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Gentlemen:

HOPE CREEK CYCLE 10 STARTUP REPORT
HOPE CREEK GENERATING STATION
F0ACILITY OPERATING LICENSE NPF-57
DOCKET NO. 50-354

PSEG Nuclear LLC hereby submits a summary report of plant startup and power escalation testing for Hope Creek Cycle 10 in accordance with the requirements of Technical Specification 6.9.1.1. The report is required since fuel manufactured by a different fuel supplier was installed for Cycle 10. A description of the fuel design changes and the summary of testing are included in Attachment 1.

Should you have any questions regarding this report, please contact Mr. Paul Duke at (856) 339-1466.

Sincerely,

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Hope Creek Generating Station

Cycle 10
Startup Test Report

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1.0 Introduction

Hope Creek Generating Station transitioned from the General Electric GE9 fuel design to the Westinghouse BWR SVEA 96+ fuel design in cycle 10. The SVEA 96+ fuel is a 10x10 water cross design consisting of 96 fuel rods. The GE9 fuel is an 8x8 design with a large central water rod, consisting of 60 fuel rods. Hope Creek Technical Specification 6.9.1.1 requires a submittal of a startup report following the installation of fuel that has a different design, or has been manufactured by a different fuel supplier. This startup report will address each of the initial startup tests identified in the Final Safety Analysis Report that could be impacted by the introduction of a new fuel design.

The fuel transition project was performed over a three-year period, and included meetings at the NRC on 4/7/1998 and 2/25/1999 to provide updates on the status of the transition project. During the Hope Creek ninth refueling outage (RFO9) that began on 4/22/2000 and was completed on 5/24/2000, 232 SVEA 96+ fuel bundles were loaded. Additionally, the Core Monitoring System (CMS), the plant process computer and the Rod Worth Minimizer (RWM) were replaced during RFO9. The following sections provide a description of the test results for those initial startup tests described in the Hope Creek FSAR that were affected by the introduction of the SVEA 96+ fuel design.

2.0 Control Rod Drive System

The description of the initial startup testing for the control rod drive system is provided in the Hope Creek FSAR section 14.2.12.3.5. The operability of the control rod system may be impacted by the introduction of a new fuel design. The new fuel design could cause additional friction on control rod movement, which may impact the scram speeds.

2.1 Control Rod Scram Time

The control rod drive (CRD) scram times were measured in accordance with procedure HC.RE-ST.BF-0001(Q)," Control Rod Scram Time Surveillance". The objective of this test was to verify that the CRD scram times meet Technical Specification acceptance criteria. The measured scram times were compared against two acceptance criteria for the purpose of determining control rod drive system performance. The Technical Specification Scram Speeds (TSSS) are given in the Hope Creek Technical Specification 3.1.3.3, and the Nominal Scram Speeds (NSS) are given in Table 2.2-1 of the Hope Creek Generating Station Cycle 10 Core Operating Limits Report. The results from the test are provided in Table 1. The results indicate that the measured scram times are faster than the acceptance criteria which demonstrates that the introduction of the SVEA 96+ fuel design did not have an adverse effect on control rod drive system performance.

Table 1 Average Scram Times

Notch Position	Measured Core Average Scram Time (Seconds)		Technical Specification Scram Speed (Seconds)	Nominal Scram Speed (Seconds)
45	0.278	≤	0.43	0.36
39	0.576	≤	0.86	0.65
25	1.289	≤	1.93	1.35
05	2.381	≤	3.49	2.43

3.0 Full Core Shutdown Margin

The description of the initial startup testing for the full core shutdown margin demonstration is provided in the Hope Creek FSAR section 14.2.12.3.4. The core neutronic characteristics, and the ability of the vendor design tools to accurately model the core in cold conditions may be impacted by the introduction of a new fuel design. The Cycle 1 startup testing demonstrated that the shutdown margin was greater than 0.38% $\Delta k/k$, and the cold reactivity anomaly was within $\pm$ 1.0% $\Delta k/k$. In addition to the shutdown margin demonstration, and the reactivity anomaly check, the startup report will provide the results of local critical tests performed during the Cycle 10 startup, which were not performed during the initial Cycle 1 startup. The local critical tests were included to obtain data for the purpose of further evaluating the application of the vendor design and licensing methods to Hope Creek.

3.1 In-Sequence Criticals

The in-sequence critical was performed, by withdrawing the control rods in the Banked Position Withdrawal Sequence (BPWS), until criticality was achieved as part of the shutdown margin demonstration that was accomplished in accordance with procedure HC.RE-ST.ZZ-0007(Q), "Shutdown Margin Surveillance". The objective of the test was to evaluate the vendor's POLCA4 methods used in the design and licensing of cycle 10. The in-sequence critical test was performed on 5/22/2000 at a temperature of 215 F.

The results for each code at the critical control rod configuration are shown in Table 2. The BOC10 cold target k_{eff} is also provided in Table 2. The results show that the difference between the BOC10 cold target k_{eff} that was established by the vendor's methods, and the cold critical k_{eff} calculated during the test is within the expected range observed from previous Hope Creek in-sequence critical calculations. The differences are acceptable, and are within the data used to establish the Cycle 10 SDM design criteria.

Table 2 In-sequence Critical Results

Measurement	POLCA4
BOC Cold Target k_{eff} →	0.99850
In-sequence #1	1.00015

3.2 Local Criticals

Local critical measurements were performed in accordance with the following procedures HC.RE-RA.ZZ-0008(Q), "Shutdown Margin Test: Local Criticals", and NC.NA-AP.ZZ-0084(Q), "Infrequently Performed Test or Experiment". The objective of the test was to evaluate the vendor's POLCA4 methods used in the design and licensing of cycle 10 in calculating local critical configurations. The local critical measurements were performed at three core locations. The locations were chosen to provide a representative sample of the mixed core loading, and to test the radial dependency of the vendor's code package. The location of the first test was adjacent to a source range monitor (SRM), and was

loaded primarily with twice burned fuel assemblies. The location of the second test was also adjacent to an SRM, and was loaded with fresh, once burned, and twice burned fuel assemblies. The location of the third test was four fuel cell pitches away from an SRM on the periphery of the core, and was loaded with fresh and once burned fuel assemblies.

The results for each code at the critical control rod configuration are shown in Table 3. The BOC10 cold target k_{eff} is also provided in Table 3. The results show that the difference between the BOC10 cold target k_{eff}, and the calculated cold critical k_{eff} are within the expected range observed from previous Hope Creek in-sequence critical calculations. The differences are acceptable, and are within the data used to establish the Cycle 10 SDM design criteria.

Table 3 Local Critical Results

Measurement	POLCA4
BOC10 Cold Target k_{eff} →	0.99850
Local Test #1	0.99846
Local Test #2	0.99924
Local Test #3	1.00083

3.3 Shutdown Margin Demonstration

The core shutdown margin (SDM) was demonstrated in accordance with procedure HC.RE-ST.ZZ-0007(Q), "Shutdown Margin Surveillance". The objective of the test was to demonstrate that the core would remain subcritical by at least 0.38% Δk/k throughout the cycle at cold xenon free conditions, with the strongest worth control rod withdrawn. The core SDM was demonstrated during the first in-sequence critical. The demonstrated SDM was 1.53%, which meets the Technical Specification requirement of 0.38%.

3.4 Core Cold Reactivity Anomaly Evaluation

The core reactivity anomaly was evaluated in accordance with procedure HC.RE-ST.ZZ-0005(Q),"Reactivity Anomaly Surveillance". The objective of the test was to demonstrate that the core reactivity is within ± 1.0% Δk/k of the predicted core reactivity. The reactivity anomaly test was performed at cold conditions during the SDM demonstration. The predicted SDM was 1.37% and the demonstrated SDM was 1.53%, resulting in a difference of 0.16%. The result from the test was within the Technical Specification requirement of ±1.0% Δk/k.

4.0 Core Performance

The description of the initial startup testing to evaluate the core performance, with respect to thermal limits, is provided in the Hope Creek FSAR section 14.2.12.3.16. The objective of the test is to calculate the principal thermal and hydraulic parameters associated with core behavior. The initial test evaluated the thermal limits at various power levels, and compared the thermal limits at rated power to the predicted values in the cycle management report. The core performance tests and evaluations performed

during the cycle 10 power ascension were the hot reactivity anomaly evaluation, thermal limits evaluation and core thermal hydraulics evaluation.

4.1 Core Hot Reactivity Anomaly Evaluation

The core reactivity anomaly was evaluated in accordance with procedure HC.RE-ST.ZZ-0005(Q),"Reactivity Anomaly Surveillance". The objective of the test was to demonstrate that the core reactivity is within $\pm$ 1.0% $\Delta k/k$ of the predicted core reactivity. The hot reactivity anomaly test was performed at 80% power equilibrium conditions at a cycle exposure of 694 Mwd/Mtu. The predicted k_{eff} was 0.9997, and the monitored k_{eff} from the CMS was 1.0002, resulting in a difference of 0.05%. The result from the test was within the Technical Specification requirement of $\pm$1.0% $\Delta k/k$.

4.2 Thermal Limits

The thermal limits, given in Table 4, were obtained from the Core Monitoring System (CMS) during the BOC power ascension. The thermal limits were of an acceptable magnitude at each power and flow condition, and trended as expected for the actual power, flow and control rod pattern conditions experienced during the startup.

Table 4 CMS Thermal Limits

Date/Time	Power (%)	Flow (%)	MFLCPR	MFLPD	MAPRAT
6/22/2000 21:31	22.9	39.8	0.629	0.248	0.241
6/23/2000 05:06	32.3	41.7	0.518	0.384	0.374
6/23/2000 08:14	40.2	55.4	0.527	0.435	0.424
6/23/2000 13:22	50.3	55.0	0.594	0.499	0.504
6/25/2000 17:40	61.7	54.4	0.658	0.580	0.584
6/25/2000 23:31	75.2	73.8	0.660	0.649	0.652
6/26/2000 18:27	89.6	92.4	0.737	0.659	0.717
6/29/2000 12:34	99.8	98.4	0.726	0.838	0.813

The thermal limits at full power conditions were compared against the predicted values from the Startup and Operations Report as shown in Table 5. The CMS data was obtained from an edit generated on 8/7/2000 23:11, at a cycle exposure of 953 Mwd/Mtu. The differences are acceptable, and are within the Cycle 10 design margin criteria specified by PSEG.

Table 5 Startup and Operations Report Predictions to CMS Thermal Limits Comparison

	Startup and Operations Report		CMS
Exposure Mwd/Mtu	550	1100	953
MFLCPR	0.744	0.747	0.729
MFLPD	0.797	0.756	0.793
MAPRAT	0.794	0.755	0.789

4.3 Core Thermal Hydraulic Evaluation

The introduction of the SVEA 96+ fuel design into the Hope Creek core has the potential to affect the thermal-hydraulic performance of the core. One of the vendor's thermal-hydraulic design bases is that the SVEA 96+ reload fuel will be hydraulically compatible with the resident GE9 fuel. The basis being that by ensuring hydraulic compatibility of

the loaded fuel assemblies, the core thermal-hydraulic performance will remain unchanged by the introduction of the new fuel design.

The core thermal-hydraulic performance evaluation is comprised of the following activities:

- A comparison of the measured and predicted Core Support Plate Pressure Drop.
- A comparison of the measured Core Support Plate Pressure Drop between cycle 10 and cycle 9 startup.
- A comparison of recirculation system loop data that was recorded during the startups of cycle 9 and 10.

4.3.1 Core Support Plate Pressure Drop Comparison

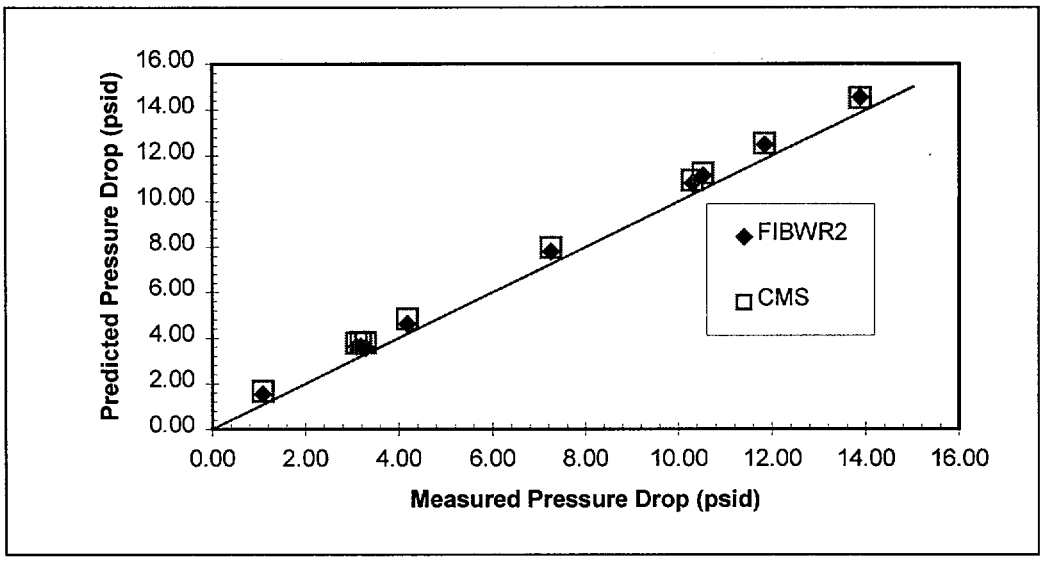
Steady state thermal-hydraulic calculations were performed with the computer code FIBWR2, and the CMS POLCA7 computer code at various operating conditions during the cycle 10 startup. The FIBWR2 code and the vendor's CONDOR code (CONDOR has a thermal hydraulic model that is equivalent to the CMS POLCA7 code) were the design tools used to ensure hydraulic compatibility in the design of the Hope Creek Cycle 10 SVEA 96+ fuel assembly. A good comparison between the predicted and measured core support plate pressure drops provides evidence that the fuel assemblies are hydraulically compatible.

The operating conditions, the measured data and the calculated results are presented in Table 6. The results show excellent agreement between the measured and predicted pressure drops. FIBWR2 and the CMS predicted the core support plate pressure drop with an average difference of 0.51 psid and 0.63 psid with a standard deviation of 0.11 psid and 0.06 psid respectively. Figure 1 presents a graphical representation of the results presented in Table 6. Figure 1 shows that the design tools over-predict the pressure drop consistently over the evaluated power and flow operating range. This bias was an expected attribute of the conservatisms that were assumed in developing thermal hydraulic models to describe the GE9B fuel. Since the pressure drop is over-predicted, any impact on MCPR will be conservative.

Table 6 Core Support Plate Pressure Drop Comparison

Power (% Rated)	Flow (% Rated)	Measured (psid)	FIBWR2 – Predicted (psid)	CMS - Predicted (psid)
32.2818	41.6922	1.0864	1.5502	1.66971
44.823	55.0947	3.0991	3.6201	3.7783
48.5984	55.1899	3.1851	3.6248	3.79946
54.0615	54.1768	3.2893	3.5766	3.79033
65.147	58.6938	4.1859	4.6097	4.8313
74.6598	73.833	7.2526	7.7931	7.96164
86.608	87.1211	10.5268	11.1288	11.2232
89.5712	92.3732	11.8431	12.4764	12.5187
90.7555	84.4894	10.2965	10.7834	10.9114
99.3882	97.9528	13.8814	14.5392	14.521

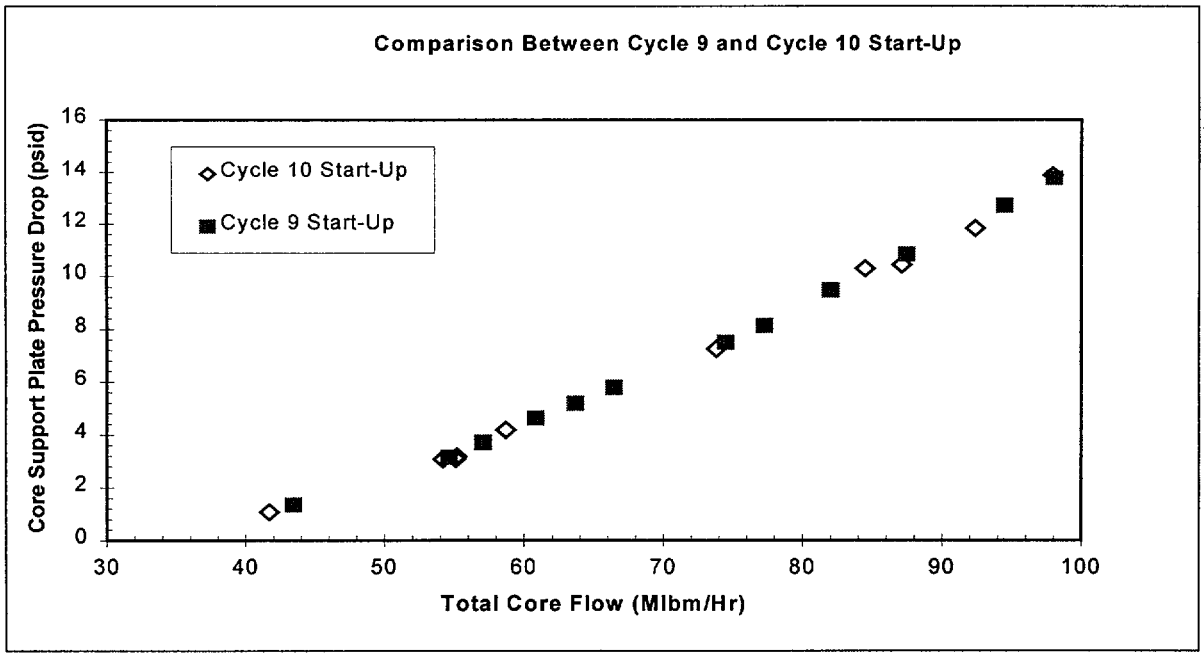
Figure 1 Predicted versus Measured Core Support Plate Pressure Drop



4.3.2 Cycle 9 and 10 Measured Core Support Plate Pressure Drop Comparison

The measured core support plate pressure drops, obtained during the cycle 9 and 10 startups, are shown in Figure 2. The measured data provide further evidence that the thermal-hydraulic performance of the Hope Creek core has not been affected by the introduction of the SVEA 96+ fuel design. The excellent comparison is indicative of the hydraulic compatibility of the two fuel designs.

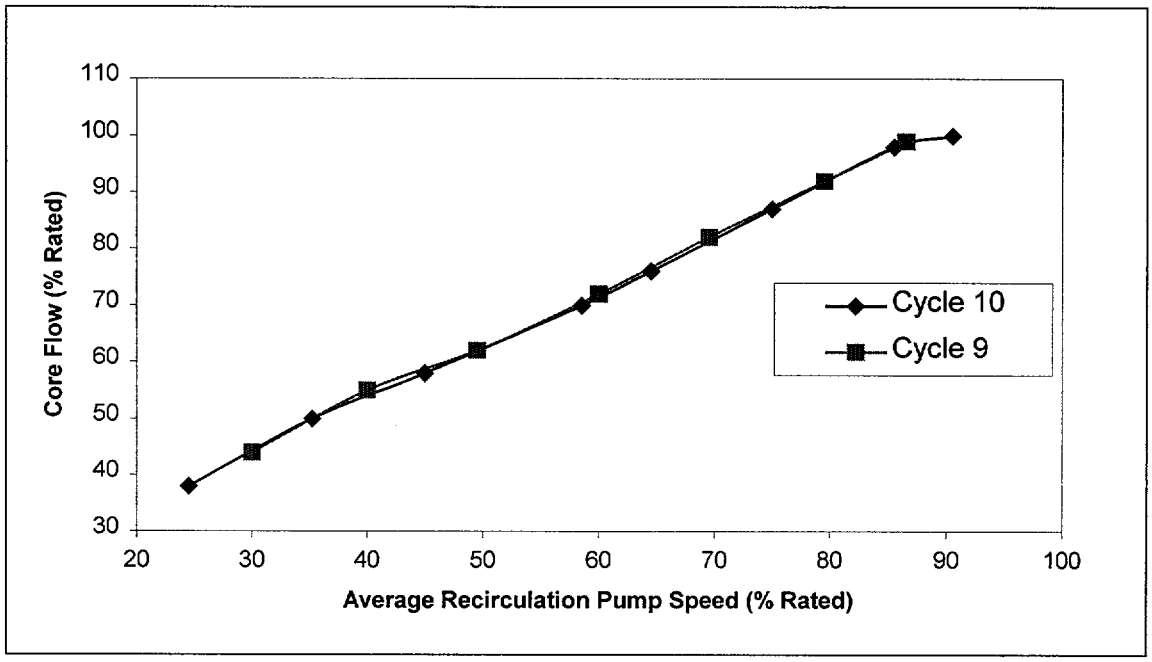
Figure 2 Cycle 9 and Cycle 10 Measured Core Support Plate Pressure Drop



4.3.3 Cycle 9 and 10 Recirculation Pump Speed to Core Flow Comparison

During reactor startup, data is recorded at various pump speeds in accordance with procedure HC.OP-FT.BB-0001 (Q), "Jet Pump Data Acquisition". The cycle 9 and 10 data is provided in Figure 3, and shows that similar recirculation pump speeds are producing the same total core flow. This shows no anomalous behavior of the recirculation control system. Similar recirculation control system performance indicates that the core thermal-hydraulics has not been affected by the introduction of the SVEA 96+ fuel assembly. This indicates that the overall hydraulic resistance of the core has not changed, which is the result of having hydraulically compatible fuel loaded in the core.

Figure 3 Cycle 9 and 10 Core Flow versus Pump Speed



5.0 NSSS Process Computer

The description of the initial startup testing to evaluate the performance of the process computer under plant operating conditions is provided in the Hope Creek FSAR section 14.2.12.3.11. The plant process computer (PPC) heat balance, and the CMS thermal limit results (thermal limit performance discussed in Section 4.2 of this report) were tested during the cycle 10 BOC power ascension.

5.1 Alternate Indication of Reactor Power

The PPC heat balance program was evaluated in accordance with procedure HC.RE-FT.ZZ-0002(Q),"Alternate Indication of Reactor Power". The objective of the test is to compare the results from the PPC heat balance program to the results of a manual heat balance. The results are shown in Table 7 at 22%, 83%, and 99% power, and were determined to be acceptable in accordance with the procedural requirements.

In addition to comparing core thermal power, inputs into the heat balance such as feedwater flow, and feedwater temperature, were also compared, and the comparisons were determined to be acceptable.

Table 7 PPC and Manual Heat Balance Results

Date/Time	PPC Heat Balance (Mwt)	Manual Heat Balance (Mwt)
6/22/2000 1140	732.2	740.4
6/26/2000 2300	2928.6	2923.1
6/28/2000 0205	3269.1	3273.2

6.0 References

6.1 NFS-0185, HCGS Cycle 10 Evaluation of the FSAR Chapter 14 Initial Cycle Startup Tests.

6.2 NFS-0181, Hope Creek Generating Station, Core Operating Limits Report, Cycle 10 / Reload 9.

6.3 NFVD-AB-2000-003, HCGS Cycle 10 Core Design Report.

6.4 NFVD-AB-2000-008, HCGS Cycle 10 Startup and Operations Report.

6.5 HCA.6-0019, Cycle 10 Startup Thermal Hydraulic Analysis.