Robert L. Cloud and Associates, Inc.

RLCA

Interim Technical Report

DIABLO CANYON UNIT 1
INDEPENDENT DESIGN VERIFICATION PROGRAM
VERIFICATION OF DCP ACTIVITIES

Intake Structure

IIR #58, Revision 1

Docket No. 50-275
License No. DPR-76

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PROGRAM MANAGER'S PREFACE
DIABLO CANYON NUCLEAR POWER PLANT - UNIT 1
INDEPENDENT DESIGN VERIFICATION PROGRAM

INTERIM TECHNICAL REPORT
INTAKE STRUCTURE

This Revision 1 to Interim Technical Report, ITR-58, is one of a series of ITRs prepared by the DCNPP - IDVP for the purpose of providing a conclusion to the program.

This is the final report on the IDVP verification of the DCP corrective action to qualify the intake structure for both seismic and non-seismic loads. The IDVP review verification addressed EOI 1022 which was redefined to track the DCP reevaluation of the intake structure being performed as part of the Corrective Action Program. The field verification of modifications was performed and is reported herein. The IDVP verification results in this ITR will be reported in Section 4.4.6 of the IDVP Final Report.

As IDVP Program Manager, Teledyne Engineering Services has reviewed this Interim Technical Report. Professors J. M. Biggs and M. J. Holley, Jr., participated in the verification efforts underlying this report, as summarized in Appendix E, Program Manager's Assessment. Reflecting that participation, they are in agreement with the contents of this report.

ITR Reviewed and Approved
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IDVP Verification of DCP Activities

Intake Structure

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1.0 INTRODUCTION

Purpose and Scope

This interim technical report (ITR) summarizes the Independent Design Verification Program (IDVP) verification of the Diablo Canyon Project's (DCP) corrective action to qualify the intake structure for both seismic and non-seismic loads. The intake structure takes salt water from the ocean to the auxiliary saltwater (ASW) pumps, where the water acts as a coolant for the component cooling water (CCW) system. The intake structure is a Design Class II structure which houses Design Class I equipment such as the ASW pumps.

The seismic load conditions are the Hosgri (both Newmark and Blume) Earthquake, Design Earthquake (DE), and the Double Design Earthquake (DDE). Non-seismic loads considered, if applicable, are thermal, tornado generated missile loads, compartment pressure, hydrostatic, soil pressure, and wave forces. The IDVP program for verification of the DCP corrective action with respect to Hosgri criteria (Phase I activities) was presented in ITR #8 (Reference 1). The IDVP program for non-Hosgri criteria (Phase II activities) was presented in ITR #35 (Reference 2).

The DCP Corrective Action Program for the intake structure specified a complete review of the dynamic analyses and member qualifications. If the DCP review showed deficiencies, these were corrected.

For the DCP methodology, the IDVP examined the scope, review, and reanalysis to ensure completeness and compliance with the licensing documents. These documents include the Final Safety Analysis Report (FSAR - Reference 3), Hosgri Report (Reference 4), and Safety Evaluation Report (SER) Supplement No. 7 (Reference 5), among others.

For the DCP procedural implementation, the IDVP compared a list of design analyses to the DCP scope. In addition, a sample of qualification analyses was selected and verified against design criteria, as-built conditions, DCP analysis methods, and results.

Background

EOI 1022 was initially issued concerning the intake structure because inapplicable spectra had been used as input for the ASW pump supports. It was redefined to track DCP's reevaluation of the structure as part of their Corrective Action Program. As a result, other EOI files related to the intake structure were combined with EOI file 1022. The DCP performed a reanalysis and the IDVP verified that the concerns of EOI 1022 were addressed and corrected; thus, EOI 1022 was closed.

ITR #8, Revision 0 presented the IDVP program to verify DCP corrective action. Phase I comprises the independent verification undertaken to ensure that the plant meet the licensing criteria for the postulated 7.5M Hosgri earthquake.

ITR #35, Revision 0 presented the IDVP program to verify the Phase II DCP activities that are not related to the Hosgri qualification. Phase II comprises the evaluation of non-Hosgri structural/mechanical loading combinations, i.e., design earthquake, double design earthquake, thermal, pipe break, and accident conditions.

Summary

The IDVP completed its verification of the intake structure at Diablo Canyon Nuclear Power Plant (DCNPP) by examining the DCP Corrective Action Program methodology and procedural implementation.

To evaluate the methodology, the IDVP reviewed the scope, criteria, and procedures described in the PGandE Phase I Final Report (Reference 6). To evaluate the procedural implementation, the IDVP selected a sample of calculations and computer files needed to qualify the structure and reviewed the sample for compliance with the DCP design criteria.

The IDVP found the DCP methodology and procedural implementation to be acceptable as a result of the review of the sampled calculations. The IDVP verified, on a sample basis, that the as-built condition corresponded to the design drawings.

The backfill soil and foundation rock properties were reviewed and found to be acceptable as reported in ITR #68, Verification of HLA Soils Work. The dynamic soil pressure was alternately calculated by the IDVP as described in ITR #68. The IDVP found the intake structure to meet licensing criteria with respect to sliding, overturning, and bearing pressure.

2.0 INDEPENDENT DESIGN VERIFICATION METHODS

2.1 PROCEDURES

2.1.1 IDVP Review of DCP Methodology

The scope of the DCP methodology is described in the PGandE Phase I Final Report. It was verified by the IDVP against the structural commitments, as described in the FSAR, Hosgri Report, Safety Evaluation Report and Supplements, and other licensing documents.

The IDVP verified the DCP methodology by examining the PGandE Phase I Final Report to ensure that all criteria, assumptions, modeling techniques, and specific structural requirements were included. The calculations chosen for the IDVP sample were also reviewed for acceptable methodology.

The three-dimensional mathematical models formulated by the DCP were examined by the IDVP with respect to assumptions, computation of mass and stiffness properties, boundary conditions, and representation of the physical structure by finite element modeling.

2.1.2 IDVP Review of DCP Procedural Implementation

Appendix A, List of DCP Qualification Analyses, contains the calculation index as supplied by the DCP (Reference 7). The IDVP examined this index to ensure that all response spectra and member qualification analyses were included. The IDVP found the index to be acceptable and selected a sample of the qualification analyses for review.

Response spectra generated by the DCP were examined to ensure that spectra were obtained for required locations and that spectral acceleration values were correctly enveloped. These spectra, required for analysis of the equipment, piping, and components supported by the structure, were also examined for utilization of proper seismic input and proper inclusion in the DCP's Design Criteria Memorandums (DCMs) for use by other disciplines.

The structural member evaluations were also reviewed (as described in Section 4.2) to ensure conformance with loading combinations and allowable stresses as specified in the DCP licensing criteria. The IDVP also reviewed the factor of safety with respect to sliding, overturning, and bearing pressure.

As the final segment of their review, the IDVP verified a portion of the sample at the field site to ensure that as-built conditions conformed to the engineering drawings used for calculations.

2.2 CRITERIA

The IDVP assembled and reviewed the applicable licensing criteria. The major documents used in the IDVP review were:

- Final Safety Analysis Report for DCNPP
- Seismic evaluation for postulated 7.5M Hosgri earthquake
- Safety Evaluation Report and Supplements.

Also used were the U.S. Atomic Energy Commission Regulatory Guides and other references listed in Section 7.0.

3.0 IDVP REVIEW OF DCP METHODOLOGY

3.1 GENERAL DCP METHODOLOGY FOR STRUCTURES

The DCP Corrective Action Program is detailed in the PGandE Phase I Final Report. The DCP effort was undertaken to ensure overall adequacy of the analyses and design of the plant.

The DCP review methodology for structures is described in Section 1.5.4.1 of Reference 6. Included are the following procedures:

- Comparison of as-built condition with design drawings; review of modifications as a result of reanalysis
- Review of proper criteria utilization from FSAR and Hosgri Report
- Review of assumptions, input data, analytical models, computer codes, and calculation techniques; reanalysis performed as necessary.

3.2 DCP METHODOLOGY FOR INTAKE STRUCTURE

The DCP methodology is described in Section 2.1.5 of Reference 6. Seismic review was performed using the FSAR and Hosgri Report criteria, with seismic input as detailed in those reports.

Although not directly stated, the DCP used a fixed base for the DE/DDE earthquake as well as for the Hosgri earthquake. The use of a fixed base for shear wave velocities $\geq$ 3500 feet per second (fps) is permitted for the Hosgri earthquake, as stated in Supplement No. 7 of the SER. Since the rock foundation that supports the intake structure meets this criteria (Reference 11), the IDVP has accepted the use of a fixed base for all earthquakes (Reference 19).

The DCP performed member evaluation for only the postulated Hosgri earthquake. The IDVP concurs with this procedure (Reference 19). Collapse is shown not to occur in the Hosgri earthquake, as required for Design Class II criteria. The Hosgri earthquake controls over DE and DDE with regard to member evaluation for equal damping and material properties.

The loading combination criteria for member evaluation do not combine the Hosgri event and wave forces at the same time. A scale model was used by the DCP to determine wave forces. The DCP presented the results of this test in the PGandE Phase I Final Report. The IDVP did not evaluate the scale model test or results, and reviewed the member evaluation for only Hosgri, dead, and live loads (and missile loads for the vent shaft).

The DCP performed analyses which produced response spectra for the DE, DDE, and Hosgri earthquakes.

Modifications to the ASW vent system were necessary to prevent ingestion of water into the ASW pump rooms. These modifications have been incorporated by the DCP in the vent shaft analyses (see Section 4.2.7).

In summary, the IDVP agrees with the DCP methodology as detailed in the PGandE Phase I Final Report. Review of the specific calculation files and the IDVP findings are presented in Section 4.0.

4.0 IDVP REVIEW OF DCP PROCEDURAL IMPLEMENTATION

4.1 SELECTION OF IDVP SAMPLE

Basis for Selection of Calculation Files

The IDVP selected a sample of calculations and computer files (see Appendix B) from the List of DCP Qualification Analyses given in Appendix A to evaluate the DCP procedural implementation for the intake structure. The sampling procedure involved examination of the list in Appendix A to assess the entire seismic qualification for completeness, including implementation of design criteria, formulation of mathematical models, response spectra, and member evaluation.

The DCP intake structure analysis utilized a series of mathematical models which reflected both physical modifications and changes in modeling methods from the 1977 Hosgri qualification. The IDVP selected calculation files to assess the following:

- o Seismic analysis with respect to licensing criteria
- o Changes to the mathematical models and subsequent dynamic analyses. The IDVP selected the Hosgri and DE mathematical models.
- o Formulation of mathematical models including mass and stiffness calculations, boundary conditions, and degrees of freedom selected
- o Generation of floor response spectra by the time history modal superposition method
- o Member qualification analyses for both dynamic and static (residual force) loads. A significant portion of the intake structure response is above the rigid (33 hertz) range, which requires imposition of the equivalent static residual force loads.
- o Stress evaluation of piers
- o Qualifying analyses for the intake vent shaft, which has been modified
- o Analyses with respect to sliding, overturning, and soil bearing pressure.

The intake structure crane member evaluation calculation file was not reviewed in detail. Only the loads imposed by the crane on the intake structure were reviewed for acceptability. The IDVP has selected the polar crane as their sample for review of the crane structures. The results of the detailed IDVP review of the polar crane were presented in ITR #54 for the containment structure.

Samples of the computer runs were selected to verify the DCP procedural implementation. Various computer codes were used to perform the seismic analysis. This ITR does not examine these computer codes for quality assurance considerations such as benchmarking, revision number, etc. R.F. Reedy, Inc. has verified computer code quality assurance on a sampling basis as reported in ITR #41 (Reference 8). This ITR reviews the technical application and suitability of each code to the analysis of the intake structure.

4.2 VERIFICATION OF DCP QUALIFICATION ANALYSES

4.2.1 Introduction to the IDVP Review

Using the DCP calculation files, the IDVP performed a review of specific DCP design assumptions, methods, and results for the intake structure. The purpose of this review was to verify that DCP results were fully supported, accurate, and documented. These reviews of the sampled DCP calculation files are documented in the design reviews (References 9 through 16 and 20) as originated by Robert L. Cloud Associates, Inc. (RLCA). These design reviews were examined by Teledyne Engineering Services (TES) and Professors J. M. Biggs, and M. J. Holley, Jr., and serve as the technical basis for this ITR.

4.2.2 Design Review Checklist

The review of each particular calculation file was accomplished through the use of a checklist. Each checklist contains general technical items which ensure that all pertinent areas required for a complete review are addressed.

The main checklist items and guidelines used to evaluate each item are as follows:

A. Use of Design Drawings

- Proper transfer of data from construction (pour lift and shop drawings) to design drawings. Verification of field conditions versus design drawings performed on a sample basis.

B. Validity of Assumptions

- Limitations as applied to formulas, mathematical models, etc. and impact on results. Degree of conservatism or unconservatism present, if any.

C. Methodology and Criteria

- Formulation of mathematical models with respect to licensing commitments and required data. Use of proper seismic ground motion.
- Inclusion of proper degrees of freedom, mass, stiffness, and boundary conditions.
- Accuracy of results obtained and assessment of any method limitations.
- Applicability of time history, response spectrum, and residual force analysis methods.

D. Use of Formulas/Accuracy of Calculations

- Verify that proper formulas are used and applied.
- Verify the mathematical accuracy of selected calculations.

E. Completeness of Results/Data Transfer

- o Verify that all required loads, displacements, and accelerations are obtained for member evaluation.
- o Review all required loading combinations and resulting stresses against allowables as per the specified criteria.
- o Perform sample verification of data transfer for both hand calculations and computer runs. Reviews are performed on computer run files, including sample reviews for accuracy of data transfer between calculation files and referenced sequences.

F. Documentation

- o Verify that all calculation files sampled are properly signed, dated, referenced, labeled, and approved.

The above checklist items are intended to provide, in summary form, the important topics and issues addressed in reviewing the intake structure calculations.

A summary of checklist item results for each DCP calculation file reviewed by the IDVP is presented in Sections 4.2.3 through 4.2.9.

4.2.3 DCP Calculation #8234-04-CA-01: August 1982 Mathematical Model

The results of the analyses for this mathematical model (eigenvectors and eigenvalues) are used to produce response spectra reported in DCM C-17 (Hosgri - Reference 17) and forces used for member evaluation. A later model is detailed in DCP Calculation #8234-04-CA-04, which assesses the impact of changes due to the vent hut physical modifications and changes in modeling. The two 3-D models used are an unsymmetrical North-South (N-S) model and a combination East-West (E-W)/Vertical symmetrical model. The major changes incorporated into this file compared to the previous Hosgri model (Reference 9) are:

- o Release of nodal degrees of freedom constrained in the previous model, converting the models into full 3-D representations
- o Inclusion of fluid masses in nodal masses
- o Revised equipment masses
- o Revisions to the vent hut structure
- o Openings in top deck slab for ASW pumps
- o Addition of nodal points where response spectra are required.

Illustrations of the DCP model are given in Figures 2.1.5-13 and 2.1.5-14 of Reference 6. Plate, brick, and beam elements were used in the SAP computer model representation of the intake structure.

Conclusions

This model gave an acceptable representation of the intake structure. The IDVP performed a sample verification of the calculation of lumped masses and determination of the finite element mesh. Boundary conditions used at the plane of symmetry are acceptable. A fixed base model was used which is acceptable, since the foundation rock meets the minimum shear wave velocity criteria of 3500 fps. The modal frequencies corresponding to local pier behavior reflected that the N-S direction was more flexible than the E-W direction due to added fluid mass and structural dimensions. In the E-W direction, the 26th mode was the dominant mode, in terms of percent participation factor. In the N-S and Vertical directions, more modes had significant participation, thus reflecting the mass and stiffness characteristics of the models used.

The resolution of modeling changes and physical modifications are discussed in the review of DCP Calculation #8234-04-CA-04. There are sufficient nodal points present in the area where response spectra are required to yield acceptable results.

4.2.4 DCP Calculation #8234-04-CO-01A to 01D (Computer Runs)

These computer runs consist of the mathematical models and associated computer programs. These programs yield natural frequencies, mode shapes, and participation factors for the free vibration of the specified model. These results are used, in turn, with a time history analysis for generation of response spectra and finally member force determination.

Conclusions

The eigensolutions for the N-S and E-W/Vertical models were produced in conformance with the model presented in DCP Calculation #8234-04-CA-01. The IDVP verified, on a sample basis, the mass, material properties, and geometry input. The results were properly saved for subsequent spectra generation and member force computations. The results obtained with respect to the mathematical model formulated are acceptable.

4.2.5 DCP Calculation #8234-04-CA-04: November 1982 Mathematical Model

This calculation incorporated changes in methodology, revised masses, and geometry differences between the physical structure and the mathematical models and assessed their influence on results. The crane mass was the largest mass previously excluded. The curtain wall on the seaward side had been modeled five feet higher than the as-built condition. These and other differences were corrected in this model.

An eigensolution was performed and compared to the results obtained from Calculation #8234-04-CA-01. Periods of vibration and participation factors were obtained. Boundary conditions were used which were identical to those in the previous model.

Conclusions

The DCP addressed all the differences previously identified in the new mathematical model, as verified by the IDVP. The IDVP compared the natural frequencies and response spectra (at selected nodes) with results from the #8234-04-CA-01 models. No significant differences were noted, with the exception of the piers. The local pier model included the proper modeling parameters for member evaluation.

The IDVP verified the DCP calculations which demonstrated that the flow straighteners beneath the wall supporting the ASW pump, the pedestal, and the top deck slab are essentially rigid; therefore, modeling methods are acceptable.

4.2.6 DCP Calculation #8234-14-CA-01: DE Eigensolution

This model and its eigensolution were used as the basis for the generation of DE and DDE response spectra. Revised equipment and crane masses, as well as minor geometry corrections, were applied to the 1982 Hosgri models discussed in Section 4.2.5. A fixed base was used in the model. The DE time history was applied to this model in order to obtain response spectra. (DDE values are twice those of DE.)

Conclusions

The required periods of vibration and participation factors were obtained from the eigensolution of the DE model. As expected, results were similar to those obtained for the Hosgri model, since the modeling changes were minor. Modes above 20 hertz were not considered, as is consistent with the 20 hertz cutoff for the DE/DDE design response spectra, established in the FSAR.

4.2.7 DCP Calculation #52.18-10: Intake Structure Vent Shaft

This calculation contains the qualification analysis for the intake vent snorkel pipes, the concrete vent shaft protruding above the top deck at elevation 17.5 feet, and supporting structure at the top deck. This assembly provides ventilation to the ASW pump system, which is Design Class I. The calculation examined the effect of seismic, hydrostatic, and tornado generated missile loads on the vent shaft.

Conclusions

The DCP performed the member evaluation for the tornado generated missile load. The IDVP performed calculations to determine the snorkel natural frequencies and resulting seismic loads, which verified that the missile load was the controlling load case. The vent shaft snorkels were found to have acceptable plastic moment capacity and anchorage in the concrete vent shaft. The vent shaft and supporting beam/wall system at the top deck were shown to meet the licensing criteria.

4.2.8 DCP Calculation #8234-04-CA-02: Hosgri Response Spectra

This calculation contains the computations and computer runs necessary for generation of response spectra using models reviewed in Section 4.2.3. Response spectra were required in a limited area at various elevations, as detailed in the DCMs. Spectra were generated for the required damping values of 2%, 3%, 4%, 7%, and then broadened according to the criteria. Peaks and valleys away from the major structural frequencies were hand-averaged and smoothed.

Conclusions

The DCP formulated a synthetic time history in order to generate the required response spectra. The 7% damped raw spectra produced by the time history gave a close approximation to the smooth design spectra. The DCP amplified the horizontal spectra by 10% to account for accidental eccentricity. The IDVP verified that this amplification was acceptable in accordance with the licensing criteria for the area in which response spectra were generated. Response spectra results were properly transmitted to DCM C-17 for use by other disciplines.

4.2.9 DCP Calculation #8234-04-CA-03: Intake Structure Member Evaluation

This calculation presented the DCP evaluation of structural members for load combinations as specified in the licensing criteria. Only the Hosgri earthquake was considered for seismic loads. The response spectrum method was used to generate loads for member evaluation. Allowable stresses were determined from the references given in the licensing criteria. A tabulation of the maximum shear stresses and allowables presented on Pages 2.1.5-25 and 2.1.5-26 of Reference 6 showed the members to be qualified.

Conclusions

Loads were generated from the response spectrum analysis resulting from structural frequencies both below and above 33 hertz. That portion of the response above 33 hertz was computed using the residual force method. This portion was a significant part of the total member load, since the intake structure itself is a relatively rigid structure. The IDVP reviewed a sample of walls, slabs, beams, and other important structural members for resultant loads and found them to be acceptable.

The flow straighteners were found to have stresses within allowables when ductility considerations were applied. A post-yield analysis, which the IDVP deems consistent with the Hosgri criteria, was performed to determine the pier ductility characteristics.

The IDVP determined that the 10% amplification of horizontal spectra, used to generate member forces, did not give conservative results compared to the imposition of 5% accidental eccentricity. A maximum increase of 17% in shear stress due to 5% accidental eccentricity occurred at the outer walls. However, the resulting increase was not large enough to result in total stresses that exceeded allowables. The IDVP found that the intent of the 10% increase in horizontal ground spectra has been satisfied.

The IDVP verified the total weight of the intake structure, including buoyancy effects, to be used in calculating the capacity to resist sliding. The applied sliding forces due to dynamic response of the structure were also reviewed and found to be acceptable.

The IDVP performed alternate analyses to determine the force due to dynamic soil pressure. The analyses and results are described in ITR #68. The IDVP concluded that a shear strength of 7.2 ksf is required in the foundation rock to attain a minimum factor of safety of 1.1 against sliding. The NRC Standard Review Plan (SRP, Reference 23), Section 3.8.5, specifies a minimum factor of safety of 1.1 against sliding and overturning. This is for a load combination consisting of dead, lateral earth pressure, and safe shutdown earthquake (Hosgri). This is the controlling load case. The IDVP then evaluated the rock with respect to field observations and literature and determined that the shear strength is greater than 7.2 ksf. Thus, the factor of safety against sliding is greater than 1.1.

The IDVP determined the factor of safety against overturning and bearing pressure. For overturning, the factor of safety was computed to be 1.4. The IDVP found the maximum bearing pressure to be 11.7 ksf. A shear strength of 7.2 ksf is equivalent to an ultimate bearing strength of 37 ksf; thus the factor of safety is 3.2, which is conservative. The IDVP therefore concluded that the intake structure meets licensing criteria with respect to structural stability.

4.3 VERIFICATION OF AS-BUILT CONDITION

The IDVP chose the snorkel and vent shaft as their sample for field verification of the as-built condition. The as-built conditions corresponded to the design drawings used as the basis for analyses.

In addition, the non-structural fillet modifications between the front curtain wall and the underside of the top slab were field verified.

5.0 EOI REPORT

EOI 1022 was redefined as an Error Class A or B to track the DCP's reevaluation of the intake structure performed as part of their Corrective Action Program. Previously, spectra produced at elevation -2.1 feet had been used as input for the upper ASW pump support 10 feet above elevation -2.1 feet.

The DCP reanalysis included nodal points in the analysis models at elevation +8.75 feet, the elevation of the ASW pump support. The IDVP verified that these spectra were included in DCM C-17 (Hosgri).

A Completion Report has been issued which closes out EOI 1022.

6.0 CONCLUSIONS

The IDVP has reviewed the DCP Corrective Action Program methodology for the intake structure as detailed in Reference 6 and found it to be acceptable.

The DCP supplied the IDVP with a list of qualification analyses (Reference 7, detailed in Appendix A) which the IDVP found to be acceptable. The IDVP selected a sample from this list in order to verify the DCP procedural implementation. The IDVP found the qualification analyses and sampled results to be acceptable. The IDVP verified through alternate calculations that the intake structure meets licensing criteria with respect to structural stability.

7.0 REFERENCES

Reference No.	Title	RLCA File No.
1	Independent Design Verification Program (IDVP) Interim Technical Report (ITR) #8, Verification Program for PGandE Corrective Action, Revision 0, October 5, 1982.	P105-4-839-008
2	IDVP ITR #35, Verification Plan for Diablo Canyon Project Activities, Revision 0, April 1, 1983.	P105-4-839-035
3	Diablo Canyon Site Units 1 and 2, Final Safety Analysis Report, USAEC Docket Nos. 50-275 and 50-323.	P105-4-200-005
4	Seismic Evaluation for Postulated 7.5M Hosgri Earthquake, USNRC Docket Nos. 50-275 and 50-323.	P105-4-200-001
5	Supplement No. 7 to the Safety Evaluation Report, Office of Nuclear Reactor Regulation, U. S. Nuclear Regulatory Commission, In the Matter of Pacific Gas and Electric Company, Diablo Canyon Nuclear Power Station, Units 1 and 2, Docket Nos. 50-275 and 50-323.	P105-4-100-013
6	Pacific Gas and Electric Company (PGandE) Phase I Final Report - Independent Design Verification Program, Diablo Canyon Nuclear Power Plant, June 21, 1983.	P105-4-200-117
7	DCP Calculation Index, Intake Structure, Revision 9, May 14, 1982.	P105-4-441-119

Reference No.	Title	RLCA File No.
8	IDVP ITR #41, Corrective Action Program and Design Office Verification Performed by R. F. Reedy, Inc., Revision 0, April 13, 1983.	P105-4-839-041
9	IDVP Design Review of DCP Calculation #0902-26.	P105-4-506-003, Rev. 1
10	IDVP Design Review of DCP Calculation #8234-04-CA-01.	P105-4-506-004, Rev. 1
11	IDVP Design Review of DCP Computer Runs #8234-04-CO-01A-01D.	P105-4-506-015, Rev. 0
12	IDVP Design Review of DCP Calculation #8234-04-CA-04.	P105-4-506-006, Rev. 1
13	IDVP Design Review of DCP Calculation #8234-14-CA-01.	P105-4-506-061, Rev. 0
14	IDVP Design Review of DCP Calculation #52.18-10.	P105-4-506-020, Rev. 0
15	IDVP Design Review of DCP Calculation #8234-04-CA-02.	P105-4-506-028, Rev. 0
16	IDVP Design Review of DCP Calculation #8234-04-CA-03.	P105-4-506-129, Rev. 0
17	Diablo Canyon Project (DCP) Design Criteria Memorandum (DCM) C-17, Hosgri Response Spectra for Structures, Systems, and Components, Revision 5.	P105-4-200-108
18	DCP DCM C-23, Auxiliary Saltwater System - Vent Shaft Extension, Revision 1.	P105-4-200-109

Reference No.	Title	RLCA File No.
19	TES Letter #5511-382, Subject: IDVP Review and Position on DCP Reevaluation of DCNPP Turbine Building and Intake Structure, June 3, 1982.	
20	IDVP Design Review of Structural Stability for the Intake Structure.	P105-4-506-205, Rev. 0
21	IDVP ITR #54, Verification of Corrective Action - Containment Building, Revision 0.	P105-4-839-054
22	IDVP ITR #68, Verification of HLA Soils Work, Revision 0.	P105-4-839-068
23	U.S. Nuclear Regulatory Commission Standard Review Plan, NUREG-0800, Revision1, July 1981.	

Appendix A
List of DCP Qualification Analyses
(1 page)

Appendix A

List of DCP Qualification Analyses

Calculation No.	Revision	Description
8234-04-CA-01*	0	Eigen Extraction Model
8234-04-CA-02*	0	Floor Response Spectra
8234-04-CA-03*	0	Building Evaluation
8234-04-CA-04*	0	Review of Computer Model
8234-04-CA-05*	0	Crane Evaluation
8234-04-CO-06	0	Local Pier Model
8234-04-IS004-CA-01	0	Residual Force Usage
8234-04-IS005-CA-01	0	Revision of Stability Calculation for Buoyant Mass
8234-04-IS006-CA-01	0	Evaluation of Crane for High Frequency Amplification
8234-04-IC002-CA-01	0	Nonlinear Analysis of Intake Crane Cable Stresses
8234-14-CA-01*	0	Eigen Extraction for DE Analysis
8234-14-CA-02*	0	DE Floor Response Spectra
52.18-1	0	Intake Structure Verification
52.18-2	0	Local Stresses at Crane Support Points
52.18-3	0	Local Stresses at Openings
52.18-4	0	Flow Straighteners (Piers)
52.18-5	0	Crane Seismic Verification
52.18-10	0	Vent Shaft
52.18-11	0	Manholes and Fillets
52.18-12	0	Wall and Slab Capacities for Flood Event
52.18-20 through 35	0	Pipe Support Loads

* Other files exist which also designate computer run volumes; in those cases, a "CO" designation is used instead of "CA".

This list was excerpted from Reference 7.

Appendix B
List of IDVP Sample - Intake Structure
(2 pages)

Appendix B

List of IDVP Sample

Intake Structure

Calculation No.	RLCA P105-4-
8234-04-CA-01	441-036
-CA-02	441-075
CA-03	431-109
CA-04	441-035
8234-14-CA-01	441-113
52.18-10	431-101

Description of IDVP Selected Computer Runs

Computer Run No. 8234-04-CO-	RLCA P105-4-	Description
01A	441-077	N-S Eigenvalues
01B	441-077	N-S Participation Factors (PF)
01C	441-077	E-W/Vertical Eigenvalues
01D	441-077	E-W/Vertical PF
02A	441-089	N-S and E-W/Vertical Mode Shapes
02C	441-090	(N-S Newmark EQ) N-S Floor Spectra
02E	441-091	(E-W Newmark EQ) N-S Floor Spectra
02F	441-084	(Vertical Newmark EQ) N-S Floor Spectra
02J	441-085	(E-W Newmark EQ) E-W Floor Spectra
02K	441-094	(Vertical Newmark EQ) E-W Floor Spectra
02M	441-096	(N-S Newmark EQ) Vertical Floor Spectra
02O	441-093	(E-W Newmark EQ) Vertical Floor Spectra
02P	441-092	(Vertical Newmark EQ) Vertical Floor Spectra
02Q	441-086	Enveloped N-S Floor Spectra

List of IDVP Sample - Intake Structure

(Continued)

Computer Run No. 8234-04-CO-	RLCA P105-4-	Description
02R	441-087	Enveloped E-W Floor Spectra
02S	441-088	Enveloped Vertical Floor Spectra
02U	441-097	Enveloped N-S Floor Spectra - Blume and Newmark
02AB	441-095	Listing of Programs MODE/1.0, ENVELOPE/1.0 and SRSS/0.0
03V	441-076	E-W/Vertical Model Newmark Response Spectrum Analysis
03W	441-076	E-W/Vertical Model Residual Forces from Newmark
03X	441-076	E-W/Vertical Model Newmark Force Analysis
03Y	441-076	E-W/Vertical Model Newmark Response Spectrum plus Residuals
03Z	441-076	SAPOST1: Newmark E-W Response Spectrum Analysis
03AA	441-115	SAPOST1: Newmark E-W Analysis of Residuals
03BB	441-116	SAPOST1: Newmark E-W Response Spectrum plus Residuals
03MM	441-106	Newmark N-S and E-W Horizontal/Newmark Vertical
03OO	441-108	SAPOST1: Newmark N-S and E-W/ Newmark Vertical
03PP	441-107	Gravity Analysis
04L		Combined E-W Floor Response Spectra-Hosgri
06A	441-105	Model Acceleration and Displacement N-S Model - Pier Study
06B	441-104	SAP Finite Element Pier Model
06C	441-103	Pier Model Rotations applied about Vertical Axis
06D	441-102	Pier Model - New Loads
06E	441-101	Pier Model - New Loads
06F	441-100	Pier Analysis - Tension and Bending

Appendix C

EOI Status - Intake Structure

(1 page)

Appendix C

EOI Status - Intake Structure

EOI File No.	Subject	Rev:	Date	By	Type	Action Required	Physical Mod.
1022	Intake Structure	0	2/18/82	RLCA	OIR	RLCA	
		1	4/30/82	RLCA	PPRR/OIP	TES	
		2	5/10/82	TES	PRR/OIP	PGandE	
		3	9/3/82	TES	OIR	RLCA	
		4	9/7/82	RLCA	PER/AorB	TES	
		5	9/10/82	TES	ER/AorB	PGandE	
		6	7/23/83	TES	OIR	RLCA	
		7	7/23/83	RLCA	PPRR/CI	TES	
		8	7/26/83	TES	PRR/CI	TES	Yes
		9	7/26/83	TES	CR	NONE	

STATUS: Status is indicated by the type of classification of latest report received by PGandE:

OIR - Open Item Report
PPRR - Potential Program Resolution Report
PRR - Program Resolution Report
PER - Potential Error Report
OIP - Open Item with future action by PGandE
ER - Error Report
CR - Completion Report
CI - Closed Item
DEV - Deviation
A - Class A Error
B - Class B Error
C - Class C Error
D - Class D Error

PHYSICAL MOD: Physical modification required to resolve the issue. Blank entry indicates that modification has not been determined.

Appendix D
Key Term Definitions
(6 pages)

Appendix D

Key Term Definitions

(The definitions in this glossary establish the meanings of words in the context of their use in this document. These meanings in no way replace the specific legal and licensing definitions.)

As-Built

- Present configuration of DCNPP-1 by the licensing criteria.

Calculation Files

- DCP term for set of individual, numbered design calculations.

Closed Item

- A form of program resolution of an Open Item which indicates that the report aspect is neither an Error nor a Deviation. No further IDVP action is required.

Completion Report

- Used to indicate that the IDVP effort related to the Open Item identified by the File Number is complete. It references either a Program Resolution Report which recategorized the item as a Closed Item or a PGandE document which states that no physical modification is to be applied in the case of a Deviation or a Class D Error.

Corrective Action

- Response of the Diablo Canyon Project to concerns related to the Hosgri qualification which were identified either by the IDVP or by the DCP Internal Technical Program.

Damping

- The measure of energy dissipation in a system.

DCNPP-1

- Diablo Canyon Nuclear Power Plant, Unit 1.

DCP

- Diablo Canyon Project: PGandE and Bechtel Power Corporation.

DDE

- Double design earthquake.

DE

- Design earthquake.

Dead Load

- A constant load exerted by the weight of a mass at rest; also known as static load.

Design Analysis

- Work performed by or for PGandE.

Design Codes

- Accepted industry standards for design (e.g., AISC, AISI, ANSI, ASME, AWWA, IEEE).

Dynamic Load

- A force exerted by a moving body on a resisting member, usually in a relatively short time interval.

Eigenanalysis/Eigensolution

- Defines frequencies of vibrations, mode shapes, and participation factor for a math model.

EOI

- Error and Open Item Report.

Equivalent Static Method

- Static analysis method whereby an acceleration applied to a system is treated as a static force.

Error Report

- An Error is a form of program resolution of an Open Item indicating an incorrect result that has been verified as such. It may be due to a mathematical mistake, use of wrong analytical method, omission of data, or use of inapplicable data.

  Each Error shall be classified as one of the following:

o Class A: An Error is considered Class A if the design criteria or operating limits of safety-related equipment are exceeded and, as a result, physical modifications or changes in operating procedures are required. Any PGandE corrective action is subject to verification by the IDVP.

  Class B: An Error is considered Class B if the design criteria or operating limits of safety-related equipment are exceeded, but are resolvable by means of more realistic calculations or retesting. Any PGandE corrective action is subject to verification by the IDVP.

o Class C: An Error is considered Class C if incorrect engineering or installation of safety-related equipment is found, but no design criteria or operating limits are exceeded. No physical modifications are required, but if any are applied, they are subject to verification by the IDVP.

o Class D: An Error is considered Class D if safety-related equipment is not affected. No physical modifications are required, but if any are applied, they are subject to verification by the IDVP.

Field Verification

- The process of verifying actual configuration of equipment, buildings and components at the installation site against PGandE drawings.

Finite Element Method

- Idealization of a structure with representation of members and masses by nodes, beams, plates, etc.

FSAR

- PGandE's Final Safety Analysis Report.

Hertz

- Unit of frequency; also known as cycles per second (cps).

Hosgri Criteria

- Licensing criteria referring specifically to the postulated 7.5M Hosgri earthquake.

Hosgri Report

- A report issued by PGandE that summarizes their evaluation of DCNPP-1 for the postulated Hosgri 7.5M earthquake; includes seismic licensing criteria.

Hosgri 7.5M Earthquake

- Maximum earthquake for which the plant is designed to remain functional.

IDVP

- Independent Design Verification Program undertaken by R. L. Cloud Associates, Teledyne Engineering Services, Stone and Webster Engineering Corporation and R. F. Reedy to evaluate Diablo Canyon Nuclear Power Plant for compliance with the licensing criteria.

Internal Technical Program

- Combined Pacific Gas and Electric Company and Bechtel Power Corporation project formed for Diablo Canyon completion.

Interim Technical Report

- Interim Technical Reports are prepared when a program participant has completed an aspect of their assigned effort in order to provide the completed analysis and conclusions. These may be in support of an Error, Open Item or Program Resolution Report, or in support of a portion of the work which verifies acceptability. Since such a report is a conclusion of the program, it is subject to the review of the Program Manager. The report will be transmitted simultaneously to PGandE and to the NRC.

Licensing Criteria

- Contained in PGandE licensing documents; includes allowable criteria (see Hosgri Report).

Load

- Consists of forces, moments, accelerations, and displacements which are applied to piping, attached equipment, or supports.

Member Qualifications

- Consists of allowable loads for a particular structural member at DCNPP-1 as specified in the design criteria.

Model Superposition Method

- Dynamic analysis method whereby responses are calculated separately on a mode-by-mode basis and then combined.

NRC

- Nuclear Regulatory Commission (formerly the AEC).

Open Item

- A concern that has not been verified, fully understood, or its significance assessed. The forms of program resolution of an Open Item are recategorized as an Error, Deviation, or a Closed Item.

Phase I Program

- Review performed by RLCA, TES and RFR, restricted to verifying work performed prior to June, 1978 related to the Hosgri reevaluation design activities of PGandE and their service-related contractors.

Phase II Program

- Work performed by RLCA, TES, Stone & Webster, and RFR; includes non-seismic-related contracts prior to June 1, 1978, PGandE internal design activities and all service-related contracts after January, 1978.

QA Review

- Quality Assurance review.

Response

- The motion resulting from an excitation of a device or system under specified conditions.

Response Spectra

- A plot, for all periods of vibration, of the maximum acceleration experienced by single degree of freedom system during a particular earthquake; used in seismic analysis. Types of spectra include both vertical and horizontal.

Spectral Input

- Acceleration value taken from response spectra for input into seismic analysis.

SRSS

- Square root of sum of the squares.

Time History Analyses

- Used to determine the dynamic response of a system excited by accelerations as a function of time.

Torsion

- The in-plane rotation of a point or body about an axis perpendicular to that plane.

Appendix E
Program Manager's Assessment
(1 page)

APPENDIX E

PROGRAM MANAGER'S ASSESSMENT

As Program Manager of the Independent Design Verification Program, TES has reviewed the verification work as described herein.

The program management function was performed by TES in accordance with the Phase I Program Management Plan. The task of additional verification of the intake structure which is part of the management function was carried out through several steps:

1. Meetings were held with RLCA and the DCP to review and discuss technical assumptions and results.

2. Calculations and reports performed by RLCA were reviewed. The underlying DCP documents were utilized in this review.

3. TES personnel, along with Professors J. M. Biggs and M. J. Holley, Jr., and RLCA had an opportunity to view the intake structure during a visit to the Diablo Canyon Nuclear Power Plant.

Professors J. M. Biggs and M. J. Holley, Jr., were involved in all aspects of the review. Their involvement included participation in open meetings in which the intake structure was a topic of discussion and review of relevant material generated by the DCP and RLCA.

The IDVP considers the intake structure to be qualified and to meet licensing requirements including those for sliding, overturning, and soil bearing pressures.