28982	S26409	S28978	S27577	S28974
54						S26337	S27557	S28970	S27613	S28966	S27665	S28962	S27593	S28958	S26301
52					S26281	S27689	S28954	S27685	S28950	S27573	S28946	S27485	S28942	S27565	S28938
50			S26257	S26249	S27649	S28934	S26345	S28930	S26317	S28926	S26445	S28922	S26381	S28918	S26361
48			S26421	S27653	S28914	S26277	VJGEL1	S26457	S28910	S27489	S28906	S27657	S28902	S26377	S28898
46		S26241	S27681	S28894	S27541	S28890	S26465	S27525	S26253	S28886	S26325	S28882	S27673	S28878	S27625
44	S26441	S27493	S28874	S27609	S28870	S26389	S28866	S26397	S28862	S27581	S28858	S27645	S28854	S26369	S28850
42	S26261	S28846	S26305	S28842	S27497	S28838	S27509	S28834	S27505	S28830	S26401	S28826	S27553	S28822	S26469
40	S26449	S27669	S28818	S27513	S28814	S26481	S28810	S26341	S28806	S26293	S28802	S27501	S28798	S27549	S28794
38	S26297	S28790	S26453	S28786	S27597	S28782	S27605	S28778	S27617	S28774	S27589	S26385	S26405	S28770	S26289
36	S26473	S27529	S28766	S27545	S28762	S26393	S28758	S27621	S28754	S27521	S28750	S26477	S28746	S27561	S28742
34	S26357	S28738	S27637	S28734	S27537	S28730	S26245	S28726	S26349	S28722	S27533	S28718	S27601	S28714	S26365
32	S26417	S27585	S28710	S26329	S28706	S26373	S28702	S27629	S28698	S26413	S28694	S26313	S28690	S26321	S26333
30	S26420	S27588	S28713	S26332	S28709	S26376	S28705	S27632	S28701	S26416	S28697	S26316	S28693	S26324	S26336
28	S26360	S28741	S27640	S28737	S27540	S28733	S26248	S28729	S26352	S28725	S27536	S28721	S27604	S28717	S26368
26	S26476	S27532	S28769	S27548	S28765	S26396	S28761	S27624	S28757	S27524	S28753	S26480	S28749	S27564	S28745
24	S26300	S28793	S26456	S28789	S27600	S28785	S27608	S28781	S27620	S28777	S27592	S26388	S26408	S28773	S26292
22	S26452	S27672	S28821	S27516	S28817	S26484	S28813	S26344	S28809	S26296	S28805	S27504	S28801	S27552	S28797
20	S26264	S28849	S26308	S28845	S27500	S28841	S27512	S28837	S27508	S28833	S26404	S28829	S27556	S28825	S26472
18	S26444	S27496	S28877	S27612	S28873	S26392	S28869	S26400	S28865	S27584	S28861	S27648	S28857	S26372	S28853
16		S26244	S27684	S28897	S27544	S28893	S26468	S27528	S26256	S28889	S26328	S28885	S27676	S28881	S27628
14			S26424	S27656	S28917	S26280	VJGEL4	S26460	S28913	S27492	S28909	S27660	S28905	S26380	S28901
12			S26260	S26252	S27652	S28937	S26348	S28933	S26320	S28929	S26448	S28925	S26384	S28921	S26364
10					S26284	S27636	S28957	S27688	S28953	S27576	S28949	S27488	S28945	S27568	S28941
8						S26340	S27560	S28973	S27616	S28969	S27668	S28965	S27596	S28961	S26304
6						S26272	S26464	S27572	S28989	S26312	S28985	S26412	S28981	S27580	S28977
4								S26356	S27680	S28002	S27520	S28997	S27644	S28993	S27664
2									S26432	S26276	S26436	S26268	S26440	S26288	S26428

FIGURE 1

SSES UNIT-2/CYCLE-9 FULL CORE LOADING PATTERN

APPROVED BY/DATE: [signature] 12/5/96
RECEIVED BY/DATE (SUPV REACT ENGRG): [signature] Jan 7, 96

PREPARED BY/DATE: [signature] 11/25/96 REVIEWED BY/DATE: [signature] 12/4/96

CASE: 41 DATE STORED: 11/25/96 TITLE: SSES UNIT 2 CYCLE 9 FULL CORE LOADING PATTERN

GE-Y/GE-X:	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59
60	S26428	S26286	S26438	S26266	S26434	S26274	S26430								
58	S27662	S28991	S27642	S28995	S27518	S28999	S27678	S26354							
56	S28975	S27578	S28979	S26410	S28983	S26310	S28987	S27570	S26462	S26270					
54	S26302	S28959	S27594	S28963	S27666	S28967	S27614	S28971	S27558	S26338					
52	S28939	S27566	S28943	S27486	S28947	S27574	S28951	S27686	S28955	S27634	S26282				
50	S26362	S28919	S26382	S28923	S26446	S28927	S26318	S28931	S26346	S28935	S27650	S26250	S26258		
48	S28899	S26378	S28903	S27658	S28907	S27490	S28911	S26458	YJGEL2	S26278	S28915	S27654	S26422		
46	S27626	S28879	S27674	S28883	S26326	S28887	S26254	S27526	S26466	S28891	S27542	S28895	S27682	S26242	
44	S28851	S26370	S28855	S27646	S28859	S27582	S28863	S26398	S28867	S26390	S28871	S27610	S28875	S27494	S26442
42	S26470	S28823	S27554	S28827	S26402	S28831	S27506	S28835	S27510	S28839	S27498	S28843	S26306	S28847	S26262
40	S28795	S27550	S28799	S27502	S28803	S26294	S28807	S26342	S28811	S26482	S28815	S27514	S28819	S27670	S26450
38	S26290	S28771	S26406	S26386	S27590	S28775	S27618	S28779	S27606	S28783	S27598	S28787	S26454	S28791	S26298
36	S28743	S27562	S28747	S26478	S28751	S27522	S28755	S27622	S28759	S26394	S28763	S27546	S28767	S27530	S26474
34	S26366	S28715	S27602	S28719	S27534	S28723	S26350	S28727	S26246	S28731	S27538	S28735	S27638	S28739	S26358
32	S26334	S26322	S28691	S26314	S28695	S26414	S28699	S27630	S28703	S26374	S28707	S26330	S28711	S27586	S26418
30	S26335	S26323	S28692	S26315	S28696	S26415	S28700	S27631	S28704	S26375	S28708	S26331	S28712	S27587	S26419
28	S26367	S28716	S27603	S28720	S27535	S28724	S26351	S28728	S26247	S28732	S27539	S28736	S27639	S28740	S26359
26	S28744	S27563	S28748	S26479	S28752	S27523	S28756	S27623	S28760	S26395	S28764	S27547	S28768	S27531	S26475
24	S26291	S28772	S26407	S26387	S27591	S28776	S27619	S28780	S27607	S28784	S27599	S28788	S26455	S28792	S26299
22	S28796	S27551	S28800	S27503	S28804	S26295	S28808	S26343	S28812	S26483	S28816	S27515	S28820	S27671	S26451
20	S26471	S28824	S27555	S28828	S26403	S28832	S27507	S28836	S27511	S28840	S27499	S28844	S26307	S28848	S26263
18	S28852	S26371	S28856	S27647	S28860	S27583	S28864	S26399	S28868	S26391	S28872	S27611	S28876	S27495	S26443
16	S27627	S28880	S27675	S28884	S26327	S28888	S26255	S27527	S26467	S28892	S27543	S28896	S27683	S26243	
14	S28900	S26379	S28904	S27659	S28908	S27491	S28912	S26459	YJGEL3	S26279	S28916	S27655	S26423		
12	S26363	S28920	S26383	S28924	S26447	S28928	S26319	S28932	S26347	S28936	S27651	S26251	S26259		
10	S28940	S27567	S28944	S27487	S28948	S27575	S28952	S27687	S28956	S27635	S26283				
8	S26303	S28960	S27595	S28964	S27667	S28968	S27615	S28972	S27559	S26339					
6	S28976	S27579	S28980	S26411	S28984	S26311	S28988	S27571	S26463	S26271					
4	S27663	S28992	S27643	S28996	S27519	S28001	S27679	S26355							
2	S26427	S26287	S26439	S26267	S26435	S26275	S26431								

FIGURE 1 (continued)

Susquehanna Unit 2
Cycle 9
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, all comments resolved, verified to be correct and successfully loaded into the POWERPLEX®-II system prior to S2C9 startup.

Susquehanna Unit 2
Cycle 9
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. However, during testing two control rods overtraveled. Both rods recoupled successfully per Technical Specification requirements.

Susquehanna Unit 2
Cycle 9
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 (SDM) exists with the strongest worth control rod fully withdrawn.

Criteria:

The minimum required shutdown margin at beginning-of-cycle (BOC) for Susquehanna Unit 2 Cycle 9 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. Next, 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 1.062% Δ K/K. The required shutdown margin to be demonstrated was calculated to be 0.538% Δ K/K. This is 0.38% Δ K/K plus a correction factor for the recirculation loop (moderator) temperature (105°F) at the time of the test. Using data supplied by Nuclear Fuels Engineering it was determined that the following rods pulled to the indicated position would demonstrate a shutdown margin of at least 0.852% Δ K/K.

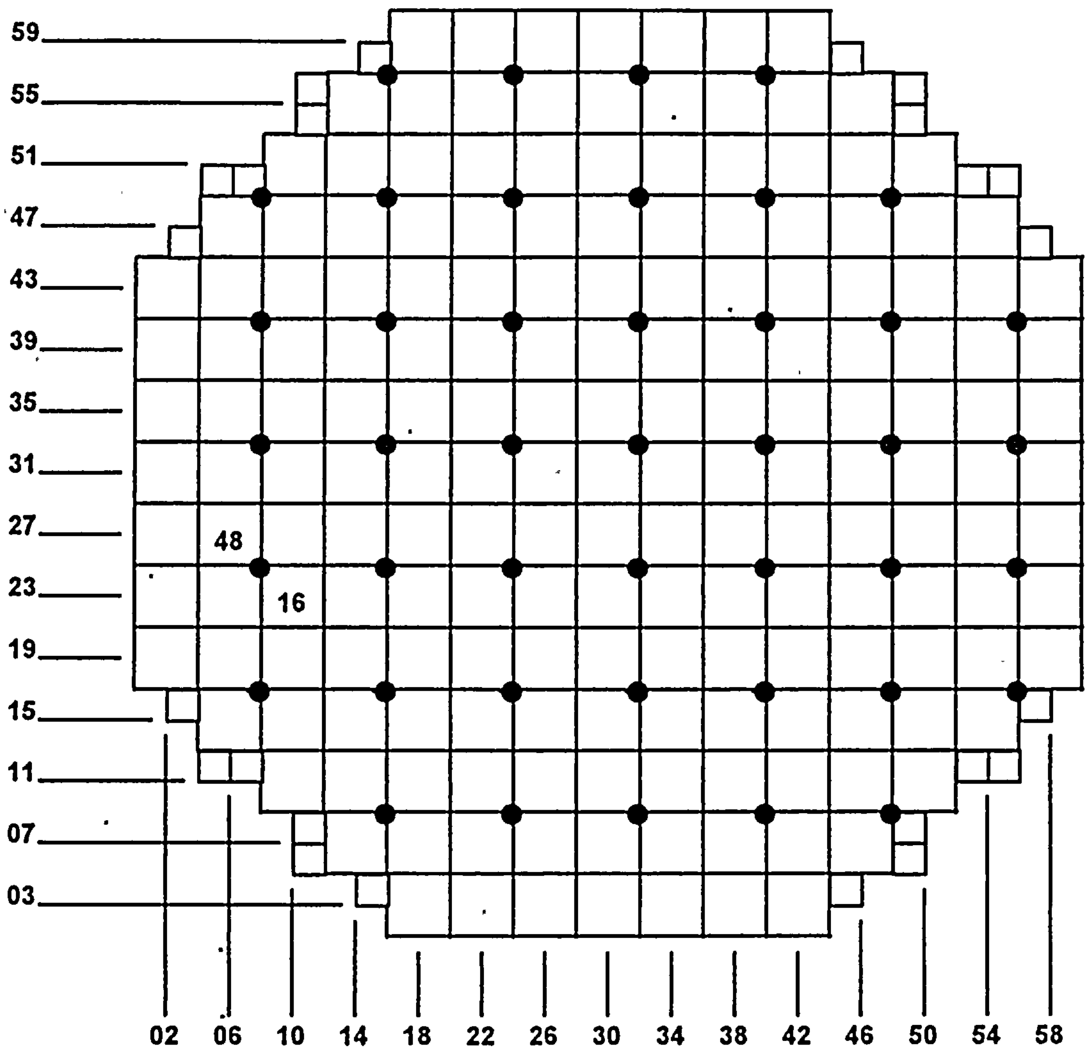
Rod	Position	Total Worth % Δ K/K
06-27*	48	--
10-23	16	1.062

* 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 9
Startup Test No. 5
Local Criticality Test

Purpose:

The purpose of the local criticality test is to obtain measured data against which the calculation of shutdown margin can be benchmarked for a new fuel design (i.e., for S2C9-SPC Atrium™-10 10 x 10 fuel assembly).

Criteria:

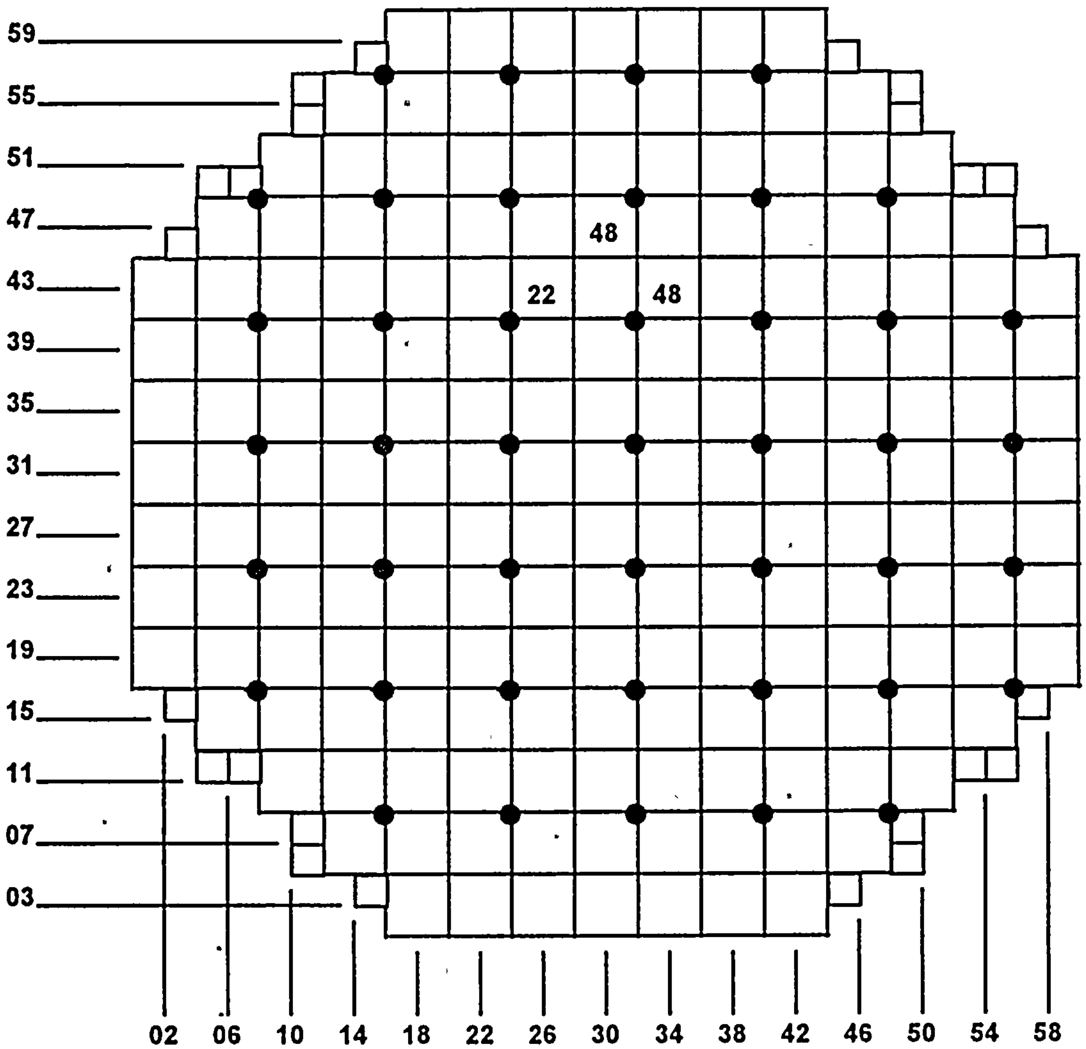
The local criticality test involves the withdrawal of up to three diagonally adjacent control rods to reach criticality in Condition 2. When criticality is achieved, the following data is recorded: test rod positions, reactor coolant temperature and reactor period. If criticality is not achieved within three rods, no data is required (i.e., indicates codes/methods are very conservative relative to shutdown margin calculations). Single notch restraint and a control rod notch-down method are utilized to minimize notch worths during the approach to criticality.

Results:

On May 8, 1997 the local criticality test was successfully performed on Unit 2. Figure 3 is the core map showing the test rod positions. The reactor coolant temperature and reactor period at criticality were ~131°F and 400 seconds, respectively. The subsequent evaluation performed by Nuclear Fuels Engineering indicated the reactivity difference (between predicted and actual) was conservative by 0.345% Δ K/K. This is less than the prediction uncertainty (±0.42% Δ K/K) and reactivity anomaly of ±1.0% Δ K/K.

FIGURE 3

CORE MAP SHOWING TEST ROD POSITIONS
FOR
LOCAL CRITICALITY TEST



BLANKS INDICATE RODS AT 00

Susquehanna Unit 2
Cycle 9
Startup Test No. 6
In-Sequence Critical and SDM Determination

Purpose:

The purpose of this startup test is to calculate the actual shutdown margin of the Cycle 9 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 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 a point in the cycle other than the initial shutdown margin (for Cycle 9, R = 0% Δ K/K). The required beginning-of-cycle SDM for Susquehanna Unit 2 Cycle 9 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 1.437% Δ K/K and the difference between actual Keff and predicted Keff at criticality was -0.094% Δ K/K.

Control rods were withdrawn in the A sequence until the reactor was on a stable, positive period. Criticality occurred on rod 34-23 at notch 24, which was step 41 of the startup sequence. A special log was initiated to record SRM count rates and recirculation loop temperatures. The average period was 138.5 seconds and the average loop temperature 153.0°F which yield period and temperature corrections of $0.43 \times 10^{-3}\ \Delta$ K/K and $3.783 \times 10^{-3}\ \Delta$ 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 (1.00328) and Ksro is Keff predicted with the strongest rod out (0.98492).

The minimum required SDM for Unit 2 Cycle 9 at beginning-of-cycle was 0.38% Δ K/K; the calculated shutdown margin based on this test was 1.437% Δ K/K, thus satisfying the acceptance criteria.

NOTE: The predicted shutdown margin provided by Nuclear Fuels Engineering was 1.531% Δ K/K

2. Reactivity Anomaly

The reactor went critical at step 41 with Kcrit of 1.00328. The equation used to calculate reactivity difference was

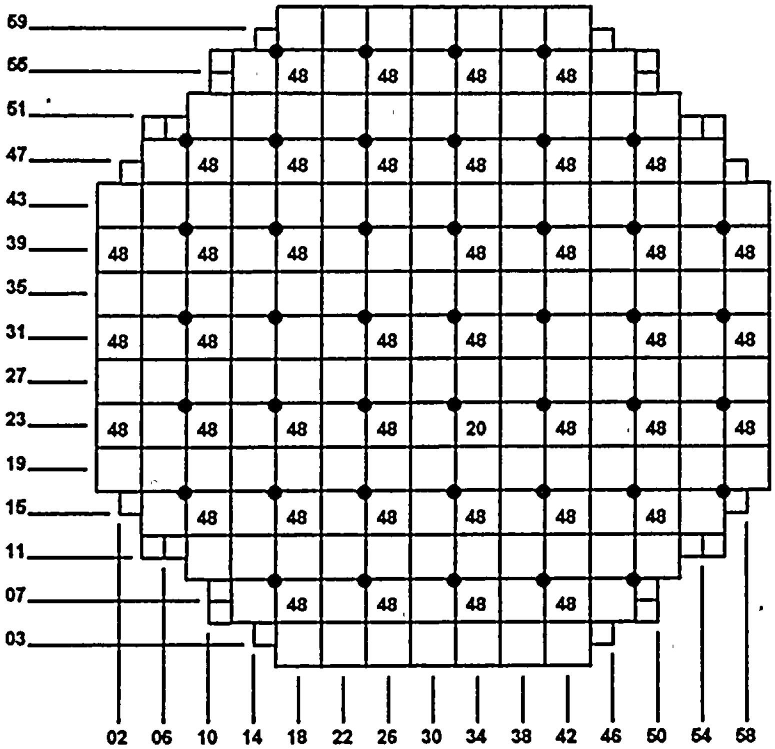
$$\text{Reactivity difference} = \frac{Kcrit - 1}{Kcrit} - \Delta\ p\ (period) - \Delta\ p\ (temp)$$

The calculated reactivity difference was -0.094% Δ K/K. This satisfies ± 1% Δ K/K acceptance criteria.

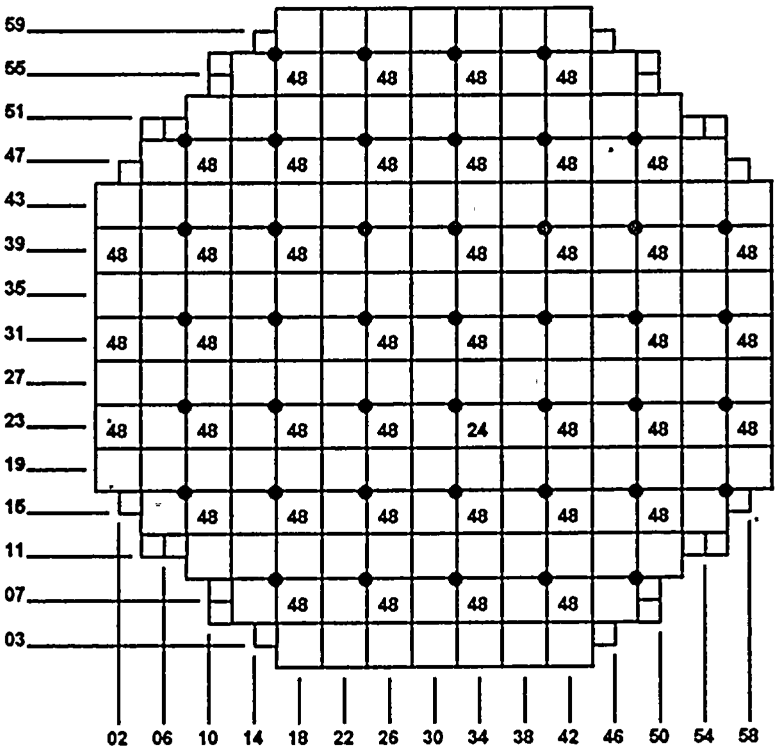
A comparison of the predicted versus actual critical control rod patterns is included as Figure 4.

FIGURE 4

COMPARISON OF PREDICTED VS ACTUAL CRITICAL ROD PATTERNS



PREDICTED CRITICAL PATTERN



ACTUAL CRITICAL PATTERN

BLANKS INDICATE RODS AT 00

Susquehanna Unit 2
Cycle 9
Startup Test No. 7
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 9 all control rod scram times were to be determined during the hydrostatic pressure test.

Results:

Control rod scram times for all 185 rods were obtained during the hydrostatic pressure test. 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	34-27	5	2.58	7.0
Average Scram Insertion Time Of Operable Rods T.S. 3.1.3.3		45 39 25 05	0.27 0.56 1.25 2.30	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 0.58 1.29 2.37	0.45 0.92 2.05 3.70

Table 1: Results of Scram Time Testing of All Control Rods S2C9.

Susquehanna Unit 2
Cycle 9
Startup Test No. 8
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 2 BOC9 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 5.89 and 3.1 respectively. The X^2 value of 3.1 is well within the 36.19 limit established by Siemens Power Corporation.

Table 2
Absolute Relative Difference

Symmetric TIP Pair	Absolute Relative Difference (dm)
1	0.87
2	0.85
3	1.68
4	2.76
5	5.27
6	0.60
7	-0.19
8	1.62
9	7.29
10	-5.98
11	1.86
12	1.65
13	4.93
14	6.06
15	-0.20
16	2.50
17	2.63
18	-0.34
19	3.38

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)

$$S^2TIPij = \sum_{M=1}^{19} \frac{dm^2}{38} = 5.89$$

Equation 5.3

$$X^2 = \frac{19\,S^2TIPij}{36} = 3.1$$

Susquehanna Unit 2
Cycle 9
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.

Specifically, a comparison was performed between the off-line predictive method (SIMULATE-E/PPL) and the on-line core monitoring system (POWERPLEX®-II). This comparison provides an indication of the off-line capability to predict the new fuel design (Atrium™-10) and mixed core (9 x 9-2 and Atrium™-10) behavior. The results are listed below (cycle exposure = 500 MWD/MT):

Core Parameter	Off-Line	On-Line	Delta
Target Rod Pattern	-	-	0 notches
Core Flow (Mlb/hr)	104	103	1
MFLCPR	0.867	0.891	-0.024
MAPRAT	0.806	0.810	-0.004
FDLRX	0.820	0.801	0.019

As shown in the table above, the off-line method accurately predicts the new fuel design and mixed core behavior.

TIP System - OD-1 Performance

A full set of TIPS was run at 48% 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 Off-Line Monitoring

A comparison was performed between the off-line predictive method (SIMULATE-E/PPL) and actual TIP power distribution data (see Figure 5). As shown in Figure 5 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 new Reference Drive Flow (WDr) for S2C9 was calculated to be 32.1 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 5
U2C9
CORE AVERAGE TIP COMPARISON AT 0.162 GWD/MTU