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James D. Shiffer
Vice President
Nuclear Power Generation

February 6, 1989

PG&E Letter No. DCL-89-030

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

Re: Docket No. 50-275, OL-DPR-80
Docket No. 50-323, OL-DPR-82
Diablo Canyon Units 1 and 2
Response to Generic Letter 88-17, Loss of Decay Heat Removal

Gentlemen:

Generic Letter 88-17, "Loss of Decay Heat Removal," dated October 17, 1988, requested a response to the eight expeditious actions, and a description of enhancements, specific plans, and a schedule, where applicable, for implementation for each of the six programmed enhancements identified in the attachment of the Generic Letter. PG&E letter DCL-89-005, "Response to Generic Letter 88-17, Loss of Decay Heat Removal," dated January 6, 1989, provided a response to the eight expeditious actions. PG&E's response to the six programmed enhancements is provided in the enclosure.

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

Subscribed to in San Francisco, California this 6th day of February 1989.

Respectfully submitted,

Pacific Gas and Electric Company

By _____
J. D. Shiffer
Vice President
Nuclear Power Generation

Howard V. Golub
Richard F. Locke
Attorneys for Pacific
Gas and Electric Company

By _____
Richard F. Locke

Subscribed and sworn to before me
this 6th day of February 1989

_____
Therese Toliver, Notary Public in
and for the City and County of
San Francisco, State of California

My commission expires December 25, 1990.

OFFICIAL SEAL
THERESE TOLIVER
NOTARY PUBLIC - CALIFORNIA
CITY AND COUNTY OF SAN FRANCISCO
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ENCLOSURE

PG&E RESPONSE TO THE PROGRAMMED ENHANCEMENTS RECOMMENDED IN GENERIC LETTER 88-17, "LOSS OF DECAY HEAT REMOVAL"

PG&E submitted a response to Generic Letter 88-17 regarding recommended "expeditious actions" in DCL-89-005 dated, January 6, 1989 (Ref. 1). This enclosure provides PG&E's description of the programmed enhancements that are presently in place or will be in place at Diablo Canyon prior to the completion of the fourth refueling outage for Unit 1 and the third refueling outage for Unit 2. The outage completions are tentatively scheduled for May of 1991 for Unit 1 and May of 1990 for Unit 2. This schedule is in accordance with that described in the Generic Letter. PG&E believes that the two responses address the three major concerns identified in Generic Letter 88-17: (1) prevention of a loss of decay heat removal, (2) mitigation of an accident before events progress to core damage, and (3) control of radioactive material should core damage occur.

INTRODUCTION

Following the 1987 Diablo Canyon loss of RHR event, PG&E performed plant specific calculations and incorporated enhancements to mid-loop procedures, training and instrumentation. Many of the items recommended as programmed enhancements in the Generic Letter have, therefore, already been implemented at Diablo Canyon. Mid-loop instrumentation, procedures, equipment, analyses, Technical Specifications and RCS perturbations were reviewed in the light of the Generic Letter and further actions were identified.

This enclosure provides a detailed response to each of the programmed enhancements recommended in the Generic Letter. Completed and planned programmed enhancements are described and the planned enhancements for each area is summarized in their respective Section of this enclosure.

For convenience the following Table summarizes programmed enhancements already completed along with additional programmed enhancements that will be in place prior to the completion of the fourth refueling outage for Unit 1 (estimated May of 1991) and the third refueling outage for Unit 2 (estimated May of 1990).

SUMMARY TABLE
OF PROGRAMMED ENHANCEMENTS

Category	Completed	Planned
Instrumentation		
Level	• Two independent RCS level indications (RVRLIS) displayed in control room.	• Complete the installation of hard tubing in RVRLIS.
	• Visible and audible alarms for RVRLIS in control room.	• Incorporate WOG final results on RCS level variations.
	• Consideration of instrument and RCS behavior in RVRLIS design.	
Temperature	• Two independent core exit temperature measurements displayed in control room.	• Trend and provide visible and audible alarms for core exit temperature in control room.
	• Two Wide Range T_{hot} RTD channels operable and recorded in control room.	• Investigate methods of monitoring core exit temperature with the reactor vessel head removed.
RHR System Performance	• Control room displays for RHR pump motor current, RHR flow, RHR pump discharge pressure, RHR heat exchanger inlet and outlet temperatures.	• Trend and provide visible and audible alarms for RHR pump motor current in control room.
		• Consider installation of an integrated RHR performance monitoring system.
Procedures		
	• Procedures OP L-5 (Ref. 3); OP L-6 (Ref. 4); OP A-2 (Ref. 5); OP A-2:I (Ref. 6); OP A-2:II (Ref. 7); and OP A-2:III (Ref. 8) cover normal operation of the NSSS under RHR cooling.	• Introduce more detail in abnormal operating procedures describing the use of hot leg injection, use of containment fan coolers, containment closure and entry conditions for uncontrolled pressurization.

SUMMARY TABLE (Cont.)
OF PROGRAMMED ENHANCEMENTS

Category	Completed	Planned
Procedures (Cont.)	• Procedures AP-16 (Ref. 9); AP-17 (Ref. 10) and AP-18 (Ref. 11) cover abnormal operation of the NSSS under loss of RHR cooling.	• Review procedures considering future generic guidance from WOG.
Equipment		
	• Reliability of the two operable RHR trains enhanced by a License Amendment permitting lower RHR flow. Conservatively high RCS level maintained and RHR suction valves autoclosure interlock function removed.	• No progammed enhancements planned at this time.
	• Gravity drain from RWST, charging pump, and medium head SI pump available for makeup.	
	• During installation and removal of nozzle dams two steam generator secondary sides filled with water.	
	• Adequate equipment provided for personnel communications.	
Analyses		
	• In-house analyses of RCS behavior including time to reach boiling, time to core uncovery, effects of vapor vents and reflux condensation with noncondensibles present.	• Extend calculations of time to reach boiling, time to core uncovery, maximum pressurizaton, and effect of hot leg vents to a wider variety of decay heats.
	• In-house containment response analysis.	• Confirm that containment fan coolers can preserve the integrity of the Penetration 63 loop-seal.
	• Involvement and review of the WOG analysis program.	• Confirm applicability of WOG recovery analyses.

SUMMARY TABLE (Cont.)
OF PROGRAMMED ENHANCEMENTS

Category	Completed	Planned
Analyses (Cont.)		• Support the EPRI effort to modify the MAAP code to provide a tool to analyze mid-loop transients.
	• Analysis of level instrumentation behavior regarding response time, RHR flow rate, air entrainment, draining location and rate, and, connection location.	• Incorporate WOG final results on RCS level variations. • Provide appropriate analytical bases for any future changes in procedures and instrumentation.
Technical Specifications (TS)		
	• TS change made to lower RHR flows. • TS change made to remove the RHR suction valve autoclosure interlock. • TS review made to assess whether further changes needed.	• No programmed enhancements planned at this time.
RCS Pertubations		
	• Identification of surveillance tests that could perturb RCS. Inclusion of a procedural caution to obtain shift foreman's concurrence.	• Revise surveillance test procedures to preclude performance during mid-loop if tests could perturb RCS.
	• Outage plans are reviewed to restrict activities that could perturb the RCS while at mid-loop.	• Require management approval prior to commencing RCS cold leg maintenance while at mid-loop.
	• Operator training programs emphasizing the need to avoid RCS perturbations.	
	• Controls in the Operating Procedures OP A 2:II (Ref. 7) and OP A 2:III (Ref. 8).	

ITEM 1. INSTRUMENTATION

Provide reliable indication of parameters that describe the state of the RCS and the performance of systems normally used to cool the RCS for both normal and accident conditions. At a minimum, provide the following in the CR:

(a) two independent RCS level indications

(b) at least two independent temperature measurements representative of the core exit whenever the RV head is located on top of the RV (We suggest that temperature indications be provided at all times.)

(c) the capability of continuously monitoring DHR system performance whenever a DHR system is being used for cooling the RCS

(d) visible and audible indications of abnormal conditions in temperature, level, and DHR system performance

RESPONSE TO ITEM 1. INSTRUMENTATION

PG&E recognizes the need for reliable indication of parameters that describe the state of the reactor coolant system (RCS) and the performance of systems normally used to cool the RCS for both normal and accident conditions. Significant quantitative and qualitative improvements have been made in the area of instrumentation since the April 10, 1987, loss of RHR event. Further upgrades are planned and new information and industry products are reviewed as they become available. The following identifies the status of PG&E's implementation of each of the control room instrumentation recommendations in the Generic Letter.

1. Two Independent RCS Level Indications

The Diablo Canyon Reactor Vessel Refueling Level Indication System (RVRLIS) has two independent level indication subsystems. Each subsystem is comprised of a level transmitter, associated tubing, power and wiring with remote indication and alarm in the control room. The subsystems are completely independent and they share no common taps, tubing, wiring or other components.

In addition to these two subsystems, there is a standpipe level indicator. The standpipe shares a common vapor space reference leg with one of the two electronic indication subsystems and is therefore not independent, but is used for verification of the two independent subsystems. The standpipe is normally isolated during mid-loop operation except for verification and readout activities.

The following instrumentation behavior and phenomena were considered in the design of the RVRLIS system.

a. Response Time

Both the transducer response time and the system response time were considered in the determination of the overall RVRLIS response time. The response of a level transducer to a step change in input was calculated and determined not to be significant relative to the time needed for operator action. Therefore, the transducer response time was determined to be adequate.

The time required to equalize upper head, cold leg and pressurizer vapor space pressures given a particular pressure differential was considered in the design of RVRLIS. The design incorporated a larger size instrument tubing to improve the communication between vapor spaces. In addition, the drain down rate was procedurally limited to minimize the potential for vapor space pressure differences.

b. Instrument Level Inadequacies That May Not Be Identified By Static Instrumentation Calibrations.

The effects of obstructions in the sensing lines, differences in reference vapor space pressures, leaks, condensation, reference leg isolation, air entrainment, temperature density differences and flashing were considered in the design of the RVRLIS. Obstructions, leaks and reference leg isolations are accounted for through the independence of the two electronic level indication subsystems. Procedure OP A-2:III (Ref. 8) requires that both electronic level indicators and the standpipe must be in agreement after taking into account instrument accuracy. Additionally, to ensure reliability, the system is walked down daily when in operation to verify the valve lineup and the reference legs are periodically blown down to clear condensation. Effects due to temperature density differences were determined to be insignificant and the design utilizes a dry reference leg and thus is not susceptible to flashing. Differences in reference vapor space pressures are discussed in subsection f below.

c. RHR Air Entrainment Influence.

The RVRLIS is referenced to either the pressurizer or the reactor vessel head vapor space and is therefore unaffected by vapor space pressure changes as a result of air entrainment in the RHR system. Air entrainment can lead to a loss of RCS inventory even though a constant RCS level is maintained. Levels are maintained above the minimum water level necessary to minimize air entrainment and preclude vortex formation.

d. RHR Flow Rate Influence.

RHR flow rate can affect the readings of level instrumentation and cause inaccurate readings by the dynamic effects of flow past a sensing tap and

the water level variations throughout the RCS that are caused by the flow itself. Ideally, the pressure tap for the narrow range level transmitter would be located on the Loop 4 hot leg where the inlet to the RHR suction line is located. However, the only available tap point on the Loop 4 hot leg is 1.5 feet away from the RHR suction inlet. During mid-loop operation, pressure fluctuations resulting from flow at the RHR inlet would cause any level readings taken there to be invalid. Therefore, a tap on the Loop 3 hot leg is used as the narrow range process tap point. Dynamic effects due to RHR flow are minimal at this location.

The second effect is the water level variations that exist throughout the reactor coolant system as a result of the RHR flow itself. The Westinghouse Owners Group (WOG) (Ref. 14) has studied this phenomenon and preliminary results indicate that the maximum differences are within operating margins. PG&E will review the final WOG report when available for additional impact at Diablo Canyon.

e. RCS Drain Location and Drain Rate Impact Influence.

Operating procedures direct that RCS inventory reduction be accomplished via the Loop No. 4 hot leg RHR suction line to the chemical and volume control system (CVCS). There is no impact on level indications due to the drain location. The impact of RCS drain rate has been minimized by procedurally restricting the letdown rate and using nitrogen injection for smooth steam generator tube draining.

f. RCS Level Errors Due to Lack of Air Space Communication and Failure of a Portion of the RCS to Drain

The Diablo Canyon reactor coolant system configuration is such that the pressurizer surge line connection to the RCS remains covered by water during reduced RCS inventory operations. However, the RVRLIS includes tubing to ensure adequate communication between the pressurizer and reactor vessel upper head vapor spaces. This tubing run will be modified to maximize the use of stainless steel tubing instead of flexible tubing.

Since the three RVRLIS level indications each sense off of a different loop, failure of a portion of the RCS to drain would be easily detected. PG&E uses nitrogen injection for steam generator tube draining while fuel is in the vessel to smoothly drain the tubes.

g. The Measured Water Level at One Location May Differ from that at the Suction Line.

The Diablo Canyon RVRLIS minimizes loop-to-loop level difference effects by sensing three different loops. Additionally, the procedures and alarms for minimum level for mid-loop operation are conservative to provide enough margin to accommodate any projected level differences. The WOG (Ref. 14) has quantified how various levels throughout the RCS differ from the level at the RHR suction. Preliminary results indicate that operational conservatisms and margins are more than adequate to accommodate loop-to-loop differences.

h. Level May Be Affected By Pressure Difference Between the RCS and the Containment Building Atmosphere.

The RVRLIS is normally refereced to the RCS. It is not referenced to the containment atmosphere unless the RCS is open and also referenced to the containment atmosphere. Therefore, the level indication cannot be affected by the pressure difference between the RCS and containment atmosphere.

In regard to the use of plastic tubing, the Unit 2 RVRLIS was modified during the most recent refueling outage to replace as much of the flexible tubing runs as possible. However, flexible tubing remains between the refueling canal and the reactor vessel head and additional short flexible metal hose spool pieces exist at two other locations. The tygon standpipe was replaced with a stainless steel standpipe which uses a magnetic flag level indicator. This type of indicator was selected over a standard gage glass to preclude breakage concerns and to provide a more visible indication. An identical RVRLIS upgrade will be implemented on Unit 1 during the third refueling outage. All flexible tubing runs will be rated for service up to and including boiling conditions in the reactor vessel by the third refueling outage for each unit.

2. <u>At Least Two Independent Temperature Measurements Representative Of The Core Exit Temperature Whenever The RV Head Is Located On Top Of The RV.</u>

It is important that operators have direct indication of the RCS temperature during reduced inventory conditions. RCS temperature is an indicator of either a slow or rapidly degrading decay heat removal capability. Following a loss of RHR flow, temperature measurement allows for determination of the RCS heatup rate and thus an estimate of the time to boiling. RCS temperature also is an indicator of the effectiveness of recovery actions taken after a loss of RHR flow.

As a prerequisite to mid-loop operation at Diablo Canyon, OP A-2:III, "Reactor Vessel - Draining to Half Loop Operations," (Ref. 8) requires that, except during preparation for removal or replacement of the reactor vessel head, a minimum of two incore thermocouples (T/C's) must be available when the reactor head is in place. The two T/C's are from separate instrumentation trains and provide a reliable indication of core exit temperature. The temperature is displayed on the Post-Accident Monitoring System (PAMS) panel located in the control room. Operating Procedure OP A-2:III (Ref. 8) also contains the precaution to notify the Instrumentation and Controls Department (I&C) to place an additional T/C in service before any scheduled maintenance is performed on the active T/C.

PG&E is investigating methods of monitoring core exit temperature with the reactor vessel head removed. The need for core exit temperature indication is less critical than when the head is on for several reasons. These reasons include, first, the time between head removal and flooding of the refueling cavity is minimal. Second, when the head is removed gravity feed from the refueling water storage tank (RWST) would not be prevented by pressurization. Third, with the head removed there is a large hot leg vent path and the rapid

core uncovery caused by inventory losses through the cold leg as described in IE Notice 88-36 (Ref. 2) cannot occur. Lastly, the operators know the time to boiling using tables that are provided in the procedures (Ref. 9). These tables provide a conservative estimate of the time to reach boiling.

Additional temperature indications for reduced inventory operations at Diablo Canyon are:

- A minimum of two Wide Range T_{hot} RTD channels operable and recorded on Control Room Vertical Board No. 2 (VB2).

- RHR temperature instrumentation for both trains operable and recorded on Control Room Vertical Board No. 1 (VB1).

The RTD channels and the RHR temperature instrumentation will provide an indication of a slowly degrading decay heat removal condition. Since, they will not provide a reliable indication of core exit temperature after a loss of RHR flow, precautions are provided in the procedures and operator training is given to advise the operators.

3. <u>The Capability Of Continuously Monitoring RHR System Performance Whenever A RHR System Is Being Used For Cooling The RCS.</u>

Diablo Canyon has control room displays for RHR pump motor current, RHR flow, RHR pump discharge pressure and RHR heat exchanger inlet and outlet temperatures. These displays are within the operator's normal range of vision.

RHR pump motor current trending information will be provided to the operator. This capability will be installed by the third refueling outage on Unit 2 and the fourth refueling outage on Unit 1.

PG&E will investigate the feasibility of installing an integrated RHR system performance monitoring display.

4. <u>Visible And Audible Indications Of Abnormal Conditions In Temperature, Level, And RHR System Performance.</u>

The following identifies visible and audible indications of abnormal conditions in temperature, level and RHR motor current that PG&E will provide by the third refueling outage of Unit 2 and the fourth refueling outage on Unit 1.

a. Temperature

The two incore thermocouples that monitor core exit temperatures will be trended and alarmed in the control room.

b. Level

The control room reactor vessel level indicators for the narrow range (NR) and wide range (WR) RVRLIS are normally used to monitor ECCS

accumulator level associated with RCS loops 2 and 3, respectively. When used for NR and WR level indications during reduced inventory conditions, these indicators are relabeled and rescaled. In addition, these level indicators are administratively controlled using a keylock switch. The associated annunciator windows are relabeled and provide visible and audible indications of abnormal level.

c. RHR Pump Motor Current

RHR pump motor current will be trended and alarmed in the control room. PG&E is evaluating the use of the plant computer or a recorder/data logger for this function.

Summary of Additional Programmed Enhancements Instrumentation

PG&E's additional programmed enhancements to instrumentation are to:

1. Incorporate the final WOG results regarding the effects of RCS level variations as appropriate. This will impact level uncertainty analyses.

2. Complete the installation of rigid tubing in the Unit 2 RVRLIS and install rigid tubing in the Unit 1 RVRLIS.

3. Investigate methods of monitoring core exit temperature when the reactor vessel head is removed.

4. Provide RHR pump motor current trending in the control room.

5. Consider installation of an integrated RHR performance monitoring display in the control room.

6. Provide visible and audible indications in the control room of abnormal RCS temperature, level and RHR pump motor conditions.

ITEM 2. PROCEDURES

Develop and implement procedures that cover reduced inventory operation and that provide an adequate basis for entry into a reduced inventory condition. These include:

(a) procedures that cover normal operation of the NSSS, the containment, and supporting systems under conditions for which cooling would normally be provided by DHR systems

(b) procedures that cover emergency, abnormal, off-normal, or the equivalent operation of the NSSS, the containment, and supporting systems if an off-normal condition occurs while operating under conditions for which cooling would normally be provided by DHR systems.

(c) administrative controls that support and supplement the procedures in items (a), (b), and all other actions identified in this communication, as appropriate.

RESPONSE TO ITEM 2. PROCEDURES

PG&E has developed procedures that adequately cover operation under the shutdown conditions for which RHR system cooling would normally be provided. The procedures address both entry into and operation in reduced inventory conditions. After the 1987 Diablo Canyon loss of RHR event, extensive revisions were made to the procedures addressing reduced inventory conditions. Most of the Generic Letter's recommendations on procedures have already been implemented, however, additional enhancements are planned. The following describes the current Diablo Canyon reduced inventory operating procedures. In addition, a summary of the further actions that will be taken to complete the programmed enhancement of procedures are outlined at the end of this section.

1. Normal Operation in a Reduced Inventory RCS Condition With RHR In Service

Entry into a reduced RCS inventory condition is required for steam generator inspection or maintenance and/or nozzle dam installation. Overall operating procedure OP L-5, "Plant Cooldown From Minimum Load to Cold Shutdown", (Ref. 3) and OP L-6, "Refueling", (Ref. 4) direct entry into system-specific operating procedures for RCS draining activities.

Operating procedure series OP A-2, "Reactor Vessel," (Ref. 5) contains system-specific procedures addressing various activities as follows:

OP A-2:I - "Reactor Vessel - Filling and Venting the RCS," (Ref. 6)

OP A-2:II - "Reactor Vessel - Draining the RCS to the Vessel Flange," (Ref. 7) and,
OP A-2:III - "Reactor Vessel - Draining to Half Loop/Half Loop Operations," (Ref. 8)

These procedures provide guidance for operation with a water solid RCS, draindown from 25 percent cold calibrated pressurizer level to the approximate level of the reactor vessel flange, draindown under reduced inventory conditions, operation while at mid-loop, and RCS fill and vent.

These operating procedures have been reviewed and it has been determined that adequate criteria and controls exist for the following:

Containment:

1. OP A-2:III (Ref. 8) requires that a containment boundary be established prior to entry into a reduced inventory condition. The containment boundary is defined in PG&E's response to the expeditious actions of the Generic Letter submitted on January 6, 1989. The containment boundary can be converted to containment closure as defined in the Generic Letter in less than 30 minutes.

2. OP A-2:III (Ref. 8) requires two containment fan cooler units be operable whenever the core is loaded. This requirement provides protection against breaching containment penetration 63, which is used for various service conduits during refueling outages. Penetration 63 is isolated from the outside atmosphere by a water loop seal. The loop seal could be breached if the containment became pressurized following a loss of RHR. However, the containment fan cooler units would control containment pressure and temperature and prevent breaching of the penetration 63 loop seal.

RCS State:

1. OP A-2:II (Ref. 7) and A-2:III (Ref. 8) contain guidance to ensure the RCS temperature is maintained below 160°F.

2. Both procedures direct that a minimum of two incore thermocouples, two wide range hot leg RTD channels, and RHR temperature instrumentation associated with both trains of RHR are available at all times when the reactor head is on the vessel with fuel in the core.

Equipment:

1. OP A-2:II (Ref. 7) and A-2:III (Ref. 8) require review of appropriate Technical Specifications regarding RHR operation and equipment operability requirements for cold shutdown conditions with loops filled, loops not filled, and RHR and coolant circulation at low water levels.

2. The RHR system motor operated suction valves are verified to be open with power removed. The autoclosure interlock function for the RHR suction valves has been deleted. (Ref. 7)

3. One charging pump is available when fuel is in the reactor vessel. As a backup, gravity fill makeup from the RWST is available. As a further backup, a medium head safety injection pump and its associated hot leg injection flow path to the RCS is available with the pump breaker racked in and DC control power removed. (Ref. 8)

4. Daily walkdown of the RVRLIS equipment, including inspection for reference leg condensation and proper system alignment, is documented in the Control Room Operator's Log. A daily channel check of the RVRLIS channels for wide range, narrow range, and standpipe levels is performed. Periodic channel checks are also performed during level change activities. The Operator reads and logs RVRLIS values every 4 hours. (Ref. 8)

Communication: 1. Periodic tailboard sessions are conducted by operations personnel to discuss expectations, events, precautions and limitations associated with reduced RCS inventory operation. Tailboard sessions are conducted for auxiliary operators to assure familiarity with the procedures to vent RHR pumps.

2. Effective communication with personnel performing activities directly or indirectly affecting the RCS is assured by the containment access radiation protection coordinator. An operable containment public address system is required during reduced inventory operation.

3. An operator is stationed inside containment during all reduced inventory conditions when fuel is in the reactor vessel. The operator is available to provide local standpipe level indication readings.

4. Prior to and during reduced inventory operations, an engineer or manager knowledgeable in the requirements of reduced inventory operation and instrumentation is on shift to supplement the normal shift operating crew.

All of the above criteria exist in operating procedure prerequisites, precautions and limitations, or instructions. The first instruction in the procedures requires a review of the prerequisites and precautions and limitations. In this manner, there is reasonable assurance that all of the above criteria are met prior to and during RCS level/inventory changes.

2. <u>Abnormal Operation Of Systems If An Off-Normal Condition Occurs While On RHR</u>

Emergency and abnormal operating procedures are entered when appropriate conditions are exhibited through control room indications, annunciators, or

other symptoms. Classroom and simulator training includes recognition of abnormal conditions, when to enter appropriate emergency or abnormal operating procedures, and actions to mitigate the condition. Training scenarios include multiple equipment failures.

The following abnormal operating procedures address equipment or system malfunctions while operating the RHR system:

OP AP-16 - "Malfunction of RHR System" (Ref. 9):
Section A, "Loss of RHR Flow,"
Section B, "RHR Loop Leakage,"
Section C, "Loss of RHR Flow While in Half Loop Configuration."

OP AP-17 - "Loss of Charging" (Ref. 10):
Section E, "Charging Line Failure on RHR."

OP AP-18 - "Letdown Line Failure" (Ref. 11):
Section B, "Letdown Line Failure on RHR (RCS Solid or With Pressurizer Bubble),"
Section C, "Letdown Line Failure on RHR - Refueling,"
Section D, "Letdown Line Failure on RHR - RCS Level at or Near Loop Centerline."

All abnormal operating procedures contain symptoms that identify control room indications and annunciators that would alert the operators to the abnormal condition. The procedures are structured using symptom-based analysis and are organized in a two column format to provide actions to be taken in the event of equipment failure. Abnormal procedures are similar to emergency procedures in that they contain sections addressing the scope of the procedure, and appendices that provide guidance for event classification and notification instructions.

The following summarizes a review of the abnormal operating procedures. Entry criteria, operation of systems, and direction of mitigation activities are considered for the off-normal conditions noted below:

1. Accidental loss of an operating RCS cooling system

   OP AP-16 (Ref. 9), Section A, addresses a loss of RHR flow while the RCS is filled.

   - Symptoms listed include: increasing RCS temperature, loss of RHR flow, and RHR system annunciation.
   - Operators are instructed to restore decay heat removal as appropriate by operation of the RHR system, repressurization of the RCS and start of a reactor coolant pump, or reactor cavity refill and containment fan cooler operation.
   - Instruction on containment closure is included in the procedure and will be enhanced in the next revision.

OP AP-16 (Ref. 9), Section C, addresses a loss of RHR flow while at mid-loop.

- Symptoms listed include: RHR pump current and flow oscillations, decreasing RCS level, loss of RHR flow, and RHR system annunciation.
- Operators are instructed to stop the RHR pump, isolate letdown, and restore RCS level by gravity feed or operation of the centrifugal charging pump. PG&E will revise Section C to include provisions to operate the backup medium head safety injection pump as outlined in the response to the expeditious actions of the Generic Letter.
- Operators verify or perform containment closure activities. PG&E will revise OP AP-16 (Ref. 9) to include operation of the two containment fan cooler units to control containment pressure if necessary.
- Following restoration of RCS level, the RHR pump is vented and returned to service.

2. Unsuccessful attempt to start a system when the system is to be used for RCS cooling and the RCS is not being actively cooled by another RHR system

   OP AP-16 (Ref. 9), Section A, provides operator guidance.

   - Start an available RHR pump and check for flow indication.
   - If no RHR pumps can be started, an alternate means of heat removal is established. This may be accomplished by starting a reactor coolant pump, or reflooding of the refueling cavity and operation of the containment fan coolers, depending on the RCS configuration when RHR is lost.

3. Uncontrolled and significant loss of RCS inventory

   Upon loss of RCS inventory, operators would observe a decrease in pressurizer or RVRLIS level, depending on system configuration, and take actions to identify the source of the loss. OP AP-16 (Ref. 9), Section B, addresses RHR loop leakage, OP AP-17 (Ref. 10), Section E, a charging line failure, and OP AP-18 (Ref. 11), a letdown line failure. These procedures include actions to isolate the leakage and restore RCS level.

   A loss of RCS inventory would eventually manifest itself as a loss of RHR flow due to loss of RHR pump suction. OP AP-16 (Ref. 9), Section C, requires initiation of RCS makeup by gravity feed from the RWST and/or operation of the available charging pump. In addition, OP AP-16 (Ref. 9), will be modified to include the medium head safety injection pump as a backup makeup source.

4. Uncontrolled and significant break in the RCS coolant boundary

   A significant compromise of RCS integrity would manifest itself as a loss of RHR flow due to the loss of RCS inventory. OP AP-16 (Ref. 9),

Section C, addresses makeup to the RCS. Core cooling would be maintained by feed and bleed. Breaks in the hot leg or cold leg are addressed by diverse makeup water flowpaths.

5. Any valid symptom of loss of control of the state of the RCS that is not contained within normal procedures.

   OP AP-16 (Ref. 9) lists symptoms including increasing RCS temperature, loss of RHR flow, and RHR pump trouble alarms. PG&E will revise OP AP-16 (Ref. 9) to address any valid symptoms of uncontrolled RCS pressurization by no later than the fourth refueling outage for Unit 1 and the third refueling outage for Unit 2.

6&7. Significant core damage expected and any valid symptom of significant core damage observed.

   In the event that decay heat removal is not restored in a timely fashion and core uncovery is expected, OP AP-16 (Ref. 9) includes guidance on activation of the PG&E emergency plan as follows:

   - After an unplanned loss of the RHR system, if at least one RHR train is not restored to operation within 10 minutes, the event is designated a "Notification of Unusual Event."
   - After an unplanned loss of the RHR system, if one train of RHR is not restored within 10 minutes and RCS temperature exceeds or is projected to exceed 200°F within 1 hour, the event is designated an "Alert."
   - After an unplanned loss of the RHR system with no other normal means of decay heat removal available, if at least one RHR train is not restored to operation within 1 hour, the event is designated an "Alert."

   The above "Alert" action levels result in activation of the Technical Support Center and Emergency Offsite Facilities. The personnel dispatched to the facilities are trained to protect the health and safety of the public in the event of a core damaging accident at DCPP.

3. <u>Administrative Controls That Support Plant Procedures</u>

Essentually all of PG&E's controls that cover reduced inventory operation are contained in the plant operating procedures discussed previously in this section. An exception is the Work Planning Center restriction of activities that could perturb the RCS during mid-loop operation. This is discussed further in Section 6, RCS Perturbations.

4. <u>WOG Operations Subcommittee Program</u>

The WOG Operations Subcommittee is funding a Mid-Loop Operations Guidance Program to develop generic mid-loop procedures. The WOG Program has issued interim mid-loop operations guidance in the form of a letter (Ref. 23) describing the issues that should be considered in developing mid-loop

procedures. The Program is now developing draft procedures. Final recommended procedures are to be issued in October of 1989 and they will be supported by analytical verification and a background document explaining the basis for the procedures. PG&E is supporting the WOG effort and will review PG&E procedures in the light of the WOG recommended procedures.

Summary of Additional Programmed Enhancements, Procedures

PG&E has reviewed the current operating procedures in the light of the recommendations contained in the Generic Letter and has identified the following enhancements by no later than the fourth refueling outage for Unit 1 and the third refueling outage for Unit 2.

1. Modify OP AP-16, "Malfunction of the RHR System," to include use of the medium head safety injection pump for hot leg injection and the use of containment fan coolers to mitigate containment pressurization. This procedure will also be modified to include symptoms and entry conditions that address uncontrolled RCS pressurization.

2. Revise the appropriate abnormal operating procedures to provide additional guidance for containment closure under harsh conditions.

3. Review PG&E procedures considering the recommended procedures that will be issued by the WOG.

ITEM 3. EQUIPMENT

(a) Assure that adequate operating, operable, and/or available equipment of high reliability is provided for cooling the RCS and for avoiding a loss of RCS cooling.

(b) Maintain sufficient existing equipment in an operable or available status so as to mitigate loss of DHR or loss of RCS inventory should they occur. This should include at least one high pressure injection pump and one other system. The water addition rate capable of being provided by each equipment item should be at least sufficient to keep the core covered.

(c) Provide adequate equipment for personnel communications that involve activities related to the RCS or systems necessary to maintain the RCS in a stable and controlled condition.

RESPONSE TO ITEM 3. EQUIPMENT

PG&E has taken actions to satisfy the recommendations concerning equipment. These actions were taken after (1) discussions with the Augmented Inspection Team that investigated the April 10, 1987, Diablo Canyon loss of RHR event and (2) in response to recommendations contained in NUREG-1269, "Loss of Residual Heat Removal System, Diablo Canyon Unit 2, April 10, 1987," (Ref. 12). Upon review of the Generic Letter, PG&E believes that Diablo Canyon is in compliance with the recommendations contained in Generic Letter 88-17 concerning equipment and, at this time, no specific programmed enhancements on this particular issue are planned. Compliance with the three recommendations is described below.

1. PG&E presently assures that adequate operating, operable, and/or available equipment of high reliability is provided for cooling the RCS and for avoiding a loss of RCS cooling. Decay heat removal can be accomplished by one RHR train. However, the Diablo Canyon Technical Specifications require that both RHR trains be operable during reduced inventory operations (Ref. 8). To lessen the chance of an RHR pump failure, the Diablo Canyon Technical Specifications were changed (Technical Specification Amendment 28 to Unit 1 and 27 to Unit 2 dated April 21, 1988) to allow for a lower RHR flow during mid-loop operations. These lower flows contribute to a lower likelihood of pump cavitation or vortexing due to air entrainment in the RHR pump suction. The current procedures require a conservatively high reactor vessel level be maintained while at reduced inventory conditions, which also reduces the probability of air entrainment. The RHR suction valves autoclosure interlock function has been removed.

2. PG&E maintains sufficient equipment in an operable or available status so as to mitigate loss of decay heat removal or loss of RCS inventory should they occur. Current procedures presently require the following systems or equipment to be operable or available to add water to the RCS and to keep the core covered. Operating Procedure OP A-2:III (Ref. 8) stipulates as a prerequisite to draining to mid-loop, (1) that one charging pump be available for cold leg injection, (2) that gravity makeup from the RWST be available, (3) that a medium head safety injection (SI) pump be available for hot leg injection and that (4) at least two steam generators be filled with water to the 15% narrow range level. The charging pump and the medium head SI pump are both safety grade and each is capable of adding water to the RCS at a rate sufficient to keep the core covered. The filled steam generators can under certain conditions provide additional decay heat removal as described in the section on analysis. Abnormal Operating Procedure OP AP-16 (Ref. 9) is being revised to instruct the operators to attempt recovery by using gravity feed and, if required, recover by using the charging pump and/or the safety injection pump.

3. PG&E presently provides adequate equipment for personnel communications that involve activities related to the RCS or systems necessary to maintain the RCS in a stable and controlled condition. This communications equipment includes a public address system in containment, personal pagers, and the plant telephone system.

Summary of Additional Programmed Enhancements. Equipment.

There are no additional programmed enhancements for equipment planned at this time.

ITEM 4. ANALYSES

Conduct analyses to supplement existing information and develop a basis for procedures, instrumentation installation and response, and equipment/NSSS interactions and response. The analyses should encompass thermodynamic and physical (configuration) states to which the hardware can be subjected and should provide sufficient depth that the basis is developed. Emphasis should be placed upon obtaining a complete understanding of NSSS behavior under nonpower operation.

RESPONSE TO ITEM 4. ANALYSES

PG&E recognizes the need to conduct analyses to supplement existing information and develop a basis for procedures, instrumentation installation and response, and equipment/NSSS interactions and response. Since the 1987 loss of RHR flow event at Diablo Canyon, PG&E has performed many analyses related to mid-loop operation and has been involved with the WOG analysis program. The WOG program has investigated such topics as reactor coolant system thermal-hydraulic behavior following a loss of RHR, the RCS level required to avoid RHR pump cavitation and the level variations that exist throughout the RCS during steady state operation of the RHR system.

As a result of the 1987 event, PG&E gathered plant design data needed for analyses and also conducted various calculations of plant behavior and instrument response following a loss of decay heat removal. Computer calculations were performed to estimate (1) when local boiling started to occur in the core and when bulk boiling began; (2) what the containment pressurization rate would have been had boiling continued; and (3) when severe core damage would have occurred had no recovery actions been taken. Subsequent analyses were conducted to quantify the steam escape rate associated with RCS vent paths of various sizes and locations. The calculations identified vent paths which are sufficient to prevent excessive RCS pressurization. Best estimates of the core decay heat at the end of an outage were made in order to quantify the extra margin to boiling that is present when the core consists of one-third new assemblies. The results were presented to the NRC inspection team.

In addition to these PG&E plant specific analyses, PG&E has particpated in the WOG efforts. Pertinent results of the WOG analyses of RCS behavior and RCS level requirements for a given RHR flow rate are being incorporated into procedures and operator training.

As discussed in the Generic Letter, there are two broad categories of analyses needed to provide the basis for mid-loop operation. The first is NSSS behavior and the second is instrument response and accuracy. NUREG-1269, "Loss of Residual Heat Removal System, Diablo Canyon Unit 2, April 10, 1987," (Ref. 12) provides guidance in specifying and determining an analytical basis for both categories. The following sections present PG&E's current analytical

bases and then specify, where appropriate, supplementary analyses that will be done in each of the two major areas. The impact of the various analyses on procedures and instrumentation is also noted as appropriate.

1. Analysis Of RCS Behavior

a. Thermal/Hydraulic Modeling With Consideration Of Noncondensibles.

When the RCS is in a reduced inventory condition, noncondensible gases are present above the water surface. These noncondensibles influence the thermal/hydraulic response of the RCS after a loss of RHR. In particular, the noncondensibles influence the efficiency of decay heat transfer from primary to secondary. To quantitatively analyze this mode of decay heat removal, noncondensibles must be considered in the thermal/hydraulic modeling.

In April of 1987 following the Diablo Canyon loss of RHR event, PG&E performed calculations to estimate the steam generator tube area in contact with steam as a function of RCS pressurization. Additionally, PG&E conducted computer analyses in which the effect of noncondensibles on reflux condensation was considered. PG&E has also been involved with the WOG analyses which considered these effects. Items (2) and (3) below further discuss the importance of including the effects of noncondensibles in thermal/hydraulic modeling.

b. Heatup Rate, Time To Saturation, Maximum Pressurization, Effect Of Water In Steam Generators (SGs), Vapor Venting, Liquid Venting, And Time To Core Uncovery.

1. Heatup Rate and Time to Saturation

An estimate of the core heatup rate and the time to saturation is important for the timing of subsequent recovery actions. Conservative time to boiling calculations have already been performed for a variety of decay heat loads. Tables summarizing these calculations are contained in current operating procedures and apply for the first few weeks of a shutdown. Additional calculations will be performed to systematically address the lower decay heat loads present in reload cores at the end of an outage.

2. Maximum Pressurization

It is important to know the RCS pressurization rate after boiling begins in order to estimate the time at which gravity drain from the RWST to the RCS is no longer possible. The RCS pressurization rate can be used to estimate when each of the makeup sources must be activated should a previous recovery action fail. The WOG analysis calculates the RCS pressurization rate for a four loop Westinghouse NSSS. This calculation analyzed a 3700 MWt plant and thus bounds Diablo Canyon Units 1

(3338 MWt) and 2 (3411 MWt). The calculation considers the case of an RCS with no vent paths, no steam generator water inventory, and no recovery actions. Consequently, this analysis provides a set of maximum pressurization rate versus time curves. These curves are generated for various decay heat loads and different initial RCS temperatures. The WOG results provide an analytical basis for having various means of providing makeup to the RCS available and they emphasize the need for a fast operator response to a loss of RHR. PG&E plans to extend the WOG pressurization results to a wider variety of decay heats and initial RCS temperatures to better quantify the necessary operator response times in a wider variety of situations.

3. Effect of Water in Steam Generators

Water in the secondary side of the steam generators can act as a heat sink and can mitigate the RCS pressurization rate. In some circumstances, this heat sink can provide a long-term means of decay heat removal after a loss of RHR cooling. The mechanism by which this is accomplished is reflux condensation: steam produced in the core comes into contact with cold steam generator tubes and is condensed, thus, providing heat transfer to the secondary side. Reflux condensation is effective when (1) no large openings exist in the RCS, and (2) the RCS level is low enough so that the steam generator tubes are drained and, (3) a steam vent path through the hot legs exists. The hot leg vent path is necessary for communication between the reactor vessel and the steam generator tubes. A quantitative analysis of this effect was conducted by PG&E in the spring of 1987 following the Diablo Canyon loss of RHR event. The WOG performed additional analyses of this effect. These analyses are reflected in current mid-loop operating procedures in that now at least two steam generators are required to be filled with water up to the narrow range level to provide mitigation of the RCS pressurization in certain circumstances.

4. Vapor Venting and Time to Core Uncovery

Vapor vent analyses for both large and small openings are important in understanding RCS behavior following a loss of RHR event. Large vent analyses determine the time to core uncovery assuming a large hot leg vent path and no makeup. The timing of core uncovery is important to confirm that a containment boundary can be established before any core damage occurs. Large vent analyses have been performed by the WOG and by PG&E, and, as part of the programmed enhancements, PG&E will extend them to a wider range of decay heats. The supplementary calculations will also take into account the so-called "spill penalty" which considers that a large vent path might be at a low enough elevation to result in some water spill as the RCS initially swells after a loss of RHR. Analyses will also be performed to confirm that the containment fan coolers can condense the steam produced when a large hot leg vent is present.

The WOG calculated the RCS response after a loss of RHR when the RCS is totally intact except for small vent paths high enough in elevation so that only steam can escape. The analyses show that these small vapor vent paths only slightly diminish the initial RCS pressurization rate and that large vent paths are needed to prevent significant pressurization of the RCS. These analytical results provide, in part, a basis for the Operating Procedure L-6, "Refueling," (Ref. 4) requiring the reactor head be fully detensioned with studs removed before all hot legs are blocked by nozzle dams. This configuration assures an upper head vent path large enough to avoid significant pressurization.

5. Liquid Inventory

The WOG has studied the RCS behavior when a cold leg opening is present before or created after a loss of RHR flow and the RCS is otherwise intact. These studies show that pressurization forces water out of the cold leg opening until the crossover leg loop seal is cleared. After the loop seal is cleared, the steam produced in the core flows through the steam generator tubes and is vented to containment through the opening in the cold leg. The studies indicate that depending on the size of the opening, the core can briefly be uncovered but becomes covered again after the loop seals clear. The core uncovery time is brief enough such that no fuel damage occurs. The analyses show that if hot leg nozzle dams are not installed, a cold leg opening does not lead to a rapid, prolonged core uncovery. Operators thus have more time to start recovery actions than when the hot leg nozzle dams are installed.

c. Influence Of Steam Generator Nozzle Dams

If the RCS is configured with large cold leg openings and no hot leg vent paths, a rapid core uncovery can occur after RHR is lost. The WOG has quantified the rate of core uncovery. This information has been incorporated into current procedures so the order of steam generator manway and nozzle dam installation and removal is strictly controlled to preclude an adverse RCS configuration.

d. Mitigation Actions Including Gravity Makeup To The RCS, Forced Makeup To The RCS, Use Of Steam Generators, Safety Injection And Bleed And Feed.

The WOG report describes the analysis of several strategies for recovering from a loss of RHR flow which are not in all cases performed for a four loop plant. As part of the supplementary analyses, PG&E will conduct a review of all the successful recovery analyses contained in the WOG report to assess whether these generic analyses are directly applicable to Diablo Canyon. If some analyses are not directly applicable, they will be performed on a Diablo Canyon specific basis.

PG&E has requested that the Electric Power Research Institute (EPRI) consider modifying the Modular Accident Analysis Program (MAAP) so that it can be used to analyze RCS transients with various mitgation actions. The proposed modifications include modeling noncondensibles and allowing for varying initial conditions for RCS temperature, decay heat, steam generator water inventory, and other parameters that could affect the RCS response. With proper modifications, MAAP can provide a useful tool to analyze mid-loop operation transients.

2. Level Instrumentation Analysis

The Generic Letter indicates that the level instrumentation area should be considered in reaching a complete understanding of behavior during nonpower operation. PG&E has considered the following areas. These areas were previously discussed in the Section on Instrumentation.

a. Response Time

The RVRLIS response time was considered when it was redesigned after the 1987 Diablo Canyon loss of RHR event. The response of the RVRLIS to a given step change in RCS level was calculated and it was determined that the response was quick enough so as not to be significant relative to the time needed for operator action. The time required to equalize RCS vapor spaces given a particular pressure differential was calculated as part of a design to improve the vapor space communication. Because of the system response documented in this calculation, current drain down rate is procedurally limited.

b. RHR Flow Rate

RHR flow can affect level instrumentation in two ways: (1) dynamic effects of flow past a sensing tap could cause inaccurate readings and, (2) physical differences in level exist throughout the RCS as a result of the flow itself.

Ideally, the pressure tap for the narrow range RVRLIS transmitter would be located on the Loop No. 4 hot leg since this is the location of the RHR suction line. However, the only available tap point on the loop No. 4 hot leg is approximately 1.5 feet from the RHR suction inlet. During mid-loop operations, pressure fluctuations resulting from flow at the RHR inlet cause level readings taken there to be invalid. Therefore, a tap on the Loop No. 3 hot leg was used as the narrow range level tap since dynamic effects due to RHR flow are minimal at this location.

The second effect is the physical level difference that exists throughout the RCS as a result of the flow itself. The WOG (Ref. 14) has studied this phenomenon and the preliminary results are that these differences are well within current operating margins. Supplementary analyses will be performed as needed after the final WOG report is issued.

c. RHR Air-Entrainment

PG&E realizes that air entrainment in the RHR system be avoided. It is also realized that if it does occur, air entrainment can potentially contribute to erroneous RCS level indication. The WOG (Ref. 14) provides guidance in avoiding or at least greatly minimizing air entrainment in the RHR system by giving a set of plant specific curves that show the minimum allowable hot leg water level as a function of RHR flow. The curve that is applicable to Diablo Canyon has been reviewed to assure that sufficient margin exists in the applicable curves that are in the mid-loop operating procedures.

d. Draining Location and Rate

Operating procedures direct that RCS be drained down using the chemical and volume control system through the Loop No. 4 hot leg RHR suction line. None of the RVRLIS level sensing taps are on the Loop No. 4 hot leg and there is no impact on the level indications due to drain location. The impact of RCS drain rate on level instrumentation has been minimized by procedurally restricting the drain rate and using nitrogen injection for a smooth draining of the steam generator tubes.

e. Connection Location

The critical parameter in avoiding air entrainment and possible pump cavitation is the water level in the hot leg containing the RHR suction pipe connection (Loop No. 4). The water level is not uniform throughout the RCS and differences in level will occur in cold legs, reactor vessel upper head, stagnant hot legs, etc. The actual Loop No. 4 hot leg level versus measured level at other locations will depend on RHR flow rate and on RHR temperature. The level at the measured location must therefore be quantitatively related to the level at the RHR suction. The WOG draft report MUHU-1031, (Ref. 14) supplies appropriate correlations. The report is currently in draft form. This report will be reviewed for applicability to Diablo Canyon upon its final issuance. Based upon PG&E's review of the draft report, PG&E does not expect any further modifications will be required.

<u>Summary of Additional Programmed Enhancements. Analyses</u>

PG&E plans to supplement its present analytical understanding of reduced inventory procedures and instrumentation by the following programmed enhancements. These programmed enhancements are to:

1. Provide an analytical basis for any future changes in instrumentation and procedures.

2. Continue to encourage and support an EPRI effort to consider modifying MAAP so that it can be used to analyze reduced inventory RCS transients.

3. Extend heatup rate and time to boiling, maximum pressurization, hot leg vent, and time to core uncovery calculations to consider a wider variety of decay heats.

4. Incorporate the results contained in the final WOG Report MUHU-1031, "RCS Level Gradients," (Ref. 14) in calculations of level instrumentation uncertainties.

5. Confirm that the containment fan coolers can prevent the breaching of the containment penetration 63 loop seal during a loss of RHR.

6. Assess whether existing WOG recovery analyses are applicable to Diablo Canyon and, if not, perform them on a plant-specific basis.

ITEM 5. TECHNICAL SPECIFICATIONS

Technical specifications (TSs) that restrict or limit the safety benefit of the actions identified in this letter should be identified and appropriate changes should be submitted.

RESPONSE TO ITEM 5. TECHNICAL SPECIFICATIONS

PG&E has reviewed the Diablo Canyon Technical Specifications (TS) in light of this Generic Letter. As discussed previously, TS changes associated with the loss of decay heat removal have been requested by PG&E and were granted by the NRC. No further Technical Specifications were identified that inadvertently restrict or degrade the operation of systems and components that are essential to the operation and maintenance of decay heat removal. Therefore, no further changes are needed to the Diablo Canyon Technical Specifications at this time.

1. Containment

The requirements for a containment boundary in plant procedures are based on refueling TS 3/4.9.4, "Containment Penetrations," (Ref. 15) and TS 3/4.9.9, "Containment Ventilation Isolation System" (Ref. 16). The containment boundary is not containment closure as defined in the Generic Letter, rather a condition where containment closure could be achieved in less than 30 minutes. This definition of a containment boundary allows for equipment and personnel ingress/egress during reduced inventory operation, while preserving the capability for expeditious containment closure. A revision to Technical Specifications that specifically calls for a containment boundary or containment ventilation isolation system operability is not necessary, as the requirements are adequately addressed in plant operating procedures.

2. RHR System Flow Rate

TS 3/4.9.8, "Residual Heat Removal and Coolant Circulation," (Ref. 17) has been amended to allow reduced (as low as 1300 GPM) decay heat removal flowrates after the reactor has been subcritical for greater than 57 hours. This amendment was based on a Westinghouse plant-specific analysis showing operation with the reduced flowrate would provide adequate decay heat removal while reducing the likelihood of vortexing at the RHR sump suction.

3. Autoclosure Interlock

As requested by PG&E and approved by the NRC Staff in a letter from H. Rood to J. D. Shiffer, "Safety Evaluation of Removal of RHR Autoclosure Interlock Function and Installation of an Alarm at Diablo Canyon Units 1 and 2," dated February 17, 1988, PG&E has removed the decay heat removal suction valve autoclosure interlock function to preclude loss of RHR pump cooling and ensure reliable residual heat removal system operation.

4. Equipment Operability, Operation and Availability

The following Technical Specification (TS) address residual heat removal system.operation:

1. TS 3/4.9.8 "Residual Heat Removal and Coolant Circulation" (Ref. 17) (Mode 6)

2. TS 3/4.4.1.4.1, "Reactor Coolant System Cold Shutdown - Loops Filled" (Ref. 18) (Mode 5)

3. TS 3/4.4.1.4.2, "Reactor Coolant System Cold Shutdown - Loops Not Filled" (Ref. 19) (Mode 5)

4. TS 3/4.5.3, "ECCS Subsystems - T_{avg} Less Than 350°F" (Ref. 20) (Mode 4).

Technical Specifications define operability as the capability of the system to perform its specified function with all necessary attendant equipment such as instrumentation, controls, electric power, cooling seal water and lubrication, and also the capability to perform any related support function. With the above TS sections, PG&E believes residual heat removal system equipment availability, operation and operability are adequately addressed.

Operating procedures for entry into and operation while in a reduced inventory condition require that a safety injection pump be available by having its breaker racked in and its DC control power removed and caution tagged. TS Surveillance Requirement 4.5.3.2 (Ref. 21) states that all centrifugal charging pumps and safety injection pumps except the allowed operable charging pump shall be demonstrated inoperable at least once every 12 hours by verifying that the motor circuit breakers DC control power is deenergized. The basis for this surveillance requirement is to protect the RCS from a cold overpressurization event.

5. Instrumentation

Instrumentation requirements are derived from the appropriate TS operability requirements. Operating procedures specifically require operability of level, temperature and flow instrumentation. These requirements are previously discussed in this enclosure in the response to programmed enhancements for instrumentation. Revisions to Technical Specifications that specify instrumentation operability are not necessary, as the requirements are adequately addressed in plant operating procedures.

6. Communication

Refueling TS 3/4.9.5, "Communications," (Ref. 22) requires that direct communication between the control room and personnel at the containment refueling station be maintained during core alterations. Operating procedures for entry into and operation in a reduced inventory condition require an operable containment public address system, an auxiliary operator stationed

inside containment, and the presence of the containment radiation protection coordinator. The coordinator is responsible to be fully aware of personnel in containment and work in process and communicating this information to the operating shift. PG&E believes that communication requirements are adequately addressed in DCPP operating procedures.

Summary of Additional Programmed Enhancements. Technical Specifications.

There are no additional programmed enhancements for Technical Specifications planned at this time.

ITEM 6. RCS PERTURBATIONS.

Item 2.5 of the expeditious actions should be reexamined and operations refined as necessary to reasonably minimize the likelihood of loss of DHR.

RESPONSE TO ITEM 6. RCS PERTURBATIONS

PG&E recognizes the importance of minimizing the probability of loss of decay heat removal while in mid-loop operation by restricting activities that have a potential to induce perturbations and reduce RCS inventory. Item 2.5 of enclosure 2 to Generic Letter 88-17 instructed licensees to implement procedures and/or administrative controls that generally avoid operations that deliberately or knowingly lead to perturbations to the RCS and/or to systems that are necessary to maintain the RCS in a stable and controlled condition while the RCS is in a reduced inventory condition. PG&E has reviewed its procedures and administrative controls to assure that they minimize the likelihood of a loss of RHR due to RCS perturbations during mid-loop conditions. Routine surveillance testing and maintenance operations have the potential for perturbing the RCS during mid-loop operations. The controls described below are sufficient to preclude perturbing the RCS and systems that are necessary to maintain the RCS in a stable and controlled condition during mid-loop conditions.

Routine Surveillance Testing

After the Diablo Canyon April 10, 1987, loss of RHR event, PG&E identified surveillance test procedures that could introduce RCS level perturbations while in mid-loop operation. These surveillance test procedures have been revised to require that prior to breaching a system, the shift foreman be notified that the system is about to be drained/vented. The procedures further caution that the shift foreman's concurrence shall be obtained prior to starting the draining/venting activity. These procedures will be further revised to preclude their performance during mid-loop operation.

Maintenance Operations

The variety and changing scope of maintenance tasks prohibits the formulation of a list of restricted activities for mid-loop operations. Outage maintenance planning is a manual activity that requires careful considerations of work scope combined with scheduling optimization. Therefore, effective outage planning, recurrent operator training, and procedural controls must be relied upon to restrict those activities that may cause a loss of RCS inventory during mid-loop operations rather than a standardized restricted work list.

- Outage Planning

  During past refueling outages when mid-loop operations were required, the outage planning organization and the operations department carefully

reviewed the outage plan to restrict activities during mid-loop operations that had the potential to perturb the RCS. Logic ties were added to the computerized outage planning scheduling system to flag out certain activities so actions can be taken to prevent them from being performed during mid-loop operation. These activities were identified by caution notes added to the outage planning schedule.

- Operator Training

  Since the outage schedule can change on very short notice, a trained operating crew is a critical item in reducing the likelihood of performing any activities that may inadvertently perturb the RCS during mid-loop operations. Operations department personnel have received extensive training on mid-loop operations and are well aware of the precursory events that led to the 1987 Diablo Canyon loss of RHR event.

- Procedural Controls

  The mid-loop operating procedures OP A 2:II (Ref. 7) and OP A-2:III (Ref. 8) contain a prerequisite to review appropriate logs and identify activities that may affect makeup or letdown paths to the RCS, create potential leakage paths affecting the RCS volume, or compromise the integrity of the containment boundary required for mid-loop operations. In addition, mid-loop operating procedures require that an engineer or manager knowledgeable, with respect to the requirements of mid-loop operation and instrumentation, be on shift to supplement the normal shift operating crew.

  PG&E believes that sufficient controls are in place to prevent RCS perturbations during mid-loop operations. However, as previously discussed in Item 3, should an unexpected loss of inventory occur, extra core cooling equipment is procedurally required in addition to that required by technical specifications. The ability to close the containment in an expeditious manner should a loss of RHR occur is procedurally required.

  Considerable effort is expended to ensure that RCS water level instrumentation is installed and functioning properly prior to entry into mid-loop operations. As previously discussed in the expeditious items response to GL 88-17 (Ref. 1), the Operations department inspects the RVRLIS system daily for system alignment and any conditions that could lead to perturbing RCS level indication. The results of these inspections are logged daily and comparison of independent level readings is also performed at least daily.

  A potential activity has been identified that may lead to an RCS inventory loss should a loss of RHR and subsequent pressurization of the RCS occur. During reactor coolant pump (RCP) maintenance, the shaft of the pump may be uncoupled and be allowed to rest on the backseat while maintenance of various RCP components is in progress. During a

postulated loss of RHR event, RCS pressure could increase to the point where the RCP pump shaft could become unseated and allow the discharge of RCS inventory to the containment. This scenario could be extended to other maintenance operations that result in creating an opening on the RCS cold leg. Operating procedures will be revised to require management approval prior to creating a cold leg opening if the plant is to be operating in the mid-loop condition. PG&E management will consider the need for hot leg venting during each of these operations and the contingency requirements for expeditious containment closure and supplemental core cooling equipment.

Summary of Additional Programmed Enhancements. RCS Perturbations.

PG&E's additional programmed enhancement to minimize the impact of RCS perturbations are to preclude certain surveillance testing during mid-loop operation and to require management consideration of the effects of RCS cold leg maintenance prior to commencing those maintenance activities.

Procedures

1. Modify OP AP-16, "Malfunction of the RHR System," to include use of the medium head safety injection pump for hot leg injection and the use of the containment fan coolers to mitigate containment pressurization. This procedure will also be modified to include symptoms and entry conditions that address uncontrolled RCS pressurization.

2. Revise the appropriate abnormal procedures to provide additional guidance for containment closure under harsh conditions.

3. Review PG&E procedures considering the recommended procedures that will be issued by the WOG.

Equipment

There are no additional programmed enhancements for equipment planned at this time.

Analyses

1. Provide an analytical basis for any future changes in instrumentation and procedures.

2. Continue to support an EPRI effort to consider modifying MAAP so that it can be used in analyzing reduced inventory RCS transients.

3. Extend heatup rate and time to boiling, maximum pressurization, the effect of hot leg vents, and time to core uncovery calculations to consider a wider variety of decay heats.

4. Incorporate the results contained in the final WOG Report MUHU-1031, "RCS Level Gradients," in calculations of level instrumentation uncertainties.

5. Confirm that the containment fan coolers can prevent the breaching of the containment penetration 63 loop seal.

6. Assess whether existing WOG recovery analyses are applicable to Diablo Canyon and, if not, perform them on a plant-specific basis.

Technical Specifications

There are no additional programmed enhancements for Technical Specifications planned at this time.

RCS Perturbations

1. Require management approval prior to opening a cold leg vent path during mid-loop operation.

2. Revise surveillance test procedures to preclude performance of those surveilance tests during mid-loop operation that could perturb the RCS.

REFERENCES

Reference No.	Reference
1	PG&E Letter DCL-89-005, "Response to Generic Letter 88-17, Loss of Decay Heat Removal," (Expeditious actions) dated January 6, 1989.
2	NRC Information Notice 88-36, "Possible Sudden Loss of RCS Inventory During Low Coolant Level Operation," dated June 8, 1988.
3	Diablo Canyon Operating Procedure L-5, "Plant Cooldown From Minimum Load to Cold Shutdown."
4	Diablo Canyon Operating Procedure L-6, "Refueling."
5	Diablo Canyon Operating Procedure A-2, "Reactor Vessel."
6	Diablo Canyon Operating Procedure A-2:I, "Reactor Vessel - Filling and Venting the RCS."
7	Diablo Canyon Operating Procedure A-2:II, "Reactor Vessel - Draining the RCS to the Vessel Flange."
8	Diablo Canyon Operating Procedure A-2:III, "Reactor Vessel - Draining to Half Loop/Half Loop Operations."
9	Diablo Canyon Abnormal Operating Procedure AP-16, "Malfunction of RHR System."
10	Diablo Canyon Abnormal Operating Procedure AP-17, "Loss of Charging."
11	Diablo Canyon Abnormal Operating Procedure AP-18, "Letdown Line Failure."
12	NUREG-1269, "Loss of Residual Heat Removal System, Diablo Canyon Unit 2, April 10, 1987," dated June 1987.
13	Westinghouse Owners Group WCAP-11916, "Loss of RHRS Cooling While the RCS is Partially Filled," dated July 1988.
14	Westinghouse Owners Group MUHU-1031, "RCS Level Gradients," dated October 1988 (draft).
15	Diablo Canyon Technical Specification 3/4.9.4, "Containment Penetrations."
16	Diablo Canyon Technical Specification 3/4.9.9, "Containment Ventilation Isolation System."

17 Diablo Canyon Technical Specification 3/4.9.8, Residual Heat Removal and Coolant Circulation."

18 Diablo Canyon Technical Specificaton 3/4.4.1.4.1, "Reactor Coolant System Cold Shutdown - Loops Filled."

19 Diablo Canyon Technical Specification 3/4.4.1.4.2, "Reactor Coolant System Cold Shutdown - Loops Not Filled."

20 Diablo Canyon Technical Specification 3/4.5.3, "ECCS Subsystems - T_{avg} Less Than 350°F."

21 Diablo Canyon Technical Specification 4.5.3.2, Surveillance Requirement for Technical Specification 3/4.5.3, "ECCS Subsystems - T_{avg} Less than 350°F."

22 Diablo Canyon Technical Specification 3/4.9.5, "Communications."

23 Westinghouse Owners Group Letter WOG-88-156, "Transmittal of Mid-Loop Operations Interim Guidance and Workshop Attendance List," dated November 7, 1988.