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SUBJECT: Forwards summary of evaluations/analyses re core protection calculator & core operating limit supervisory sys flow coastdown penalties, per EA Licitra 870407 request for addl info.

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June 22, 1987
161-00293-JGH/BJA

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

Subject: Palo Verde Nuclear Generating Station (PVNGS)
Units 1, 2 and 3
Docket Nos. STN 50-528 (License No. NPF-41)
STN 50-529 (License No. NPF-51)
STN 50-530 (License No. NPF-65)
RCP Coastdown Safety Analysis
File: 87-A-056-026

References: (1) Letter from J. G. Haynes, ANPP, to USNRC Document Control Desk dated April 30, 1987 (161-00180-JGH/BJA). Subject: RCP Coastdown Safety Analysis.
(2) Letter from E. A. Licitra, NRC, to E. E. Van Brunt, Jr., ANPP, dated April 7, 1987. Subject: RCP Coastdown Safety Analysis.

Dear Sirs:

In response to the NRC Staff request for additional information on the RCP coastdown safety analysis, ANPP committed to provide a summary of this analysis for NRC Staff review.

This summary of the analysis that was conducted by the NSSS vendor is presented in the attachment to this letter. If you have any additional questions on this matter, please contact Mr. W. F. Quinn of my staff.

Very truly yours,

J G Haynes

J. G. Haynes
Vice President
Nuclear Production

JGH/BJA/dlm
Attachment

cc: O. M. De Michele (all w/a)
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PALO VERDE UNITS 1 AND 2

SUMMARY OF EVALUATIONS/ANALYSES PERTAINING TO

CPC/COLSS FLOW COASTDOWN PENALTIES

The evaluations and analyses in response to faster Reactor Coolant Pump (RCP) coastdowns observed at Palo Verde Units 1 and 2 can be grouped under the following categories to summarize the procedure employed in, first installing the COLSS/CPC penalties and, then removing the penalties.

1. COMPARISON OF PCHF RCP COASTDOWN TEST DATA (w/o Electrical Breaking)

The post core hot functional (PCHF) RCP coastdown test data is not impacted by the electrical braking effect since the RCPs are isolated from the electrical bus that powers them at the initiation of the event. This data was compared against the CESSAR RCP flow coastdown prediction (CESSAR Figure 15.3.1-7) for both Units 1 and 2 to determine the conservatism in the CESSAR prediction. The comparison for Unit 1 suggested that the test data is conservatively predicted by the CESSAR curve.

Three sets of PCHF test data (test dates: 04/02/86, 07/31/86 and 09/11/86) were collected on Unit 2 RCP coastdown. The first set of data, when compared to CESSAR, was determined to represent a 2% faster RCP coastdown during the time frame of interest for the DNBR calculation (0.0 - 3.0 sec.). In order to accommodate the 2% faster Unit 2 RCP coastdown a penalty factor of 2% was installed in both the Core Protection Calculator (CPC) and the Core Operating Limit Supervisory System.(COLSS).

The second and third sets of Unit 2 PCHF RCP coastdown test data were compared against the Unit 1 PCHF RCP coastdown data. This comparison indicated that there was no significant difference between Unit 1 and Unit 2 PCHF test data. Further, it was verified that the CESSAR prediction was conservative with respect to the test data. This later information on the Unit 2 RCP coastdown was employed to remove the 2% flow coastdown penalties installed in the CPC/COLSS.

2. EVALUATION OF ELECTRICAL BRAKING EFFECT

An electrical braking effect of the RCPs was experienced in both Unit 1 and Unit 2. This effect was discovered in Unit 1 during the turbine trip test (with a failure to fast transfer) and in Unit 2 during the loss of offsite power test. These events cause a simultaneous loss of power to all four RCPs, resulting in a four pump flow coastdown.

The evaluation of the Unit 1 coastdown data (with electrical braking) indicated that the flow coastdown was approximately 1.5%

faster than that predicted in the CESSAR. The evaluation of Unit 2 data indicated that the Unit 2 RCPs coasted down slightly faster than the Unit 1 RCPs under the influence of the electrical braking effect. The Unit 2 RCPs were determined to coastdown 2.8% faster than the CESSAR prediction.

The reason for this faster coastdown was due to the sharing of the same electrical bus with the RCPs and various house loads. Since the maximum possible house load was not employed in the test, a calculation was performed to determine the worst case RCP coastdown with the RCP bus fully loaded. This was achieved by;

(1) using the torque balance equation for the RCPs as $\Sigma T = -I(dw/dt)$, where ΣT = friction and windage torque + hydraulic torque + torque due to electrical braking and,

(2) estimating the magnitude of the "worst case" electrical braking torque and its variation with time using the turbine trip test data.

A comparison of the calculated worst case RCP flow coastdown curve with the CESSAR flow coastdown curve indicated that the maximum flow deficit is about 2% during the first second of the coastdown. At later times the flow deficits were lower. Any COLSS\CPC penalties to be installed would be conservatively based on this maximum flow deficit.

An evaluation of the FSAR Chapters 6 and 15 safety analyses was undertaken to quantify the impact of a 2% faster RCP coastdown. This evaluation identified that the Excess Load transient and the Loss of Flow event needed to be evaluated for the impact of a faster than anticipated coastdown.

> Note: All events in combination with a loss of offsite power would be impacted by the faster coastdown. However, if acceptable consequences can be demonstrated for the loss of flow event, then those events in combination with a loss of offsite power would also show acceptable consequences. Additionally, the Loss of Flow event is the only PVNGS accident analysis that uses the best estimate flow coastdown curve. For any of the other PVNGS accident analyses, the assumed coastdown is conservatively fast since only 90% of the RCP rotational inertia is assumed.

Evaluations of the Excess Load and the Loss of Flow event determined that a penalty of 1.8% (in CPC/COLSS) was necessary to ensure acceptable consequences under the condition of a faster coastdown, due to electrical braking. This penalty was conservatively rounded to 2.0%.

Based on the faster RCP coastdown observed for Unit 1 due to electrical braking effect and the faster RCP coastdown observed from the first set of Unit 2 PCHF data, a larger penalty was installed in Unit 2 CPC/COLSS. This amounted to a 4% penalty (2% for PCHF penalty and 2% for electrical braking effect). The

actual flow deficit (2.8%) for Unit 2 represents the cumulative impact on the RCPs due to all effects, including the electrical braking effect. Therfore, the 4% penalty installed in Unit 2 CPC/COLSS is considered to be a conservative upper bound.

These initial evaluations of the effect of the more rapid coastdown only consider the negative effect of the lower flow. No attempt was made to credit the fact that a faster coastdown would result in a faster trip.

3. EVALUATIONS TO REMOVE COLSS/CPC PENALTIES

The COLSS/CPC penalties installed on both units were eliminated by careful consideration of the following factors related to a reduction in the time it takes for the CPC to generate a trip on flow projected low DNBR. These considerations were necessary to ensure acceptable consequences for the Loss of Flow event and the Excess Load transient with a loss of offsite power.

(a) The reduction in measured flow compared to predicted flow.

(b) The derivatives of flow with respect to time.

To facilitate the removal of the penalties (after consideration of both events and the penalities used in both plants) it was determined that a reduction in the time to trip from 0.6 seconds (CESSAR value) to 0.3 seconds would be required.

Consistent with this requirement, an evaluation of the CPC hardware/software capability was undertaken to determine whether a CPC flow projected low DNBR trip signal can be generated within this time (i.e. 0.0 - 0.3 seconds). The CPC Simulation computer code was run with the electrical braking effect data to prove that the time to trip response meets the requirements for the affected events. Pump speed data (conservatively modified) was used as inputs to the CPC Simulation code to predict a maximum time to trip for the affected events. To this calculated time to trip all possible delays were added. These delays include the CPC timing cycles, CPC application program execution times and the safety system hardware response times as recorded by ANPP in their Safety System Response Time Test. The results of the analysis showed that the CPC would meet the required time to trip of less than or equal to 0.3 seconds for the affected events.

The following sample of actual plant data is provided as additional verification that the Palo Verde Units will generate a trip signal before 0.3 seconds.

Unit 1: January 9, 1986, Turbine Trip Test (73PA-1MT02)
Trip Signal Generated at 0.287 seconds
Reference: PTRR 1-86-001, dated 01-09-86

Unit 2: Sept. 11, 1986, Unit Load Rejection Test (73PA-2MA01)
Trip signal generated at 0.259 seconds
Reference: PTRR 2-86-009, dated 09-11-86

PALO VERDE UNITS 1 & 2

CHRONOLOGY OF EVENTS PERTAINING TO

CPC/COLSS FLOW COASTDOWN PENALTIES

1. 05/21/85, V-CE-32408, Post Core Reactor Coolant System Flow Measurements

   Document shows comparison of the predicted coastdown against Unit 1 post core hot functional RCP coastdown test data.

2. 01/17/86, FAR #14273-1612, 100% Turbine Trip RCP Coastdown

   Electrical Braking effect on Unit 1 RCP coastdown was observed. Evaluated impact of the faster coastdown on FSAR safety analyses. Identified Loss of Flow and Excess Load transients as being impacted. Proposed CPC/COLSS penalties of 1.8% to compensate for a 2% faster coastdown.

3. 02/18/86, V-CE-33438, Removal of Flow Coastdown Penalties for Unit 1

   Evaluated capability of CPC to provide a faster trip signal than that assumed in FSAR (0.6 sec.). Evaluation determined that within 0.3 seconds a CPC trip on flow projected low DNBR can be obtained.

4. 04/10/86, V-CE-33638, Evaluation of Unit 2 RCP Coastdown Data

   Unit 2 post core hot functional (PCHF) RCP coastdown test data (no electrical braking effect) was evaluated. Data showed 2% faster coastdown in comparison to Unit 1 PCHF data and CESSAR prediction. Assuming the electrical braking effect to be similar to that for Unit 1 RCPs, it was recommended that a 4% CPC/COLSS penalty be installed.

5. 09/12/86, V-CE-34093, Partial Removal of RCP Coastdown Penalty for Unit 2

   More Unit 2 PCHF RCP coastdown test data became available. Comparison of the data from these tests against Unit 1 data showed that the Unit 2 data is very similar to Unit 1. Thus, 2% of the 4% penalty imposed on Unit 2 was recommended to be removed.

6. 10/09/86, V-CE-34167, Removal of Entire Flow Coastdown penalty Unit 2

   Data from the 50% power loss of offsite power test was obtained. RCP coastdown was faster (2.8%) than that predicted by CESSAR. A further evaluation of the CPC was made to determine whether the 2.8% faster RCP coastdown can be accommodated by the CPCs capability to generate a faster trip signal. This was confirmed and it was recommended that the entire 4% penalty be removed.