LICENSEE EVENT REPORT (LER)

FACILITY NAME (1)	DOCKET NUMBER (2)	PAGE (3)
Diablo Canyon Unit 1	0 5 0 0 0 2 7 5	1 OF 11

TITLE (4) Lack of 10 CFR 50.59 Safety Evaluation for Changes to Reactor Coolant System Precision Flow Calorimetric

EVENT DATE (5)			LER NUMBER (6)			REPORT DATE (7)			OTHER FACILITIES INVOLVED (8)	
MON	DAY	YR	YR	SEQUENTIAL NUMBER	REVISION NUMBER	MON	DAY	YR	FACILITY NAMES	DOCKET NUMBER (5)
									Diablo Canyon Unit 2	0 5 0 0 0 3 2 3
03	30	94	96	- 0 1 6 -	0 0	1	13	97		0 5 0 0 0

OPERATING MODE (9): 1

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR: (11)

POWER LEVEL (10): 1 0 0

X 10 CFR OTHER - Voluntary

(Specify in Abstract below and in text, NRC Form 366A)

LICENSEE CONTACT FOR THIS LER (12)

NAME	TELEPHONE NUMBER AREA CODE	
Vickie A. Backman - Senior Regulatory Services Engineer	805	545-4289

COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT (13)

CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS	CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS

SUPPLEMENTAL REPORT EXPECTED (14)		EXPECTED SUBMISSION DATE (15)	MONTH	DAY	YEAR
[ ] YES (If yes, complete EXPECTED SUBMISSION DATE)	[X] NO				

ABSTRACT (16)

This voluntary LER is submitted for information purposes only as described in item 19 of Supplement 1 to NUREG-1022.

On March 30, 1994, PG&E revised the reactor coolant system flow calorimetric (RCSFC) test procedure to allow the RCSFC to be performed either at end of cycle (EOC) or beginning of cycle (BOC). This revision to the RCSFC procedure incorporated a flow penalty method to offset increased measurement uncertainties to ensure adequate determination of minimum measured RCS flow. A 10 CFR 50.59 screen was performed for the change to the test procedure and determined that the proposed changes did not involve a change to the Technical Specifications (TS) or require a written 10 CFR 50.59 safety evaluation. However, in retrospect, PG&E believes that a written safety evaluation and a TS Bases change should have been performed.

The cause of this event was personnel error (cognitive), in that non-licensed engineering personnel did not prepare a written 10 CFR 50.59 safety evaluation.

PG&E is evaluating alternatives to mitigate the hot leg streaming effects that led to adoption of the EOC method, including the continued use of the EOC RCSFC test or the use of elbow tap methodology. In the interim, PG&E has returned to the BOC RCSFC method in mid-cycle on Units 1 and 2 based on data taken at the beginning of the current operating cycle (Cycle 8). Also, the RCS low flow reactor trip setpoints were reset in the current cycle to correspond to BOC loop flows.

I. Plant Conditions

Units 1 and 2 have operated at various modes and power levels while the condition described in this report existed.

II. Description of Problem

A. Summary:

This voluntary LER is being submitted for information purposes only as described in item 19 of Supplement 1 to NUREG-1022.

During the preparation of a 24 month fuel cycle license amendment request (LAR), a concern was identified that a 10 CFR 50.59 written safety evaluation was not prepared for a previous revision made to the Diablo Canyon Power Plant (DCPP) reactor coolant system flow calorimetric (RCSFC) (AB) procedure. A license basis impact evaluation screen was performed in conjunction with the procedure change. However, the evaluation incorrectly determined that a 10 CFR 50.59 safety evaluation was not required.

B. Background:

Surveillance Test Procedure (STP) R-26, "RCS Primary Coolant Flow Measurements," determines reactor coolant loop flows by performing simultaneous primary and secondary calorimetrics at or near full power. This is known as the RCSFC. The calculated RCS loop flows are utilized to verify acceptable RCS total flow (as required by Technical Specification (TS) 4.2.3.5) and to provide calibration data for the 12 elbow tap flow transmitter channels (TS 4.2.3.4). Specifically, the calibration data is used to normalize the Eagle 21 RCS flow channels, and to set the plant process computer (PPC) and vertical board RCS flow indication conversion constants (percent flow to gpm). These flow indications are used to satisfy TSs 4.2.3.2 and 4.2.3.3.

TS 3.2.3 provides the requirements for RCS flow and indicates that the RCS flow rate shall be maintained within the region of allowable operation shown on TS Figure 3.2-3(a) and (b) (Units 1 and 2, respectively). Figures 3.2-3(a) and (b) provide the RCS flow rate limits and includes measurement uncertainties of 2.4 percent. The applicable TS Bases section indicates that no additional allowances are necessary prior to comparison with the limits of Figures 3.2-3(a) and (b), and a measurement error of 2.4 percent for RCS flow rate has been allowed for in the determination of the design departure from nucleate boiling ratio (DNBR) values.

The minimum measured total RCS flowrate, which is required by TS 3.2.3, is called the minimum measured flow (MMF). It is equal to the thermal design flow (TDF) plus an allowance for measurement uncertainty of 2.4 percent. TDF is 350,800 gpm and

354,000 gpm for Units 1 and 2, respectively. MMF is 359,200 gpm and 362,500 gpm for Units 1 and 2, respectively.

The total RCS flow assumed in the safety analyses depends on the methodology used for each specific analysis. For non-DNBR related events or DNB events for which the Improved Thermal Design Procedure (ITDP) is not employed, the TDF value is used in the analysis. The TDF is met by ensuring that the MMF required by the TS is higher than the TDF value by the 2.4 percent TDF allowance for total flow measurement uncertainty. For DNB analyses that employ the ITDP, the MMF value is assumed directly in the analysis. In the ITDP for DCPP, a random flow uncertainty of 2.4 percent of flow was accounted for in a statistical square-root-of-the-sum-of-squares (SRSS) combination with other appropriate plant input parameter uncertainties to set the DNBR design limit.

The radial temperature gradient in the core was made more pronounced with the advent of lower leakage core loading patterns. Increases in the radial core exit thermal gradient result in an increase in the hot leg temperature gradient at the location of the three (per loop) hot leg narrow range (NR) reactor temperature detectors (RTDs)(AB)(DET). Even though these three RTDs are spaced 120 degrees apart, the nonlinear nature of the hot leg gradient causes the average indicated NR RTD reading within a loop to exceed the true hot leg bulk fluid temperature by approximately 1-2 degrees F.

This temperature offset is known as hot leg streaming. It varies between Units and loops and depends on the radial core power distribution, the reactor vessel internals, and the location of the hot leg RTDs. Hot leg streaming generally results in total RCS flow being underpredicted by the RCSFC, primarily because an accurate RCS bulk hot leg temperature cannot be measured.

C. Event Description:

<u>Introduction</u>

TS 4.2.3.5 requires an RCS total flow measurement, i.e., a RCSFC, at least once per 18 months while in Mode 1 (Power Operation). Although the TS do not specify that the RCSFC be performed at beginning of cycle (BOC), information included in PG&E letter DCL-93-200, dated August 11, 1993, in support of LAR 92-05, "Eagle 21 Process Protection System Upgrade and Resistance Temperature Detector Bypass Elimination," provided instrument uncertainties associated only with a RCSFC that is performed at BOC (i.e., not including feedwater venturi fouling allowances).

The use of end of cycle (EOC) RCSFC data to calibrate the elbow tap flow channels for use in the following cycle assumes that RCS alterations made during the refueling outage will not cause a shift in the calibration of the elbow taps (AB)(PSF), i.e., the actual flow versus actual elbow tap differential pressure

correlation does not change. This assumption was previously justified by Westinghouse for typical RCS alterations such as steam generator (SG) tube plugging, fuel assembly design changes, etc., as part of a PG&E project to justify the "elbow tap method" to resolve hot leg streaming issues.

Historically, the RCSFC has been performed throughout the industry at BOC. To minimize the hot leg streaming bias in the RCSFC, PG&E revised the RCSFC procedure on March 30, 1994, to allow the RCSFC to be performed at EOC instead of BOC. This revision included the use of a flow penalty method to offset the portion of the random error exceeding the 2.4 percent TDF allowance; thereby, ensuring that the measured flow was conservatively corrected. PG&E began performing the RCSFC at EOC in Cycle 6 on both DCPP Units. Despite a slight increase in random uncertainty at EOC, overall the EOC RCSFC results in a more accurate determination of flow because of the flatter radial core power distribution at EOC. Thus, performing the RCSFC at EOC reduces the RCS hot leg temperature streaming error, which exists throughout the cycle, but is more pronounced at BOC.

Flow Penalty Method

The EOC RCSFC flow calculation has some additional flow measurement uncertainties associated with it. The largest contributor to the additional uncertainty is from the feedwater fouling correction factor determined by cross-correlation to flowmeters. Also, the use of EOC RCSFC data to normalize and calibrate the elbow tap flow channels involves additional elbow tap transmitter uncertainties which would be normalized to zero with BOC RCSFC data. The revision to the RCSFC procedure incorporated a flow penalty method to offset the higher EOC instrument uncertainties and to ensure that the measured RCS flow exceeds MMF. The revision with the flow penalty therefore ensures that the TS for total RCS flow with a maximum uncertainty of 2.4 percent is met. PG&E calculation files properly accounted for all sources of error used in determining the flow penalty.

For operation in Cycle 8, the EOC 7 RCSFC required that the following penalties be included in the RCS flow indications: 0.19 percent MMF for Unit 1 and 0.52 percent MMF for Unit 2. Unit 2 had a larger penalty because of a required correction for EOC feedwater venturi fouling. Unit 1 does not exhibit venturi fouling due to use of ethanolomine chemistry.

Although technically conservative, the EOC flow penalty method was not part of the previously established licensing basis for DCPP. Also, PG&E letter DCL-93-200, dated August 11, 1993, was submitted to the NRC in support of Eagle 21 and RTD bypass elimination. The letter stated that the BOC flow measurement uncertainty (FMU) was 2.1 percent MMF (or 2.15 percent TDF), not including feedwater venturi fouling allowances. The EOC RCSFC with the penalty method results in an FMU of 2.34 percent of indicated flow (2.4 percent TDF) (i.e., 2.34

percent indicated flow is equivalent to 2.4 percent TDF). Although this FMU does not exceed the TS 3.2.3 allowance, it is greater than the previously reported best estimate value of 2.1 percent of indicated flow.

On March 30, 1994, to mitigate the RCS temperature measurement effects caused by hot leg streaming, PG&E revised the RCSFC test procedure to allow the RCSFC to be performed either at EOC or BOC. This revision to the RCSFC procedure incorporated a flow penalty method to offset increased measurement uncertainties to ensure adequate determination of minimum measured RCS flow. The EOC RCSFC was used on both Units 1 and 2 during Cycle 7 and a portion of Cycle 8.

The changes to the RCSFC test were made based on technical justification provided by PG&E Calculation J-084, which incorporated the methodologies contained in WCAPs 13566 and 110882. A 10 CFR 50.59 screen was performed and concluded that the RCSFC procedure change did not involve a change to the TS or result in an unreviewed safety question. In addition it was determined that no written safety evaluation was required. This was based on extensive reviews of PG&E licensing basis documentation which constituted the safety analysis report, as well as a review of the procedure commitment database (PCD). Because the TS did not specifically identify when the RCSFC is performed, all references found to a RCSFC test at BOC were considered to be descriptive in nature, and therefore not to constitute licensing bases. In addition, the PCD did not identify the performance of the RCSFC during BOC condition a licensing commitment. Since the EOC test required the use of an additional flow penalty as opposed to additional uncertainty, it was believed that this new methodology continued to meet the uncertainty of 2.4 percent given in TS figure 3.2-3(a) and (b).

On September 27, 1996, a safety evaluation was prepared for the change to the EOC method and was presented to the plant staff review committee (PSRC). At this time, the PSRC requested that a TS Bases change be prepared and the 10 CFR 50.59 evaluation be revised to include a justification for the TS Bases change. In addition, the PSRC requested that the revised 10 CFR 50.59 evaluation and the TS Bases change be submitted to the NRC. Subsequently, during preparation of the TS Bases change, the licensing commitments regarding RCS flow BOC measurements were reviewed again and determined to constitute licensing commitments. PG&E then determined that it was advisable to contact the NRC.

PG&E appraised the NRC on November 1, 1996, and November 5, 1996, via telephone conference calls of this issue. PG&E appraised the NRC staff that the EOC RCSFC change was made in 1994. PG&E presented and discussed PG&E correspondence from 1993 and the NRC safety evaluation report associated with License Amendment 84/85 for Units 1 and 2, respectively. PG&E presented the technical justification for the EOC RCSFC change. PG&E staff expressed the opinion that EOC RCSFC change did not involve an unreviewed safety question and that no TS change was required. NRC staff personnel expressed a concem that prior NRC

review and approval may have been required prior to implementing the EOC RCSFC method. Following these calls, pending resolution of the concern, PG&E conservatively returned to the BOC method for both Units 1 and 2, and reset the trip setpoints accordingly.

A preliminary review of BOC STP R-26 data taken on both units was performed on November 1, 1996, using BOC 8 data. The results indicated that all loop RCS flows were above MMF with the exception of Unit 1, Loop 1. Since the low flow trip setpoint is set at 90 percent of nominal flow and nominal was less than MMF, the trip setpoint needed to be greater than 90 percent to ensure the 90 percent of MMF was valid. For conservatism, PG&E management decided to have the low flow trip setpoints bound the BOC 8 data. On November 4, 1996, Instrumentation and Controls changed the low flow trip setpoint from 90.325 percent of nominal flow to 90.89 percent of nominal flow for all three channels on Loop 1 for Unit 1. The resetting of the Unit 1, Loop 1 flow trip setpoints was performed as a prudent action. No operability concerns were identified as part of this change, since PG&E continued to meet the TS requirements for TDF and uncertainty.

On November 7, 1996, BOC STP R-26 calculations were completed, including the determination of new Eagle 21 scaling constants. On each unit, the Eagle 21 scaling constants, the PPC flow constants (percent flow to gpm), and the vertical board flow constants (percent flow to gpm) for the 12 RCS flow channels were changed on November 7, 1996, to reflect the new BOC 8 RCSFC flows instead of the EOC 7 RCSFC flows. As expected, the indicated flows decreased due to the effects of hot leg streaming.

On November 21, 1996, PG&E received the Westinghouse final evaluation of the flow penalty method, which is used to account for increased RCS flow measurement uncertainty. Westinghouse concluded that the use of a measured flow penalty conservatively accounts for an increase in the flow uncertainty above the 2.4 percent TDF value defined in the DCPP TS. Assuming the additional flow uncertainty and corresponding bias are accurately determined and applied, it is concluded that the results and conclusions of the Final Safety Analysis Report Update (FSARU) safety analyses are valid.

A written 10 CFR 50.59 safety evaluation was reviewed and approved by the PSRC on January 10, 1997 (Attachment 1). The PSRC concluded that previous operation with the RCSFC being performed at EOC and use of the flow penalty method did not require a change to the TS or result in an unreviewed safety question. However, given recent industry sensitivity to document compliance with the license basis, the PSRC did note that a written safety evaluation and a TS Bases change should have been performed to support the procedure change. In addition, the PSRC noted that the NRC should have been notified that a change to licensing commitments had been made in accordance with 10 CFR 50.59.

D. Inoperable Structures, Components, or Systems that Contributed to the Event:

None.

E. Dates and Approximate Times for Major Occurrences:

August 11, 1993:	PG&E letter sent to the NRC with PPC indicated flow uncertainty value of ±2.1 percent of indicated flow based on a BOC RCSFC, excluding any allowance for feedwater venturi fouling.
October 7, 1993:	NRC issued safety evaluation report on Eagle 21 and RTD bypass elimination stating that the total FMU, including the required feedwater fouling allowance of 0.1 percent, is 2.2 percent of indicated flow and was acceptable based on being less than the TS FMU of 2.4 percent.
March 30, 1994:	PG&E revised STP R-26 to allow the RCSFC to be performed at EOC and to require a flow penalty to offset random flow uncertainty in excess of 2.34 percent of indicated flow (2.4 percent TDF).
September 27, 1996:	A written 10 CFR 50.59 safety evaluation was presented to the PSRC on the EOC change. At this time, the PSRC requested that a TS Bases change be prepared and the 10 CFR 50.59 evaluation be revised to include justification for the change. In addition, the PSRC requested that this information be submitted to the NRC. Subsequently, during preparation of the TS Bases change, the licensing commitments regarding RCS flow BOC measurements were reviewed again and determined to constitute licensing commitments. PG&E determined that it was advisable to contact the NRC.
November 1, 1996:	PG&E indicated on a telecon with the NRC that PG&E will submit a TS Bases change and 50.59 to describe the EOC methodology.
November 4, 1996:	The low flow trip setpoints were conservatively reset from 90.325 percent to 90.89 percent of nominal flow for all three channels on Loop 1 for

Unit 1, to bound preliminary BOC 8 RCSFC flow data.

November 7, 1996: The Eagle 21 scaling constants and the PPC and vertical board flow constants were updated based on the finalized BOC 8 RCSFC flows for each unit.

November 21, 1996: PG&E received the Westinghouse evaluation of the flow penalty bias method, which is used to account for increased RCS flow measurement uncertainty.

January 10, 1997: A written 10 CFR 50.59 safety evaluation was reviewed and approved by the PSRC.

F. Other Systems or Secondary Functions Affected:

None.

G. Method of Discovery:

Review of Eagle 21 and RTD bypass elimination licensing information during the preparation of 24-month cycle submittals.

H. Operator Actions:

None.

I. Safety System Responses:

None.

III. <u>Cause of the Event</u>

A. Immediate Cause:

A written 10 CFR 50.59 safety evaluation was not prepared for the STP R-26 procedure changes which allowed the RCSFC test to be performed at EOC with the flow penalty method.

B. Root Cause:

The cause of this event was personnel error (cognitive), in that non-licensed engineering personnel did not prepare a written 10 CFR 50.59 safety evaluation due to the following:

1. An incorrect understanding by PG&E of the methodology required to meet TS 3/4.2.3, Figures 3.2-3(a) and (b). PG&E Engineering personnel believed that the additional flow measurement errors (i.e., feedwater fouling measurement and instrument drift) associated with performing the RCSFC at EOC could be treated as a flow penalty with no impact to the TS uncertainty of 2.4 percent.

2. Information contained in the PG&E licensing basis relative to performing the RCSFC at BOC conditions was considered descriptive in nature rather than constituting license basis.

IV. Analysis of the Event

A. Accuracy of EOC versus BOC

The change from BOC to EOC assumed that the RCSFC gives a more accurate flow at EOC. Prior to making this change, PG&E had extensively studied the changes in hot leg temperature indication due to low leakage loading patterns by determining true changes in flow from a combination of the elbow tap flows and the Westinghouse hydraulic model predicted flows. For example, the change between the Cycle 1 loop average indicated T_{hot} and the Cycle 6 loop average indicated T_{hot} due solely to the transition to low leakage core (AC) designs was estimated to be +0.7 degrees F for Unit 1 and +1.8 degrees F for Unit 2 using the model. The increase in hot leg streaming, which is a direct correlation to low leakage core designs combined with actual increases in hydraulic flow resistance, has resulted in a decrease in the BOC RCSFC calculated flow of 2.6 percent for Unit 1 and 4.4 percent for Unit 2.

During the same period, RCS flow determination based on the elbow tap differential pressure flow decreased by only 1.6 percent for both Units. Also, the predicted net decrease in flow due to the introduction of VANTAGE 5 fuel (AC), the removal of thimble plugs, SG tube plugging, and reactor coolant pump impeller (AB)(P)(FAN) "smoothing" was 1 percent for both Units. Thus, the indicated decrease in RCS flow overestimated the true decrease by about 1-1.6 percent on Unit 1 and 2.8-3.4 percent on Unit 2. Furthermore, Westinghouse's best estimate BOC-1 predicted flows were above the BOC 1 RCSFC flows by 0.31 percent for Unit 1 and 0.51 percent for Unit 2. Thus, it appears that the true BOC 6 flows were at least 1 percent higher on Unit 1 and 3 percent higher on Unit 2 than the BOC 6 RCSFC flows.

In Cycle 6, the RCSFC total flow was 0.8 percent higher at EOC than BOC for Unit 1, and 2.1 percent higher at EOC for Unit 2. Similarly, for Cycle 7, the RCSFC total flow was 1.3 percent higher at EOC than BOC for Unit 1, and 1.4 percent higher at EOC for Unit 2. It can be concluded that the flows given by the EOC RCSFC were more realistic than the BOC RCSFC flows and they are conservative relative to the best estimate predicted flows. Therefore, there was no safety concern associated with the use of the EOC RCSFC during Cycle 7 and a portion of Cycle 8 operation.

B. Flow Penalty Method

Non-ITDP Safety Analyses

The indicated RCS flow incorporated a flow penalty bias to account for random uncertainty greater than 2.4 percent TDF. This is equivalent to comparing an unbiased flow measurement to a higher MMF requirement based on the total random error. Therefore, the flow penalty method ensures that the actual flow exceeded the TDF assumed in the safety analyses, and thus the results and conclusions of the non-ITDP safety analyses always remained valid.

ITDP Safety Analyses

The existing design DNBR limits determined by the ITDP calculation for DCPP assume an RCS flow random uncertainty of ±2.4 percent of indicated flow. If the total flow uncertainty assumed in the ITDP calculation is increased above 2.4 percent of indicated flow, this would result in increased (more restrictive) design DNBR limits for the typical and thimble fuel assembly cells. However, with the flow penalty bias method, the additional random flow uncertainty above 2.34 percent is already accounted for directly in the absolute flow value that is compared to the MMF.

The flow penalty method is a conservative methodology for accounting for additional flow uncertainty associated with the EOC RCSFC. Normally, independent uncertainties are statistically combined using the SRSS method. This results in an uncertainty lower than the strict summation of the uncertainties. Since the additional uncertainties are in excess of the nominal 2.4 percent value assumed, it was decided that the excess uncertainties should be applied deterministically (i.e., no credit is taken for the statistical independence of these terms). The flow penalty method conservatively ensured that the results and conclusions of the ITDP DNB safety analyses remained valid.

At no time did either Unit operate outside of the design basis. Thus, the health and safety of the public were not affected by this event.

V. Corrective Actions

A. Immediate Corrective Actions:

Both Units 1 and Unit 2 have been returned to 100 percent RCS flow values corresponding to BOC data and documented on STP R-26 procedure data sheets. Low flow trip setpoints were adjusted to correspond to BOC loop flows for the loop that was below MMF.

B. Corrective Actions to Prevent Recurrence:

1. PG&E will issue a case study detailing this event to personnel that prepare and revise procedures. The case study will discuss lessons learned from this event and reiterate management's expectations that it is incumbent upon the individual preparing or revising a procedure to fully understand the applicable license basis relative to the activity being performed. The case study will emphasize management's expectation that if personnel preparing and revising procedures do not fully understand the license basis, then they should involve the applicable licensing personnel to assist in the determination of the impact of the procedure revision on DCPP licensing basis. The case study will include the importance of identifying procedural commitments that are contained in licensing correspondence to ensure that they are maintained in the PCD.

2. PG&E will include the results of the case study for this event in a future Engineering support personnel training session.

As discussed in a Predecisional Enforcement Conference in Arlington, Texas, on December 18, 1996, on a failure to perform a 50.59 evaluation for a procedure change, PG&E has initiated the following actions:

1. A nonconformance report was initiated to review the 10 CFR 50.59 program and determine corrective actions to strengthen the procedure revision process.

2. PG&E management issued a memorandum to all procedure sponsors that emphasized the expectation that each person performing a procedure revision must be fully aware of all applicable license bases and that a detailed evaluation is required for each procedure revision.

VI. Additional Information

A. Failed Components:

None.

B. Previous LERs on Similar Problems:

None

LICENSING BASIS IMPACT EVALUATION

DIABLO CANYON POWER PLANT
TS3.ID2

TITLE: LICENSING BASIS IMPACT EVALUATION (LBIE) SCREEN

REFERENCE DOCUMENT No. ______________________________ Doc. Rev. No.________
(i.e.. indicate the Procedure Number. DCP Number or other reference document for which the Screen is done. including the document revision number or date).
Reference Document Title ____
Sponsoring Organization Regulatory Services __________________ Sponsor Pat Nugent
(Print)

DESCRIPTION
Summarize the proposed activity or CTE and how it differs from the presently approved condition. The reason for the proposed activity or CTE should also be described. Cite applicable drawings and other documents as necessary to describe the current condition. Briefly describe how the issue may interface with the licensing basis (documents).

The FSAR discusses the requirement to perform a flow calorimetric every 18-months. Although not expressly stated, the FSAR implies that a flow calorimetric is performed at the beginning of each refueling cycle. The following evaluation considers changing the performance of the flow calorimetric to the end of each refueling cycle.

SCREENING FOR DETERMINING THE NEED FOR PRIOR REGULATORY AGENCY APPROVAL

	Yes	No
Does this activity or CTE involve a change to the Facility Operating License (OL), including OL Attachments (Technical Specifications, Environmental Protection Plan and Antitrust Conditions)?	( )*	(X)

* If "Yes", submit an LAR to the NRC and continue this Screen subject to the approval of the contents of the LAR. LAR#______ Do not release the Reference Document above for use, construction, etc., until the LA is received. The originator of the Reference Document should provide a reconciliation between the LA and LAR to the PSRC to justify release for use, construction, etc.

Is the Reference Document a procedure? (If "No", skip the next question.)	( )	(X)
Does the Procedure Commitment Database (PCD) contain any commitment to a Regulatory Agency that must be changed and which would either:	( )**	( )

a) Require notification to that agency, or
b) Require prior approval from that agency?

** Follow the requirements of IDAP XI4.ID2, Commitment Change Process. Continue this Screen subject to the contents of the request for prior regulatory approval. Requesting document #___________. If no prior approval is required, continue the Screen.

TITLE: LICENSING BASIS IMPACT EVALUATION (LBIE) SCREEN

SCREENING FOR DETERMINING THE NEED FOR A SPECIFIC EVALUATION

For the activity or CTE under consideration answer the following questions. Any "Yes" response (except the answers for items 3.a and 4.a below) requires the appropriate sections of Form 69-10431 (LBIE) to be completed.

		Yes	No
SECTION 1.	10 CFR 50.59, 10 CFR 50.54(a)(3) and OL Condition 2.C.(5)b./2.C.(4)b. Screen		
a)	Does it involve a change to the facility design, function or method of performing the function as described in the SAR, including text, tables and figures+ and including the Fire Protection Program (FSAR Update, Section 9.5) and Quality Assurance Program (FSAR Update, Chapter 17)? (+See Appendix 7.5 of TS3.ID2)	( )	(X)
b)	Does it involve a change to procedures, system operation or administrative control over plant activities as described in the SAR, including procedures related to the Fire Protection Program (FSAR Update, Section 9.5) and the Quality Assurance Program (FSAR Update, Chapter 17)?	(X)	( )
c)	Does it result in a test, experiment, condition or configuration that might affect safe operation of the plant but was not anticipated, described or evaluated in the SAR?	( )	(X)
SECTION 2.	Environmental Protection Screen		
a)	Does it involve changes to or new effluents discharged to air, fresh water, sea water or land?	( )	(X)
b)	Does it involve a change in quantity* or use or storage of materials classified as hazardous (including oils) or the generation of hazardous wastes? (*See Paragraph 5.4.2 of TS3.ID2)	( )	(X)
c)	Does it result in disturbance of any previously undisturbed land?	( )	(X)
d)	Does it alter surface water runoff patterns or amounts?	( )	(X)
e)	Does it involve work within the SLO-2 archeological site boundary?	( )	(X)
SECTION 3.	Emergency Plan Screen		
a)	Does the Emergency Plan (EP) require review on the basis of Appendix 7.1? If "No", skip the next question and signature.	( )	(X)
b)	If "Yes", does the activity or CTE result in a change to the EP? (See Paragraph 5.5.4.a of TS3.ID2)	( )	( )

_______________________ /

Emergency Plan Reviewer Signature / Date

TITLE: LICENSING BASIS IMPACT EVALUATION (LBIE) SCREEN

SECTION 4. Security Plans' Screen

		Yes	No
a)	Do any of the security plans (PSP, SCP, STQP) require review on the basis of Appendix 7.2? If "No", skip the next question and signature.	( )	(X)
b)	If "Yes", does the activity or CTE result in a change to a security plan?	( )	( )

If so, which plan(s)? ____________________

____________________ / ______

Security Plan Reviewer Signature / Date

REMARKS: For each Screen Section above having all "No" answers, provide the logic for the "No" answers if clarification is required.

REFERENCES/ATTACHMENTS:

Based upon the above criteria, I have determined that an LBIE is X is not ____ required.

F. J. [signature] 1/6/97

Preparer Signature Date

Based upon my independent technical review, I concur with the above conclusion.

See Attached

Independent Technical Reviewer Signature Date

TITLE: LICENSING BASIS IMPACT EVALUATION (LBIE) SCREEN

SECTION 4. Security Plans' Screen	Yes	No
a) Do any of the security plans (PSP, SCP, STQP) require review on the basis of Appendix 7.2? If "No", skip the next question and signature.	( )	(X)
b) If "Yes", does the activity or CTE result in a change to a security plan? If so, which plan(s)?	( )	( )

_______________ /
Security Plan Reviewer Signature / Date

REMARKS: For each Screen Section above having all "No" answers, provide the logic for the "No" answers if clarification is required.

REFERENCES/ATTACHMENTS:

Based upon the above criteria, I have determined that an LBIE is _X_ is not ____ required.

Preparer Signature   Date

Based upon my independent technical review, I concur with the above conclusion.

Lionel D. Bates
Independent Technical Reviewer Signature

January 6, 1997
Date

DIABLO CANYON POWER PLANT
TS3.ID2

TITLE: LICENSING BASIS IMPACT EVALUATION (LBIE)

REFERENCE DOCUMENT No. ______________ Doc. Rev. No.________
(i.e.. indicate the Procedure Number, DCP Number or other reference document for which the Evaluation is done, including the document revision number or date).
Reference Document Title ______________
Sponsoring Organization Regulatory Services Sponsor Pat Nugent (Print)

As a result of the LBIE Screen (Form 69-10430), indicate which sections of this LBIE have been completed and are attached. Refer to TS3.ID2 to complete each evaluation.

[ ] SECTION 1 10 CFR 50.59 Safety Evaluation (including 10 CFR 50.54(a)(3) and OL Condition 2.C.(5)b./2.C.(4)b. Evaluations)
[ ] SECTION 2 Environmental Protection Evaluation
[ ] SECTION 3 Emergency Plan Evaluation - 10 CFR 50.54(q)
[ ] SECTION 4 Security Plans' Evaluation - 10 CFR 50.54(p)

Explain why this LBIE is being performed (i.e., Why were Screen questions answered "Yes"?)

The purpose of this licensing basis impact evaluation (LBIE) is to demonstrate that performance of a reactor coolant system flow calorimetric (RCSFC) at the end-of-cycle (EOC) instead of the beginning-of-cycle (BOC) does not constitute an unreviewed safety question. This LBIE and the attached evaluation were developed based upon an affirmative answer to LBIE screen question 1.b. Question 1.b. was answered yes because the change from BOC to EOC would require a revision of Surveillance Test Procedure (STP) R-26. The revision of STP R-26 is considered a change to a procedure described in the safety analysis report (SAR). Additionally, the change in the time of performance of the RCSFC also affects the determination of the uncertainty in the RCS loss of flow trip setpoints.

The evaluated change would allow the RCSFC to be performed at the end of a fuel cycle (EOC) and the RCS total flow rate to be verified by plant indication after startup of the next fuel cycle. Though the change does not conflict with the Diablo Canyon Power Plant (DCPP) Technical Specification (TS) requirements, it is not clear that this test sequence was anticipated or evaluated in the DCPP Final Safety Analysis Report (FSAR) Update. The allowance for flow measurement error included in the DCPP TS Figures 3.2-3 a(b) for Unit 1(2) is 2.4% thermal design flow (TDF). When the RCSFC is performed at EOC, the flow measurement error may exceed the allowance and a flow penalty is applied to the measured flow to account for the random instrument uncertainty greater than 2.4%. It is this corrected flow that is used to confirm compliance with TS Figures 3.2-3a(b). The attached LBIE and evaluation describe this flow penalty approach. It is necessary to evaluate the acceptability of the flow penalty method used to compensate for the excess error in RCS flow measurement, flow indication, and the RCS loss of flow (LOF) reactor trip setpoint if the EOC flow methodology is used.

PSRC REVIEW: MEETING NO. 97-004 DATE 1/10/97 RECOMMEND APPROVAL Yes (X) No ( )
APPROVED (PLANT MANAGER) R. P. [signature] DATE 1-10-96

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SECTION 1. 10 CFR 50.59 Safety Evaluation

For the issue under consideration, provide an explanation justifying each of the Yes/No answers. The detail provided shall be commensurate with the nuclear safety significance of the activity or CTE.

		Yes	No
1.	May the probability of occurrence of an accident previously evaluated in the SAR be increased?	( )	(X)

Justification:

The measurement of the RCS flow cannot initiate an accident. Consequently, the measurement of RCS flow cannot impact the probability of occurrence of an accident. The change to EOC for performing the RCSFC does not affect the method for collecting data as compared to the performing the RCSFC at BOC. The proposed change does not affect operation of any plant equipment. Measurements taken to perform a RCSFC do not require manipulation of any plant equipment; the measurements are passive. The change in the time of collecting the data does not change or affect the nature or method of the measurements.

Therefore, the proposed change does not increase the probability of occurrence of an accident previously evaluated in the SAR.

		Yes	No
2.	May the consequences of an accident previously evaluated in the SAR be increased?	( )	(X)

Justification:

Measurement of RCS flow using the RCSFC at BOC introduces a conservative measurement error into the flow. This error is due to hot leg streaming resulting from implementation of lower leakage core loading patterns. The lower leakage core loading patterns result in thermal stratification of the reactor coolant in the hot leg since more power is produced at the center of the core than at the periphery of the core. The radial power distribution of the lower leakage cores produces a radial temperature gradient across the core. The temperature gradient is not fully eliminated by mixing prior to entering the RCS hot legs, resulting in a temperature gradient in the hot legs.

Although the hot leg steaming error is generally conservative and provides for a conservative measurement of RCS flow, the result can be so conservative that operation at full power is not permissible. Performance of a RCSFC at EOC reduces the conservative error introduced by the hot leg streaming since the radial flux profile of the core is much flatter at EOC than at BOC, and consequently, hot leg streaming is reduced and the measured RCS flow is greater. However, performance of a RCSFC at EOC introduces additional instrument error not present during BOC. This includes allowances for instrument drift and calibration and feedwater venturi fouling. However, the additional instrument error is accounted for prior to verifying that adequate RCS flow is available to assure that all departure from nucleate boiling (DNB) parameters are satisfied by using figure 3.2-3a(b).

Figure 3.2-3a(b) allows for instrument inaccuracy of 2.4%. Any RCSFC that has less than 2.4% instrument accuracy can be compared to the figure and provide conservative results.

If a RCSFC has greater than 2.4% instrument error, the figure may not produce conservative results.

When measuring RCS flow using an EOC RCSFC, any instrument error greater than 2.4% is treated as a flow penalty. Rather than treating the additional instrument uncertainty as a random error, which could result in a positive or negative error, the flow value indicated by plant instrumentation is decreased by the amount of uncertainty greater than 2.4%. This adjusted value is then compared to the TS figures. Since the number being compared to the TS figures is conservative with respect to any possible instrument uncertainty greater than 2.4% that may exist, and the 2.4% instrument uncertainty is still assumed for using the figure, the figure will continue to provide conservative margin to DNB. Since the figure still provides conservative DNB results, consequences of an accident will not change.

The sensitivity of DNBR to the errors in plant inputs to the Improved Thermal Design Procedure (ITDP), such as the error in RCS flow measurement, may be non-linear. While it is unlikely that any non-linearity in the sensitivity would have a larger effect on DNBR than the conservatism of the flow bias approach, it is prudent to bound the allowable flow penalty by an evaluation of the change in DNBR with the change in the flow measurement uncertainty. Westinghouse performed such an evaluation which is reported in letter PGE 96-628. For DNB events, the evaluation concluded that the Diablo Canyon UFSAR results are valid with flow measurement uncertainty of 3.5% of thermal design flow even without the use of a flow penalty. Therefore the consequences of an accident previously evaluated in the SAR are not affected as long as the flow penalty and Technical Specification uncertainty (added together) do not exceed 3.5% of thermal design flow.

Additionally, the use of the flow penalty does not adversely affect the LOF reactor trip setpoint. The reactor will continue to trip at no less than 87% minimum measured reactor coolant flow as defined by the TS.

Therefore, performing the RCSFC at EOC does not result in an increase in the consequences of an accident previously evaluated in the SAR.

3. May the probability of occurrence of a malfunction of equipment important to safety previously evaluated in the SAR be increased? ( ) (X)

Justification:

The measurement of the RCS flow cannot initiate an accident. Consequently, the measurement of RCS flow cannot impact the probability of malfunction of equipment. The change to EOC for performing the RCSFC does not affect the method for collecting data as compared to the performing the RCSFC at BOC. The proposed change does not affect operation of any plant equipment. Measurements taken to perform a precision flow calorimetric do not require manipulation of any plant equipment: the measurements are passive. The change in the time of collecting the data does not affect the nature or method of the measurements.

Therefore, performing the RCSFC at EOC does not result in an increase in the probability of occurrence of a malfunction of equipment important to safety previously evaluated in the SAR.

4. May the consequences of a malfunction of equipment important to safety previously evaluated in the SAR be increased? ( ) (X)

Justification:

To increase the consequences of a malfunction, the dose to the public must increase. When performing a RCSFC at EOC, all design bases including the assumption regarding the point at which the reactor will trip on loss of RCS flow, will continue to be met. When performing the RCSFC at EOC and accounting for the additional uncertainty introduced by the change in the time that the RCSFC data is collected, the plant will perform the same as if the data had been collected at BOC. Since the plant will perform the same if the data is collected at EOC as it would if the data was collected at BOC, and all design bases will continue to be met, the dose to the public will not increase. Additionally, this change does not involve any new hardware or changes in key plant parameters which could impose new loads on or affect the operation of plant systems or components.

Therefore, performance of the RCSFC at EOC will not result in an increase in the consequences for any malfunction of equipment important to safety previously evaluated in the SAR.

5. May the possibility of an accident of a different type than any previously evaluated in the SAR be created? ( ) (X)

Justification:

The performance of the RCSFC at EOC does not change any system configuration or hardware. No new failure mechanisms are introduced.

Therefore, performance of the RCSFC at EOC does not create the possibility of an accident which is different than any already evaluated in the SAR.

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		Yes	No
6.	May the possibility of a malfunction of equipment important to safety of a different type than any previously evaluated in the SAR be created?	( )	(X)

Justification:

Since the RCSFC would be performed using existing equipment and would not be performed more frequently than at present, the performance of the RCSFC at EOC would not adversely impact the performance of any plant system.

Therefore, performing the RCSFC at EOC does not create the possibility of a malfunction of equipment important to safety of a different type than previously evaluated in the SAR.

		Yes	No
7.	Is there a reduction in the margin of safety as defined in the basis for any Technical Specification?	( )	(X)

Justification:

TS 3.2.3, Figure 3.2-3a(b) specifies the allowable RCS flow versus power. Figure 3.2-3a(b) states that measurement uncertainty of 2.4% is included in the figure. The 2.4% instrument uncertainty was determined using the methodology contained in Westinghouse WCAP-11594.

In PG&E Letter DCL 93-200, PG&E stated that the RCSFC was performed at BOC, and that the instrument uncertainty in that condition was less than 2.4%. In the safety evaluation for License Amendments 84 and 83, the NRC accepted the new instrument rack-up that would be present upon installation of the Eagle 21 system when the RCSFC is measured at BOC on the basis that it was conservative when compared to the assumed instrument uncertainty in Figure 3.2-3a(b). The statement that a RCSFC is performed at BOC is considered descriptive information rather than a requirement. The 2.4% instrument uncertainty is related to measurement of flow at BOC. PG&E believes that the 2.4% reference on the figure is descriptive and is intended to ensure that the required TDF is maintained. Since the method used to determine the RCS flow at EOC incorporated a flow penalty to account for instrument uncertainty greater than 2.4% in the non-conservative direction (due to the EOC measurement), the 2.4% instrument uncertainty in Figures 3.2-3a(b) is satisfied. Therefore, after imposition of the flow penalty, all instrument uncertainty in the non-conservative direction is within the 2.4% value specified in the TS figures.

Additionally, the Bases for TS 3.2.3 states that when RCS flow is measured, no additional allowances are necessary prior to comparing the flow to the TS figure, since the figure already assumed instrument error of 2.4% to assure that DNB parameters are satisfied.

As previously indicated, when changing from a BOC RCSFC measurement to a EOC RCSFC measurement, additional instrument uncertainty was introduced, although the change to EOC actually improved the correlation between the actual RCS flow and the measured RCS flow. To account for the increased instrument uncertainty and assure that the requirements of the TS Bases (that the measured flow would not have to be adjusted to use the Figure 3.2-3a(b)) would be satisfied, the measured RCS flow in STP R-26 was

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adjusted prior to being used as the final RCS flow and used to satisfy the surveillance requirements. Any random instrument error greater than 2.4% is considered a conservative bias (i.e. a flow penalty) applied to the indicated RCS flow. This has the effect of assuring that any random instrument error (which could normally be positive or negative) is always accounted for in the conservative direction. Since the measured flow is adjusted prior to the value being used as the measured RCSFC value or being compared to the TS figure, the intent of the TS Bases is still satisfied. However, the TS Bases should be clarified to more completely describe the use of the flow penalty if an EOC measurement were used again.

The total RCS flow assumed in the safety analyses depends on the methodology used for each specific analysis. For non-DNBR related events, or DNB events for which the Improved Thermal Design Procedure (ITDP) is not employed, the TDF value is used in the analysis. The TDF is met by ensuring that the minimum measured flow (MMF) required by the TS is higher than the TDF value by the 2.4% TDF allowance for total flow measurement uncertainty. For DNB analyses that employ the ITDP, the MMF value is assumed directly in the analysis. In the ITDP for DCPP, a random flow uncertainty of 2.4% of flow was accounted for in a statistical square-root-of-the-sum-of-squares (SRSS) combination with other plant condition uncertainties to set the DNBR design limit.

The use of the flow penalty also assures that random instrument error is conservatively accounted for in the RCSFC and that the margin to DNB remains conservative. Use of the additional flow penalty effectively reduces the measured RCS flow. This is bounded by accidents for which all forced RCS flow is lost. Consequently, the reduction of RCS flow was evaluated using the same criteria as used for loss of forced RCS flow accident in standard review plan (SRP) Section 15.3.1. SRP section 15.3.1 has acceptance criteria to assure that required fuel limits are not exceeded. This is assured by maintaining DNBR limits.

The purpose of Figure 3.2-3a(b) is to maintain margin to DNB by ensuring adequate RCS flow for an associated reactor power level. The loss of forced reactor coolant flow accident bounds a reduction in RCS flow from a DNBR perspective. The acceptance criteria stated in SRP section 15.3.1 as it relates to reduced RCS flow would be assuring that the minimum DNBR remains above the 95/95 DNBR limit. The incurred flow penalty assures that the margin to DNBR remains in place, and that the 95/95 DNBR limit is maintained.

The instrument error also affects the loss of flow reactor trip setpoint. The margin in this case is assuring that the reactor continues to trip at no less than 87% MMF RCS flow. The integrity of the RCS LOF trip safety analysis limit is assured by the application of the flow penalty to the measured RCS flow for each RCS loop. The flow penalty, together with the consideration of all other appropriate setpoint errors, ensures that the reactor trip will occur at no less than 87% MMF RCS flow. Since the flow penalty assures that the minimum setpoints are set at least at 90% of minimum measured flows for the respective units, there is no uncertainty unaccounted for in excess of the setpoint total allowance and the setpoint safety analysis limits (SALs) are assured. The SALs associated with the OTdT and OPdT setpoints are also assured because the DNBR safety analysis limits are not challenged as evaluated in Westinghouse letter PGE 96-628. In that letter Westinghouse reported that in the event of greater flow measurement instrument uncertainty (as much as 3.5%) and without the use of a flow penalty, only 0.6% of DNBR margin would be used and there would remain at least 21.4% DNBR margin to the DNBR SAL.

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Therefore, measurement of the RCSFC at EOC does not decrease the margin of safety as defined in any TS basis.

8. Is there a change to the Fire Protection Program (FPP) (FSAR Update, Section 9.5, including tables, figures and appendices)? ( )† (X)

9. Is there a change to the Quality Assurance (QA) Program (FSAR Update, Chapter 17)? ( )† (X)

†Complete and attach the next form sheet to this 10 CFR 50.59 Safety Evaluation.

Based upon the above criteria and justification, I have determined that an unreviewed safety question is*_____ is not __X__ involved. A change to the DCPP Technical Specifications is*_____ is not _X_ involved. Further, any resulting changes to the FPP or QA Program are documented as being within the licensing basis.

Preparer Signature Date

REVIEWED: Based upon my independent technical review, I concur with the above conclusion.

Independent Technical Reviewer Signature Date

* If an unreviewed safety question, change to DCPP Technical Specifications or other license amendment is involved, NRC approval is required prior to implementing the activity or CTE.

TECHNICAL EVALUATION OF END OF CYCLE RCS FLOW MEASUREMENT

1.0 OVERVIEW

This technical evaluation discusses the changes made to procedure STP R - 26, "RCS Primary Coolant Flow Measurements" which was revised in 1994 to accommodate an end of cycle (EOC) Reactor Coolant System Flow Calorimetric (RCSFC)RCSFC and the verification of adequate Reactor Coolant System (RCS) flowrate at the beginning of the subsequent cycle using plant indications. This method of RCS total flowrate verification results in a higher and more accurate RCS flowrate measurement as the effect from an overly conservative hot leg streaming bias is reduced. While the TS do not prohibit this changed method of RCS total flowrate verification, it is generally assumed in the industry that the RCSFC is done at beginning-of-cycle (BOC) to verify adequate RCS total flowrate following RCS modifications, core changes, steam generator tube plugging, etc. The procedure change supports the verification of adequate RCS total flowrate by accommodating an end-of-cycle (EOC) RCSFC which is used for normalizing the cold leg elbow tap ΔP output to RCS flowrate. The normalized cold leg elbow tap outputs provide the plant indication at either the plant process computer (PPC) or operator vertical board from which the RCS total flowrate is verified to be in compliance with the TS paragraphs 4.2.3.2 and 4.2.3.3 at the beginning of the subsequent fuel cycle. The STP R-26 procedure change was necessary because the EOC method resulted in uncertainty errors in RCS flow measurement in excess of the allowances which were provided in the DCPP Technical Specifications and existing design basis. The procedure was changed to include calculated flow penalties which account for the errors in excess of the allowances.

The RCSFC, (procedure STP R-26), was previously performed at BOC to verify that RCS total flowrate is in compliance with TS paragraph 4.2.3.2.a (and associated Figures 3.2-3a and 3.2-3b, "RCS Total Flowrate Versus R", for Unit 1 and Unit 2 respectively). The performance of this test also satisfies the TS requirement in 4.2.3.5 to determine the total RCS flowrate by measurement at least once per 18 months. The performance of the RCSFC at BOC confirmed that the RCS flowrate required by the TS was met after refueling and maintenance activities were completed. The performance of the RCSFC also provides the basis for the setting of the RCS Loss of Flow-Low (LOF) setpoints in Table 2.2-1 of the TS. In accordance with STP R-26, the LOF setpoints for reactor trip are set at 90% of the actual loop flowrate measured by RCSFC but not less than the TS specified minimum setpoint of 90% minimum measured flow (MMF). The errors in the performance of the RCSFC at EOC RCSFC affect the error in the RCS LOF setpoint.

The assumption of a BOC Precision Flow Calorimetric was included in WCAP-11082 Rev. 2, "Westinghouse Setpoint Methodology For Protection Systems Diablo Canyon Stations Eagle 21 Version," and WCAP-11594 Rev. 0, "Westinghouse Improved Thermal Design Procedure Instrument Uncertainty Methodology." These WCAPs have been previously submitted to the NRC. PG&E calculations N-191, N-193, J-084 and J-108 address the EOC method.

2.0 DEFINITIONS

<u>BOC</u>: The period following initial startup of a new core after reaching 100% power and extending for several weeks.

EOC: There is no specific cycle timing requirement for the performance of the RCSFC, only that one be performed every 18 months. In this changed method, the end-of-cycle RCSFC is performed within the month before the scheduled plant shutdown for refueling.

Flow Penalty: The stated assumption for RCS flowrate measurement error or allowance in the TS Figures and setpoint Table 2.2-1 remain the same in the changed methodology. If the RCS flowrate error (random) in the indication used to verify compliance with the TS requirements is greater than the 2.4% Thermal Design Flow allowance, then the RCS flowrate measured by RCSFC is penalized by the error in excess of the allowance. This is called a flow penalty. In effect, the flow penalty method conservatively assumes that the excess random error is a bias, which it then corrects for. Also, a flow penalty for the RCS Loss of Flow Low setpoint is applied. It is equal to the amount of the calculated setpoint uncertainty (EOC method) in excess of the setpoint uncertainty allowance.

Mechanical Design Flow: As described in FSAR Update paragraph 5.1.5.4, mechanical design flow (MDF) is the RCS flow used in the mechanical design of the reactor vessel internals and fuel assemblies. It is a conservatively high flow established on the basis of reduced RCS resistance (about 90% of best estimate) and on increased pump head capability (107% of best estimate).

Minimum Measured Flow: Another RCS total flowrate term used in the TS is minimum measured flow (MMF). MMF equals 1.024 times Thermal Design Flow (from FSAR Update Table 4.1-1 and Technical specification Figures 3.2-3a and 3.2-3b). MMF is the total RCS flowrate assumed in the Improved Thermal Design Procedure. If total measured RCS flow is less than MMF, Unit power is limited by DCPP Technical Specifications.

Normalized: The term "normalized" signifies that the elbow tap ΔP transmitters, which drive plant indications of RCS flowrate, have been benchmarked to the RCS flowrate measured by RCSFC such that 100% indicated RCS flow is equal to the RCSFC measured flowrate in gallons per minute.

Reactor Coolant System Flow Calorimetric: The Reactor Coolant System Flow Calorimetric (RCSFC)RCSFC is the plant test in procedure STP R - 26 which is used to measure RCS flowrate. The RCSFC uses the measurement of secondary power output (calorimetric) and primary temperature and pressure to calculate RCS flowrate.

Thermal Design Flow: Thermal Design Flow (TDF) is the RCS total flowrate assumed in the DCPP safety analyses for transients which are not analyzed using the Improved Thermal Design Procedure (see WCAP-8568). As discussed in DCPP FSAR Update Section 5.1.5.3, TDF is the total RCS flow predicted by conservative analysis of the RCS flow characteristic (flow resistance of RCS components increased by about 15% over best estimate resistance) and reactor coolant pumps' best estimate characteristic curves. Actual RCS flow was verified to be in excess of TDF during each DCPP Units' startup.

Comparison of Defined Flows (all in gpm)	**Unit 1**	**Unit 2**

Thermal Design Flow	350,800	354,000
Minimum Measured Flow	359,200	362,500
Mechanical Design Flow	384,600	388,200

The comparison of flows is from FSAR Update Table 4.1-1 and Figure 5.1-2.

3.0 TIME LINE

November 29, 1993	Letter from NES NUCLEAR ENGINEERING to VARIOUS outlined a need for developing a new method for determining RCS flow due to hot leg streaming error. Elbow taps was the primary method being looked at but this would require a LAR and would not be available until Unit 2 Cycle 7. A backup plan was to look into an EOC method. (reference AR A0312595)
March 16, 1994	NES Calculation File J-084 for EOC flow calorimetric approved.
March 29, 1994	OTSC to STP R-26 Rev 11 written to enable the 18 month RCS flow measurement to be performed at end of cycle 6 on Unit 1.
March 30, 1994	First EOC RCS flow calorimetric completed -Unit 1 cycle 6
September 12, 1994	EOC RCS flow calorimetric completed for Unit 2 cycle 6.
September 12, 1995	EOC RCS flow calorimetric completed for Unit 1 cycle 7.
October 26, 1995	Calculation N-193 approved for EOC Flow Calorimetric uncertainty for Eagle 21.
March 21, 1996	Calculation N-191 approved for EOC Flow Calorimetric uncertainties for AMAG Ultrasonic Flow Measurement
March 29, 1996	EOC RCS flow calorimetric completed for Unit 2 cycle 7.
June 5, 1996	Draft 10 CFR 50.59 generated on the EOC calorimetric method based on questions raised during 24 month cycle planning and low flow trip setpoint issues.
July 1996	Questions were raised about the effects on DNBR margin and the EOC calorimetric method. Westinghouse was contacted and requested to perform an evaluation of the issue.
August 8, 1996	Quality Evaluation Q0011893 initiated to deal with inadequacies in the calculations N-191 and N-193. Also to address the Eagle 21 License Amendment reference to BOC calorimetric.

September 1996	Questions were raised on the adequacy of exceeding the 2.4% uncertainty margin noted in Figure 3.2-3a and 3.2-3b in the Technical Specifications even though a penalty is applied for the excess uncertainty.
November 1, 1996	First call made to NRR to discuss the EOC calorimetric method.
November 4, 1996	Generated Non Conformance Report N0002002 to address quality concerns with the EOC calorimetric license basis.
November 6, 1996	Second call made with NRR to continue EOC calorimetric discussions.
November 8, 1996	Decision made to return measured RCS flow to the BOC method based on continuing concerns over the validity of the EOC calorimetric license basis. Unit 1 data from 12-8-95 was used and Unit 2 data from 5-31-96 was used to establish the new 100% RCS flow values based on BOC plant data.
November 21, 1996	PG&E received the Westinghouse evaluation of the flow penalty bias method which is used to account for increased RCS flow measurement uncertainty.

4.0 BACKGROUND

Because of the effects of the current use of lower leakage core loadings in the DCPP Units, there is increased hot leg temperature streaming. The lower leakage core designs have a higher percentage of the core power produced in the inner core regions. This leads to an increased temperature distribution (skewing) within the hot leg due to incomplete mixing in the upper plenum. In both Units 1 and 2, the RCSFC performed at the beginning of the fuel cycle has more skewing of the temperature profile from the increased hot leg streaming, the three resistance temperature devices (RTDs) in each hot leg overstate the average bulk temperature, resulting in an overly conservative temperature bias. The hot leg temperature streaming effect is worsened at DCPP because the RTDs are mounted more closely (due to physical constraints) than usual to the reactor vessel. This results in an indicated reduced RCS flowrate value. The problem of hot leg temperature streaming is common to a varying degree in other plants using low leakage core loading.

In addition to the excessive conservatism in indicated flowrate measurement from hot leg temperature streaming, there are other factors that can adversely affect the actual RCS flowrate, such as the degradation of the steam generator (SG) tubes. This necessitates that tubes be plugged, which increases the pressure drop in the steam generators and consequently reduces flowrate through the core. Other changes that can affect the RCS flowrate are changes in fuel design and possibly pump impeller wear. Though some of these effects are small for DCPP, the combination of all these effects, and the difference between

the indicated and actual RCS flowrate, may make it difficult to meet the TS minimum total flowrate requirements in the future.

The RCS flowrate is obtained from a RCSFC which is taken on each side of the steam generator. The flowrate on the secondary side is measured by the feedwater venturi meters. The primary side heat balance in conjunction with the secondary side heat balance are used to derive the RCS flowrate. This flowrate is the measured flowrate that is used to meet the requirement for the TS 18 month flowrate measurement in paragraph 4.2.3.5.

The accuracy of this method of obtaining the RCS flowrate is based on a detailed flow measurement uncertainty analysis for the DCPP plant-specific instrumentation. Currently DCPP uses a flowrate measurement uncertainty of 2.4% Thermal Design Flow (or 2.34% MMF) which is based on the Westinghouse method for combining uncertainties. The RCS flowrate is measured within the desired probability and confidence level. The errors in parameters for obtaining flow measurement include errors classified as precision (random) errors and bias (fixed) errors. These are combined using a square-root-of-the-sum-of -the-squares (SRSS) combination of the random errors which are added to the bias errors to obtain the overall uncertainty.

In the EOC approach the RCS flowrate is measured at EOC using the RCSFC. The elbow tap ΔPs are then normalized to the measured flowrates (inches of water elbow tap ΔP set equal to gallons per minute of RCSFC measured flowrate in each loop), the flowrate correlation coefficient is obtained for each elbow tap, the elbow tap ΔP transmitters are calibrated during refueling, and the RCS total flowrate is verified at plant re-start by reading and summing the RCS loop flowrate indications. The new RCS total flowrate is proportional to the square root of the ΔP as measured by the elbow taps. The flow indications are not adjusted to all indicate 100% loop flowrate after startup. Every 18 months, the RCSFC is run and the data is used as a standard to obtain a new RCS flowrate correlation coefficient for each of the elbow tap readings. The errors inherent in this approach are calculated using the Westinghouse methodology and are either shown to be within the bounds of existing analyses or a flow penalty is applied to the RCSFC result which biases the flowrate measurement in the low (conservative) direction. This ensures that the uncertainty remains within the 2.4% uncertainty of the TS.

The DCPP cold leg elbow tap configuration for RCS flowrate measurement is not calibrated in advance in a laboratory; nor are the DCPP elbow taps standard ASME flow measurement devices (this is applicable to all plants using elbow tap devices). However, the cold leg elbow tap pressure drop is normalized against the established RCS flowrate for each cycle based on the RCSFC results. The purpose of the elbow tap reading at BOC is to ascertain that full-power steady-state flowrate meets TS minimum requirements of Figures 3.2-3a and 3.2-3b. The elbow tap pressure drop correlation to RCS flowrate is also used for the LOF reactor trip.

5.0 Evaluation of EOC Method for RCS Flowrate Measurement

The criteria established in 10 CFR 50, Appendix A, require a high degree of assurance that specified acceptable fuel design limits (SAFDL) are not exceeded. The SAFDLs for anticipated operational occurrences are that neither DNB nor melting at the fuel centerline

occurs. The results of the safety analyses calculation are used to assure, with high confidence (95%) and high probability (95%) that the SAFDLs are met. The safety analyses assume that the Technical Specification RCS total flowrate is met as an initial condition of the analyses and that the minimum RCS LOF reactor trip occurs before the actual RCS loop flow decreases below the trip setpoint safety analysis limit. However, the importance of RCS low flowrate to reactor trip is diminished by other trip parameters used at DCPP, such as loss of pump power (reactor coolant pump breaker open, under-voltage, and under-frequency), too large a temperature difference between the hot and cold legs (OTDT), or high pressurizer pressure; all trip parameters that may cause reactor trip prior to a low flowrate trip. The RCS LOF reactor trip provides primary protection for partial loss of flow accidents.

The effect of the changed method on RCS flowrate verification and the RCS LOF trip will be evaluated. The principal features of the changed method which are different from the previous BOC method are the performance of the RCSFC at EOC, the use of the elbow taps to verify adequate RCS flowrate at BOC, and the use of flow penalties, for flow indication and setpoints, to ensure sufficient allowance for flowrate error.

5.1 Evaluation of RCS LOF Reactor Trip and RCS Flowrate Verification

PG&E determined the uncertainty associated with performing the RCSFC at EOC rather than at BOC would require the use of flow penalties. The principal differences in the errors are due to the fact that in the BOC approach there were some flow transmitter ΔP errors which were normalized out when the correlation was made between flowrate and ΔP. Since, in the EOC approach, the transmitters are calibrated between the time the flow correlation is made and the plant is re-started, the additional transmitter errors due to calibration, transmitter adjustment, temperature effect and pressure effect were included. All the errors inherent in the DCPP plant instrumentation were considered and the total RCSFC error, RCS total flowrate indication error and RCS LOF setpoint errors were calculated using the Westinghouse methodology of WCAP-13556, "Bases Document For Westinghouse Setpoint Methodology For Protection Systems." WCAP-13556 is the basis document for WCAP-11082, which is the Westinghouse setpoint study for DCPP. This methodology assures a high confidence and high probability (95%/95%) determination of the errors. The errors were first calculated in J-084 which was superseded by calculations N-191 Rev. 1 (for Unit 2), N-193 Rev. 1 (for Unit 1), and J-108 Rev. 2 (for both Units RCS LOF reactor trip).

In calculation J-084 the uncertainty in RCS flowrate measurement, flowrate verification, and LOF (LOF) trip were determined assuming a RCSFC performed at EOC. Calculation J-084 established the flow penalty, which was applied in STP R - 26, such that the LOF setpoint in DCPP TS Table 2.2-1 was met and the safety analysis limit was protected. The TS requirement is that the LOF setpoint be set at greater than or equal to 90% MMF and that the reactor trip be assured to occur before actual loop flow decreases below 87% MMF (from DCPP FSAR Update Table 15.1-2 for Trip Setpoints assumed in accident analyses). The purpose of the setpoint setting limit in the TS is to ensure that the reactor trip on Loss of Flow Low occurs at or above the safety analysis limit. The purpose of the flow penalty for the setpoint is to provide this assurance.

In the flow penalty method, the total setpoint uncertainty was apportioned between the penalty and the TS allowance (90% MMF minus 87% MMF). The amount of the uncertainty calculated in J-084 which was in excess of the allowed flow uncertainty, was subtracted from the RCSFC measured loop flowrate. A check was made to ensure that the penalized flowrate was greater than MMF. If the penalized flowrate was greater than MMF, the setpoint was set at 90% of the penalized flowrate. If the penalized flowrate was less than MMF, then the LOF was set at 90% of MMF using scaling which assumed the actual loop flow was the penalized flowrate.

An example of penalty methodology illustrates how the safety analysis limit (SAL) is assured. The MMF value per loop for Unit 1 is 89,800 gpm. The SAL value is 89,800* 0.87 = 78,126 gpm. The setpoint error allowance is 3% of MMF or 2,694 gpm. The setpoint uncertainty from calculation J-084 was 3.9% flow. Since flow measured in the loop by RCSFC was 90,600 gpm (a value assumed for illustration) the uncertainty in the setpoint was 3,533 gpm (= 90,600*0.039). The uncertainty in the setpoint was greater than the allowance and the difference (3533 - 2694 = 839 gpm) was applied as a flow penalty. The loop flow minus flow penalty was 90,600 - 839 = 89761 gpm. Since this is less than MMF, the setpoint is set at 90% of MMF or 80820 which is also 80820/89761 or 90.04 percent of flow. This value assures that the SAL (87% MMF) is met after the flow penalty is applied. In summary (all in gpm):

Loop MMF =	89,800
Uncertainty =	3,533
Error allowance	2,694
Measured Flow (RCSFC)	90,600
Flow penalty (3533 - 2694)	839
Penalized Flow	89,761
90% of MMF	80,820
Setpoint 80820/89761 =	90.04% Penalized Flow
SAL Test: Setpoint of	80820
Plus penalty	839
Total:	81659
Subtract Total Uncertainty	3533

Setpoint is assured to occur: 78,126 which is also the SAL

The application of the flow penalty for the RCS LOF trip setpoint ensured that the setpoint would occur at or before the safety analysis limit was reached. The flow penalty for RCS LOF trip was calculated before the RCSFC was run at EOC 6 and the revised scaling for LOF setpoints was implemented in the DCPP Units before they were restarted in cycle 7.

The calculations N-191 and N-193 superseded calculation J-084. These calculations updated the RCS flowrate related uncertainties to account for the addition of the AMAG feedwater flow measuring device, which was to be used in Unit 2 at EOC 7, and to reflect updated vendor specifications on equipment performance. Calculations N-191 and N-193 used a conservative application of the same methodology used in calculation J-084. This was the Westinghouse methodology of WCAP-11594 and WCAP-13566. The calculation results were incorporated as flow penalties in STP R-26.

Assumptions are:

1. There is high confidence and high probability that the flow correlation coefficient determined by RCSFC at EOC and at 100% RCS loop flowrate is valid at approximately 90% of actual loop flowrate (where the Loss of Flow Low setpoints are set).

2. There is high confidence and high probability that the flow correlation coefficient is constant from the time of RCSFC test at EOC and over the subsequent fuel cycle (even after refueling activities) until the next RCSFC test within 18 months.

3. While the key consideration in using the RCSFC performed at EOC and the elbow tap measurements for flow verification is the allowance of sufficient margin to accommodate the total flowrate uncertainty, it is also assumed that the EOC method of RCS total flowrate measurement is sufficiently sensitive to detect changes in flow due to steam generator tube plugging or reactor fuel changes.

The first assumption made concerning the validity of the elbow tap flow correlation coefficient at 90% actual loop flow versus the establishment of the correlation at 100% loop flow is supported by the flow measurement characteristics of the elbow tap and is an assumption contained within the current DCPP design basis. The elbow tap flow correlation coefficient is currently assumed to be the same at 90% actual loop flow as it is at 100% loop flow in WCAP-11082 Rev. 2 which is the current DCPP setpoint design basis.

The second assumption made is that the flow correlation coefficient has a high confidence and high probability of being constant from the time at test near EOC and over the subsequent fuel cycle (even after refueling activities) until the next RCSFC test within 18 months. The elbow tap flow correlation coefficient could be disturbed by erosion, deposition of impurities, dimensional changes, and upstream velocity distribution effects. These potential disturbances were investigated by Westinghouse for PG&E. Westinghouse reported their findings in Report FSE/WGL - 2182, "Diablo Canyon Nuclear Power Plant Justification of Elbow Taps For RCS Flow Verification." This Report was intended to justify the use of the elbow taps to verify RCS total flowrate without any periodic (18 month) RCSFC tests.

The Westinghouse report concluded that deposits resulting in changes in pipe elbow surface roughness do not occur and therefore would not affect the elbow tap flow correlation coefficient. The assertion of no expected change in flow correlation coefficient is also supported by the fact that the TS and design bases currently assume that there is no significant change in the elbow tap flow correlation coefficient over an 18 month period. Fouling or deposits within the instrument tubing between the elbow tap and the differential pressure instrument is not a concern since no flow is transmitted within the tubing.

In addition, the Westinghouse report concluded that dimensional changes would be minimal and that erosion (flow accelerated corrosion) is not a concern since the velocity of the RCS fluid is small relative to velocities known to cause erosion in stainless steel. This supports the current DCPP design and licensing bases which assume that erosion of the RCS piping will be

nonexistent between each 18 month RCSFC test for correlation of the elbow taps. The Westinghouse Report concluded that "the elbow meter is considered to be a highly stable flow measurement element."

The effect of upstream fluid velocity distribution changes is also expected to be negligible over an 18 month period between RCSFC tests. Velocity distribution changes are caused by steam generator tube plugging. Of particular concern would be tube plugging concentrated in one area of the steam generator. The Westinghouse report evaluated this supposed condition and concluded that "...any tube plugging, even if asymmetrically distributed, would not affect the elbow flow measurement repeatability."

The Westinghouse report addressed the question of elbow tap repeatability and stability as well by presenting a comparison of flow measurement test data taken at Prairie Island using an Ultrasonic Leading Edge Flow Meter (LEFM) and elbow tap flowrate data taken over an eleven year span. During this time there were significant changes in system hydraulics. The impeller of one of the reactor coolant pumps was replaced which produced a higher RCS loop flowrate. The LEFM and elbow tap flow indications average difference during the test period was within 0.3% of flowrate. The maximum single difference was 0.5% flowrate with the elbow meter indicating the lower flow. The difference in measured flowrates after the pump impeller replacement was just 0.2% flowrate. The report concluded that the Prairie Island data further confirms the accuracy of relative flowrate measurements with elbow taps.

From this discussion one can conclude that there is high confidence and high probability that the flow correlation coefficient is constant from the time of RCSFC test at EOC and over the subsequent fuel cycle (even after refueling activities) until the next RCSFC test within 18 months. Further, the technical concerns: a) that the elbow tap normalization to RCS flowrate measured at EOC may not be correct for RCS LOF trip or total flowrate verification at BOC due to outage activities, and b) that the normalization of the elbow taps may not be stable, i.e. that the elbow tap physical characteristics or the RCS loop flow profile may change during the refueling outage such that the accuracy of the normalization is affected, have been addressed and were shown to not significantly affect the error of the RCS LOF setpoint or the RCS flowrate verification.

Since over the first seven cycles the DCPP steam generators had very little tube plugging (less than 1% of total tubes in each Unit), the effects of tube plugging were not seen in the Westinghouse evaluation of DCPP RCS flowrate data. During the last refueling outages in the DCPP Units before the start of cycle eight, the total steam generator tube plugging was raised to 1.68% of all tubes in Unit 1 and 2.54% of all tubes in Unit 2. This change in tube plugging raises the question as to whether or not the elbow tap measurement of RCS flowrate would detect this change in tube plugging. This question is associated with the third assumption made that "the elbow tap method of RCS total flow rate measurement is sufficiently sensitive to detect changes in flow due to steam generator tube plugging or reactor fuel changes." The technical concerns related to this assumption were: a). that the error in the RCS total flowrate verification using the EOC method may become so large that safety significant trends in RCS total flowrate would not be detected, and b). that the RCS total flowrate, as verified by the EOC method, may become significantly biased over time and that the bias may not be detected.

The Westinghouse report addressed the above assumption and the technical concerns as well by an analysis of the DCPP Units best estimate calculated flowrates and measured elbow tap flowrates over the first 5 cycles of plant life. The Westinghouse report did not include the RCS flowrate data from the sixth and seventh cycles because the report was prepared prior to the start of those cycles. In addition, the RCSFC test for the elbow tap normalization for cycle 7 was performed at the end of cycle six and the test for cycle 8 elbow tap normalization was performed at the end of cycle seven. Since the RCSFC tests were run at EOC with reduced hot leg streaming, the flowrate results are not directly comparable to the flowrate results of the first five cycles when the RCSFCs were run at BOC. Therefore the Westinghouse report has not been updated, but the EOC flowrate data for EOC cycle 7 (the latest data available) is included in this evaluation.

Westinghouse, as reported in FSE/WGL - 2182, "Diablo Canyon Nuclear Power Plant Justification of Elbow Taps For RCS Flow Verification," performed a best estimate analysis for DCPP that supports the expected repeatability of the EOC Precision Flow Calorimetric and the use of elbow taps to verify adequate RCS flowrate after refueling. The analysis included pertinent data related to the RCS flowrate measurement which was compiled from the Unit 1 and 2 refuelings that occurred prior to 1992.

Westinghouse made hydraulic calculations to demonstrate PG&E's ability to accurately obtain the estimated RCS flowrate for each cycle using the initial or baseline RCS pump flowrate test data. The RCS pump test data was used with pressure drop calculations of the primary loop to predict the best estimate RCS flowrate for each cycle. The calculations included those for the primary system in its original condition during the first cycle and then for succeeding cycles (through cycle 5). The calculations for each cycle included the cumulative effects of changes from modifications such as steam generator tube plugging, fuel type, thimble plug removal, etc. Westinghouse compared the RCS flowrates for the previous cycles using two methods: (1) predictions from hydraulic calculations, (2) the elbow tap measurement.

The Westinghouse comparison of the model's best estimate flows with the flows measured by elbow tap over the first five fuel cycles shows that the model and elbow tap flows agree to within a repeatability band of $\pm$ 0.4% flow (total RCS flowrate). RCS total flowrate decreased in both Units over the first five cycles from about 100.5% of baseline flowrate to 99% of baseline elbow tap measured flowrate. The cycle 5 and the added cycle 7 data are shown below:

Unit 1, Cycle 5 RCSFC Flowrate:	97.9% baseline flowrate
Unit 1, Cycle 5 Model Flowrate:	99.3% baseline flow
Unit 1, Cycle 5 Elbow Tap Flowrate:	99.2% baseline flowrate
Unit 1, Cycle 7 EOC/RCSFC Flowrate:	98.3% baseline flowrate
Unit 1, Cycle 7 Model Flowrate:	not available
Unit 1, Cycle 7 Elbow Tap Flowrate:	98.34% baseline flowrate
Unit 2, Cycle 5 RCSFC Flowrate:	95.8% baseline flowrate
Unit 2, Cycle 5 Model Flowrate:	99.1% baseline flowrate
Unit 2, Cycle 5 Elbow Tap Flowrate:	98.84% baseline flowrate

Unit 2, Cycle 7 EOC/RCSFC Flowrate: 97.3% baseline flowrate
Unit 2, Cycle 7 Model Flowrate: not available
Unit 2, Cycle 7 Elbow Tap Flowrate: 98.6% baseline flowrate

The differences between the RCSFC test results and the elbow tap flowrate measurements were smaller in both Units at the end of cycle 7 than in cycle 5. It is clear that the RCSFC at EOC produces results which more closely agree to the elbow tap data and which are known to be more accurate. (The higher flowrate measurements at EOC are certainly due to less hot leg streaming bias). The elbow tap flowrate data, over both cycles and Units, is more consistent which implies, but does not prove, that the elbow tap flowrate measurement is more accurate than the RCSFC measurement. Even at EOC, a RCSFC measurement of RCS flowrate remains biased to some degree due to hot leg streaming.

The flow model predictions and the elbow tap data agreement provides assurance that the elbow taps do not introduce a significant and undetected bias in the RCS flowrate measurement over time and that the error in RCS flowrate measurement will not become so large as to mask significant changes in the true RCS flowrate. This result is similar to the flowrate data taken from Prairie Island in which the LEFM and elbow tap flowrates were comparable over an eleven year period. The expectation that the EOC method will not introduce a significant flowrate measurement bias or result in undetectable error is further supported by the fact that RCSFC tests will be performed each cycle.

The assumptions concerning the elbow tap flow correlation coefficients are that the flow correlation coefficient determined by RCSFC at EOC and at 100% RCS loop flow is also valid at approximately 90% of actual loop flow, that the flow correlation coefficient is essentially constant from the time of test near EOC and over the subsequent fuel cycle until the next RCSFC test within 18 months, and that the elbow tap method of RCS total flow rate measurement is sufficiently sensitive to detect changes in flow due to steam generator tube plugging or reactor fuel changes. These assumptions have been shown to be reasonable and supportable. The elbow taps provide a pressure of several hundred inches of water. The elbow tap configuration makes it less precise over a range of flow conditions than a venturi, but the restricted usage to the small range of Reynold's Numbers associated with variation of flowrate within normal power operations alleviates such concerns. Once calibrated, and provided uncertainty and any potential hardware changes are correctly considered, the EOC Precision Flow Calorimetric and the elbow tap RCS flow verification, with high confidence and high probability, may be used to meet the intent of TS's 4.2.3.2, 4.2.3.3 and 4.2.3.5.

5.2 RCSFC Uncertainty at EOC, Flowrate Verification and the Flow Penalty

In the EOC approach to RCS flow rate measurement and verification, the RCS flowrate is measured at EOC using the RCSFC, the elbow tap ΔPs are normalized to the measured flows, the flow correlation coefficient is obtained for each elbow tap, and the RCS total flowrate is verified at plant re-start by reading the RCS flow indications. The new RCS total flowrate is proportional to the square root of the ΔP as measured by the elbow taps. The flow indications are <u>not</u> adjusted to all indicate 100% flowrate after startup. The errors inherent in this approach are calculated using the Westinghouse methodology and are either shown to be within the

bounds of existing analyses or a flow penalty is applied to the RCSFC result which biases the flow measurement in the low (conservative) direction. Since the flowrate correlation is obtained at EOC, the errors due to possible transmitter change-out are included in this changed methodology.

Errors in RCS flowrate measurement by RCSFC are calculated using a Westinghouse methodology which is described in WCAP-13556, "Bases Document For Westinghouse Setpoint Methodology For Protection Systems." This WCAP is the basis document for the Westinghouse setpoint study for DCPP, WCAP-11082. A similar methodology, but also including the calculation of error in the plant indication of RCS flowrate and the EOC associated errors, is documented in Westinghouse SECL-93-092 found in PG&E Chron 215306. The Westinghouse SECL was originally authored to provide the 10 CFR 50.92 Evaluation for the justification of using elbow taps at DCPP as the only method for RCS total flowrate measurement (eliminating the RCSFC altogether). The aspects of the SECL which are pertinent to this technical evaluation are those associated with the performance of the EOC Precision Flow Calorimetric each cycle to normalize the elbow tap ΔP to RCSFC measured flowrate, and the use of the elbow tap ΔP to verify total RCS flowrate.

The error in the measurement of RCS flowrate by RCSFC is included in the error of the RCS Loss-of-Flow Low reactor trip and in the error of RCS total flowrate measurement by plant indication. PG&E has calculated the total error in the EOC Precision Flow Calorimetric and in verification of RCS total flowrate by plant indication. These calculations are N-191 Rev. 1 (for Unit 2), and N-193 Rev. 1 (for Unit 1). The calculation of the error in the RCS LOF setpoint was discussed in Section 5.1.

The verification of adequate RCS total flowrate is based on an end-of-cycle RCSFC. The normalized cold leg elbow taps are used to provide the plant indication at either the plant process computer or operator vertical board from which the RCS total flow rate is verified to be in compliance with the TS's 4.2.3.2 and 4.2.3.3, at the beginning of the next fuel cycle. A measurement error of 2.4 percent Thermal Design Flow (TDF) for RCS flowrate has been allowed for in the determination of the design DNBR values. A measurement error of 4 percent for $F^N_{\Delta H}$ has also been applied to the design DNBR. The stated assumption for flow measurement error in the TS Figures 3.2-3a and 3.2-3b is 2.4 percent TDF. If the RCS flow indication random error used for flow verification is greater than the allowance, the RCS measured flow is penalized by the indication error which is in excess of the 2.4% TDF allowance (a flow penalty is applied).

An RCS flowrate penalty (currently about 0.5%) which is specific to total flowrate verification has been calculated for both DCPP Units in Calculations N-191 and N-193. A reasonable limit for this flowrate penalty is 1.1% TDF. This limit is based on the Westinghouse Evaluation of the flow penalty bias method to account for increased RCS flow measurement uncertainty which was reported in letter PGE 96-628 dated November 21, 1996. Westinghouse evaluated a flow measurement uncertainty of as much as 3.5% TDF and found that there was a consequent loss of just 0.6% DNBR design margin. This loss would result in at least 21.4% DNBR design margin remaining. This limit on the flow penalty of 1.1% is conservative because the penalty ensures that the DNBR design margin is actually not lost at all. The effect of the larger flow measurement uncertainty was evaluated by Westinghouse as if the flow penalty

were not imposed. Therefore if DCPP were to have the larger flow measurement uncertainty and not take a flow penalty, the result would be a loss of just 0.6% DNBR design margin. This statement is made assuming that RCS flow would be verified to be greater than TDF, including any flow measurement error, for non-ITDP analyzed events. Thus, a 1.1% TDF flow penalty limit is conservative.

The flow penalty is accounted for in the conversion of the indicated flow from percent loop flow to gallons per minute (gpm) flow. One hundred (100) percent indicated flow is converted to flow in gpm by equating the RCSFC measured flow, for example 90,000 gpm, to 100 percent flow. The flow penalty correction is made by subtracting the excess error (in gpm) as a bias or penalty from the RCSFC measured (in gpm) flow in each loop. The flow indication (in percent loop flow from either the PPC or the operator vertical board) is, until the next RCSFC test, converted to gpm flow based on the corrected flow value in gpm (for example after the flow penalty is applied, 100 percent indicated flow would be equated to 89,000 gpm instead of 90,000 gpm).

The imposition of the flow penalty is accomplished in plant procedure STP R-26 such that when RCS flowrate and $F^N_{\Delta H}$ are measured, no additional allowances are necessary prior to comparison with the limits of Figures 3.2-3a and b. The use of the flow penalty approach is conservative with respect to the calculated minimum DNBR because the allowances for the several sources of error included in the TS Figures have been combined by SRSS in the Westinghouse methodology while the flow penalty is treated statistically as a bias.

The $F^N_{\Delta H}$ allowance for error in the Figures is determined in WCAP-7308L, "Topical Report - Evaluation of Nuclear Hot Channel Factor Uncertainties." The methodology of this Report is consistent with the statistical methodology used to calculate the RCS flowrate measurement. uncertainty with high confidence and high probability (again 95%/95%). The errors in the $F^N_{\Delta H}$ measurement are due to measurement repeatability, power to reaction rate mismatch, extrapolation of measurements, and radial local error. The errors are statistically independent and are combined by SRSS. As documented in the Report, there is negligible bias error. The reported error result is 3.18% which is noted to exhibit sufficient margin to the 4% allowance in the Figures to accommodate moveable detector deletion down to 75% of the maximum possible number of thimbles.

The combination of the errors in the parameters affecting the calculated minimum DNBR and reflected in the Figures (of which the RCS flow and $F^N_{\Delta H}$ measurement errors are two of the eight error sources) is described in WCAP-8568, "Improved Thermal Design Procedure." The errors from the eight sources are combined by SRSS as modified by sensitivity factors which relate the percent error in the parameter to percent error in minimum DNBR. The sensitivity factors are treated as constants over the expected range of variation of the parameters. This method can be illustrated with the sensitivity factors (S) assumed to be one (it doesn't matter what is assumed in the illustration since they are constants and what we are looking for is the relative result). The RCS flowrate measurement error (3.0% TDF using PPC indication) from calculation N-191 is combined with the $F^N_{\Delta H}$ measurement error (3.18% plus 0.82% margin) assuming all the RCS flowrate error is included in the minimum DNBR error as follows (in this example only two of the eight sources of error in minimum DNBR are illustrated and where all S's = 1):

$DNBR_C$ = (S)*0.82 (margin) + $((S*3.18)^2 + (S*3.0)^2)^{1/2}$ = 5.19%

When the same combination is done but the excess error in the RCS flowrate measurement is taken as a flow penalty, the total allowance is:

$DNBR_{CB}$ = S*0.82 (margin) + S*(3.0 - 2.34 of flow) + $((S*3.18)^2 + (S*2.34)^2)^{1/2}$ = 5.43%

The significance of this result is that the flow penalty approach would provide a greater total allowance for error in the calculated minimum DNBR than the straight SRSS approach. Therefore the flow penalty method is conservative because it makes the assumption that all of the excess random uncertainty is a bias, which it then corrects for. Consequently, the uncertainty in the indicated flows given by the flow penalty method does not exceed the 2.4% TDF allowance in the TS Figures 3.2-3a and 3.2-3b. In other words, the flows given by the flow penalty method do not exceed the true flow by more than 2.4% TDF at least 95% of the time.

In the actual application of the ITDP methodology, the plant parameter errors are manipulated in their standard deviation form; such that the standard deviations of the errors are combined by SRSS to yield the standard deviation of the probability distribution of minimum allowable or limit DNBR. The mean of the DNBR probability distribution is the DNBR which the safety analysis results must exceed. (In actual safety analysis practice, there is margin included in the safety analysis DNBR limit such that it is greater than the mean of the DNBR probability distribution.) If the DNBRs determined in the safety analyses are greater than the mean of the DNBR distribution, then there is 95 percent probability with 95 percent confidence that the design minimum DNBR is met. A bias in DNBR uncertainty causes a linear shift of the mean of the DNBR probability distribution while a random error of the same magnitude as the bias would cause a smaller shift in the mean because random error is combined by SRSS with the other random errors in DNBR uncertainty to determine the DNBR distribution standard deviation. Therefore it is conservative to treat additional RCS flow error as a bias versus treating it as a random error. The flow penalty approach is conservative because it assumes that the excess error is all bias.

The Westinghouse Evaluation of the flow penalty bias method to account for increased RCS flow measurement uncertainty, which was reported in letter PGE 96-628 dated November 21, 1996, concluded that "the use of a measured flow penalty bias conservatively accounts for an increase in the flow uncertainty above the 2.4% TDF value defined in the Diablo Canyon Technical Specifications .... it is concluded that the results and conclusions of the UFSAR safety analyses are valid." It is concluded that the use of a flow penalty is conservative and that it is acceptable, from a safety perspective, to treat the excess flow measurement uncertainty as a bias or flow penalty. This penalty was applied by DCPP Plant procedure STP R-26.

This conclusion is also supported by flow margin that is indicated by the Westinghouse Report FSE/WGL - 2182. The report indicates that the actual loop flowrates in each DCPP Unit are higher than those measured by current RCSFC tests because there is hot leg streaming even at EOC which biases the flow measurement to the low side. For example in Unit 2 during cycle 5 the RCSFC measured flowrate was 95.8% of baseline while the elbow tap measured flow

was 98.9% of baseline. The results of the EOC Precision Flow Calorimetric at end-of-cycle 7 can be compared to the earlier data. For Unit 2 (which had the more dramatic difference in the measurements) the RCSFC measured flowrate at EOC 7 was 97.3% of baseline or about 1.5% higher than for cycle 5. The results indicate that actual RCS total flowrates are greater than measured by beginning-of-cycle RCSFC tests and that there is additional margin in flowrate for added assurance that the DNBR limit is protected.

There is an additional concern that the flow penalty could lead to under-estimation of the RCS flow and consequent damage to RCS components. The component analysis for the RCS assumes MDFs of 384,600 and 388,200 gpm in Units 1 and 2 respectively. The most optimistic prediction of RCS flowrates are the elbow taps which measured 98.34% and 98.6% of baseline flows at end of cycle 7 in Units 1 and 2 respectively. The total flowrate penalty from calculations N-191 and N-193 are both about 0.5%. The optimistic flowrates and the penalty added together are less than 100% of baseline flows in each Unit. The baseline flows from FSE/WGL-2182 are about 1.5% less than the MDFs. After the flow penalty is considered, there is about 2% margin to the MDFs even in the most optimistic flow measurements. Therefore under-measuring RCS flow due to the flow penalty does not challenge the MDF limit unless hydraulic changes are made to the RCS to increase flowrate.

6.0 Accident Evaluation:

Non-LOCA Analyses

The total RCS flowrate assumed in the safety analyses depends on the methodology used for each specific analysis. For non-DNB related events, or DNB events for which the Improved Thermal Design Procedure (ITDP) is not employed, the TDF is used in the analysis. The TDF is guaranteed to be met by ensuring that the measured flowrates required by DCPP Technical Specifications Figures 3.2-3a and 3.2-3b are higher than the TDF value for each Unit by at least an amount which includes sufficient allowance for the flow measurement uncertainty. The sufficient allowance for uncertainty has been assured by the use of a flow penalty. The flow penalty has been shown to be a conservative approach because it has been applied as a bias to the actual flowrate measurement. Therefore the TDF flowrates have been assured and the results from the non-LOCA analyses which assume TDF flowrates remain valid. For DNB analyses that employ the ITDP a MMF value was assumed. A flow penalty was applied to the measured flowrate to assure that the MMF requirements for Units 1 and 2 were met. The flow penalty approach has been shown to be conservative when used in conjunction with the ITDP methodology. Therefore, since MMF is assured, the results of the DNB analyses which use the ITDP methodology and the conclusions of the DCPP FSAR Update remain valid.

LOCA Analyses:

TDF is assumed as an initial condition in the LOCA analyses as documented in FSAR Update Table 15.4. Since TDF is assured by the consideration of flow measurement uncertainty and the use of the flow penalty, there is no effect on the LOCA analyses results and consequences.

Component Analysis:

The upper bounds on RCS flowrates are the respective Unit's MDF. The MDFs assumed in the RCS component analyses are significantly above the cycle 1 flowrate in each Unit and the most optimistic estimates of current Unit 1 and 2 RCS flowrates. The most optimistic estimates are from the elbow taps. When the flowrate current penalty of 0.5% MMF is added to the elbow tap flows, the result is still more than 1% below the baseline flow (cycle 1 flow in each Unit). Again, the baseline flows were, in turn, significantly below the MDFs. By all indications actual Unit 1 and 2 flowrates are significantly below the respective Unit's MDF and the use of a flow penalty will not increase that flowrate nor challenge the validity of the component analyses.

<u>Safety System Setpoints</u>:

The integrity of the RCS LOF safety analysis limit (SAL) is assured by the application of a flow penalty to the flowrate measurement in each RCS loop. The flow penalty, together with the consideration of all other appropriate setpoint errors, ensures that the reactor trip will occur in conformance with the assumed SAL. Since the flow penalty assures that the MMFs for the respective Unit's ITDP are met, there is no unaccounted for uncertainty in excess of the setpoint total allowance and the setpoint SALs are assured. The SALs associated with the OTΔT and OPΔT setpoints are also assured.

7.0 SUMMARY

Procedure STP R-26 had previously been performed at the beginning of the fuel cycle (BOC). The methodology change allows the RCSFC test to be performed at the end of a fuel cycle (EOC). Adequate RCS total flow rate is verified by plant indication at the beginning of the subsequent fuel cycle. Since the procedure STP R-26 does not specify when it must be run, there was not a change to the timing of the procedure. The procedure was changed to include the use of flow penalties to ensure that minimum measured flow and setpoint safety analysis limit requirements are met. The performance of the procedure has been used to meet the requirement of DCPP Technical Specification (TS) 4.2.3.5 which requires that the RCS total flow rate be determined by measurement at least once per 18 months. TS's 4.2.3.2 and 4.2.3.3 require that the RCS total flow rate and nuclear enthalpy rise hot channel factor be within the limits of Figures 3.2-3a (for Unit 1) and 3.2-3b (for Unit 2). The Figures assume that the measured RCS total flow rate does not exceed the true flow by more than a 2.4% Thermal Design Flow (TDF) allowance for measurement error at least 95% of the time. When the RCSFC is done at the end of the fuel cycle, it results in flow measurement error in excess of the allowance in the Figures (when RCS total flow is read from the DCPP plant process computer (PPC) or is computed from the operator control board indication). The methodology change permits the random error in excess of the 2.4% allowance to be accounted for by penalizing the indicated RCS total flow by the amount of error in excess of the allowance. This method conservatively assumes that the excess random error is a bias, which it then corrects for. The resulting flows then meet the 2.4% TDF TS allowance.

The increased flow measurement error also affects the flow error contributed to the RCS Loss-of-Flow Low setpoint. When the RCSFC is performed at EOC the flow transmitters which monitor RCS loop flow may be adjusted during the refueling outage after the RCSFC is run.

Therefore the correlation of RCS loop flow to the flow transmitters output may have additional error due to the adjustment. The potential errors are included in the calculation of the uncertainty in the RCS Loss of Flow Low reactor trip setpoint. In the changed methodology, the additional errors in excess of the setpoint error allowance are accounted for in a flow penalty such that the reactor trip is assured to meet the Technical Specification Table 2.2-1.

Calculations N-191 Rev. 1 (Unit 2) and N-193 Rev. 1 (Unit 1) incorporate the additional errors associated with performing the RCSFC at the end of a fuel cycle. The calculations determine the flow penalties to be applied to the RCS total flow rate measurement when the measurement is based on the RCSFC performed at end of a fuel cycle, when the RCS total flow rate is verified to meet Technical Specification requirements at the beginning of the next fuel cycle by reading plant indications (either the PPC or vertical board indications), and the penalty for the RCS Loss of Flow Low setpoints. It is conservative to apply the flow measurement error greater than 2.4% Thermal Design Flow as a bias or penalty (subtract the flow error in excess of 2.4% TDF from the indicated flow). Therefore it is technically conservative to perform the RCSFC at the end of a fuel cycle and use the correlation of RCS total flow rate to elbow tap delta pressure (and read plant indications based on elbow tap outputs) to determine the RCS total flow rate at the beginning of the next fuel cycle.

The Westinghouse Evaluation of the flow penalty bias method to account for increased RCS flow measurement uncertainty, which was reported in letter PGE 96-628 dated November 21, 1996, concluded that "the use of a measured flow penalty bias conservatively accounts for an increase in the flow uncertainty above the 2.4% TDF value defined in the Diablo Canyon Technical Specifications. Assuming the additional flow uncertainty and corresponding bias are accurately determined and applied, it is concluded that the results and conclusions of the UFSAR safety analyses are valid."