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SUBJECT: Forwards summary rept of unit core protection calculator/ COLSS operational experience for Cycle, per NRC 850515 request.

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Docket No. STN 50-528

U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Document Control Desk

Reference: Letter from G. W. Knighton (NRC), to E. E. Van Brunt, Jr. (ANPP) dated May 15, 1985. Subject: Software Changes for Palo Verde Unit 1, CPC/CEAC.

Dear Sirs:

Subject: Palo Verde Nuclear Generating Station (PVNGS)
Unit 1
Response to a request for a summary report
regarding CPC operational experience at PVNGS Unit 1
File: 87-056-026; 87-006-545

Attached please find the report regarding the summary of CPC/COLSS operational experience for PVNGS Unit 1 Cycle 1 which the staff requested in the referenced letter.

If you should have any questions, please contact A. C. Rogers at extention (602) 371-4041.

Very truly yours,

E E Van Brunt

E. E. Van Brunt, Jr.
Executive Vice President
Project Director

EEVB/LJM/cal

Attachment

cc: O. M. DeMichele
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A001
1/1

ENCLOSURE 1

SUMMARY OF CPC/COLSS OPERATIONAL

EXPERIENCE FOR PVNGS UNIT 1 CYCLE 1

SUMMARY

Unit 1 achieved criticality for Cycle 1 on May 25, 1985. The early months of operations were governed by power ascension testing, which was completed in February, 1986 when the plant met APS conditions for commercial operations. Commercial operations continued through 1986 and most of 1987. Due to the unplanned extension of the scheduled maintenance outage in early 1986, the operating cycle was extended to the early fall, 1987. Unit 1 completed Cycle 1 operations on October 2, 1987.

During Cycle 1 operations there were 27 reactor trips. These trips are identified in Table 1. Of these, 9 were CPC/CEAC generated trips. These 9 trips are summarized in Table 2 and categorized in the following comments. In addition, changes in the CPC software for Cycle 2 that will reduce or eliminate the trip condition are noted.

1. One trip (1-85-003) was due to a CEA hardware failure which generated erroneous penalty factors from one CEAC.

2. Four trips were related to the Reactor Coolant (RC) pumps. In at least one trip (1-86-001) the reactor trip could have been delayed or avoided if the flow-projected DNBR algorithm had been nullified. Nullifying the flow-projected DNBR algorithm was implemented in the CPC Rev. 03 software, which has been installed in Units 2 and 3. The algorithm has been deleted from the CPC Rev. 04 software (Cycle 2) to be installed in Unit 1.

3. Two trips were related to single CEA or CEA subgroup misoperations. In one trip (1-86-006), the Cycle 2 software could have avoided the trip because of the implementation of larger deadbands, time delay on application of penalties from only one of two operable CEAC's and activation of CEA Withdrawal Prohibit on deviation alarm setpoint.

4. One trip (1-86-013) was the result of an asymmetric steam generator transient (ASGT) condition which occurred at approximately 42% power. The ASGT trip occurred when the compensated cold leg temperature difference reached or exceeded the trip setpoint of 13°F even though the actual temperature difference was approximately 3°F. The rapid CPC response was primarily due to the sensitivity of the ASGT algorithm to the rate of change of the temperature difference. For Cycle 2 the sensitivity of the ASGT algorithm is reduced, and the increased margin available at lower powers is credited in order to increase the operating margin to trip at lower powers. Therefore, for Cycle 2 there should be a better chance of surviving this type of event.

5. One trip (1-87-003) occurred at approximately 10% power due to a high negative ASI. For Cycle 2 the possibility of getting into this situation will be reduced or eliminated by maintaining the fixed ASI up to approximately 15%-17% power and having the actual ASI available to monitor on the Operator's Module.

6. Seven trips occurred either during or as a result of power ascension testing, surveillance testing, or weekly preventive maintenance (PM) testing. These trips were not all CPC generated. One trip (1-86-006) occurred during the monthly test for CEA operability. One trip (1-87-002) occurred during a weekly PM test on main feedwater pump over speed trip. The pump tripped, Reactor Power Cutback was activated and was successful, but the

power bounce exceeded the response capability of the PPS VOPT trip function, and a VOPT was generated. Three trips (1-85-004, 1-86-001, 1-86-009) occurred due to failure of the fast bus transfer. The first two of these trips occurred during power ascension testing. The remaining two trips (1-85-007, 1-86-002) occurred during power ascension testing and were unrelated to CPC operations.

During Cycle 1 operations there were four significant CPC software versions generated for use. These versions are summarized in Table 3. The Rev. 03 software was authorized for use too late for implementation in Unit 1. The Rev. 02 software was generated partly to correct some executive program errors and partly to provide additional margin to permit the Unit to operate at 100% power to the end of Cycle 1 (approximately 450 EFPD).

Operations were affected by monthly surveillance tests. When performing the CEAC functional tests and the test for CEA operability, the normal operating practice has been to reduce power and to declare both CEAC's inoperable. As a result any CEA misoperations become transparent to the CPC/CEAC System. One reason for this mode of operation is apparent from the summary of trip 1-86-006. Another reason is the concern for auto-restarts, although the CEAC's have not been very sensitive to conditions that initiate auto-restarts (see auto-restart comments below). The Cycle 2 software should allow the plant to maintain 100% power during these surveillance tests or to significantly reduce the time needed for the power reduction by declaring CEAC inoperability only during CEA operability testing. The Cycle 2 software will accomplish this relief with a larger deadband at the top of the core and by initiating a time delay before applying a large default penalty when one CEAC is in-test and the other auto-restarts. The time delay is large enough to allow a normal auto-restart to clear.

One condition that has affected CPC operations is auto-restarts (ARS). The predominant number of ARS has been due to a floating point arithmetic fault. An ARS occurs when a floating point calculation results in a number so large or so small that it can not be represented by the hardware. When this condition is detected by the hardware, an interrupt occurs. For this condition the CPC software trips the channel and restarts. During 1985 and 1986 Channels A and B were especially sensitive to the floating point arithmetic fault. A summary of the total number of ARS for Unit 1 Cycle 1 is:

	A	B	C	D
1985	26	13	4	2
1986	45	16	6	1
1987	7	1	1	1

A study was performed in the fall of 1986 to try to find the cause of the floating point ARS. The results of the study indicated a design problem causing erratic operation of a Flip-Flop on the floating point processor "A" circuit board. The erratic operation is the result of a timing problem involving an asynchronous control communication between the CPU and the floating point processor. In addition, review of CPC operations indicated some floating point boards are more sensitive to this problem than others. Discussions were held with the computer manufacturer and the NSSS vendor, and a hardware fix was agreed to. The processor boards are gradually going through the modification process. As the revised boards are received, they will replace the unrevised boards concentrating first on the most sensitive boards.

During Cycle 1 operations, the RSPT's functioned with little problems. Towards the end of Cycle 1 RSPT's for CEA's 4 and 83 began to miss steps. During the refueling outage these RSPT's were replaced.

During Cycle 1 operations control room operators and Reactor Engineers used information available from the CPC's for functions other than Technical Specification requirements. For the CPC's these functions included:

a. monitoring CEA position during the CEA operability test;
b. monitoring thermal power and neutron flux power for power information;
c. monitoring ASI when COLSS ASI is not available;
d. monitoring input parameters when an input sensor is going bad.

During Cycle 1 operations COLSS operated normally with no significant problems. Control room operators and Reactor Engineers also used information available from COLSS for functions other than Technical Specification requirements. For COLSS these functions included:

a. monitoring ASI and comparing it to the ESI;
b. monitoring plant power and the power operating limit;
c. during maneuvering monitoring the effects of Regulating Group insertion on power distribution.

TABLE 1

UNIT 1 CYCLE 1 TRIP SUMMARY

REPORT #	DATE	DESCRIPTION
1-85-001	06/14/85	HI PRZ PRESSURE - MFWP trip/CD pump trip (20%)
1-85-002	07/01/85	HI PRZ PRESSURE - Feedwater oscillations Power Ascension
1-85-003	07/17/85	LO DNBR - CEAC #2 failure (50%)
1-85-004	09/15/85	LO DNBR - RPCB Testing (53%)
1-85-005	10/03/85	LO DNBR - PMUX Failure LOP S05/S06
1-85-006	10/07/85	LO SG #1 FLOW - LOP/13.8kV/(Mode 3)
1-85-007	10/24/85	LO SG #2 LEVEL - T/G Testing (80%)
1-85-008	12/04/85	LO DNBR - Drop PLCEA Subgroup (54%)
1-85-009	12/16/85	LO SG #1 LEVEL - AFN-P01 Failed to start @ 2%
1-85-010	12/20/85	HI PRZ PRESSURE - Following Turbine trip
1-86-001	01/09/86	LO DNBR - During performance of 72PA-1MT02
1-86-002	01/24/86	HI PRZ PRESSURE - During performance of 72PA-1MT02
1-86-003	02/03/86	LO SG #2 LEVEL - FW Oscillations
1-86-004	02/07/86	LO SG #1 LEVEL - FW Oscillations @ Swapover
1-86-005	03/07/86	LO SG #2 LEVEL - FW Pump Speed Control
1-86-006	06/17/86	LO DNBR - CEA Misalignment
1-86-007	07/12/86	LO SG #2 FLOW - LOP S01/S02
1-86-008	08/06/86	LO DNBR - Loss of S/U XFMER due to FW leak
1-86-009	08/15/86	HI PRZ PRESSURE - during 73TI-1NA02 fast xfer failure
1-86-010	08/30/86	LO SG #1 FLOW
1-86-011	09/02/86	LO SG #2 FLOW
1-86-012	09/11/86	LO SG #1 PRESSURE - Loss of both Steam Flow signals
1-86-013	10/06/86	Power to Load Unbalance on False Brk Open Signal w/CPC trip
1-86-014	11/19/86	LO SG #1 LEVEL - SG Level XMIT Failure
1-87-001	01/10/87	HI SG 2 LEVEL - RPCB & Load Rejection
1-87-002	05/30/87	VOPT - MFWP "A" Overspeed/RPCB Due to Power Bounce
1-87-003	08/27/87	LO DNBR - HI ASI During power decrease

NOTE:

Report # refers to Post Trip Review Report prepared by the STA Group after each plant trip.

TABLE 2

SUMMARY OF UNIT 1 CYCLE 1
CPC/CEAC GENERATED TRIPS

Report #	Summary
1-85-003	At 50% reactor power, CEAC 2 had a hardware failure which could not be reset and which generated erroneous penalty factors. DNBR and LPD margins indicated zero. Approximately one minute later the reactor tripped on Hi LPD and Lo DNBR.
1-85-004	During 50% load rejection test the turbine tripped and no fast bus transfer took place. Reduced bus frequency lowered RCP speed which caused a low flow projected Lo DNBR trip.
1-85-005	With the reactor at 52% power supply breakers to NAN-S05 and NAN-S06 opened causing a Loss-of Power (LOP), with resultant reduction in RCP speed. All 4 CPC channels tripped the reactor on flow projected Lo DNBR.
1-85-008	With the reactor initially at 54% the reactor tripped on Lo DNBR. This was caused due to a high penalty factor being inserted by the CEAC's due to dropping Subgroup 12 (Part length CEA's). The cause was attributed to a fault in CEDMCS on a phase sync card for Subgroup 12.
1-86-001	During a 100% power turbine trip test the fast transfer to off-site power supply power did not occur. A reduction in RCP speed generated a reactor trip from the CPC's from the flow projected Lo DNBR algorithm.
1-86-006	At 100% power during CEA Operability Checks (41ST-1SF01), CEA #6 was driven in greater than 6.6 inches. The reactor tripped from CPC generated DNBR trips caused by CEAC #2 penalty factors.
1-86-008	At 100% power Start-up transformer NAN-X03 tripped causing RCP's 1A and 2A to trip. The reactor tripped on a low flow projected Lo DNBR.
1-86-013	A Power to Load Unbalance (PLUB) transient resulted in a reactor power cutback to 42% power and a manually initiated turbine trip. Due to a Feed Water Control System malfunction the #1 Steam Generator was fed with an excessive amount of 150°F, non-reheated water. The cold leg temperature (Tc) rapidly decreased in Loop 1. All 4 CPC's generated a Lo DNBR trip based on a calculated Hi rate of change of ΔTc (between RCS loops 1 and 2.)
1-87-003	During a reactor shutdown to evaluate a possible RCS leak, with reactor power at approximately 10% and ASI near -0.331, the REG Groups were driven into the core to dampen the ASI oscillation. Before REG Group 4 could substantially affect the strongly negative ASI, a channel A CPC auxiliary trip was generated when the CPC's calculated an ASI outside of its operating range. 22 seconds later CPC Channel B also generated an ASI auxiliary trip. These two channels satisfied the 2 out of 4 RPS trip logic and a reactor trip occurred.

TABLE 3

CPC/CEAC SYSTEM SOFTWARE REVISIONS FOR UNIT 1 CYCLE 1

Rev. 0 1983	- Initial version of PVNGS CPC/CEAC System software.
Rev. 01 1985	- Changed pump related flow constants due to impellar rework. - Changed DNBR trip setpoint to 1.231 per NRC approval of Statistical Combination of Uncertainties methodology. - Changed high pressurizer pressure setpoint, which increased the RCS pressure operating bands. - Reduced CEAC INOP penalty, took credit for Tech Spec required power reduction. - In CEAC set 4-fingered CEA penalty factors to 1.0. - Made several corrections in Executive program.
Rev. 02 Oct. 1986	- Changed Temperature Shadowing Factor algorithm to piece-wise linear function with two slopes. - Implemented the secondary calorimetric power uncertainty over the power range. - Implemented a DNBR region-dependent penalty on the updated DNBR. - Limited the 21st node heat flux distribution extrapolation in STATIC program to a small positive value if initially extrapolated as a negative value. - Clarified the underflow conditions occurring with the compensated cold leg temperature difference in the Asymmetric Steam Generator Transient protection algorithm. - Corrected several Executive program errors.
Rev. 2.01 May 1987	- Corrected an error in the write-protect test function of the Periodic Test option.
Rev. 03 Aug. 1987	- Nullified the flow-projected DNBR algorithm by setting certain data base constants to zero and raising the low RC pump shaft speed trip setpoint to 95% of nominal rotational speed.