PACIFIC GAS & ELECTRIC COMPANY

DIABLO CANYON NUCLEAR POWER PLANT

INDEPENDENT DESIGN VERIFICATION PROGRAM

INTERIM TECHNICAL REPORT NO. 46

REVISION 0

ADDITIONAL VERIFICATION OF SELECTION OF SYSTEM DESIGN PRESSURE AND TEMPERATURE AND DIFFERENTIAL PRESSURE ACROSS POWER-OPERATED VALVES

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DIABLO CANYON NUCLEAR POWER PLANT - UNIT 1

INDEPENDENT DESIGN VERIFICATION PROGRAM

INTERIM TECHNICAL REPORT

ADDITIONAL VERIFICATION OF SELECTION OF SYSTEM DESIGN

PRESSURE AND TEMPERATURE AND DIFFERENTIAL PRESSURE

ACROSS POWER-OPERATED VALVES.

This is the forty-sixth of a series of Interim Technical Reports prepared by the DCNPP-IDVP for the purpose of providing a conclusion of the program.

This report provides a description of the work done, summary and evaluation of the results, and conclusions of the IDVP with respect to the conclusion of selection of system design pressure and temperature and differential pressure across power-operated valves.

As IDVP Program Manager, Teledyne Engineering Services has approved this ITR. The methodology followed by TES in performing this review and verification is described by Appendix A to this report.

ITR Reviewed and Approved
IDVP Program Manager
Teledyne Engineering Services

D. C. Stratouly
Assistant Project Manager

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SECTION 1

INTRODUCTION

Interim Technical Report (ITR) No. 34, Revision 1, describes all additional verification work required to be performed based on the initial sample. This ITR describes work performed in one of the areas of concern, specifically, the selection of system design pressure and temperature and differential pressure across power-operated valves.

The Independent Design Verification Program (IDVP) review of the Auxiliary Feedwater (AFW) System indicated that the applicable piping design code was not completely complied with for selection of design pressure and isolation of low pressure portions of the system from higher pressure portions of the system. The review also showed that a low differential pressure was specified for the purchase of the AFW turbine pump power-operated steam supply valve.

Pacific Gas & Electric Company (PG&E) determined that modifications were necessary to assure the system's code compliance and to assure that the power-operated valve could function under all expected pressure conditions. It should be noted that although code allowable stress levels due to overpressure may have been exceeded without the proposed modifications, in most cases, no physical damage to equipment or components would be expected due to conservative factors of safety contained in the applicable codes. The AFW System had been operated at these higher than original design pressure conditions for extended periods of time, including the most severe turbine speed test condition for short intervals, with no apparent physical

damage. In one case, however, equipment (bearing coolers for the AFW turbine) designed for low pressure could have been damaged if exposed to high pressure caused by improper throttling of the valve added to increase backpressure.

PG&E performed a review of all PG&E designed safety-related systems to ensure compliance with the applicable codes for the selected system design pressure and temperature. The PG&E review also addressed the proper selection of differential pressure across control valves.

The IDVP verified, on a sampling basis, the work performed by PG&E. The two systems that were selected for the IDVP review were the safety-related portions of the Main Steam (MS) System and Component Cooling Water (CCW) System. These systems were reviewed and verified for the specific areas of concern described in this ITR.

SECTION 2

SUMMARY

PG&E performed a review of the selected system design pressures, temperatures, and differential pressures across control valves for the PG&E designed safety-related systems. The IDVP's selected sample of the safety-related portions of the MS and CCW Systems was verified for design pressure and temperature selection, isolation of low pressure portions, and differential pressure across power-operated valves. In addition, revised pressure/temperature values were verified for the AFW System as a result of the specific concerns described in the initial sample.

The results of the PG&E review of the sample systems show, in general, that actual design pressures and temperatures are higher than the originally selected design conditions. Equipment, piping, valves, components, and power-operated valve actuators were evaluated individually to determine their acceptability.

The IDVP reviewed the PG&E analysis and performed verification using Diablo Canyon Nuclear Power Plant - Unit 1 (DCNPP-1) design documentation. The IDVP found:

- The PG&E reanalysis methodology for the safety-related portions of the MS and CCW Systems was rigorous, thorough, and met the intent of the piping design code for selection of system pressure and temperature. PG&E also used proper engineering practice for

selecting differential pressure across power-operated valves. The IDVP concurs with the methodology and results of this reanalysis.

- The system pressure and temperature conditions determined by the PG&E reanalysis are higher than originally specified or selected for the MS System and portions of the CCW System.

- Concerns similar to those originally found in the pressure/temperature review of the AFW System were found by PG&E also to exist in the MS System and portions of the CCW System.

- No further additional verification is required as PG&E is reanalyzing all of the PG&E designed safety-related systems in accordance with ITR No. 34.

SECTION 3

BASIS OF CONCERN

The selected design pressures/temperatures for AFW piping, valves, fittings, and equipment were reviewed based on system operating conditions. The major items reviewed included the following:

- Specification of design pressure for pipe fittings, equipment, and stress input

- Isolation of low pressure components and piping from the effects of the higher pressure portion of the system

- A review of all equipment and components for compatibility with the specified design pressure.

The review determined that the applicable piping design code for selection of design pressure was not met. The design code (i.e., ANSI B31.1, Paragraph 101.1) requires the system to be designed for the most severe condition of coincident pressure, temperature, and other loadings. Additionally, the effects of static head, maximum sustained pressure at any pump load and pressure surges must be accounted for. The design pressure originally shown in the Line Designation Table did not meet the requirements of the code as shown by independent calculation and by field operating test data.

The review of the separation of low pressure portions from higher pressure portions of the system also indicated that code criteria were not met. A division valve was located such that overpressurization of low pressure components could occur.

A review of actuator sizing for compatibility with the system design conditions indicated that certain valves could be called upon to operate against differential pressures in excess of their specified design conditions.

3.1 EOI FILES

An identified concern in the initial sample was that the most severe design condition of coincident pressure, temperature, and other loadings had not been considered in system design pressure and temperature selection. PG&E re-evaluated the AFW system design temperature/pressure and provided a resolution for this file which involved physical modifications to the system by replacing 42 valves. This resolution was reviewed, found acceptable, and field-verified by the IDVP after modifications were made. To further reduce the maximum pressure that could be developed by the turbine-driven AFW pump, PG&E will reduce the setpoint for the overspeed trip during plant startup. EOI File 8009 was issued addressing this concern.

Another concern was the inclusion of a valve in the system to provide additional backpressure and flow through the turbine bearing coolers violates the ANSI Code and leaves some components unprotected against higher than design pressures for certain operating conditions. PG&E has provided a

resolution changing the piping configuration on the turbine pump recirculation line. The change is code acceptable and was field-verified by the IDVP as installed. EOI File 8010 was issued addressing this concern.

A final concern identified that several valve actuators may be undersized and might not function during periods of time with large differential pressures across the valves. PG&E provided a resolution consisting of changes to FCV 95 and a licensing basis explanation of why FCV 37 and FCV 38 are acceptable as designed. This resolution has been reviewed and accepted. Gear modifications to the FCV 95 actuator were made and documentation was reviewed by the IDVP showing the modifications were complete. During a steam line break event, adequate redundancy of equipment and systems is available to safely shut down the plant; thus, the closure of FCV 37 and FCV 38 is not a design basis for the valves. EOI File 8062 was issued addressing this concern.

No EOI files were opened as a result of the additional verification reported in this ITR.

3.2 SCOPE OF ADDITIONAL VERIFICATION

As stated in ITR No. 34, PG&E developed a Scope of Work to determine whether the problems identified in the initial sample were present in other safety-related systems. PG&E stated it would review all safety-related systems it designed to determine if the identified problems occurred elsewhere. Two additional systems were chosen by the IDVP for verification of selection of design temperature and pressure and differential pressure across power-

operated valves. These systems are the safety-related portions of the MS System and the CCW System.

To determine the acceptability of the systems, the following items were reviewed:

- Selection of design pressure and temperature for system piping, fittings, components, and mechanical equipment

- The isolation of low pressure piping, fittings, components, and mechanical equipment from the higher pressure portion of the system

- A review of all system piping, fittings, components, and mechanical equipment, including power-operated valve actuators for compatibility with the specified design pressure and temperature.

The IDVP original analysis for the AFW System identified concerns regarding the selection of system design pressure and differential pressure for power-operated valves. No specific concerns were identified for the selection of system design temperature; however, the determination as to whether piping system components or equipment can accommodate a selected design pressure is also a function of the selected system design temperature. Generally, the allowable pressure or stress that piping system components or equipment can withstand will be reduced as temperature increases.

The calculation of design temperature can be quite straightforward (e.g., ambient temperature or steam saturation temperature). In other cases, such as for the CCW System, it can be based on equipment generated heat loads (vendor supplied) and heat transfer characteristics. As no concerns were originally found in the selection of design temperature, the system design temperatures recalculated by PG&E were used by the IDVP.

SECTION 4

ANALYSIS

The safety-related portions of the CCW System are necessary for the removal of heat generated by the reactor plant equipment and components during normal plant operation, plant cooldown, and following a loss-of-coolant accident (LOCA). The safety-related portion of the MS System is required to remove heat from the Reactor Coolant System during some plant operating conditions. The safety-related portion of the MS System also provides steam to the AFW pump turbine during normal and emergency cooldown. The Final Safety Analysis Report (FSAR) states that portions of both systems are designed to Class I criteria. FSAR Tables 3.2-3 and 3.2-4 identify the applicable piping codes for both systems.

The IDVP performed calculations for CCW and MS system design pressures. The results were used to verify the design pressure calculations performed by PG&E. Piping, fittings, components, and mechanical equipment ratings were reviewed to determine compatibility with the pressures, including actuator sizing to meet valve differential pressures. System arrangements were reviewed against code criteria for protection of low pressure components.

PG&E notified the IDVP on June 8, 1983, that systems identified in Section 4.2 of ITR No. 34 had been reviewed. PG&E stated the results as:

- Operating pressures and temperatures for all reviewed systems have been established.

- All components, pipes, valves, and flanges within the reviewed systems have been identified and their design pressure and temperature identified with several exceptions. Information requests to vendors are outstanding for these exceptions.

- All components, pipes, valves, and flanges where the design pressure and temperature have been established are acceptable or will be modified. Upon receipt of vendor information for the exceptions identified, the components will be reviewed for acceptability and modifications made, if required.

These items are consistent with the review process that was made for the CCW and MS Systems.

4.1 ACCEPTANCE CRITERIA

The acceptance criteria for satisfactory verification of the MS and CCW Systems are determined by the applicable codes to which the systems are designed. In general, piping, fittings, components, and mechanical equipment must be designed to withstand the most severe combination of pressure, temperature, and loading conditions credibly possible as determined by the system designer.

4.2 MAIN STEAM SYSTEM

The safety-related portions of the MS System include all piping from the steam generators up to the main steam isolation valves. This also includes

the steam supply piping to the AFW turbine pump. The steam generator blowdown and sampling lines were not included in the scope of this analysis. The remainder of the system is design Class II, including the atmospheric steam dump valves, and is outside the scope of this review.

4.2.1 Calculation Methodology

The PG&E design pressure/temperature calculation for the MS System was reviewed to evaluate the methodology and assumptions used. The results were verified by an IDVP calculation. The PG&E calculation determined pressures and temperatures for the various modes of operation. The most severe set of conditions would then be used to evaluate the equipment. Based on the IDVP review and analysis, the PG&E calculation has considered and incorporated the most severe set of conditions; thus, the new design pressure/temperature satisfies code criteria.

4.2.2 Comparison of Old and New Values

The PG&E calculation resulted in the following revised design pressures and temperatures:

	Previous Design Values	
	Pressure, psig	Temperature, °F
Main Steam Lines	918	536
AFW Turbine Steam Supply		
Lines 593 and 594	878	536
Line 760	918	536

	New Design Values	
	Pressure, psig	Temperature, °F
Main Steam Lines	1,179	567
AFW Turbine Steam Supply		
Lines 593 and 594	1,179	567
Line 760	1,179	567

The new design values are in compliance with the applicable piping codes.

Piping, fittings, components, and mechanical equipment ratings were reviewed to determine compatibility with the new design values. All piping except the 24-inch safety valve headers are acceptable for continuous use at the new design values. The safety valve headers are code acceptable based on the piping code criteria for variations from normal operation. These piping code criteria allow a 15-percent overstress for 10 percent of an operating period. The upset conditions which the new design values are based on (i.e., relief valves lifting) are not expected to last for more than 10 percent of an operating period. The safety valve header will not be overstressed, from pressure effects, at normal system operating pressures.

The new design values for the MS System fall marginally outside the allowable ANSI B16.5 flange and valve ratings for 600 lb class components.

This code does not allow for an overstress condition for short intervals of time similar to the piping code (ANSI B31.7). Table 5 of ANSI B16.5 allows, for the materials of concern, the following:

Service Temperature, °F	Pressure, psig
550	1,180
600	1,110

By interpolation, the new design value of 1,179 psig is acceptable for temperatures less than 550.7°F and, similarly, the new design temperature of 567°F is acceptable for pressures less than 1,156.2 psig. The combination of design conditions is outside the ratings. This required a design evaluation of all 600 lb components in the MS System which includes virtually all manual valves, control valves, and components such as steam traps. PG&E is continuing this evaluation and, at this time, has only identified steam trap modifications as being required. The acceptability of these items will be addressed by PG&E as described in ITR No. 34, Section 4.2, and Section 4.3.2 of this ITR.

4.2.3 Protection of Low Pressure Components

No low pressure interconnected sections exist in the safety-related portions of the MS System.

4.2.4 Differential Pressure Across Power-Operated Valves

The maximum differential pressure was determined for all power-operated valves in the scope of the MS system review. Purchase specifications or manufacturer's data were then reviewed to assure that actuator sizing was sufficient to operate against the maximum pressure. Actuator ratings for electrically powered valves at 80-percent voltage were considered.

The additional verification determined all safety-related valve actuators are sufficient except for the AFW system turbine steam supply valve FCV 95. The actuator rating for FCV 95 was established as part of the AFW system review prior to revision of the MS system design pressures. At that time the actuator was shown to be sufficient for a differential pressure of 1,150 psid. Based on the new MS system pressures, the valve may be required to operate against a maximum differential pressure of approximately 1,175 psid.

PG&E has stated all equipment ratings will be re-reviewed when the new design pressures are incorporated into design criteria documents and FCV 95 will be reviewed at that time.

4.0.5 Documentation Used

The following documents were used in the review of the PG&E analysis for the MS System:

- System Description and Design Information
- PG&E MS System Design Pressure and Temperature Calculation
- Valve Specifications and Data Sheets
- Piping, Valve, and Flange Codes
- MS System Drawings
- Pressure/Temperature Operating Mode Data
- Piping Specifications
- MS System Design Review Isometrics

- DCNPP-1 Technical Specifications
- MS System Piping Schematics
- FSAR Section 3.2.

4.3 COMPONENT COOLING WATER SYSTEM

The CCW System consists of two vital service headers and one non-vital header. This review considers the safety-related sections of the CCW System.

4.3.1 Calculation Methodology

The PG&E design pressure/temperature calculation for the CCW System was reviewed to evaluate the methodology and assumptions used. The results were verified by an IDVP calculation. Temperatures given by PG&E for the CCW System were not calculated. The IDVP concern was selection of pressure. The selection of temperature is used as an input to determine overall acceptability.

Based on the IDVP review and analysis for design pressure, the PG&E calculation has considered and incorporated the most severe set of conditions; thus, the new design pressure satisfied code criteria.

4 Comparison of Old and New Values

The PG&E calculation resulted in the following revised design pressures:

	Previous Design Pressure, psig	New Design Pressure, psig
Reactor Coolant Pump Thermal Barrier and Labyrinth Seal	2,485	2,545
Associated Lines Inside Containment	2,485	2,548
Associated Lines Outside Containment	2,485	2,592
Reactor Coolant Pump Oil Coolers	150	151
and Reactor Vessel Support Coolers	150	156.5
Associated Lines Inside Containment	150	158.5
Associated Lines Outside Containment	150	201
Excess Letdown Heat Exchanger	150	159.5
Associated Lines Inside Containment	150	159
Associated Lines Outside Containment	150	200

	Previous Design Pressure, psig	New Design Pressure, psig
Supply Piping to the Component Cooling Water Heat Exchangers	150	151

The remainder of the design pressures did not increase.

Piping, fittings, components, and mechanical equipment ratings were reviewed to determine compatibility with the new design values. All components were found to be acceptable with the following exceptions:

	PG&E Revised Design Conditions	Manufacturer's Rating
RC Pump Upper and Lower Bearing Oil Coolers	151 psig/132°F	150 psig/200°F
CCW Pump Oil Coolers	148 psig/150°F	125 psig/300°F
Excess Letdown Heat Exchanger	160 psig/130°F	150 psig/250°F
RV 41, 42, 43, and 44	2,548 psig/135°F	2,000 psig/400°F
Reactor Coolant Pump Thermal Barrier	2,545 psig/135°F	2,500 psig/315°F

The acceptability of these items will be addressed by PG&E as described in ITR No. 34, Section 4.2.

The acceptability of these items will not be verified by the IDVP as it is considered part of PG&E's normal design process which was not identified as a concern by the IDVP. The IDVP concern addressed the selection of system design pressure and temperature, and differential pressure across power-operated valves and its use for the specification of equipment. The IDVP concern did not address the engineering process of determining equipment acceptability once the proper pressure/temperature of differential pressure is identified and specified.

4.3.3 Protection of Low Pressure Components

CCW lines associated with the reactor coolant pump thermal barrier would be exposed to high pressure in the event of rupture. These lines are of an appropriate pressure class of pipe or are acceptably isolated and protected from the pressure source.

4.3.4 Differential Pressure Across Power-Operated Valves

The maximum differential pressure was determined for all power-operated valves in the scope of the CCW system review. Purchase specifications or manufacturer's data were reviewed to assure that actuator sizing was sufficient to operate against the maximum differential pressure. Actuator ratings at 80-percent voltage were considered for electrically-powered valves. The CCW demineralized water makeup supply valve actuator ratings for LCV 69

and LCV 70 were not evaluated as the upstream piping was outside the scope of this review.

All the actuators (with the exception of four valves currently being reviewed by PG&E for actuator ratings at 80 percent voltage) within the scope of the CCW System review were found to be sufficient to operate against the maximum differential pressure that exists when the valves are required to function.

4.3.5 Documentation Used

The following documents were used in the evaluation of the CCW System:

- System Description and Design Information
- PG&E CCW System Design Pressure and Temperature Calculation
- Valve Specifications and Data Sheets
- Piping, Valve, and Flange Codes
- CCW Pump Curves
- CCW System Isometrics
- CCW System Piping Schematics
- Piping Specifications
- FSAR Section 3.2.

SECTION 5

CONCLUSIONS

The conclusions concerning the additional verification of design, pressure, temperature, and differential pressure across power-operated valves follow:

- The IDVP concurs with the methodology used by PG&E for their reanalyses and with the specific results for the MS and CCW Systems.

- The PG&E reanalysis for the MS and CCW Systems was rigorous, thorough, and meets the intent of the design for selection of pressure and temperature.

- Concerns similar to those originally addressed in the initial sample were found by PG&E to also exist in the MS and CCW Systems.

- No additional verification is required by the IDVP based upon the review of the selected sample systems. The review indicated that proper methodology and application of design codes were used.

- FCV 95 (part of the initial sample) and steam traps (as identified by PG&E) required replacement or modification as a result of the design pressure/temperature review for the MS System.

Components requiring possible replacement, modification, or revised vendor analysis as a result of the design pressure/ temperature review for the CCW System include:

- The RC Pump Upper and Lower Bearing Oil Coolers
- The CCW Pump Lube Oil Coolers
- The Excess Letdown Heat Exchanger
- RV 41, 42, 43, and 44
- Reactor Coolant Pump Thermal Barriers

APPENDIX A

PROGRAM MANAGER'S ASSESSMENT

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PROGRAM MANAGER'S ASSESSMENT

Independent review by TES of the tasks performed by SWEC to verify the Diablo Canyon Project (DCP) efforts was done in accordance with the IDVP Phase II Program Management Plan and ITR-34.

ITR-34, Revision 1, issued on March 24, 1983, identified five (5) areas of concern which required additional verification. The work was performed by the DCP and the conclusions were verified by SWEC.

This ITR describes the work performed by the DCP for the concern of selection of system design pressure and temperature and differential pressure across power-operated valves. The results are reported herein.

The IDVP concurs with the methodology used by PGandE for their analyses and with the specific results for the MS and CCW Systems, and that these analyses met the intent of the design for the selection of pressure and temperature. No EOI files were issued.

Accordingly, no further additional verification is required.

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REVISION 0

ADDITIONAL VERIFICATION OF ENVIRONMENTAL CONSEQUENCES OF POSTULATED PIPE RUPTURES OUTSIDE OF CONTAINMENT

STONE & WEBSTER ENGINEERING CORPORATION