Robert L. Cloud and Associates, Inc.

RLCA

Interim Technical Report

DIABLO CANYON UNIT 1
INDEPENDENT DESIGN VERIFICATION PROGRAM
REVIEW OF DCP ACTIVITIES
- Fuel Handling Building -
ITR #57
REVISION 1

Docket No. 50-275
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PROGRAM MANAGER'S PREFACE

DIABLO CANYON NUCLEAR POWER PLANT - UNIT 1

INDEPENDENT DESIGN VERIFICATION PROGRAM

INTERIM TECHNICAL REPORT

FUEL HANDLING BUILDING

This revision 1 of Interim Technical Report, ITR 57, is one of a series of ITRs prepared by the DCNPP - IDVP for the purposes of providing a conclusion to the program.

This report summarizes the IDVP verification of the DCP corrective action to qualify the fuel handling building (FHB) for both seismic and non-seismic loads. The IDVP review verification addressed those concerns previously reported in EOI 1092 regarding inconsistencies among the IDVP field observations, design drawings, and figures reported in the Hosgri Report. The DCP took steps to address these concerns in their corrective action program. The IDVP has completed its field verification and found the as-built conditions agree with the design and modification drawings. The IDVP verification results in this ITR will be reported in Section 4.4.3 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 Review and Approved
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IDVP Review of DCP Activities

Fuel Handling Building

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1.0 INTRODUCTION

Purpose and Scope

This interim technical report (ITR) summarizes the Independent Design Verification Program (IDVP) review of the Diablo Canyon Project's (DCP) corrective action to qualify the fuel handling building (FHB) for both seismic and non-seismic loads. The FHB is a Design Class 1 steel-framed structure supported at elevation 140 feet on the auxiliary building. It supports a fuel handling bridge crane which services both units. The structure contains cross-braced columns in the north-south direction, and moment-resisting steel frames in the east-west direction. A portion of the end frames share a concrete wall with the fan rooms of the auxiliary building.

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, compartment pressure, pipe reaction, missile impact, dead, and live loads. 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 FHB specified a complete review of the as-built conditions, analyses, and member qualifications. Where the DCP review showed deficiencies, these were corrected.

For the DCP methodology, the IDVP examined the scope, review, and reanalysis to assure 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 the DCP's list of design analyses to the DCP scope. A sample of qualification analyses was selected and verified against design criteria, DCP analysis methods, and results. In addition, the IDVP verified the as-built conditions and found agreement with the design and modification drawings.

Background

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 FHB 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 Phase I Final Report. To evaluate the procedural implementation, the IDVP selected a sample of those calculations and computer files which comprised the qualification analyses for the structure and reviewed the sample for compliance with the DCP design criteria. Verification of the as-built condition (including modifications) was performed to ensure consistency between as-built conditions and design drawings.

The IDVP found the DCP methodology to be acceptable. The IDVP found the DCP procedural implementation to be satisfactory as a result of the review of the sampled calculations.

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 (Reference 6). 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.

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. The IDVP selected a sample of the qualification analyses for review.

Response spectra generated by the DCP were examined to ensure that spectra were determined for all 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 Design Criteria Memorandums (DCMs) for use by other disciplines.

The structural member evaluations were also reviewed (as will be described in Section 4.2) to ensure conformance with loading combinations and allowable stresses as specified in the DCP licensing criteria.

In addition, the IDVP verified a portion of the sample at the field site to ensure that as-built conditions conform to engineering drawings used for calculations and that modifications have been completed.

2.2 CRITERIA

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

- o Final Safety Analysis Report for DCNPP
- o Seismic evaluation for postulated 7.5M earthquake (Hosgri)
- o 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:

- o Review of as-built condition and design drawings to ensure compliance with criteria; modifications made as necessary
- o Review of proper criteria utilization from FSAR and Hosgri Report
- o Review of assumptions, input data, analytical models, computer codes, and calculation techniques; reanalysis performed as necessary.

3.2 DCP METHODOLOGY FOR FUEL HANDLING BUILDING

The DCP methodology is described in Section 2.1.3 of Reference 6. Seismic review was performed using the FSAR and Hosgri Report criteria.

The DCP examined the as-built condition of the FHB and the analytical models used to represent the behavior of the structure during its review process. This review indicated that certain simplifying assumptions in the previous models had not given conservative results and that modifications were necessary to meet the licensing criteria. Thus, a complete reanalysis of the FHB using 3-D models was performed by the DCP.

The DCP presented results of the 3-D models and noted locations where members did not meet criteria. Modifications were proposed and evaluated through an iterative process. Required modifications were incorporated into the final design analysis. The DCP provided a list of these required modifications in Section 2.1.3.4.2.1 of the PGandE Phase I Final Report.

The DCP approach in analyzing the FHB involved the use of two uncoupled dynamic models to determine dynamic characteristics. One model represented the five end bays (Model 2.1); the other, the five middle bays (Model 2.2). The seismic input for the FHB dynamic models consisted of acceleration time histories (translational and torsional) from the auxiliary building dynamic analysis developed at the center of mass, elevation 140 feet. No provision was made for accidental eccentricity of the FHB itself in either the auxiliary building or FHB analysis. However, the effects of accidental eccentricity of the auxiliary building are included in the elevation 140 feet time histories. The fuel handling crane was analyzed separately. The crane evaluation used the response spectrum at elevation 140 as input, except for the vertical Hosgri analysis, where a nonlinear time history analysis was used. Various crane positions were considered. The DCP noted that the dynamic characteristics of the 3-D models showed little difference from the original single-stick/mass representation of the FHB.

The building dynamic models were used to generate response spectra at required locations. In addition, acceleration profiles were determined and used to generate equivalent static loads on the full building static model. Loads from the crane analysis were also superimposed on the static model, and member loads were generated.

In summary, the IDVP agrees with the DCP methodology as described in the PGandE Phase I Final Report. Specific calculation files and the IDVP review results are presented in greater detail 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 from the list of DCP qualification analyses given in Appendix A to review the DCP procedural implementation for the FHB. This sample is given in Appendix B. The sampling procedure includes examination of these analyses to assess the entire seismic qualification for completeness, including implementation of design criteria, formulation of mathematical models, mathematical accuracy, response spectra, and member evaluation.

The DCP's FHB analysis utilized dynamic and static models for evaluation and determination of required modifications. The IDVP selected calculation files in order to assess:

- Formulation of building dynamic models including selection of dynamic degrees of freedom, extent of bays represented, and boundary conditions
- Evaluation of dynamic characteristics of building dynamic models - natural frequencies and mode shapes
- Determination of final nodal accelerations used in the static model, including seismic input
- Generation of response spectra
- Application of nodal accelerations used to determine member loads in the static model
- Evaluation of selected members for maximum stresses against allowables
- Comparison of proposed modifications with analysis models and design drawings.

The fuel handling crane dynamic analysis was not reviewed in detail. Only the loads imposed by the crane on the FHB were reviewed for acceptability. The IDVP has selected the polar crane as its sample for review of the crane structures. The results of the detailed IDVP review of the polar crane will be 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). The technical application and suitability of the STARDYNE code to the analysis of the FHB has been reviewed in this ITR.

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 FHB. 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 and 10) 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 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 (shop drawings) to design drawings. Verification of field conditions versus design drawings was 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

- o Formulation of mathematical models with respect to licensing commitments and required data. Use of proper seismic input.

- o Inclusion of proper degrees of freedom, mass, stiffness, and boundary conditions.

- o Accuracy of results obtained and assessment of any method limitations.

- o Applicability of time history or response spectrum analysis methods.

D. Use of Formulas/Accuracy of Calculations

- o Verify that proper formulas are used and applied.

- o 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 FHB calculations.

A summary of checklist item results for each DCP calculation file reviewed by the IDVP is presented in Sections 4.2.3 through 4.2.16.

4.2.3 DCP Calculation #52.15.7.1.2.1 - Dynamic Models 2.1 and 2.2 - Introduction and Procedure

A description of the structural dynamic models is provided, with a flow chart linking results for use in the static analysis. Geometry, member properties, and dynamic degrees of freedom are discussed. There are no boundary conditions, such as stiffness, applied at the interface of the dynamic models. Time history analyses of the cases computed were East-West (E-W), North-South (N-S), and Vertical. For Hosgri, a vertical dynamic analysis was performed, while for DE/DDE, vertical accelerations were taken as two-thirds of the peak horizontal ground acceleration.

Conclusions

An acceptable overview of the DCP approach for analyzing the structural dynamic models was presented. The DCP did not provide justification for the lack of interface boundary conditions for the dynamic models. A comparison of the fundamental frequencies (Table 2.1.3-3 of Reference 6) showed close correlation between the two dynamic models in both horizontal directions. Thus, no significant coupling between the two models would be expected, and the lack of interface boundary conditions is acceptable. The selection of five consecutive bays to represent dynamic behavior at the end and center of the FHB is also acceptable.

4.2.4 DCP Calculation #52.15.7.1.2.4 - Model 2.1 - Time History Dynamic Analysis, E-W Hosgri

The STARDYNE computer program was used to obtain the time history response of the dynamic models. The translational and torsional time history inputs were applied at the center of mass of the auxiliary building at elevation 140 feet. The DCP selected time histories to provide the maximum response corresponding to the structural frequencies of the FHB. Selected degrees of freedom were chosen at which the nodal time history response was computed.

Conclusions

The first 99 modes were considered, at 7% damping, and time history modal responses added. Since 86% of the total modal effective mass was contained in the first mode, nearly all of the mass was included in computing responses. The time history analysis procedure is acceptable.

4.2.5 DCP Calculation #52.15.7.1.2.5 - Model 2.1 - FHB Spectra Generation

Acceleration response spectra were produced from the acceleration time history of the dynamic analysis. Spectra were broadened according to the licensing criteria and results from the two dynamic models were enveloped for inclusion into the Design Criteria Memorandums.

Conclusions

Response spectra were produced at the proper locations according to licensing criteria. The IDVP verified that the enveloped spectra from this calculation agreed with those contained in the DCM C-17 controlled spectra (Hosgri - Reference 11).

4.2.6 DCP Calculation #52.15.7.1.3.1 - Model 2.2 - Geometry for Dynamic Analysis

Nodal and element locations were presented for the dynamic model. Coordinates agreed with information presented on the drawings. Computer plots of the model were also included.

Conclusions

The DCP presented an acceptable pictorial description of the model geometry used for the dynamic analysis. This geometry agreed with the design and modification drawings issued. These drawings were field verified on a sampling basis and were found to agree with the as-built conditions.

4.2.7 DCP Calculation #52.15.7.1.3.2 - Model 2.2 - Mode Shapes and Frequencies

A copy of the computer program input used by the DCP to generate natural frequencies and mode shapes was provided. This included material, geometry, section properties, weights, and specification of dynamic degrees of freedom as designated by the DCP. One hundred and five modes were extracted, with frequencies ranging from 1.534 hertz to 100.85 hertz. Participation factors and modal weights were also included. For the horizontal cases, the DCP demonstrated that the sum of selected modes (up to the 80th mode) gave a good representation of the total weight horizontally (minimum 86.3%). Computer plots of the dominant mode shapes were included.

Conclusions

The natural frequencies obtained from the 3-D analysis showed good agreement with the results obtained from the DCP's single-stick/mass representation of the FHB. Mode shapes presented were acceptable given the stiffness and mass distribution of the dynamic model.

4.2.8 DCP Calculation #52.15.7.1.1.1 - Equivalent Static Analysis Introduction and Procedure

A flow chart was provided by the DCP which linked use of dynamic analysis results to the static member evaluation. The analytical model used for the equivalent static analysis is designated as Model 1.0 in the PGandE Phase I Final Report. This is a 3-D model, comprised of beam and truss elements, which represents the entire FHB structure. Provisions were made for incorporation of field modifications. Crane girder runway analyses, not reviewed by the IDVP, were described. Calculations regarding the adequacy of member connections and related modifications were also described.

Conclusions

An acceptable overview of the DCP approach for analyzing the static model was presented.

4.2.9 DCP Calculation #52.15.7.1.1.2 - Geometry of Computer Model 1.0

Computer plots of the full static model detailing nodal and element data were presented. Computer runs serving as the basis for these plots were referenced.

Conclusions

Computer plots gave an acceptable representation of the static model. These plots corresponded to the design and modification drawings issued. These drawings were field verified on a sampling basis and were found to agree with the as-built conditions.

4.2.10 DCP Calculation #52.15.7.1.1.3 - Geometric and Weight Properties

Member properties required for the various model elements were computed. Standard section properties were taken from handbooks or computed according to standard practice. Weights were computed to account for siding, roofing, and structural members. The total listed estimated weight of the FHB was acceptable.

Conclusions

The DCP presented an acceptable set of computations detailing section and weight properties for the static model. The IDVP verified the lumped mass values at selected nodes at which nodal accelerations were applied.

4.2.11 DCP Calculation #52.15.7.1.1.4 - Equivalent Static Loads: Acceleration Profiles

Peak accelerations were selected from the dynamic analyses for the designated dynamic degrees of freedom. These accelerations were selected regardless of time of occurrence. The Hosgri, DDE, and DE earthquakes were considered. Peak nodal accelerations were averaged at each elevation for each of the two dynamic models; then the results of the two dynamic models were averaged. The acceleration profiles were divided into two parts: (1) a uniformly applied acceleration equal to the column base acceleration applied over the full building height, and (2) the remaining portion (residual) of the nodal acceleration at each elevation.

Conclusions

Nodal accelerations used as input were determined in an acceptable manner. Conservatism exists in selecting maximum nodal accelerations at all elevations without regard for time of occurrence. References to computer runs producing nodal acceleration values were verified by the IDVP and are acceptable.

4.2.12 DCP Calculation #52.15.7.1.1.5 - Loadings and Loading Combinations for Hosgri and DDE Equivalent Static Analyses

This calculation file describes the procedures and rationale for determining load cases to be examined. One model (E-W) had bottom chord diagonal compression members released for buckling considerations. Crane positions and crane wheel loads were presented. A description of the load cases, designation of loads, and comments were also included. Tables for equivalent static loads detailed the concentrated loads applied to the static model. These were determined by multiplying the static nodal lumped weight by the residual accelerations.

Conclusions

For the E-W analyses, the crane was placed at the center of the FHB for one load case and at the north end for the other case. The first position is critical for symmetrical deflection, while the second position is critical for unsymmetrical deformation, considering global behavior. A similar approach was used for the N-S and Vertical cases; there, the crane's influence is more localized. The DCP methodology is acceptable for consideration of static load cases.

4.2.13 DCP Calculation #52.15.7.1.1.6 - Member Load Tabulation - Hosgri Condition

The IDVP selected a sample of members to review for load cases. These members consisted of the lateral braces, roof braces, roof top chords, E-W knee braces, columns, column base reactions, vertical struts between the top and bottom roof chords, and braces at the north and south end bays.

Conclusions

Member loads were tabulated for critical load cases. Designation was made as to tension or compression for evaluation against allowables. Base reactions and member forces were properly determined by combining the dead load results with the SRSS combination of E-W, N-S, and Vertical seismic results. All member group loads were tabulated, as shown in the index. Axially released members, representing members to be deleted as a result of the modifications, were shown as receiving no load.

The computer input and output were reviewed for a sample load case by the IDVP (Reference 12). Input was consistent with previously defined geometry, member and weight properties; output was correctly transferred to the calculation file.

4.2.14 DCP Calculation #52.15.7.1.1.8 - Member Allowables and Capacities

The IDVP selected the same member groups for review as previously described in Section 4.2.13. The provided index indicated that all member groups were evaluated for allowable stresses. Members were evaluated according to American Institute of Steel Construction (AISC) specifications (Reference 13) and the DCP's DCM C-35 (FHB - Reference 14) Failure modes for the column anchorages were identified and evaluated.

Conclusions

Evaluation of member allowable loads and stresses was acceptable. Several notes were made referring to required modifications (specifically filler plates between double-angle braces) which were field verified by the IDVP on a sampling basis.

4.2.15 DCP Calculation #52.15.7.1.1.9 - Evaluation of Adequacy of Members and Anchorages for Hosgri, DDE, and DE Conditions

Again, the IDVP selected members to review identical to those described in Section 4.2.13. The DCP index indicated that all member groups were evaluated. Stress ratio interaction equations per the AISC were evaluated where required, or actual stresses were compared to allowable stresses. All actual stresses and loads were below allowables.

Conclusions

The DCP used acceptable methods to evaluate both actual and allowable loads and provided comparisons to show that all members met licensing criteria. The DCP presented a summary comparison of maximum stresses against allowables in Table 2.1.3-5 (Reference 6).

4.2.16 DCP Calculation #52.15.7.1.1.13 - FHB Summary and Conclusions

This file summarizes results of the dynamic and static analyses. A table of the maximum stress ratios was given showing a maximum stress ratio of 0.98 (Hosgri and DDE) for the N-S braces, at the north end. The columns have a maximum stress ratio of 0.97 for the DDE event. Most of the stress ratios are in the 0.75 range. The crane girder is shown to have acceptable stress ratios. Thermal stresses are stated to be self-relieving, while wind loads are demonstrated to be substantially less than seismic loads.

Conclusions

All members are shown to be qualified. Proposed modifications have little effect on the dynamic characteristics. The IDVP agrees with the DCP assessment of thermal and wind loads. The DCP provided an acceptable summary section for the qualification of the FHB.

4.3 VERIFICATION OF AS-BUILT CONDITION

The IDVP field verified the as-built condition of portions of the sample described in Section 4.1. The as-built conditions agreed with the design and modification drawings used as the basis for calculations (Reference 16).

5.0 ERROR AND OPEN ITEM REPORT

EOI 1092 was issued to track the DCP corrective action for the FHB. The initial concerns on the FHB were that the IDVP field verifications, design drawings, and figures from the Hosgri Report were not consistent. The DCP has reanalyzed the FHB and presented new figures. The IDVP verified the as-built condition against the revised design drawings and qualification analyses.

This EOI has been closed as an Error Class A.

6.0 CONCLUSIONS

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

The DCP supplied the IDVP with a list of qualification analyses (Reference 7) which the IDVP has 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 results sampled to be acceptable. In addition, the IDVP verified the as-built conditions and found agreement with the design and modification drawings.

The IDVP has completed all efforts related to verification of the fuel handling building.

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, Auxiliary Building and Fuel Handling Building, Revision 6, June 1, 1983.	P105-4-431-286

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 FHB.	P105-4-506-085, Revision 0
10	IDVP Design Review of DCP FHB.	P105-4-506-120, Revision 0
11	Design Criteria Memorandum (DCM) C-17, Hosgri Response Spectra for Structures, Systems, and Components, Revision 5.	P105-4-200-108
12	DCP Computer Input and Output for Static Load Case 6H, Fuel Handling Building.	P105-4-431-297 P105-4-431-298
13	American Institute of Steel Construction, Manual of Steel Construction, 7th and 8th Editions.	
14	DCM C-35, Criteria for Fuel Handling Building Verification, Revision 2.	P105-4-200-150

Reference No.	Title		Revision	RLCA File No.
15		PGandE Drawings:		
	1)	438435	9	P105-4-457-1025
	2)	438436	6	P105-4-457-1025
	3)	438440	9	P105-4-457-1026
	4)	439505	4A	P105-4-457-1027
	5)	439506	5A	P105-4-457-1028
	6)	439507	5A	P105-4-457-1029
	7)	439508	5A	P105-4-457-1030
	8)	439509	1	P105-4-457-1031
	9)	439510	5	P105-4-457-1032
	10)	443338	3	P105-4-457-1033
	11)	443348	3	P105-4-457-1034
	12)	443474	2	P105-4-457-1035
	13)	443475	1	P105-4-457-1036
	14)	451597	4A	P105-4-457-1037
	15)	451598	2A	P105-4-457-1038
	16)	463693	3	P105-4-457-1039
	17)	SK-468145	01C	P105-4-457-1040
	18)	SK-468146	01C	P105-4-457-1041
	19)	SK-468151	01D	P105-4-457-1042
	20)	SK-468152	01C	P105-4-457-1043
	21)	SK-468153	01E	P105-4-457-1044
	22)	59608	5	P105-4-457-1045

Reference No.	Title	RLCA File No.
16	IDVP Field Verification Records	P105-4-591.5-245 thru 260

Appendix A

List of DCP Qualification Analyses

(3 pages)

Appendix A

List of DCP Qualification Analyses

Calculation No./Rev.		Model No.	Description
52.15.7.1.2.1	0	2.1 and 2.2	Introduction and Procedure
52.15.7.1.2.2	0	2.1	Geometry for Dynamic Analysis
52.15.7.1.2.3	0		Mode Shapes and Frequencies
52.15.7.1.2.4	0		Time History Dynamic Analysis
52.15.7.1.2.5	0		FHB Spectra Generation
52.15.7.1.3.1	0	2.2	Geometry for Dynamic Analysis
52.15.7.1.3.2	0		Mode Shapes and Frequencies
52.15.7.1.3.3	0		Time History Dynamic Analysis
52.15.7.1.3.4	0		FHB Spectra Generation
52.15.7.1.3.5	0		Stiffness and Single Degree of Freedom Dynamic Characteristics
52.15.7.1.1.1	0	Final Model 1.0	Equivalent Static Analysis Introduction and General Procedure
52.15.7.1.1.2	0		Geometry of Computer Model
52.15.7.1.1.3	0		Geometric and Weight Properties
52.15.7.1.1.4	0		Equivalent Static Loads: Acceleration Profiles
52.15.7.1.1.5	0		Loadings for Equivalent Static Analysis
52.15.7.1.1.6	0		Member Load Tabulations (Hosgri)
52.15.7.1.1.7	0		Member Load Tabulations (DDE)
52.15.7.1.1.8	0		Member Allowables and Capacities

Calculation No./Rev.		Model No.	Description
52.15.7.1.1.9	0	Final Model 1.0	Evaluation of Adequacy of Members and Anchorages
52.15.7.1.1.10	0		Crane Girder Runway Evaluation (3 Span)
52.15.7.1.1.11	0		Crane Girder Runway Evaluation (2 Span)
52.15.7.1.1.12	0		Crane Girder Runway Evaluation (1 Span)
52.15.7.1.1.13	0	Final Model 1.0	Summary and Conclusions
52.15.7.2.1	0		Design of Connections Modifications Roof Top Chord
52.15.7.2.2	0		Design of Connections Modifications Roof Bottom Chord
52.15.7.2.3	0		Design of Connections Modifications East and West Side Walls
52.15.7.2.4	0		Design of Connections Modifications Roof Trusses
52.15.9.1	0		Fuel Handling Crane Forces to Fuel Handling Building
52.15.9.2	0		Fuel Handling Crane East, West Models EW1 and EW2 URS/Blume Calc. No. 8234-03-CA-004, Revision 0
52.15.9.3	0		Maximum Accelerations for Fuel Handling Crane, 7.5M Hosgri
52.15.9.4	0		Fuel Handling Crane North-South URS/Blume Calc. No. 8234-03-CA-005, Revision 0
52.15.9.5	0		Fuel Handling Crane Vertical Analysis URS/Blume Calc. No. 8234-03-CA-006, Revision 0

Calculation No./Rev.		Description
52.15.9.6	0	Post Processing of Fuel Handling Crane Analysis Results URS/Blume Calc. No. 8234-03-CA-007, Revision 0
52.15.9.7	0	Stress Check of Fuel Handling Crane URS/Blume Calc. No. 8234-03-CA-008, Revision 0
52.15.9.8	0	Survey of Mill Test Data on Steel Used to Fabricate Crane
52.15.9.9	0	Structural Evaluation of FHB Crane

Note:

1) This list is excerpted from Reference 7.

2) Study model 1.0 (static model) calculation numbers are not listed.

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Appendix B

List of IDVP Sample -

Fuel Handling Building

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Appendix B

List of IDVP Sample

DCP Calculation No./Rev.		RLCA P105-4-
52.15.7.1.2.1	0	431-192
52.15.7.1.2.4	0	431-269
52.15.7.1.2.5	0	431-268
52.15.7.1.3.1	0	431-193
52.15.7.1.3.2	0	431-194
52.15.7.1.1.1	0	431-184 (374)
52.15.7.1.1.2	0	431-185 (373)
52.15.7.1.1.3	0	431-186 (375)
52.15.7.1.1.4	0	431-187 (376)
52.15.7.1.1.5	0	431-188 (372)
52.15.7.1.1.6	0	431-189 (377)
52.15.7.1.1.8	0	431-190
52.15.7.1.1.9	0	431-191
52.15.7.1.1.13	0	431-266

Reference 7 was also reviewed by the IDVP.

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Appendix C

Error and Open Item Status

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Appendix C

Error and Open Item Status

EOI File No.	Subject	Rev.	Date	By	Type	Action Required	Physical Mod.
1092	Fuel Handling Building	0	6/11/82	RLCA	OIR	RLCA	
		1	6/11/82	RLCA	PPRR/OIP	TES	
		2	6/21/82	TES	PRR/OIP	PGandE	
		3	7/20/82	TES	OIR	RLCA	
		4	7/21/82	RLCA	PER/A	TES	
		5	7/23/82	TES	ER/A	PGandE	
		6	8/10/82	TES	ER/A	PGandE	
		7	8/31/83	TES	OIR	RLCA	
		8	8/31/83	RLCA	PPRR/CI	TES	
		9	9/6/83	TES	PRR/CI	TES	
		10	9/6/83	TES	CR	None	YES

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.

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Appendix D

Key Term Definitions

(7 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.

Blume Spectra

- Hosgri response spectra generated for DCNPP-1 by URS/Blume.

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.

Envelop

- Response spectra "A" is said to envelop response spectra "B" if all the accelerations on "A" are higher than those on "B" for the same frequency region.

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 intensity 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.

Sample

- Initial sample stipulated in Phase I Program of equipment, components, and buildings to be design verified by independent analysis.

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.

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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 Fuel Handling Building 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 J.M. Biggs and M.J. Holley, Jr. and RLCA had an opportunity to view the FHB 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 Fuel Handling Building was a topic of discussion and review of relevant material generated by the DCP and RLCA.

The DCP has completed modifications to the FHB which were determined to be necessary by their review. The IDVP has field verified portions of the FHB modifications addressed in the IDVP sample and found that the as-built conditions agreed with the design and modification drawings.