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March 14, 1990

PG&E Letter No. DCL-90-074

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555

Re: Docket No. 50-275, OL-DPR-80
Diablo Canyon Unit 1
Unit 1 Cycle 4 Startup Report

Gentlemen:

Pursuant to Diablo Canyon Power Plant Technical Specifications 6.9.1.1 and 6.9.1.3, enclosed is a summary report of Diablo Canyon Unit 1 Cycle 4 startup and power escalation testing following installation of VANTAGE 5 fuel.

Kindly acknowledge receipt of this material on the enclosed copy of this letter and return it in the enclosed addressed envelope.

Sincerely,

J. D. Shiffer

cc: A. P. Hodgdon
J. B. Martin
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Enclosure

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ENCLOSURE

DIABLO CANYON POWER PLANT
UNIT 1 CYCLE 4 STARTUP REPORT

SUMMARY

Diablo Canyon Power Plant (DCPP) Technical Specification (TS) 6.9.1.1(3) requires that a summary report of plant startup and power escalation testing be submitted following installation of fuel that has a different design. TS 6.9.1.3(2) requires that this startup report be submitted within 90 days following resumption of commercial power operation. Pursuant to these technical specifications, this enclosure provides the DCPP Unit 1 Cycle 4 startup report following installation of VANTAGE 5 fuel. This is the first cycle using VANTAGE 5 fuel.

The DCPP Unit 1 Cycle 4 startup program extended from pre-critical testing through the completion of power ascension testing at 100 percent Rated Thermal Power (RTP). Significant milestones included:

Fourth cycle criticality: December 10, 1989

Commercial operation (breaker closure): December 15, 1989

Full power operation: December 31, 1989

The startup testing was divided into three phases: subcritical testing, low power physics testing, and power ascension testing. Results indicated little effect due to the change in fuel design.

UNIT 1 CYCLE 4 CORE

The DCPP Unit 1 Cycle 4 core is the first transition core leading to an all VANTAGE 5 fuel core in Cycle 6. Cycle 4 contains 137 standard Westinghouse 17 x 17 fuel assemblies that were irradiated in previous fuel cycles and 56 fresh Westinghouse VANTAGE 5 fuel assemblies (serial numbers F&FH series, see Figure 1). Compared to the standard assemblies, the VANTAGE 5 assemblies have slightly smaller diameter fuel rods and guide tubes, and contain three extra flow mixing grids, one each midway between four of the five upper grids. Cycle 4 VANTAGE 5 fuel assemblies also contain a burnable absorber coating on the outside of the fuel pellets in 2496 fuel rods, an axial blanket of natural uranium pellets at the top and bottom of each fuel column, and an improved bottom nozzle design known as the debris filter bottom nozzle.

The VANTAGE 5 fresh fuel assemblies and irradiated standard fuel assemblies are arranged in an octant - symmetric pattern (Figure 1). Westinghouse fuel designers used a random quadrant fuel shuffling routine to design the core and smooth out power tilts from previous cycles of operation. The core was designed with low power assemblies in the corners to cause a reduced fast neutron flux (low leakage core) at the reactor vessel wall.

After refueling for Cycle 4, underwater cameras were used to videotape assembly serial numbers. Two independent observers verified that the Cycle 4 core was correctly configured.

SUBCRITICAL TESTING

Several plant tests were conducted prior to initial cycle criticality. One of these, rod drop testing, measured the drop times of control rods from the initiation of a reactor trip to the time of rods entering the guide tube dash pots. Because of the smaller VANTAGE 5 guide tube diameters, the Technical Specification limit was changed from a maximum of 2.2 seconds (for standard fuel) to 2.7 seconds (for VANTAGE 5 or mixed cores). The average drop time that was observed was on the order of 1.4 to 1.5 seconds and showed little difference between the two types of fuel assembly (no more than about 10 percent).

LOW POWER PHYSICS TESTING PROGRAM

Objective

The objective of low power physics testing was to verify that the nuclear characteristics of the core were consistent with Westinghouse design calculations.

Methodology

Testing was performed in accordance with the following general sequence:

1. Approach to and achievement of initial criticality: First, all shutdown banks were withdrawn and then control banks were withdrawn to a Control Bank D position of 170 steps. Then an RCS dilution was executed until the core was within about 100 PCM of criticality. Finally, control rods were withdrawn until criticality was achieved.

2. Determination of physics testing flux level.

3. Reactivity computer on-line check.

4. All-rods-out (ARO) critical boron concentration measurement.

5. ARO Isothermal Temperature Coefficient (ITC) measurement: ITC was based on the reactivity change resulting from an RCS temperature change. Moderator Temperature Coefficient (MTC) was inferred from ITC.

6. Rod worth measurements using the "Rod Swap" method: Rod banks were interchanged and bank worths were inferred from the position of a "Reference Bank." The reference bank was first moved to the bottom of the core by dilution of the soluble boric acid in the reactor coolant system.

7. Calculation of boron worth.

Results

Because of a high gamma-to-neutron signal ratio due to the low leakage core design, a compensating current was applied to the neutron detectors to cancel the gamma component interference. This yielded test results that agreed well with predictions.

Low power physics results are summarized in Table 1. All acceptance and review criteria were met. Results indicated little or no effect due to changing fuel design.

POWER ASCENSION TEST PROGRAM

Objective

The main objectives of power ascension testing were to monitor core power distribution at various power levels and to recalibrate instrumentation for important plant parameters. This ensured that normal, full power operation could be reached and sustained while meeting all design requirements.

Methodology

Testing was performed at specified power plateaus. For Unit 1 Cycle 4, the primary test plateaus were 30, 50, 75, 90 and 100 percent RTP. Power level changes were governed by operating procedures and fuel pre-conditioning guidelines specified by Westinghouse, the fuel vendor.

To determine the steady state core power distribution, flux mapping was accomplished by use of the Movable Incore Detector System. To determine any limitations on further power ascension, the measured peaking factors were compared to Technical Specification limits. Also, thermal-hydraulic parameters, nuclear parameters, and related instrumentation were monitored throughout the power ascension. The major areas addressed were:

- Steam and feedwater flows: Flows were measured and correlated to verify calibration of the steam flow and feedwater flow transmitters. Subsequent corrections or calibrations were performed as necessary.

- RCS temperature: RCS temperatures and steam generator pressures were monitored to verify alignment of the RCS delta-T instrumentation, Tavg instrumentation, and the Tref program. Subsequent instrument adjustments were made as necessary to assure that appropriate delta-T power level signals were sent to the overpower delta-T (OPDT) and overtemperature delta-T (OTDT) trip circuitry. The need to reset or maintain the Tref program was based on extrapolated, full power steam generator pressures.

- RCS flow: A primary-side heat balance was performed concurrent with a secondary side heat balance and RCS flow was calculated from the data. RCS flow transmitters were scaled as necessary.

- Reactor power level: Secondary plant heat balance calculations were performed on a daily basis (more often if needed). If necessary, the nuclear instrumentation system (NIS) power indications were adjusted to agree with the heat balance.

- Incore/excore calibration: Through rod motion and a subsequent xenon oscillation, the core was operated with a variety of axial power shapes. Axial power distributions (in terms of axial offset and axial flux difference) calculated by the movable incore detectors then were related to currents from the upper and lower power range excore detectors. From this relationship, scaling factors were calculated and used to recalibrate the power range excore nuclear detectors.

Results

During Unit 1 Cycle 4 power ascension, core performance was acceptable. Flux maps were performed at 35, 50 and 100 percent power. The results are summarized in Table 2.

The initial flux map at 35 percent power showed an incore tilt of 1.028. Westinghouse was consulted and attributed the tilt to small differences in burnup and enrichment unrelated to the change in fuel design. They provided a revised position paper on core tilts. Westinghouse accepts core tilts above 1.02 and up to 1.04 as being within analyzed conditions. They recommend a normal ascension to full power as long as they evaluate any tilt over 1.02. The enthalpy hot channel factor (FDHN), measured at 35 percent power, was high enough to establish 96 percent as the maximum allowable power level for further ascension. All other flux map parameters were within limits.

Because of uncertainty about the core tilt and xenon and core stability during the first flux map, a second flux map was performed the next day at 35 percent power. Results confirmed the earlier observations.

Power ascension continued toward 75 percent power. However, due to quadrant power tilt ratio (QPTR) alarms and calculated excore tilts of over 1.02, operators were forced to reduce power to below 60 percent power. Prior to this, just enough time was spent at 73 percent power to allow one set of data to be gathered on feedwater and steam flows, RCS loop temperatures and flows, and steam generator pressures. From these data, it was noted that feedwater and steam flows were in agreement, RCS loop flows met all limits, loop delta-T's were scaled conservatively high by a few percent, and steam generator pressures were close to optimum. None of the associated instruments required immediate recalibration. There was no unexpected effect on the plant due to the change in fuel design.

A full core flux map was performed at 50 percent power as part of the incore-excore detector calibration test. Results are shown in Table 2. The data from the test were used to recalibrate excore nuclear instruments. Following recalibration, the QPTR alarm cleared and the unit core conditions were considered acceptable for power escalation. The full core flux map indicated that there was still an incore tilt of about 1.03 (Table 2). However, all peaking factors were within limits, and power ascension could continue as high as full power with no fuel-related limits.

The power level was escalated to 90 percent and held there for a few hours. A heat balance was performed and feedwater and steam flows, RCS loop temperatures, and steam generator pressure were checked. Results of the RCS loop temperature testing revealed that power level could be escalated to 97 percent without challenging delta-T protection setpoints. At 97 percent power, the RCS loop temperatures were determined and used to scale full power loop delta-T's. Once the delta-T instruments were rescaled, the unit was brought to full power.

At full power, a final set of data was gathered on feedwater and steam flows, RCS loop flows, RCS loop temperatures, and RCS Tref - first stage turbine pressure and steam generator pressure scalings. Results indicated that steam

flow transmitters had to be rescaled to a lower indicated flow by 2 to 5 percent. Also, as expected, the calculated RCS flow was slightly higher than in Cycle 3.

In addition, all RCS loop temperatures were in specification after the recalibration at 97 percent power. Finally, steam generator pressures were observed to be within a few psi of the optimum of 830 psia, and therefore rescaling of RCS Tref - first stage turbine pressure was not needed. Selected RCS thermal hydraulic data are shown in Table 3. Results were similar to previous cycles of operation.

A full power flux map revealed that incore tilt was reduced to 1.023 (Table 2). The power distribution (Figure 2) revealed that the tilt was generalized, asymmetric, and not related to the fuel design change. A follow-up map a few days later confirmed the 100 percent power distribution.

One peaking factor was in excess of limits, however. Total peaking factor (Fq) was in excess of its limit in the lower part of the core (Figure 2). The Technical Specifications permitted continued full power operation with a concurrent reduction in AFD limits to compensate for the elevated Fq. Fq for the first full power flux map exceeded its limits by a maximum of 2.14 percent. AFD limit curves were each redrawn closer together by about this amount. Two days later, the second flux map was performed to evaluate the accuracy of the previous map. Again Fq exceeded its limit, this time by a maximum of 2.73 percent. Again, AFD limit curves were redrawn closer together. Since the maximum Fq(z)/K(z) ratio had increased in the second flux map, Technical Specifications required the surveillance frequency for flux mapping to be increased from every 31 effective full power days (EFPD) to every 7 EFPD.

Westinghouse was consulted concerning the above-limit Fq. They explained that the operation of DCPP Unit 1 to the high end of the allowable Cycle 3 burnup caused the Cycle 4 core design to be right at Fq limits with no design margin at the beginning of cycle. The problems with Fq were unrelated to the change in fuel design, but rather were a function of the overall cycle core design. Fq was predicted to be fairly constant but decreasing slowly over the first few months of full power operation. Flux mapping is being used to monitor the changes in Fq to ensure that full power operation can continue within Fq limits.

TABLE 1

LOW POWER PHYSICS TEST RESULTS: UNIT 1 CYCLE 4

STP	ITEM	UNITS	TEST VALUE	PREDICTED VALUE	DIFFERENCE	REVIEW CRITERIA	ACCEPTANCE CRITERIA
R-30	RCS Boron at Criticality (Bank D at 185 steps)	PPM	1792	1801	-9(-71 PCM)	N/A	±1000 PCM
R-6	ARO Boron Endpoint	PPM	1804.5	1817	-12.5	N/A	±50
R-6	Bank D-in Boron Endpoint	PPM	1684	1691	-7	±50	N/A
R-7A	ITC (ARO)	PCM/°F	+.09	+.73	-.64	±2	N/A
	MTC (ARO)	PCM/°F	+1.61	+2.25	-.64	N/A	<+5
R-6	Boron Worth (ARO)	PCM/PPM	-8.19	-7.98	-3%	N/A	±15%
R-31	Control Bank D Worth	PCM	986	963	+2%	±10%	±15%
R-31	"SWAP" Worths						
	Shutdown Bank A	PCM	867	886	-2%		
	Shutdown Bank B	PCM	795	765	+4%	±15%	±30%
	Shutdown Bank C	PCM	345	340	+1.5%	±15%	±30%
	Shutdown Bank D	PCM	435	406	+7%	±15%	±30%
	Control Bank A	PCM	796	801	-1%	±15%	±30%
	Control Bank B	PCM	458	434	+5.5%	±15%	±30%
	Control Bank C	PCM	736	705	+4%	±15%	±30%
	Total	PCM	5418	5300	+2%	< +10%	> -10%

TABLE 2

POWER ASCENSION FLUX MAP RESULTS: UNIT 1 CYCLE 4

Date of Map	12-17-89	12-18-89	12-23-89	01-03-90	01-05-90
Power Level (%)	35	35	51	100	100
Bank D Position (Steps)	196	190	204	228	228
RCS Boron (PPM)	1512	1486	1411	1259	1252
Incore Tilt	1.028*	1.029*	1.0305*	1.023*	1.024*
FDHN (V5/Std.)	1.609**/1.364	1.606**/1.372	1.577/1.382	1.542/1.374	1.540/1.368
Fq	2.389	2.413	2.242	2.080+	2.093++
Fz	1.34[illegible]	1.337	1.230	1.230	1.230

* Westinghouse informed when greater than 1.02; no impact on safety analyses.

** Power level limit = 96%

\+ Fq over surveillance limit; AFD limits made more restrictive by 2.2%.

++ Fq over surveillance limit and increasing; AFD limits made more restrictive by 2.8% and flux map surveillance frequency increased from 31 EFPD to 7 EFPD.

TABLE 3

FULL POWER THERMAL - HYDRAULIC DATA: UNIT 1 CYCLE 4

Reactor Coolant System average temperature values*:

Loop 1: 571.7°F
Loop 2: 571.4°F
Loop 3: 572.5°F
Loop 4: 571.5°F

Average: 571.8°F

Reactor Coolant System core delta-T values:

Loop 1: 62.1°F
Loop 2: 60.0°F
Loop 3: 63.7°F
Loop 4: 61.3°F

Average: 61.8°F

Reactor Coolant System flows**:

Loop 1: 93,750 gpm
Loop 2: 91,370 gpm
Loop 3: 93,740 gpm
Loop 4: 94,010 gpm

TOTAL: 372,870 gpm (Tech. Spec. minimum 359,200 gpm)

* Cycle 3 reference temperature 572.8°F. This temperature maintains steam generator pressures at approximately 830 psia at full load. Final Tavg adjustments may be based on future turbine performance optimization.

** All thimble plugs removed from Unit 1 Cycle 4 core to compensate for slightly higher pressure drop and lower flow in VANTAGE-5 fuel assemblies.

DIABLO CANYON UNIT 1
CORE LOADING PLAN
CYCLE 4

180

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1					3 C48	4B D60H	5 E46	4A D32	5 E55	4B D65H	3 C16				
2			4A D34	3 C27	6B F02H	6B F18H	6B F10H	5 E50	6B F12H	6B F22H	6B F04H	3 C23	4A D40		
3		4A D19	6A F01	6B F24H	5 E21	5 E58	4A D35	6A F05	4A D09	5 E59	5 E14	6B F30H	6A F02	4A D21	
4		3 C18	6B F31H	5 E27	5 E73	5 E22	5 E28	5 E19	5 E37	5 E02	5 E65	5 E26	6B F19H	3 C19	
5	3 C46	6B F03H	5 E01	5 E70	4B D46H	6A F14	4B D63H	6A F09	4B D54H	6A F16	4B D49H	5 E69	5 E13	6B F06H	3 C35
6	4B D62H	6B F32H	5 E52	5 E17	6A F17	5 E61	5 E12	5 E68	5 E06	5 E71	6A F22	5 E10	5 E51	6B F20H	4B D45H
7	5 E49	6B F13H	4A D06	5 E23	4B D51H	5 E11	4B D47H	6A F23	4B D48H	5 E35	4B D53H	5 E20	4A D41	6B F14H	5 E47
8	4A D25	5 E41	6A F06	5 E40	6A F10	5 E76	6A F13	2 B18	6A F24	5 E72	6A F11	5 E34	6A F07	5 E42	4A D29
9	5 E44	6B F15H	4A D12	5 E30	4B D55H	5 E08	4B D50H	6A F15	4B D57H	5 E18	4B D56H	5 E33	4A D05	6B F09H	5 E60
10	4B D59H	6B F27H	5 E54	5 E25	6A F20	5 E64	5 E15	5 E67	5 E03	5 E66	6A F21	5 E36	5 E53	6B F28H	4B D58H
11	3 C17	6B F07H	5 E22	5 E62	4B D67H	6A F18	4B D68H	6A F12	4B D61H	6A F19	4B D66H	5 E75	5 E09	6B F01H	3 C56
12		3 C05	6B F25H	5 E32	5 E74	5 E04	5 E39	5 E24	5 E05	5 E38	5 E63	5 E31	6B F26H	3 C47	
13		4A D31	6A F03	6B F21H	5 E07	5 E48	4A D38	6A F03	4A D36	5 E43	5 E16	6B F23H	6A F04	4A D20	
14			4A D10	3 C02	6B F08H	6B F17H	6B F16H	5 E45	6B F11H	6B F29H	6B F02H	3 C32	4A D01		
15					3 C63	4B D64H	5 E57	4A D03	5 E56	4B D52H	3 C36				

90 (left side) / 270 (right side)

0 DEG.

KEY

R ID	R = REGION NUMBER ID = FUEL ASSEMBLY IDENTIFICATION

FUEL/REGION LOCATIONS

FIGURE 1

DCPP UNIT 1 1/ 3/90 3339.0 MW   470. MWD/MT 228.0 1MAP010390RUN404   01/03/90 12:01:18 DCIS7
INCORE 3.9.3.II PAGE-   249   COPYRIGHT WESTINGHOUSE ELECTRIC CORP.

MEASURED AND PERCENT. DIFF. OF FDHN

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
					0.315	0.455	0.550	0.443	0.546	0.451	0.306				
1					3.7	1.8	0.7	-0.6	-0.1	1.0	1.0				
			0.301	0.550	1.202	1.279	1.277	1.073	1.259	1.242	1.146	0.518	0.280		
2			4.7	4.6	3.7	2.0	0.8	-0.2	-0.5	-0.9	-1.1	-1.4	-2.7		
		0.296	1.045	1.319	1.190	1.189	1.040	1.368	1.023	1.113	1.123	1.255	0.989	0.276	
3		2.7	2.7	3.7	3.7	3.7	0.6	-0.2	-1.0	-2.9	-2.1	-1.4	-2.9	-4.1	
		0.535	1.296	1.198	1.165	1.141	1.080	1.146	1.065	1.092	1.121	1.141	1.231	0.503	
4		1.7	1.8	2.1	1.6	1.4	0.0	-0.9	-1.5	-2.9	-2.4	-2.8	-3.3	-4.2	
	0.311	1.185	1.168	1.170	1.076	1.335	0.986	1.301	0.959	1.271	1.026	1.107	1.130	1.146	0.310
5	2.5	2.3	1.8	1.9	1.9	2.1	0.8	-1.7	-2.0	-2.8	-2.8	-3.6	-1.5	-1.1	2.0
	0.464	1.290	1.166	1.143	1.335	1.215	1.223	1.201	1.199	1.182	1.293	1.096	1.136	1.246	0.456
6	3.8	2.9	1.7	1.6	2.0	1.0	0.7	-2.0	-1.3	-1.7	-1.2	-2.6	-1.0	-0.6	2.0
	0.566	1.308	1.057	1.107	1.002	1.238	1.093	1.382	1.082	1.219	0.975	1.073	1.035	1.275	0.553
7	3.7	3.3	2.3	2.4	2.4	1.9	1.4	1.2	0.4	0.4	-0.3	-0.6	0.1	0.7	1.3
	0.469	1.[illegible]17	1.419	1.188	1.359	1.249	1.385	1.086	1.365	1.219	1.315	1.145	1.368	1.067	0.443
8	4.0	3.9	3.5	2.7	2.6	1.9	1.5	0.4	0.0	-0.5	-0.7	-1.0	-0.2	-0.8	-1.7
	0.569	1.318	1.075	1.116	1.010	1.247	1.101	1.381	1.072	1.203	0.961	1.062	1.023	1.254	0.535
9	4.1	4.1	4.0	3.3	3.2	2.7	2.1	1.2	-0.5	-1.0	-1.8	-1.7	-1.0	-1.0	-2.0
	0.459	1.289	1.198	1.129	1.316	1.209	1.232	1.234	1.226	1.182	1.277	1.097	1.109	1.225	0.437
10	2.6	2.8	4.5	0.4	0.6	0.5	1.4	0.7	0.5	-1.7	-2.3	-2.5	-3.3	-2.3	-2.3
	0.306	1.166	1.156	1.150	1.053	1.311	0.986	1.329	0.975	1.278	1.019	1.107	1.097	1.152	0.302
11	0.8	0.7	0.8	0.2	-0.2	0.2	0.7	0.4	-0.4	-2.3	-3.5	-3.6	-4.4	-0.6	-0.5
		0.537	1.320	1.167	1.125	1.103	1.088	1.157	1.079	1.098	1.105	1.128	1.205	0.510	
12		2.1	3.7	-0.6	-2.1	-2.0	0.7	0.1	-0.1	-2.4	-3.7	-3.9	-5.3	-2.9	
		0.296	1.047	1.286	1.127	1.134	1.034	1.368	1.032	1.141	1.107	1.193	0.957	0.273	
13		2.9	2.9	1.1	-1.8	-1.1	0.1	-0.3	-0.1	-0.5	-3.5	-6.3	-5.9	-5.1	
			0.296	0.530	1.142	1.244	1.267	1.074	1.273	1.277	1.128	0.489	0.271		
14			2.8	0.7	-1.4	-0.8	0.1	-0.1	0.6	1.9	-2.6	-7.0	-6.0		
					0.302	0.447	0.543	0.447	0.547	0.454	0.296				MEAS
15					-0.3	-0.1	-0.6	-0.7	0.1	1.7	-2.6				DIFF

FIGURE 2
RADIAL POWER DISTRIBUTION (ARO, 100% RPT)